EDITORIAL

Greetings from AIISH, Mysore!

The Journal of All India Institute of Speech and Hearing (JAIISH) which was resumed as an indexed journal with the ISSN No.0973-662X in the year 2007 is publishing its annual volumes regularly. e-format of the Journal is also accessible in the portal http://aiish.ac.in directly or through the AIISH website, aiishmysore.in.

There was overwhelming response in terms of the number of papers submitted for publication this year. In view of this, each volume of Journal of AIISH will be brought out biannually as two numbers. I am happy to put before you the 29th Volume, No.1 of Journal of AIISH for the year 2010.

The present volume has certain special features. The authors/editors of three books consented for the review of their book and publication of the same in JAIISH. Three book reviews have been included in this volume namely; Audiology in Developing Countries edited by Mc Pherson, B., Brouillette, R; Portage Guide to Early Childhood Education edited by Smt. Indumathi Rao, CBR Network (South Asia) and Clinical Audio-Vestibulometry for Otologists and Neurologists (IV Edition) by Anirban Biswas. Our sincere thanks to them for consenting to offer their books for review. The book review section was started in the year 2009 with the intention of sharing information regarding the publication of books, particularly those published in India, for the benefit of readers. The eminent reviewers of the books namely Dr. M. N. Nagaraja, Dr. S. Venkatesan and Dr. Alok Thakar are sincerely acknowledged for providing their valuable opinion regarding the book.

It was intended that the review of the book “Clinical Audio-Vestibulometry for Otologists and Neurologists (IV edition)” be done by an otologist as well as an audiologist. The review by the otologist was received well on time to be included in this number and hence this has been included. I hope the review by an audiologist will be published in Vol. 29, No.2.

The other special feature of this volume is a write up by Dr. Prathibha Karanth titled “Women in Science.” This is the plenary address she delivered on the theme of “Speech Language Hearing Sciences and Disorders” at the Second National Women's Science Congress hosted by the All India Institute of Speech and Hearing in November 2009. The National Women's Science Congress is organized by ‘Matru Vedike’ which is a sub organization of Swadeshi Vijnana Andolana-Karnataka, a unit of Vijnana Bharati, an Indian Scientists' Forum. Matru Vedike conducts women science congress annually. This unique venture encourages the organization of a science congress solely for women scientists by women scientists. The congress invites scientific papers on several themes such as Chemical, biological and material sciences; Physical & mathematical sciences; Health and medical sciences including Ayurveda; Civil mechanical, aerospace and transportation sciences; Agriculture, horticultural, fishery and veterinary sciences; Psycho-spiritual and philosophical sciences; Cosmology, geology, geography, archaeology, earth science, ecology, biodiversity, environment; Electrical, electronics, communication and energy; Socio-economic including economics, politics, history, commerce and management; and Socio-cultural sciences including arts and music. In the second National Women's Science Congress, which was hosted by AIISH, Mysore, a new theme on ‘Speech language hearing sciences and disorders’ was proposed and accepted. This attracted several women scientists in this area for the congress.
The present volume 29 (1) has ten articles in the area of speech and language covering the topics on bilingualism, dementia, dyscalculia, and topics in the area of voice and speech intelligibility, phonological awareness skills, communication disorders in actual seizures. There are five articles in the area of hearing covering topics of cochlear implant, hearing aid, auditory speech processing etc.

As mentioned earlier, since there were more than 50 articles received for review, the articles which were reviewed by the editorial board and finalized by mid July 2010 have been chosen for publication in No.1. The other articles which are pending review will be published in Vol. 29 (2) in the latter half of 2010.

I am disappointed to note that there are no letters to the editor regarding any aspect of the journal including the book review section. I request the readers to please respond and react so that your feedback will help us in improving the journal.

It is proposed to include a new section on “case reports” in the forthcoming volumes. I look forward to your feedback and suggestions on this. The 15 articles included in this volume were reviewed by 4 guest editorial members apart from the designated editorial members of the journal. Their contribution is sincerely acknowledged. Our appreciation to all the members of the Editorial Board for meeting our deadlines in reviewing the articles. Ms. K. Yeshoda, Lecturer in Speech Sciences who is the Coordinator for the journal has put in a lot of effort in getting this publication through and this is sincerely appreciated and acknowledged.

I look forward to your continued support in contributing your valuable research publications in the Journal of All India Institute of Speech and Hearing. You may please email your suggestions regarding improving the standard of the journal to aiish_dir@yahoo.com.

Dr. Vijayalakshmi Basavaraj

Director & Chief Editor
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COGNITIVE-LINGUISTIC ABILITIES IN BILINGUAL CHILDREN

*Steby Stephen, **Sindhupriya C., ***Rupali Mathur, & ****Swapna N.

Abstract

There has been much debate among researchers and educators on the effects of bilingualism on the young children. Literature hints that bilingual children have a cognitive advantage. However, studies to explore the effect of bilingualism on cognitive and linguistic abilities are limited. The main aim of the present study was to evaluate the performance of bilingual children on cognitive-linguistic tasks. The participants in the study included 12 bilingual children and 12 monolingual children in the age range of 7-8 years. The Cognitive Linguistic Assessment Protocol for Children (CLAP-C) (Anuroop a & Shyamala, 2008) for children was administered on the selected participants. The CLAP-C assesses the performance of the children in three domains i.e. attention/discrimination, memory and problem solving. The analyzed data was tabulated for each subject and subjected to appropriate statistical analysis. The results revealed that bilingual children were superior to monolingual children on all the cognitive-linguistic tasks, assessed in CLAP-C (attention/discrimination, memory and problem solving). Both the groups scored maximum in attention domain, followed by problem solving and then memory. The results of the present study revealed that bilingual children had a clear cognitive-linguistic advantage compared to monolingual children. The results firmly supported the claim that the bilingualism fosters the development of cognitive-linguistic functions in young children. Generalizing these results to the clinical population it is implicated that even children with communication disorders can be taught two or more languages, provided they have the potential to learn the languages.

Key Words: CLAP-C, dominant bilinguals, cognitive-linguistic advantage.

Communication is the most significant characteristic of human being throughout the entire span of life. Speech and language, the two important components of human communication involves learning and using a code, retrieving a linguistic unit, organizing and further processing; all of which requires cognitive abilities. Thus communication results from the interaction of cognition and language and the cognitive processes shape the use of language skills for communicative functions. Cognition involves a wide range of mental processes such as attention, pattern recognition, memory, organization of knowledge, language, reasoning, problem solving, classification, concept and categorization (Best, 1999). These cognitive processes are interrelated with one another rather than existing in isolation. According to Choi (1997) there is a close interaction between children’s cognitive capacity and the influence of language specific input from the very beginning of linguistic development.

Cognition is affected by the process of learning one or more languages. Children who have the ability to communicate in two languages viz. the bilingual children are different from monolinguals in various ways. The differences are evident in the way they acquire language, their experiences in school, and their socialization with their peers. The linguistic experience is spread over two languages, experience is encoded in either of the two languages and can be expressed in both languages and information representation can be switched between the languages. Researchers have studied the effects of bilingualism on cognitive and linguistic abilities; they have focused on how a child with more than one language mentally organizes language and on the repercussion of bilingualism on cognitive and linguistic development.
Some of the earliest empirical work related to bilingualism reported the detrimental effects of bilingualism on cognition and language. Saer (1923) concluded that bilinguals are mentally confused and are at a disadvantage in thinking compared to monolinguals. Bilinguals consistently scored lower on verbal intelligence (IQ) tests and are disadvantaged on performance tests as well (Darcy, 1963). Further an overwhelming majority of studies found strong evidence for the so-called 'language handicap in bilingual children (Arsenian, 1937; Darcy, 1953, 1962; Macnamara, 1966). When compared to monolinguals, the bilingual children appeared inferior on a wide range of linguistic abilities. Among other things, bilinguals were shown to have a poorer vocabulary (Saer, 1923; Grabo, 1931; Barke & Perry-Williams, 1938; Smith, 1949; Ben-Zeev, 1977; Doyle, Champagne & Segalowitz, 1978), deficient articulation (Carrow, 1957), lower standards in written composition and more grammatical errors (Saer, 1923; Harris, 1948). The reason proposed for the poorer vocabulary was that the bilingual children had to learn two different labels for everything, which reduced the frequency of a particular word in either language (Ben-Zeev, 1977). This made the task of acquiring, sorting, and differentiating vocabulary and meaning in two languages much more difficult when compared to the monolingual child's task in one language (Doyle et al., 1978). Further, Gollan, Montoya and Werner (2002) suggested that the semantic fluency of monolinguals is higher than bilingual, i.e., the bilingual needs to ensure that the correct word is chosen from their two languages and they are more likely to report a 'tip of the tongue state' possibly because they use some words in both the languages less often (Gollan & Acenas, 2004).

Some studies found no differences between monolingual and the bilingual group in cognitive and linguistic tasks (Rosenblum & Pinker, 1983). According to Toukomaa and Skutnabb-Kangas (1977) children with native competency in one language only, normally their mother tongue but with a much less command of the other language, showed neither positive nor negative cognitive effects i.e. their performance did not differ from that of monolingual children.

On the contrary, there are a few other studies that support the view that speaking two languages does not tax either the cognitive or the linguistic system; rather bilingualism confers advantages upon children with respect to various cognitive and linguistic abilities (Ben-Zeev, 1977; Francis, 1990a; Diaz & Klinger, 1991; Hoffman, 1991; De Groot & Kroll, 1997). Ben-Zeev (1977) studied Hebrew-English and Spanish-English bilingual children and concluded that bilinguals process the semantic information more deeply than the monolinguals and showed greater cognitive flexibility and was capable of more complex analytical strategies in their approach to language operations. These findings are consistent with the views of Vygotsky (1962) who argued that being able to express the same thought in different languages will enable the children to see the language as one particular system among many, to view it’s phenomena under more general categories, and this leads to awareness of the linguistic operations. Bilingual children have accelerated metalinguistic awareness compared to monolingual children (Cummins, 1978; Mohanty, 1982; Galambos & Goldin-Meadow, 1990; Bialystok, 1991). They also excel at paying selective attention to relatively subtle aspects of language tasks, ignoring more obvious linguistic characteristics (Bialystok, 1992; Bialystok & Majumdar, 1998; Cromdal, 1999). Campbell and Sias (1995) reported that bilinguals performed at higher level than monolinguals on the phonological tasks.

Kessler and Quinn (1987) found that the bilingual children outperformed the monolinguals in the ability to formulate scientific hypothesis in a problem-solving setting and on semantic and syntactic measures. This was perceived to be an indication of enhanced linguistic and cognitive creativity directly related to their bilingual language proficiency. Findings of Komi-Nouri, Moniri and Nilsson (2003) suggested that bilingual children integrate and/or organize the information of two languages, and therefore bilingualism creates advantages in terms of cognitive abilities (including memory). It extends the individual’s capabilities and promotes mental processing (i.e. problem solving, thinking, flexibility and creativity).

A similar study was carried out in the Indian context by Rajasudhakar and Shyamala (2008) in bilingual adults and elderly. They studied two groups of subjects consisting of forty young and old individuals. Each group had 20 monolinguals and 20 bilinguals. Cognitive Linguistic Assessment Protocol
(CLAP) for adults developed by Kamath and Prema (2003) in Kannada was used for assessing the cognitive-linguistic abilities of young as well as older monolinguals and bilinguals. The results indicated that bilingual adults and elderly performed better on all the domains of CLAP indicating a cognitive-linguistic advantage.

Need for the study

In summary, the findings from the literature revealed mixed evidence of the effects of bilingualism on cognition and language in young children. This inconsistency could partly be because of the wide variations in the proficiency in the second language in children, the aspects of cognition and language studied, the methodological differences etc. Since the findings from different studies are contradictory, further evidence is essential to corroborate these results. Further, as the chances of exposure to other languages and culture is becoming a common phenomenon with the advanced life styles and life circumstances, especially in a fast developing country like India, there is a need to further investigate in detail whether bilingualism creates positive or negative impacts in the overall development and functioning of an individual. Hence, it is important to establish the precise effects of bilingualism on cognitive-linguistic processing. However, in the Indian context such studies to explore the relationship between bilingualism and cognitive-linguistic performance especially in young children are limited. Thus this investigation was undertaken to examine whether introducing two languages right from the preschool period would facilitate or hamper the child's cognitive-linguistic abilities.

Aim of the study

The main aim of the present study was to investigate the performance of the bilingual children on cognitive-linguistic tasks and to explore the presence of bilingual advantage, if any.

Method

Participants: Two groups of typically developing children ranging in age from 7 to 8 years who were native speakers of Kannada participated in the study.

Group 1: Comprised of twelve (6 males and 6 females) Kannada speaking monolingual children.

Group 2: Comprised of twelve (6 males and 6 females) Kannada-English speaking dominant bilingual children who were more proficient in Kannada.

The participants were selected from schools in the city of Mysore and Chamarajanagar (Karnataka state). The children included in the Group 1 were studying in Kannada medium schools with English as the second language from grade I. These children had limited exposure to English while the children included in the Group 2 were studying in English medium schools and had greater exposure to English since the entire curricula was taught in English language. All ethical standards were met for subject selection and their participation.

Participant selection criteria:

The criteria considered for the selection of monolingual and bilingual subjects were:

1. No history of language, hearing, neurological, developmental, academic and intellectual disorders, which was ensured using the 'WHO Ten-question disability screening checklist' (Singhi, Kumar, Malhi & Kumar, 2007).
2. Participants belonging to lower and middle socioeconomic status with one of the parent employed and monthly income not exceeding Rs.15,000.
3. A rating of 'minimal social proficiency' (a score of 2) in their second language to be considered as a bilingual and a rating of 'initial proficiency' (a score of 0+) on all the macro skills of the International Second Language Proficiency Rating scale (ISLPR) (Ingram, 1985) to be considered as a monolingual. ISLPR describes language performance at eight points along the continuum from zero to native like proficiency in each of the four macro skills (speaking, listening, reading and writing). However, only few aspects relevant for the children were utilized from the scale. The teachers handling the children were also consulted while rating these children for their language proficiency.

Procedure:

The Cognitive Linguistic Assessment Protocol for children (CLAP-C) developed by Anuroopa and Shyamala (2008) was administered on the selected participants. This is a test developed to assess the cognitive-linguistic abilities of Kannada speaking children in the age group of 4-8 years. CLAP-C consists of three domains viz. attention/discrimination, memory and problem solving and each domain consists of three auditory and three visual
subtasks. A total of 5 or 10 levels are included in each subtask and these are arranged in a hypothetical order from simple to complex.

The participants were seated comfortably and were tested in a room with minimum external noise and distractions. Instructions specific to the task were given in Kannada. The testing was carried out in one session which lasted for approximately 45 minutes and was done in both the auditory and visual sensory modalities. The tasks were scored as per the scoring procedure provided in the test for each item. Every correct response was given a score of ‘1’ and every wrong response was given a score of ‘0’. Subsequently, the total score for each of the domain was tabulated and the data obtained was subjected to appropriate statistical analysis.

**I. Effect of group and gender within each domain**

The performance of the monolingual and bilingual children was compared across the three domains of CLAP-C viz. attention/discrimination, memory and problem solving. The mean and the standard deviation (SD) of both the groups are depicted in Table 1. A comparison of the mean scores of both the groups in each of the three domains revealed that the bilingual children performed better than the monolingual children. The same has been depicted in Figure 1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>Domain</th>
<th>Attention/discrimination</th>
<th>Memory</th>
<th>Problem solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monolingual children</td>
<td>Male</td>
<td>Mean</td>
<td>35.33</td>
<td>13.00</td>
<td>23.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>3.14</td>
<td>2.36</td>
<td>2.63</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mean</td>
<td>35.50</td>
<td>12.50</td>
<td>23.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>2.42</td>
<td>3.14</td>
<td>2.94</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Mean</td>
<td>35.41</td>
<td>12.75</td>
<td>23.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>2.67</td>
<td>2.66</td>
<td>2.67</td>
</tr>
<tr>
<td>Bilingual children</td>
<td>Male</td>
<td>Mean</td>
<td>37.66</td>
<td>18.83</td>
<td>35.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>1.21</td>
<td>3.65</td>
<td>2.63</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Mean</td>
<td>37.00</td>
<td>17.33</td>
<td>34.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>1.54</td>
<td>0.51</td>
<td>4.50</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Mean</td>
<td>37.33</td>
<td>18.08</td>
<td>34.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SD</td>
<td>1.37</td>
<td>2.60</td>
<td>3.53</td>
</tr>
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</table>

**Statistical analysis:**

A commercially available SPSS package (version 16.0) was used for statistical analysis. The mean and the standard deviation were obtained for each of the domain in the two groups of children. Two-way MANOVA was used to compare the performance within the three major domains of CLAP-C across the two groups and gender. Repeated Measure ANOVA was done to compare the performance across domains within monolingual and bilingual group. Independent t-test was also used to compare performance of the groups within the subtask of each domain.
The mean scores obtained for the various domains were subjected to two-way MANOVA which revealed that there was a significant difference between the monolingual and the bilingual children in all the three domains. However, there was no effect of gender and no significant interaction between group and gender in any of the three domains. The results of the two-way MANOVA are depicted in Table 2.

Table 2: F-values and significant level for the two groups, gender and the interaction between group and gender

<table>
<thead>
<tr>
<th>Domain</th>
<th>F-values (1, 20)</th>
<th>Significant level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>4.48</td>
<td>0.05*</td>
</tr>
<tr>
<td>Memory</td>
<td>23.43</td>
<td>0.00**</td>
</tr>
<tr>
<td>Problem solving</td>
<td>72.92</td>
<td>0.00**</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>0.08</td>
<td>0.79</td>
</tr>
<tr>
<td>Memory</td>
<td>0.82</td>
<td>0.38</td>
</tr>
<tr>
<td>Problem solving</td>
<td>0.00</td>
<td>0.95</td>
</tr>
<tr>
<td>Interaction between group and gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>0.21</td>
<td>0.65</td>
</tr>
<tr>
<td>Memory</td>
<td>0.21</td>
<td>0.66</td>
</tr>
<tr>
<td>Problem solving</td>
<td>0.19</td>
<td>0.67</td>
</tr>
</tbody>
</table>

*p<0.05, **P<0.01

These results are in agreement with the studies by Ben-Zeev, (1977); Kessler and Quin, (1987); Diaz and Klinger, (1991); Hoffman, (1991); Bialystok, (1992); De Groot and Kroll, (1997); Bialystok and Majumdar, (1998); Cromdal, (1999); Francis, (1990a); Bialystok, (2001); Korimi-Nouri, Moniri and Nilsson, (2003) who found that bilingualism creates advantages in cognitive and linguistic abilities. However, the results are in contrast to the studies by Saer, (1923); Arsenian, (1937); Darcy, (1953, 1963); Jensen, (1962); Macnamara, (1966); Toukomaa and Skutnabb-Kangas, (1977); Rosenblum and Pinker, (1983) which revealed negative effects of bilingualism or no differences between the two groups. However Lambert (1977) pointed out serious methodological flaws in these earlier studies such as the following: the bilingual and the monolingual groups were not controlled for differences in socio-economic status, education, degree of bilingualism and monolingualism and they used an inadequate criteria for selecting the bilingual children. However, the recent studies do support the fact that bilingualism is associated with some advantages in using cognitive and linguistic processes. This is because the bilingual children integrate and/or organize the information of two languages. One possible reason for the bilingual advantage is that bilingual children must learn to reduce the interferences between their two languages in order to speak only one. Another possibility is that bilingualism trains children to focus their attention on the relevant variables in the context, particularly information that is ambiguous or contradictory (Bialystok, 1991).

II. Comparison of domains within each group

Repeated measure ANOVA was administered to examine whether any differences existed within the monolingual and the bilingual group across the three domains. The results revealed that there was a significant difference in the monolingual group [F(2,22)=237.39, p<0.01] and the bilingual group [F(2,22)=106.35, p<0.01] across the domains. Further, within the domains the monolingual and bilingual children attained maximum scores in attention/discrimination followed by problem solving and memory domain (Table 1). This could be attributed to the fact that the bilingual children are constantly involved in focusing their attention to reduce the interference between their languages ensuring that the right words are chosen while speaking. This results in an overall improvement in the attention processes. (Bialystok, 1992; Bialystok & Majumdar, 1998; Cromdal, 1999). These results further confirm the fact that attention/discrimination is one of the prerequisite cognitive-linguistic tasks which forms the foundation for the other cognitive domains such as memory and problem solving to develop.

III. Comparison between the groups within the three subtasks in each domain

1. Attention/discrimination:

The attention/discrimination domain consisted of two main subsections i.e. visual and auditory tasks. The auditory task consisted of three subtasks including digit count test (A-DCT), sound count test (A-SCT) and auditory word discrimination test (A-AWD). The visual task consisted of three subtasks including odd one out (V-OOT), letter cancellation (V-LC) and visual word discrimination test (V-VWD). The mean and the standard deviation scores and the t-values obtained for the two groups of children for each of the subtasks in the attention domain is depicted in Table 3. The mean scores for all the auditory and visual subtasks in the attention domain was higher for bilingual children compared to the monolingual children which indicated better performance by the bilingual children on the attention domain.
This indicates that both monolingual and bilingual children are comparable in their auditory and visual attention skills. Thus it can be inferred that attention is a basic prerequisite skill necessary for language acquisition and communication. However the bilingual children did show the advantage in attention as a result of the representation of two languages in their brain and the need to constantly focus on the right selection of the language and the other components of it depending on the context and the communication partner. These results are in consonance with the findings of several other studies by Bialystok, (1992); Bialystok and Majumdar, (1998) and Cromdal, (1999). Constant experience in attending to one of the languages and ignoring the other might enhance the ability of bilingual children to selectively attend to appropriate cues and inhibit attending to others (Bialystok & Martin, 2004). Bilingual children have better inhibitory control for ignoring perceptual information and selectively paying attention to appropriate information (Bialystok, 2001).

2. Memory

The memory sub-section of CLAP-C consists of two modes, i.e. auditory and visual. Auditory mode consists of three subtasks-digit forward (A-DF), word recall (A-WR) and digit backward (A-DB). Visual mode consists of three subtasks-alternate sequence (V-AS), picture sequencing (V-PS) and story sequencing (V-SS). The mean, standard deviation and the t-values obtained for the two groups of children for each of the subtasks in the memory domain is depicted in Table 4. The mean scores for all the auditory and visual subtasks in the memory domain was higher for bilingual children compared to the monolingual children which indicated better performance by the bilingual children on the memory domain.
Although the bilingual children performed better on all the subtasks, the independent t-test revealed a significant difference existed in all visual subtasks (alternate sequencing, picture counting and story sequencing) between monolingual and bilingual children. This indicated that the bilingual children have a stronger visual memory than auditory memory. The Figure 3 depicts the differences between two groups of children across the various subtasks.

These results are in consonance with the study by Feng, Bialystok and Diamond (2009) who showed a bilingual advantage in visual-spatial working memory but not on verbal-auditory working memory and the study by Kormi-Nouri, Moniri, and Nilsson, (2003) who found that bilingualism had positive effect on both episodic memory and semantic memory at all age levels.

### Table 4: Mean, SD (Standard deviation) and t-values of performance on the subtasks in the memory domain across the groups

<table>
<thead>
<tr>
<th>Subtasks in the memory domain</th>
<th>Groups</th>
<th>t-value df (22)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monolingual children</td>
<td>Bilingual children</td>
</tr>
<tr>
<td>Auditory</td>
<td>Mean</td>
<td>S.D</td>
</tr>
<tr>
<td>Digit forward</td>
<td>40.00</td>
<td>12.06</td>
</tr>
<tr>
<td>Word recall</td>
<td>40.00</td>
<td>12.06</td>
</tr>
<tr>
<td>Digit backward</td>
<td>23.33</td>
<td>7.79</td>
</tr>
<tr>
<td>Visual</td>
<td>Mean</td>
<td>S.D</td>
</tr>
<tr>
<td>Alternate sequencing</td>
<td>60.00</td>
<td>28.28</td>
</tr>
<tr>
<td>Picture counting</td>
<td>45.00</td>
<td>12.43</td>
</tr>
<tr>
<td>Story sequencing</td>
<td>46.67</td>
<td>17.75</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01

### 3. Problem solving

The problem solving domain consisted of tasks in auditory and visual mode. Auditory mode further comprises of sections on predicting the outcome (A-PO), predicting the cause (A-PrC) and compare & contrast (A-CC) tasks. In visual mode, the subtasks include overlapping test (V-OT), association tasks (V-AT), and mazes (V-MZ). The mean, standard deviation and the t-values obtained for the two groups of children for each of the subtasks in the problem solving domain is depicted in Table 5. The mean scores for all the auditory and visual subtasks in the problem solving domain was higher for bilingual children compared to the monolingual children which indicated better performance by the bilingual children on this domain.
Table 5: Mean, SD (Standard deviation) and t-values of performance on the subtasks in the problem solving domain across the groups

<table>
<thead>
<tr>
<th>Subtasks in the problem solving domain</th>
<th>Groups</th>
<th>t-value df (22)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monolingual children</td>
<td>Bilingual children</td>
</tr>
<tr>
<td>Predicting the outcome</td>
<td>72.50</td>
<td>94.17</td>
</tr>
<tr>
<td>Predicting the cause</td>
<td>54.17</td>
<td>78.33</td>
</tr>
<tr>
<td>Compare and contrast</td>
<td>17.50</td>
<td>65.00</td>
</tr>
<tr>
<td>Association task</td>
<td>56.67</td>
<td>66.67</td>
</tr>
<tr>
<td>Overlapping task</td>
<td>63.33</td>
<td>78.33</td>
</tr>
<tr>
<td>Mazes</td>
<td>60.00</td>
<td>76.67</td>
</tr>
</tbody>
</table>

*p<0.01

Although the bilingual children performed better on all the subtasks, the independent t-test revealed a significant difference in all subtasks except the visual association task. The Figure 4 depicts the differences between two groups of children across the various subtasks.

![Figure 4: Performance on individual subtasks in the problem solving domain across groups](image)


These results are well supported by studies done by Brain, (1975); Kessler and Quinn, (1987); Stephens, (1997) and Bialystok and Majumdar, (1998). Bilingual children between four and eight years demonstrated a large advantage over monolingual children in solving problems that required controlling attention to specific aspects of a display and inhibiting attention to misleading aspects that are salient but associated with an incorrect response (Bialystok, 1999). According to Carlson and Meltzoff, (2008) early exposure to more than one language may foster the inhibition and working memory skills necessary for cognitive flexibility in a variety of problem-solving situations.

Thus to summarize, the bilingual children performed better on all the cognitive-linguistic tasks included in the CLAP-C compared to the monolingual children. A significant difference was found between both the groups on the auditory digit count test of the attention domain, visual memory subtests and on the entire problem solving tasks except the visual association subtask. However, a significant difference was not found on the other subtasks. This could have resulted because of the subject sample considered for the study. The monolingual children were not pure monolinguals in that they did know a few words in the second language because of school exposure. However they were not as proficient as the bilingual children as stated previously. Moreover the bilinguals were dominant in their first language although they were quite proficient in their second language. This could have influenced the results of the study.

**Conclusion**

The current study was designed to evaluate the cognitive-linguistic performance in bilingual and monolingual children and to make a comparison between the two groups. A total of 12 bilingual children and 12 monolingual children in the age group of 7-8 years participated in the study. The important findings drawn from the present study are that the bilingual children performed superior to the monolingual children on cognitive-linguistic tasks including attention/ discrimination, memory and problem solving.

These results firmly support the claim that the bilingualism fosters the development of cognitive and
linguistic functions. The results of this study would enrich theoretical knowledge on the relations among bilingualism/monolingualism and cognition. In addition, it can be inferred from the results of the present scenario, it is worthwhile to teach two languages right from the preschool period which will enhance their cognitive-linguistic development rather than hampering. These results can be generalized to the clinical population and it can be inferred that even children with communication disorders can be taught two languages, if they have the potential to learn both the languages. But this has to be probed further with respect to the type of bilingualism preferred and supported with further research.

Since India is a multilingual country, there is a pressing need to carry out similar kind of research, in more number of languages and in multilingual children belonging to various cultural backgrounds to explore their cognitive and linguistic processes. In addition, further research is required considering a large sample of subjects, age groups, other cognitive domains (pattern recognition, reasoning, and orientation), different types of bilingualism (successive, co-ordinate, compound, passive, balanced) and in various speech and language disorders to discover the exact relationship between language and cognition. How much bilingualism is necessary, what type of bilingualism is required, and what particular language pairs maximize bilingual advantage are all questions that are still waiting to be answered.

References


**COMPLEX DISCOURSE PRODUCTION IN PERSONS WITH MILD DEMENTIA: MEASURES OF RICHNESS OF VOCABULARY**

*Deepa M. S. & **Shyamala K. C

**Abstract**

Dementia is characterized by the breakdown of intellectual and communicative functioning accompanied by personality change (DSM IV, American Psychiatric Association, 1994). Differentiating mild dementia from normal cognition in aging is a compelling social, clinical, and scientific concern. The present study aimed to determine whether a complex discourse production task distinguished normal older adults from adults with dementia with the measures of richness of vocabulary. Considered for the study were 10 healthy elderly adults and 10 persons with mild dementia. Spontaneous, conversational speech in dementia participants and healthy elderly was analyzed using three linguistic measures of richness of vocabulary. These were evaluated for their usefulness in discriminating between healthy and persons with dementia. The measures were, type token ratio (TTR), Brunet's index (W) and Honore's Statistic (R). Results suggest that these measures offer a sensitive method of assessing spontaneous speech output in dementia. Comparison between dementia and healthy elderly participants demonstrates that these measures discriminate well between these groups. These findings also suggest that performance on a complex elicited discourse production task uncovers subtle differences in the abilities of persons with dementia (mild) such that measures of length and quality differentiated them from individuals with normal cognition. This method serves as a diagnostic and prognostic tool and as a measure for use in clinical trials.

**Key Words:** dementia, conversational speech, quantitative measures.

Discourse is a naturally occurring linguistic unit that entails the use of suprasegmental, generative language, and requires complex ideation that involves planning, organisation and cognitive flexibility (Brownwell, Michel, Powerson & Gardner, 1983; Patry & Nespoulous, 1990 and Brookshire, 1997). Discourse production activates and highlights the interrelatedness of multiple cognitive processes, and various discourse genres seem to require different cognitive processes and cognitive efforts (Coelho, Liles & Duffy, 1991; Harris, Rogers & Qualls, 1998; Hartley & Jensen, 1991 and Ulatowska, Allard & Chapman, 1990). Discourse comprehension and production tasks are integral to the diagnostic repertoire of clinical speech-language pathologists precisely because discourse behaviors provide a rich corpus for a wide variety of cognitive-linguistic analyses. Thus, an elicited discourse sample seems especially well suited for taxing and assessing the cognitive-communicative abilities of persons with dementia.

Discourse analysis is acknowledged as an important tool for speech-language pathologists, although it is often not the assessment tool of choice due to its apparent time-consuming nature and the overwhelming number of options available. The wide range of analyses available to clinicians such as the number of T-units and total words produced or Pragmatic Protocol checklists make it difficult to choose assessment measures.

**Discourse analysis and speech-language pathology in the 20th century:**

The developments in the 20th century have led to a staggering proliferation of different theoretical perspectives underlying discourse analysis and the publication of multiple complex levels of analysis. Since the early discourse studies (E.g., Mentis &
Prutting, 1987; Milton, Prutting, & Binder, 1984 and Ulatowska, North, & Macaluso-Haynes, 1981), there has been increasing attention paid to different types of discourse genres and an array of approaches to measure them. Most of these approaches have been borrowed from the disciplines of pragmatics, behavioral psychology, and sociolinguistics. Particular techniques in discourse analyses have been derived from both the psycholinguistic and sociolinguistic perspectives. The psycholinguistic analyses include measures of syntax (Chapman et al., 1992; Glosser & Deser, 1990 and Liles, Duffy & Zalagens, 1989), productivity (Hartley & Jensen, 1991 and Mentis & Prutting, 1987), and content (Hartley & Jensen, 1991). On the other hand, sociolinguistic techniques include cohesion analysis (Coelho, Liles, & Duffy, 1991; Hartley & Jensen, 1991; McDonald, 1993 and Mentis & Prutting, 1987), analysis of coherence (Chapman et al., 1992; Ehrlich & Barry, 1989 and McDonald, 1993), analysis of topic (Mentis & Prutting, 1991), and compensatory strategies (Penn & Cleary, 1988). There are a number of published books from the last decade, which focus on the analysis of discourse samples from individuals with neurological impairment (E.g., Bloom, Obler, DeSanti & Ehrlich, 1994; Brownell & Joanette, 1993; Cherney, Shadden & Coelho, 1998 and Joanette & Brownell, 1990).

Dementia is characterized by the breakdown of intellectual and communicative functioning accompanied by personality change (DSM IV, American Psychiatric Association, 1994). Communication disorders are a common feature of dementia (Bayles et al 1987, Kemper, 1992), being present in 88-95% of sufferers (Thompson, 1987). They are particularly pronounced in probable dementia of Alzheimer's type (DAT, Cummings et al., 1985) and include word finding deficits, paraphasias and comprehension impairment (Alzheimer, 1907; Appell et al., 1982, Bayles, 1982; Obler, 1983 and Frigaray, 1973). More recent research has found additional evidence for impaired performance on verbal fluency tasks (Phillips et al., 1996 and Becker et al., 1988), circumlocutory responses (Hodges, Salmon & Butters, 1991) and impairments in discourse, which worsen over the course of the disease (Hutchinson & Jensen, 1980; Ripich & Terrell, 1988 and Ulatowska & Chapman, 1991). Phonemic and syntactic processes, however, have been shown to be relatively preserved (Hodges et al., 1991; Kertesz et al., 1986; Appell et al., 1982; Hier et al., 1985; Kempler & Zelinski, 1994 and Schwartz et al., 1979).

The role of speech language pathology in the assessment and treatment of cognitive communicative disorders like dementia is well established (American Speech-Language Hearing Association, 1990, 2005; Brookshire, 1997). Thus, the cognitive-communicative problems associated with dementia fall within the scientific and clinical purview of communication sciences and disorders professionals, who will increasingly participate in the identification and assessment of individuals with a range of expertise on aspects of cognitive-communicative processes across the lifespan and can contribute to the comprehensive work-up on individuals with dementia.

Many 'structured' tasks have been used to assess individuals with DAT, such as confrontation naming (Eg. Bayles et al., 1987; Bayles et al., 1989 and Hodges et al., 1991), single word production (Eg. Martin & Fedio, 1993), or generation of words beginning with a certain letter (Phillips et al., 1996). However, although previous researchers have found deficits in qualitative aspects of DAT sufferer's conversation using discourse techniques (Ripich et al., 1991 and De Santi et al., 1994), a search of the literature yielded little previous research into quantitative characteristics of conversational, spontaneous speech in DAT. Many of the studies purportedly assessing spontaneous speech have actually measured picture description (Nicholas et al., 1985; Hier et al., 1985 and Criolisele et al., 1996).

Three other studies used spontaneous speech. The first used a semi-standardized interview to compare the performance of 10 DAT, 5 Wernicke's aphasics and 5 normal older controls on spontaneous speech (Blanken et al., 1987). Participant's speech was transcribed and a mixture of methods used to analyse the conversations, including measures of average sentence length (divided into simple and complex sentences), number of words in each class (nouns, verbs, adjectives and adverbs), type token ratio and instances of word finding difficulties. Significant differences between participant groups were found, though the study was compromised by a difference in the total length of speech recorded for each group and the relative brevity (5-10 minutes) of the interviews.
Sevush et al. (1994) assessed language in 150 patients with DAT using spontaneous speech, comprehension, repetition, oral reading, writing and naming. Spontaneous speech was evaluated for fluency, syntax and paraphasias. Each participant’s performance was graded as normal, mildly impaired, or markedly impaired. They found differences in early and late onset DAT patient’s performance on these measures. Interestingly, object naming was worse in late onset DAT, but spontaneous speech was worse in early onset DAT participants.

Romero and Kurz (1996) studied 63 patients with Alzheimer’s disease and rated their spontaneous speech during a 4 minute interview on 6 scales (communication, articulation and prosody, automatic speech, semantic structure, phonemic structure and syntactic structure). Despite large samples, the study was limited by the use of qualitative rating scores, which might have reduced the sensitivity of the measures employed.

To date, there are very few standardized tests of cognitive-communicative function designed specifically for persons with dementia. Nevertheless it follows that, as in dementia, subtle changes in communicative abilities may be the important symptom of declining neurological status. Assuming that subtle decline may first occur within the context of relatively complex linguistic behaviours, detection of minor changes should be enhanced by using a task sufficient complexity to tax seemingly intact cognitive-linguistic abilities.

Bucks, Singh, Cuerden and Wilcock (2000) analysed linguistic measures in spontaneous conversational speech in probable dementia of Alzheimer’s type. They considered 24 participants (8 persons with dementia and 16 healthy elderly) for the study. They measured noun rate, pronoun rate, verb rate, adjective rate, clause-like semantic unit (CSU), type token ratio (TTR), Brunet’s index (W) and Honore’s Statistic (R). Results suggest that these measures offer a sensitive method of assessing spontaneous speech output in DAT and that these serve as diagnostic and prognostic tools for use in clinical trials.

Calderon, Perry, Erzinclioglu, Berrios, Dening, and Hodges (2001) tested the hypotheses that visuoperceptual and attentional ability are disproportionately impaired in patients having dementia with Lewy Bodies (DLB) compared with Alzheimer’s disease (AD). Patients with DLB have substantially greater impairment of attention, working memory, and visuoperceptual ability than patients with AD matched for overall dementia severity. Semantic memory seems to be equally affected in DLB and AD, unlike episodic memory, which is worse in AD. These findings may have relevance for our understanding of the genesis of visual hallucinations, and the differential diagnosis of AD and DLB.

Silveri, Reali, Jenner and Puopolo (2007) aimed to investigate whether attention may be specifically impaired in Alzheimer’s disease from the early stages of the disease. Subgroups of patients with different types of mild cognitive impairment were selected according to standard criteria. Patients and controls were given tasks exploring various subcomponents of attention and executive functions. Only subgroups of mild cognitive impairment characterized by memory disorders obtained lower scores than controls on attention and executive tasks. On the basis of the scores obtained on the Clinical Dementia Rating at the 1-year follow-up, patients were redistributed into 2 groups: those who developed and those who did not develop dementia. Patients who presented evolution to dementia already had, at baseline, lower scores than patients who did not evolve on tasks exploring attention and executive functions. The results suggest that not only memory disorders but also attention/executive deficits may characterize dementia at the onset.

The purpose of the present study was to determine whether a complex discourse production task distinguished typical older adults from adults with dementia with the measure of richness of vocabulary. Specifically the question was whether group differences existed in terms of generated discourse complexity.

### Method

#### Sample

There were 20 participants: 10 persons with diagnosis of mild dementia (6 males and 4 females) and 10 healthy elderly (5 males and 5 females). The dementia group comprised of persons suffering with mild cognitive impairment as measured by the Mini-Mental Status Examination (MMSE: Folstein et al., 1975). Each patient attended a geriatric clinic at National Institute of Mental Health and Neurosciences (NIMHANS) where they underwent thorough medical screening in order to rule out any other treatable pathology that could explain their impairment. This included neuropsychological assessment, laboratory blood testing and Computerized Tomography (CT) scanning of the head. In addition, the following criteria
were fulfilled for the participants from dementia group.

- The age range of the participants should be between 65-89 years
- All participants should have a minimum of 12 years of formal education
- All of them should have Kannada as their first (L1) and English as their second language (L2).
- All of the clinical population must be diagnosed by neurologists/ psychiatrists/ neurosurgeons or geriatric specialist.
- At least 12yrs of formal education.
- Vision and hearing acuity corrected to normal / near normal limits.
- A Score of “1” (mild) should be obtained from Clinical dementia rating scale (Hughes, Berg, Danziger, Coben & Martin, 1982).

Healthy elderly participants were not suffering from any neurological or psychological illness likely to impair performance and were not complaining of memory or other cognitive difficulties. Table 1 shows the mean age, years of education, and handedness of all the participants, MMSE scores and duration of illness for persons with dementia. There were no significant differences in the distribution of males and females (p> 0.05). Also the participants in the dementia group exhibited similar cognitive decline despite having different types of dementia.

Table 1. Demographic and neurological details of patient participants.

<table>
<thead>
<tr>
<th>Sn no.</th>
<th>Age/sex</th>
<th>CDR score</th>
<th>Diagnosis of dementia</th>
<th>Neuroimaging result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67/f</td>
<td>1</td>
<td>Mild AD</td>
<td>Bilateral medial temporal atrophy</td>
</tr>
<tr>
<td>2</td>
<td>72/f</td>
<td>1</td>
<td>Mild AD</td>
<td>Diffuse central atrophy</td>
</tr>
<tr>
<td>3</td>
<td>69/f</td>
<td>1</td>
<td>Mild Frontotemporal</td>
<td>Left frontotemporal atrophy</td>
</tr>
<tr>
<td>4</td>
<td>68/m</td>
<td>1</td>
<td>Mild Frontotemporal</td>
<td>Bilateral frontotemporal lobe atrophy</td>
</tr>
<tr>
<td>5</td>
<td>86/f</td>
<td>1</td>
<td>Mild AD</td>
<td>Bilateral medial temporal atrophy</td>
</tr>
<tr>
<td>6</td>
<td>68/m</td>
<td>1</td>
<td>Mild vascular</td>
<td>Diffuse brain atrophy</td>
</tr>
<tr>
<td>7</td>
<td>66/m</td>
<td>1</td>
<td>Mild AD</td>
<td>Bilateral sub-cortical infarcts</td>
</tr>
<tr>
<td>8</td>
<td>71/m</td>
<td>1</td>
<td>Mild vascular</td>
<td>Multiple cerebral infarcts</td>
</tr>
<tr>
<td>9</td>
<td>69/m</td>
<td>1</td>
<td>Mild Frontotemporal</td>
<td>Left frontotemporal atrophy</td>
</tr>
<tr>
<td>10</td>
<td>75/m</td>
<td>1</td>
<td>Mild AD</td>
<td>Bilateral medial temporal atrophy</td>
</tr>
</tbody>
</table>

(CDR= Clinical dementia rating, m= male, f = female, AD = Alzheimer's dementia).

Table 2. Age, years of education, and handedness of all the participants, MMSE scores and duration of illness for persons with dementia

<table>
<thead>
<tr>
<th></th>
<th>Healthy elderly N= 10</th>
<th>Participants with dementia N= 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>72.6yrs 6.39792</td>
<td>70.8yrs 6.97296</td>
</tr>
<tr>
<td>Years of education</td>
<td>12.8yrs 1.68655</td>
<td>11.9 2.46982</td>
</tr>
<tr>
<td>MMSE scores</td>
<td>29.6 1.07497</td>
<td>21.1 1.10050</td>
</tr>
<tr>
<td>Duration of illness (in months)</td>
<td>7.7months</td>
<td>1.82878</td>
</tr>
<tr>
<td>Handedness</td>
<td>right</td>
<td>right</td>
</tr>
</tbody>
</table>
Procedure:

All the participants were interviewed using a semi-structured interview format in which they were encouraged to talk about two topics. The first one being the arrangements to be made for a marriage and the second one is the differences in present generation as compared to that of previous generation. Participants were asked open ended questions, which did not restrict or control either the extent or the nature of their response. Responses were not corrected by the interviewer and no stimulus or interruption was provided unless the participants were clearly becoming distressed by their inability to respond. Clear interview guidelines were followed. Questions were asked slowly and repeated or reworded as necessary. Interviews were recorded with a Handycam (Sony digital recorder H302233). Interviews lasted between 15-25 minutes allowing as much time as was needed to collect at least 700 words of conversation from each participant.

Transcription:

Interviews were transcribed using IPA (International Phonetic Alphabets) rules. Only words spoken by the participants were transcribed. Transcripts were analyzed using Systematic Analysis of Language Transcripts (SALT: Miller & Iglesias, 2006). As it was an exploration of the technique in dementia, initially all words were transcribed exactly as they had been spoken, including repetitions, incomplete words, interjections, paraphasias and mispronunciations. Subsequently, the discourse was rephrased deleting repetition, incomplete words and interjections and were therefore not counted for analysis. Stereotypical set phrases such as, “ning gotta” (you know) “alvamma” (right girl) were excluded, because such expressions were not acceptable as proper clauses or full sentences. Numbers were transcribed as words. Multiple attempts at the same word were only recorded once. For each participant, transcription and lexical analysis were performed by the same researcher in order to maintain consistency. Data was analyzed for the complexity and mainly the vocabulary was considered for this study and assessed.

Three measures of the richness of vocabulary were used: type token ratio (TTR), Brunet’s index (W) and Honore’s Statistic (R). Type-Token Ratio (TTR):

TTR represents the ratio of the total vocabulary (V) to the overall text length (N). It is the measure of vocabulary size, which is generally found to correlate with the length of text sampled (N).

Brunet’s index (W):

Brunet’s index was included because, it quantifies lexical richness without being sensitive to text length (Brunet, 1978). It is calculated according to the following equation: \[ W = NV (-0.165) \] where N is the total text length and V is the total used by the participant.

Honore’s Statistic (R):

Honore’s Statistic (Honore, 1979), is based on the notion that the larger the number of words used by a speaker that occur only once, the richer the lexicon. Words spoken only once (V1) and the total vocabulary used (V) has been shown to be linearly associated. Honore’s Statistic generates a lexical richness measure that establishes the number of words used only once by the participant as a proportion of the total number of words used, according to the following formula: \[ R = 100 \log N / (1-V1/V) \] where, R is the Honore’s Statistic, N is the total text length, V1 is the words spoken only once and V is the total vocabulary. The higher the values of R, the richer the vocabulary used by the participant.

Results

Three linguistic measures, Type-Token Ratio (TTR), Brunet’s index (W) and Honore’s Statistic (R) were calculated for each participant and between the groups (healthy elderly and participants with dementia) comparisons of the measures were carried out using independent sample t test as p<0.001 level. The results of these measures are depicted in Table 3. As it is seen from the table, the three linguistic measures of richness of vocabulary in conversation speech showed statistically significant differences between the groups at p<0.0001 level. Graphs 1, 2, 3 and 4 show the mean scores of all the participants for MMSE and three measures of richness of vocabulary respectively.
Table 3: results showing the measures of richness of vocabulary

<table>
<thead>
<tr>
<th>Groups</th>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>Sig. (2 tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMSE</td>
<td>HE</td>
<td>29.60</td>
<td>1.07</td>
<td>17.472</td>
<td>18</td>
<td>.000**</td>
</tr>
<tr>
<td></td>
<td>PD</td>
<td>21.10</td>
<td>1.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type Token Ratio</td>
<td>HE</td>
<td>0.40</td>
<td>0.05</td>
<td>7.040</td>
<td>18</td>
<td>.000**</td>
</tr>
<tr>
<td></td>
<td>PD</td>
<td>0.20</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brunet's Index</td>
<td>HE</td>
<td>9.614</td>
<td>1.39</td>
<td>6.797</td>
<td>18</td>
<td>.000**</td>
</tr>
<tr>
<td></td>
<td>PD</td>
<td>5.186</td>
<td>1.51</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honore's Statistic</td>
<td>HE</td>
<td>362.9</td>
<td>28.8</td>
<td>11.434</td>
<td>18</td>
<td>.000**</td>
</tr>
<tr>
<td></td>
<td>PD</td>
<td>233.1</td>
<td>21.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(HE = healthy elderly, PD = participants with dementia, SD = standard deviation, df = degrees of freedom, Sig. = significance, ** = highly significant).

As it is seen from graph 1, significant difference between the groups for MMSE helped to discriminate healthy elderly from mild cognitive impairment. A closer inspection of the data revealed that participants with dementia (PD hereafter) used more pronouns. Healthy elderly (HE hereafter) used fewer pronouns (nearly 3 times more) than PD (refer graph 2, 3 and 4). All three measures of lexical richness showed that most of the HE had lexically richer speech than PD. Statistically significant difference in the results suggest that there were clear differences between PD and HE in lexical items and lexical richness measures.

As seen from graphs 2, 3 and 4, Type-Token Ratio (TTR), Brunet’s index (W) and Honore’s Statistic (R) appears to represent a lexical richness and phrase making factors which was clearly different for the two groups. This study demonstrated that there are significant objectively measurable lexical differences in the spontaneous conversational speech of person with a diagnosis of dementia and healthy elderly.

PD = Participants with dementia.
TTR = Type Token ratio.
Graph 2: Mean scores for Type-Token Ratio.

Discussion

As anticipated, HE adults produced richer spontaneous speech on all three lexical richness measures. Lexical richness measures for different classes of lexical units such as nouns and verbs will...
also be a useful way of investigating the significant differences between the groups. Research studies focused on deficits associated with PD have proposed a breakdown of semantic memory (Martin, 1992 and Roger & Hodges, 1994). Hence there is no doubt that working memory deficits account for poor vocabulary in the mild stage of dementia. It is also evident from the present findings that semantic representation breakdown occurs at this stage (Nebes & Brady, 1988; Barr & Brandt, 1996). Impaired performance in PD reflect an impaired ability to maintain all the information in working memory that is necessary for successful and complete discourse output (Smith et al., 1995 and Johnson, Bonilla & Hermann, 1997).

Complex task of discourse and the measurement of richness of vocabulary, detected subtle changes in communicative ability between the groups in terms of complexity (as it can be seen form graphs 2, 3 and 4). The HE used more words to complete the task as compared to PD group. The sparseness in description by the PD group seems to reflect the inability of the PD group to retrieve words and provide a detailed discourse sample. The complex discourse task was enough to detect the subtle deficit in word retrieval. This difference in the complexity was more related to PD group's decreased competence in planning, problem solving and organisational abilities. This decreased higher order cognitive skills also seems to be reflected in the qualitative differences in the discourse sample as measured by the measures of richness of vocabulary. The scoring and calculations from these measures explored the depth of the spoken discourse samples. The PD group's inability to produce the discourse with rich vocabulary seemed to highlight decreased planning, organisation and cognitive flexibility skills which are the hallmark of dementia (Cummings, 2000).

Graph 3: Mean scores for Brunet's Index

PD = Participants with dementia.
BI = Brunet's Index

Graph 4: Mean scores for Honore's Statistic.

PD = Participants with dementia.
HR = Honore's statistic

Graph 4: Mean scores for Honore's Statistic.

Planning, organisation and cognitive flexibility are important components of executive functions (Crawford, 1998 and Godefroy, 2003) and they have been shown to influence discourse production in traumatic brain injury (Coelho, Liles & Duffy, 1995). However, it is beyond the scope of the present study to determine specifically how executive function will influence the discourse or word retrieving abilities. Nevertheless, the HE adults in this study demonstrated richer vocabulary as measured by three measures of richness of vocabulary. Measures of vocabulary seem to reflect both intact and preserved planning, problem-solving and organisation abilities. These higher-order cognitive skills may be the first to deteriorate in dementia and they are least likely to be captured by less complex linguistic tasks such as naming.

All participants in the present study readily responded to the discourse task. This indicates that task-requirement familiarity was not a confounding variable for the participants in this sample.

Another explanation for the finding in the present study will be reduced vocabulary for the PD group are reflective of impaired memory and reduced ability to retrieve information from their general knowledge stores (Rusted, Gaskell, Watts & Sheppard, 2000). Additionally persons with dementia lack cognitive
inference ability. The topics of conversation in the present study required multiple inferences based on the instruction to “imagine” a hypothetical situation i.e., participants had to provide conceptual content to a virtually empty frame.

Although, the HE adults used more words, there was no difference between the groups in terms of syntactic complexity. Syntactic complexity in persons with dementia appears relatively spared in mild stage (Cummings, 2000). Such complexity in speech challenges the act of detecting decrements in communicative ability. Hence to a casual listener, decreased length of output and sparseness of thematic detail may be misunderstood as structurally complete sentence pattern. This supports previous studies that phonological and syntactic abilities are spared in early dementia (Bayles, 1982; Bayles, Kaszniak & Tomoeda, 1987). Although we did not compare the syntactic complexity between the groups, the length of discourse indirectly accounted for the same. There was no difference between the groups studied in the length of discourse produced.

The use of a complex discourse production task confirmed the need for a cognitively demanding task to magnify subtle changes in communication with PD. The subtle changes are better identified through length and complexity of a spoken discourse that sufficiently trigger the cognitive system. Our results seem to support the use of complex generative discourse production task, to differentiate typically aging adults from persons with dementia.

Conclusion

In conclusion, complex discourse production distinguishes persons with typical cognitive aging and from those with dementia. Differences emerged in terms of length and richness of the vocabulary in their spoken discourse sample. The HE scored higher than PD group. The outcome of this study is expected to contribute to knowledge of changes in the performance of PD and healthy older participants have been demonstrated using measures of richness of vocabulary. These measures discriminate well between participants groups. An additional advantage of the method used in this study is that all measures are word-frequency dependent and can therefore be combined to yield a final index of performance. This index helps one to measure pre and post therapy improvements, or the performances at different stages of dementia. This study has identified the relative importance of such variables in discriminating across PD and HE, which is helpful in understanding of qualitative deficits in PD. Further work is now necessary to explore specific type of deficits among varieties type of dementia. This would show the path to discriminate between types of dementia using linguistic measures alone. And of course, the suggestion from different professionals/ multidisciplinary team input is taken into consideration for identification and assessment of dementia.

The method used in this study adds to the sensitivity of the technique, and to investigate the relationship between these measures and other aspects of cognitive functioning such as semantic memory, working memory etc. Further studies should examine higher order abilities such as cognitive flexibility and planning to determine, if they are predictors of spoken discourse production. This information can provide answers to the questions on the importance of these abilities to spoken discourse production. In addition to using linguistic analysis of conversation to further understanding of dementia, the measures of richness of vocabulary may also be used as a basis for developing new tests of language function. There is a need for clinical tools which can be administered more easily by psychologists and speech-language pathologists and which may in turn help to improve diagnostic and prognostic accuracies.

References


25, 305-315.
DISCOURSE FUNCTIONS OF CODE-SWITCHING AMONG NORMAL KANNADA-ENGLISH & MALAYALAM-ENGLISH BILINGUALS – A PILOT STUDY

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Abstract

Code-switching is a complete shift to other language for a word, a phrase, a sentence and an utterance or borrowing a word from the other language and integrating it into the base language. Munhoas (1997) studied pragmatic functions among normal Basque-Spanish bilinguals and concluded that Basque-Spanish bilinguals use code-switching for a wide variety of purposes, from the need to fill lexical gaps to more complex discourse-level functions. There are no studies reported on pragmatic functions of code-switching in Indian languages. Present study focuses to look at: the discourse functions of code-switching among normal Kannada-English & Malayalam-English bilingual adults. 6 Kannada-English & 6 Malayalam-English bilingual speakers were taken. Speech samples were recorded, transcribed and studied for the presence of different code-switching patterns such as: inter-sentential code-switching, intra-sentential code-switching, tag switching and borrowing. Results revealed subjects with Malayalam as their L1 showed intra-sentential code switching for about 82 times, borrowing occurred 16 times, inter-sentential code switching was observed 4 times and tag switching occurred only once. Similarly, in subjects with Kannada as their L1, intra-sentential code-switching was seen 100 times, borrowing occurred 14 times and tag switching 4 times. Inter-sentential code switching was absent. Intra-sentential code-switching is commonly seen among the subjects followed by borrowing, tag-switching and inter-sentential switching. These types of switching to L2 could be due to the English educational background of subjects, linguistic motivation, lack of technical terms in native languages, also the fact that English might express the message better. Hence, present study contributes to a better understanding of code-switching as a bilingual phenomenon in general and also gives an overview of Kannada-English & Malayalam-English bilingualism. In order to validate these results, more number of bilinguals has to be studied across various Indian languages.

Key Words: Inter-sentential code-switching, intra-sentential code-switching, tag switching and borrowing.

Code-switching is mixing of words, phrases and sentences from two distinct grammatical systems across sentence boundaries within the same speech events (Bokamba 1989). It has been estimated that over half of the world’s population is bilingual or multilingual (Romaine, 1989), with one-third speaking English as a first or second language or learning it as a foreign language (Crystal, 1985). A non-normative or “quaint” linguistic behavior of bilinguals or developing bilinguals is code-switching. Code-switching is the use of two languages simultaneously or interchangeably (Valdes-Fallis, 1977). It implies some degree of competence in the two languages even if bilingual fluency is not yet stable. Code-switching may be used to achieve two things: (a) fill a linguistic/conceptual gap, or (b) for other multiple communicative purposes (Gysels, 1992). While in some places and cases, code switching is the exception in many multilingual and bilingual communities, it is and should be seen as the norm (Swigart, 1992; Goyvaerts & Zembele, 1992). It appears that where code-switching is the norm it is perceived as fluid, unmarked and uneventful and where it is the exception, it will be perceived as
marked, purposeful, emphasis-oriented and strange. Woolford (1983) views code-switched sentences as resulting from a mixture of phrase structure rules extracted from the two languages. She argues that phrase structure rules of two languages can be freely mixed in the construction of the phrase structures of code-switched sentences.

A particular language is a set of parameter values over the range of variations permitted by universal grammar and code switching involves the mixing of discrete languages. Hence positing a constraint or other principle which explicitly refers to code switching suggests that particular languages are primitives in syntactic theory, leading to an ordering paradox. Thus principles or constraints on code switching should not refer to the phenomenon of code switching itself but should rather appeal to independently motivated principles of linguistic theory. Code switching is universally constrained by the government relation holding between sentence constituents.

Sridhar and Sridhar (1980) assume that there is a basic language bilingual discourse and propose the terminology of guest and host languages to describe code-switched utterances. They argue that intra-sentential code-switching is a case where guest elements, which have their own internal structure, occur in the sentences of the host language, obeying the placement rules of the host language or the matrix language (at least as they saw it in the study of Kannada/English mix). Chana (1984) describes code-switching as the juxtaposition within the same speech exchange of passages of speech belonging to two different grammatical systems or subsystems. The items are tied together prosodically as well as by semantic and syntactic relations equivalent to those that join passages in a single language. Heller (1992) stated that "The absence of code-switching can be as significant as the presence of it". If it is something which happens naturally in the schema of bilingualism, it must serve important functions for the language learner or user. This natural language function is in direct conflict with normative or conventional forms and attitudes about what is "Good Language" and thus, it is not appreciated or supported.

Grosjean (1982) & Sanchez (1983) agree that code-switching seems to be the norm rather than the exception in the bilingual speech mode. Studies have shown that code-switching is a rule governed phenomenon. On the functional level, it is often used as a communicative strategy and therefore, can express several and different functions within the discourse. On the structural level, several studies provide evidence that certain linguistic constraints govern code switching. Several studies have shown that intra-sentential code switching is a very common phenomenon in communication among bilinguals.

Two main lines of research on code-switching have developed. The first is "Linguistic" research on the syntactic nature of the switch. Such research examines the part of speech which is switched, usually in relation to the speaker's linguistic proficiency and also investigates the type of constraints on switching which function to maintain grammaticality during the switch. The general conclusion is that code-switching is almost always grammatical (Myers-Scotton, 1993b) therefore; its nature is determined by the individual's fluency in two languages. Less-proficient bilinguals tend to switch single items, such as, nouns or idioms because such switches are structurally less integrated into the discourse and do not require much proficiency (McClure, 1977; Poplack, 1980). On the other hand, proficient bilinguals are able to switch grammatically at the sentence level or even within a sentence. In general, though, it has been found that nouns and other single-item switches tend to be the most common, regardless of the languages used or the proficiency of the speakers (Meisel, 1994).

In contrast to the historical view of code-switching as ungrammatical and haphazard, switching is now acknowledged to be so grammatical that it has become an important research tool for investigating rules of syntax i.e., pronoun placement in different languages (Jake, 1994). Code-switching is also used to study principles of Universal Grammar, particularly grammatical constraints (Belazi, Rubin & Torivio, 1994 & Meisel, 1994). Several specific constraints on switching have been found (Belazi, Rubin & Torivio, 1994 & Myers-Scotton, 1993b). One is the free morpheme constraint, which states that a switch cannot occur between a lexical item and a bound morpheme like "-ing" or the past tense "-ed". Second is the equivalency constraint, which states that there should be the same type of word order around the switch in both languages. Although these constraints were found to hold in switches of syntactically similar languages such as Spanish and English (Poplack, 1980; 1981), studies of syntactically
dissimilar language switching show that these and other local constraints are not always observed (Myers-Scotton, 1992b, 1993b). However, switching always remains within the framework of Government and Binding, constrained by the operation of Universal Grammar (Belazi, Rubin & Toribio, 1994).

The second line of research on code-switching studies the “Sociolinguistic Function” performed by the switch. At the group level, such research investigates switching for the establishment and maintenance of social relationships. This is called “Situational Code-switching” (Dabne & Billiez, 1986; McClure & McClure, 1988; Myers-Scotton, 1992a; 1993a) and it is often analyzed through Speech Accommodation Theory (Genesee & Bourhis, 1982). Situational switching depends on the setting and the roles and relationships of the people involved. In some contexts, switching is normal and expected and a phrase from linguistics is used to describe it: switching is “Unmarked”. In other contexts, switching is unusual and unexpected and it is “Marked” (Myers-Scotton, 1992). In this case, the switch is deliberately used to send messages about social membership, status and power.

Switching can be used to call attention to and dramatize key words during the course of a conversation (Auer, 1988; McClure, 1981; Valdes, 1981) and it can also be used to emphasize a statement by repeating important items in the other language. Bilinguals can use code-switching for clarification by switching and elaborating on a confusing statement in the second language. Switches can also be used to set off reported speech, while code-switched discourse markers can be used to attract and hold attention during speech in other language.

There are few studies done on the functional aspects of code-switching. Research regarding the pragmatic constraints on code-switching has differed in the extent to which they are prepared to assign a specific meaning to every instance of code-switching (Romaine, 1989). Poplack (1980) regards ‘true’ code-switching as essentially void of pragmatic significance. Blom & Gumperz (1972) introduced the concepts of transactional and metaphorical switching (also referred to as situational & non-situational code-switching). Transactional code-switching under the heading of the type of switching most commonly described as being controlled by components of the speech event such as topic and participants. On the other hand metaphorical switching concerns the communicative effect, the speaker intends to convey (E.g. reported speech or quotations, to mark interjections or to serve as sentence fillers, to reiterate what has just been said in order to clarify or emphasize a message etc.). Gumperz (1982) suggests that linguists look at code-switching as a discourse mode or a communicative option which is available to a bilingual member of a speech community on the same basis as switching between styles or dialects is an option for the monolingual speaker. Switching in both cases would serve as an expressive function and have pragmatic meaning.

There have been researches done which have studied the specific functions of code-switching in bilingual discourse. Analysis of the functions and the relationship between code-switching and different speech acts and styles in the Chicano community in the Southwest has been carried out and it is noted that switches are triggered by different speech acts (challenge, requests, agreement etc) different styles (Evaluative vs. Narrative) and differences at connotational level, Sanchez (1983). Similar uses of code-switching among English-Japanese and Hebrew-English bilinguals has been reported respectively by Nishimura (1995) and Maschler (1991, 1994).

Study of the Pragmatic/Discourse aspects of code-switching includes different types of research. For example Blom & Gumperz, (1972); Sanchez, (1983) & others tried to assign specific functions to code-switches whereas, Heller (1992) viewed code-switching and language choice as a political strategy. In between these two extremes, studies done by McConvell, (1988); Myers-Scotton, (1993b) & Scotton & Ury, (1977) take in to account both the specific functions of switches within the discourse (i.e. to express anger, authority, emphasis etc.) and also the role of code-switching within the more general patterns of language choice within the community (i.e. is Code-switching the expected choice for the situation under study or not?). Munhoa (1997) studied the pragmatic functions among normal Basque-Spanish bilinguals and concluded that Basque-Spanish bilinguals use code switching for a wide variety of purposes, from the need to fill lexical gaps to more complex discourse-level functions. There are no studies reported on pragmatic functions of code-
switching and the various types of switching (inter-sentential, intra-sentential, tag switching, etc) in Indian languages. The present study tries to fill a gap by conducting a pilot study among Kannada-English and Malayalam-English normal bilingual adults.

**Aims**

Present study focuses to look at:
- The discourse functions of code-switching among normal Kannada-English bilingual adults.
- The discourse functions of code-switching among normal Malayalam-English bilingual adults.

**Method**

**Subjects**

12 neurologically normal subjects of the age range 19-23 years participated in the study. Six Kannada-English bilingual speakers (3 males & 3 females) & six Malayalam-English bilingual speakers (3 males & 3 females) were taken. For all six bilingual speakers of Kannada-English, Kannada was the mother tongue (L1) and English was the second language (L2). For all six bilingual speakers of Malayalam-English, Malayalam was the mother tongue (L1) and English was the second language (L2). Both the groups learnt their second language, English from at least at 6 years of age in the formal setting at school. Language Experience Proficiency Questionnaire (LEAP-Q) (Marian, Blumenfeld & Koushanskaya, 2007) was administered to check their language proficiency.

All subjects would have completed all or part of their higher education in English.

**Procedure**

Speech samples were collected for 8 minutes. Subjects were instructed to speak in a language they are comfortable with, either L1 or L2. Two tasks were given. The tasks carried out were general conversation, monologue. The task of general conversation included subject's name, place and hobbies, about family and friends, routine activities, personal experiences, their school and college life etc. For the task of monologue, topic of their own interest was allowed to narrate. Speech recording with each subject for both the tasks followed the similar pattern. The obtained data of 8 minutes were transcribed using standard IPA symbols for the further analysis.

A quite sound treated room was selected for recording purpose. The subjects were seated comfortably on the chair at a distance of 1 feet from the laptop placed on the table. Each subject's speech was recorded individually using a standard laptop computer with inbuilt microphone with the help of PRAAT voice recording and analysis software 5.1 Version, (Boersma & Weenick, 2009). Sampling rate was 44100 Hz and quantization level was set at 16 bits.

**Results**

Analysis was carried out to study the different code-switching patterns such as, inter-sentential code-switching (at sentence level), intra-sentential code-switching (at constituent or clause level), emblematic switching (at the level of tags/also known as tag switching) and borrowing (words are borrowed from L2 and used in L1).

![Fig 1: Different Code-switching patterns in Kannada & Malayalam Bilinguals](image-url)
Tag-Switching was higher among subjects with Kannada as their L1 and occurred only once in subjects who had Malayalam as their L1. Hence, it can be noted that both Kannada-English and Malayalam-English bilinguals used various types of code-switching for variety of purposes.

Thus, findings of the present study are in agreement with the previous findings, Munhoa (1997) where the Basque-Spanish bilinguals used for variety of purposes, from the need to fill lexical gaps, to more complex discourse level functions. The result also supports the notion by Sridhar and Sridhar (1980). This also supports the other studies, Gumperz (1982), Sanchez (1983), Romaine (1989), Maschler (1991; 1994) and Nishimura (1995).

Conclusion

Present study focused on the discourse functions of code switching among two groups of bilinguals (i.e. Kannada-English & Malayalam-English bilinguals) and it is evident that subjects used code switching for various purposes, considering from filling lexical gaps to complex discourse functions. There were variations in the frequency of code switching and not in the type, which supports the universal grammar. Thus, code switching is used as an additional resource to achieve particular conversational goals in interactions with other bilingual speakers. Present study contributes to a better understanding of code-switching as a bilingual phenomenon in general and also gives an overview of Kannada-English & Malayalam-English bilingualism. In order to validate these results, more number of bilinguals has to be studied across Indian languages.

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DO DEVELOPMENTAL DYSCALCULIC CHILDREN HAVE SPATIAL BIASES IN PROCESSING NUMBERS? EVIDENCES FROM SNARC EFFECT

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Abstract

Developmental dyscalculia (DD) is a specific learning disability affecting the normal acquisition of arithmetic skills, it is hypothesized that they may be lacking ability to represent and manipulate numerical magnitude nonverbally on an internal number line. Hence the present study was attempted with the aim of observing spatial biases if any in children with developmental dyscalculia using spatial numerical association of response codes (SNARC) paradigm. Participants consisted of 12 children with developmental dyscalculia and thirty typically developing children in the age range of 9-10 years. Each participant received four white pages containing written instructions on the first page; and the other 2 pages contained 16 strings of digits and the other with 16 lines. All participants were instructed to bisect each stimulus in the middle. The distance between a bisection mark and both ends of a line was determined to the nearest millimeter, yielding a left and right interval for each stimulus. The difference score (left interval minus right interval) yielded a negative value when performance was biased to the left and a positive value when performance was biased to the right. The results revealed no evidence of SNARC effect in both the groups of children i.e., normal controls exhibited a right handed bias for both small and large numbers and left handed bias for lines whereas children with developmental dyscalculia exhibited a left sided bias for both lines and numbers. In the present study, we investigated spatial biases if any while processing numbers in children with developmental dyscalculia. The results revealed no evidence of SNARC effect in both the groups of children. The present observations, if substantiated by further research, may be useful for the diagnosis of number comprehension skills in children with developmental dyscalculia.

Key Words: SNARC effect, Developmental dyscalculia, internal number line

Numbers consist of one unique feature, which represents a particular aspect of quantitative information (Noel, 2001). Psychologists have tried to answer the question of how quantitative information is internally represented in the brain (Dehaene, 1989; Moyer & Landauer, 1967; Reynvoet & Brysbaert, 1999). Galton (1880a, 1880b) surveyed a mental representation of numbers and reported that subjects saw each number as a stable spatial mental structure. Seron, Pesenti, Noel, Deloche, & Cornet (1992) reported that 10 of his 15 subjects possessed a left-to-right-oriented mental representation. These studies indicate that the quantitative representation of numbers has a spatial structure, and that it may orient from left to right. In line with this, behavioral data also indicate that the quantitative representation might orient from left to right (Brysbaert, 1995; Fias, 2001; Fias, Brysbaert, Geypens, & d’Ydewalle, 1996; Ratinckx & Brysbaert, 2002).

Earlier behavioral data were collected by asking subjects to conduct a parity (i.e., odd even) judgment task (Dehaene, Bossini, & Giraud, 1993). These data provided evidence of an association between number magnitude and the spatial location of response. Of late, a bisection task has been used for the same. Here digits are positioned in a left-to-right order according to the magnitude they represent. Digits representing small magnitudes (henceforth, called small digits) would be located further on the left along this number line and would benefit from a spatial compatibility advantage when speeded responses were required with the left hand. Digits representing larger magnitudes (i.e., large digits) would be positioned further on the right along the number line and would benefit from a spatial compatibility advantage when speeded responses were required with the right hand. The assignment of response (left...
Responses are found to be more towards the left hand when the number represented a small magnitude (e.g., 1 or 2) and more towards the right hand when the number represented a large magnitude (e.g., 8 or 9). This result was obtained despite the fact that magnitude information was not required to perform the task. The reaction time advantage of a spatially compatible mapping between stimulus numerals and manual responses is termed as spatial numerical association of response codes (SNARC) effect (SNARC; Dehaene, Bossini, & Giraux, 1993; Shaki & Petrusic, 2005; Vallesi, Binns, & Shallice, 2008). This effect emerges with numerical skill acquisition but does not extend to the categorization of letters of the alphabet. Normally developing children tend to show a subtle leftward bias on versions of line bisection task giving rise to negative values for asymmetry indices (Dobler, et al., 2001).

The SNARC effect might reflect automatic activation of the semantic representation of numbers, namely a spatially coded magnitude representation. This SNARC is notable because magnitude information is not strictly needed for deciding parity. Consequently, the presence of the SNARC effect has been taken to support the idea that the meaning of numerals (i.e., numerical magnitude) is activated in an automatic fashion when numerals are presented for view for any purpose. It is this explanation of the SNARC effect that we investigated in children with developmental dyscalculia.

Since developmental dyscalculia (DD) is a specific learning disability affecting the normal acquisition of arithmetic skills, it is a disorder of the notion termed 'number sense', characterized by deficits in very basic numerical skills such as number comparison (Dehaene, 1997, 2001; Landerl, Bevan, Butterworth, 2004; Rubinstein & Henik, 2005; Butterworth, 2005). There is available literature on developmental aspects of the SNARC effects in DD affected children as well as typically developing normal children. Gender based differences have been reported as positive correlations between SNARC effect and mathematical ability in male children but not in the female children in the second grade levels. Although females possessed a mental number line representation, they were not as prepared as males to use this newly acquired tool to solve mathematical problems. This is attributed to female preference for language dependent strategies as with male preference for visuospatial and functional motor strategies. But controversy remains if the SNARC effect remains true for people who write from right to left as in Arabic and Hebrew. However, SNARC effect was found to be missing in 7-12 year old children with visuospatial deficits (Geary & Hoard, 2001; Bachot, Gevers, Roeyers, 2005; Von Aster & Shalev, 2007). As the number comprehension deficits are usually seen in DD populations we felt the need for investigating the SNARC effect in children with developmental dyscalculia without requiring them to perform arithmetic computations or generate results. Hence the present study is an attempt in this direction.

**Method**

**Participants:** Participants were divided into two groups. Group 1 consisted of twelve children with developmental dyscalculia in the age range of 10-11 years. All these children were studying in 4th and 5th grade. The diagnosis of mathematical disability was confirmed through arithmetic diagnostic test of primary school children (Ramaa, 1994). All these children have reading and writing deficits as assessed through informal testing procedures and diagnostic reading test in kannada developed by Purushothama (1992). Group 2 consisted of thirty typically developing age matched children studying in the 4th and 5th grade. All participants had normal or corrected vision and had no known speech, language, hearing and neurological disorders. They were naive about the hypothesis to be tested.

**Materials:** Each participant received four white pages, each 21.1 cm wide by 29.6 cm long. The first page contained written instructions, emphasizing accuracy and speed of responding. In addition, it contained blanks in which the participants entered their initials, age, and sex. The other two pages contained 16 strings of digits and fourth page consisted of 16 lines. The digit strings were generated as follows (Appendix 1): Two sets of digits represented small (1,2) and large magnitudes (8,9). From each of these four digits, two strings were generated, containing an odd (17 digits) or even (18 digits) number of elements yielding 52mm and 55mm respectively. This was done to see whether participants could bisect digit strings accurately. The strings were printed in 18 point Times New Roman font, yielding 3.05 mm per digit.

Each of the eight digit strings was positioned in
a random fashion on a single page (left half, right half and center of the page). Position on the page was manipulated to see whether this spatial variable affected the spatial accuracy of responses, for example in a compensatory fashion. Endpoints of the stimuli were not aligned to prevent participants from referring to their previous bisection judgments. These numbers (1, 2, 8, 9) were selected on the basis of previous study by Fischer, 2001.

The 16 control stimuli were horizontal black lines with 0.9 mm width that matched the digit strings with respect to their length and positions on the page, yielding eight lines each of 84 mm and 87 mm in length. Order of stimulus type (lines and digit strings) was counter balanced across participants, and all sheets were presented in midsagittal plane.

Procedure: All participants used a sharp pencil and positioned the stack of last three pages (stimuli) in their midsagittal plane. Participants were asked to give visual estimates and to avoid counting digits. All the participants waited until the experimenter gave a signal and their task was to bisect each stimulus in the middle. For digit strings, they were instructed to position a vertical mark such that half the digits were on the left and the other half on the right of it. After bisecting all stimuli on the second page, participants immediately turned to the third page and bisected all stimuli there.

Analysis: The distance between a bisection mark and both ends of a line was determined to the nearest millimeter, yielding a left and right interval for each stimulus. The difference score (left interval minus right interval) yielded a negative value when performance was biased to the left and a positive value when performance was biased to the right. Similarly, the number of digits to the left and right of each bisection mark was determined for each digit string. The difference score (number of digits on the left minus number of digits on the right) yielded a negative value when performance was biased to the left and a positive value when performance was biased to the right. The digits which were bisected at the midline were not considered for the analysis.

Results
In the present study, we investigated spatial biases if any in children with developmental dyscalculia using SNARC effect. Descriptive statistics was employed to find out the mean and standard deviation.

The results are shown in the graph 1

From the graph1, it is clear that normal controls have a differential processing for number and lines indicated by right sided bias for numbers and left sided bias for lines whereas in children with learning disabilities, left sided bias was seen for both numbers and lines.

Independent t-test and paired t-test was employed to find out the statistical inferences. The average bisection scores for lines in the clinical and the control group were -2.67 and -1.50 respectively and there was no statistically significant difference between the two groups at p>0.05 representing a reliable left bias in both the group of children. The average bisection scores for small and large numbers in the control group were +.1208 and +.2028 respectively and there was no significant difference between the bisection scores for small and large numbers indicating a reliable right bias for both small and large numbers and no evidence of SNARC effect. Comparisons across lines and numbers in the control group revealed significant differences indicating numerical symbols require specialized visuospatial processing than non meaningful stimuli like lines.

The average bisection scores for small and large numbers in children with developmental dyscalculia were -.0870 and -.1087 respectively and there was no significant difference between the bisection scores for small and large numbers at p>0.05 indicating a reliable left bias and no evidence of SNARC effect even in the clinical group. Comparisons across lines and numbers revealed no significant differences indicating children with developmental dyscalculia process both numbers just as processing of non meaningful stimuli such as lines.

However comparisons across the two groups for small and large numbers revealed a significant difference i.e., right side bias for typically developing
children and left side bias for developmental dyscalculia group suggests that children in the typically developing group are on their way towards developing SNARC effect.

Discussion

In the present study, we investigated spatial biases if any while processing numbers in children with developmental dyscalculia. The results revealed no evidence of SNARC effect in the typically developing children i.e., bias was observed towards right hand side for small and large numbers. This suggests that SNARC effect has not developed completely even at the age of 9-10 years. The result of the present study contradicts the previous findings that SNARC effect emerges over the course of elementary school years (Berch, Foley, Hill, & Ryan, 1999; van Galen & Reitsma, 2008; Bachot, Gevers, Fias, & Roeyers, 2005). Though the SNARC effect is not evident in the control group, the difference between line bisection and digit string bisection is highly significant indicating that normal children have a differential processing for both numerical symbols and lines at the age of nine and ten. This supports the view that numerical symbols receive specialized visual processing which differs from the processing of non meaningful numbers such as line (Fischer, 2001). This finding also indicates that human beings are not endowed with the complete association between number magnitude and internal representational space, but this association may be constructed completely at a relatively later stage of development presumably after fifth grade. As there were uneven number of males and females, gender based differences were not carried out which adds limitations to the present study.

On the other hand, left sided bias was observed in developmental dyscalculia for both small and large numbers as well as lines. The difference between line bisection and digit string bisection is not significant indicating that developmental dyscalculia process numbers just as the processing of non meaningful stimuli such as lines. This indicates the difficulty with mapping the numbers on an internal number representation indicating the visual-spatial deficits in children with developmental dyscalculia. This could be that number line for children with developmental dyscalculia are misoriented i.e., more towards left than normal children where the bias is more towards right. A possible reason for the misoriented number line is that the children with developmental dyscalculia are far too heterogeneous to obtain reliable measures. However, this does not seem plausible because the subjects were carefully selected in order to obtain homogeneity in the group. Probably, the involvement of spatial working memory processes in the neural underpinnings of developmental dyscalculia might be a contributing factor (Rotzer et al., 2009). These poor spatial working memory processes may inhibit the formation of spatial number representations (mental number line) as well as the storage and retrieval of arithmetical facts.

Though SNARC effect is not evident in both the group of children, normal controls exhibited a right handed bias and children with developmental dyscalculia exhibited a left sided bias. This suggests that children in the control group are partially on their way towards developing SNARC effect. However, this is not observed in children with developmental dyscalculia suggesting that there could be a visual spatial deficit in children with developmental dyscalculia. This presumption is supported by the findings that SNARC effect was missing in 7 to 12-year-old children with visual-spatial deficits (Bachot, Gevers, Roeyers, 2005).

Conclusions

In the present study, we investigated spatial biases if any while processing numbers in children with developmental dyscalculia. The results revealed no evidence of SNARC effect in both the groups i.e., normal controls exhibited a right handed bias for both small and large numbers and left handed bias for lines whereas children with developmental dyscalculia exhibited a left sided bias for both lines and numbers. This suggests that children in the control group process numbers and lines differently. However children with developmental dyscalculia did not exhibit a differential processing of numbers and lines indicating the visual spatial deficit in these children. The present observations, if substantiated by further research with more number of samples in both the gender in normal and DD children, may be useful for the diagnosis of number comprehension skills in children with developmental dyscalculia. Also, SNARC effect in people who write from right to left as in Arabic and Hebrew would be interesting and adds further information to the existing knowledge.
References


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36
DOES SOCIO ECONOMIC STATUS INFLUENCE PHONOLOGICAL AWARENESS SKILLS?

*Bilvashree C., **Akshatha S., ***Deepthi M., & ****Narasimhan S.V.

Abstract

Researchers have reported the influence of various factors affecting phonological awareness in children, but there appears to be limited literature reporting the influence of socio economic status on the phonological awareness in Indian context. Hence the present study was planned to see the difference in performance between children from lower and middle socio economic status for phonological awareness tasks. A total of 20 native Kannada speaking children within the age range of 6 to 14 years were selected for the study and were divided into 2 groups, Group 1 consisted of 10 normal children with lower socio economic status & Group 2 consisted of 10 normal children with middle socio economic status. 'Test of Learning Disability' in Kannada which had 7 subtests to assess phonological awareness was used. The responses were collected from each child and statistically analysed.

Results revealed high scores for middle socio economic status children and the lower scores were obtained by lower socio economic grade children. There was significant difference in terms of performance in all tasks except, syllable oddity (final) task. Hence, it was evident from the result that, children from low socio economic status background performed below than the children from middle socio economic status. Therefore from the present study it can be concluded that socio economic status is evident for development of phonological awareness and clinician has to concentrate also on certain factors as poorer home literacy, including limited access to reading materials or modelling of reading by adults in the home, during the assessment of phonological awareness.

Key Words: Learning Disability, Poor Academic Performance, Syllable oddity.

Phonological awareness is the capacity that the individual knows that the spoken word can be segmented into smaller units, and that he can distinguish and synthesize these units (Francis 1987). It is also considered part of metalinguistic abilities, referring to the ability to perform mental operations on the output of speech-perception mechanism (Tunmer & Rohl, 1991). In the recent years like the order meta linguistic skills phonological awareness has been explored and studied, though there are conflicts to demarcate the boundaries between these skills, researchers have proposed their own classification to explain the phonological awareness skills. According to Lewis (1996) phonological awareness consists of following tasks: listening, rhyming, word awareness, phonemic awareness and syllabic awareness. Rhyming is the ability to match the ending sounds in words, alliterations is the ability to generate words that begin with the same sounds, where sentence segmentation is the ability to break spoken sentences into separate words, and syllabic awareness refers to the ability to blend syllables into words or segmenting words into corresponding syllables. This skill begins to emerge about the age of four.

Phonological awareness is the understanding of different ways that oral language can be divided into smaller components and manipulated. Spoken language can be broken down in many different ways, including sentences into words and words into syllables (e.g., in the word simple, /sim/ and /ple/), onset and rhyme (e.g., in the word broom, /br/ and /om/

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Manipulating sounds includes deleting, adding, or substituting syllables or sounds (e.g., say can; say it without the /k/; say can with /m/ instead of /k/). Being phonologically aware means having a general understanding at all of these levels (Francis, 1999).

Operationally, skills that represent children’s phonological awareness lie on a continuum of complexity. At the less complex end of the continuum are activities such as initial rhyming and rhyming songs as well as sentence segmentation that demonstrates an awareness that speech can be broken down into individual words. At the center of the continuum are activities related to segmenting words into syllables and blending syllables into words. Next are activities such as segmenting words into onsets and rimes and blending onsets and rimes into words.

Different researchers have postulated that phonological awareness is important for reading (Shapley, 2001; Gillet, 2004). An awareness of phonemes is necessary to grasp the alphabetic principle that underlies the system of written language. Specifically, developing readers should be sensitive to the internal structure of words. If children understand that words can be divided into phonemes and phonemes can be blended into words, they are able to use letter-sound knowledge to read and build words. As a consequence of this relationship, phonological awareness becomes a strong predictor of later reading success. Researchers have shown that this strong relationship between phonological awareness and reading success persists throughout school days.

According to some theories, the ability to succeed in phonological awareness tasks is related to the representational status of words in the mental lexicon (Ziegler & Goswami, 2005). For example, according to the lexical restructuring model (LRM; Metsala & Walley, 1998) the development of well-specified phonological representations is a byproduct of increases in receptive vocabulary size. Early in development, phonological entries in the mental lexicon are proposed to code fairly global phonological characteristics. As more and more words are acquired, these global features are thought to become insufficient for distinguishing between the increasing numbers of similar-sounding words, necessitating the development of phonemic-based representation. According to the LRM, receptive vocabulary growth drives lexical units toward phonemic representations. Hence, words from denser neighborhoods appear to have better specified phonological representations.

Ziegler and Goswami (2005) suggested that words in the mental lexicon were represented at different phonological “grain sizes” during development: syllable, rhyme, and phoneme. The dominant grain sizes early in development were the larger grain sizes, corresponding to the linguistic units of syllable and onset/rime. In their psycholinguistic grain size theory, Ziegler and Goswami (2005) argued that it was necessary to add the concept of grain size to the LRM. They proposed that phonemic representation emerged largely as a consequence of the orthographic learning required to read an alphabetic script. According to their psycholinguistic grain size theory, as more and more vocabulary items are acquired, the number of similar sounding words (neighborhood density) for a particular lexical entry increases, and this phonological similarity is one developmental driver for the representation of the larger grain sizes of syllable and rime. This effect of neighborhood density might be predicted to be particularly evident in onset/rime tasks, because it has been found that in spoken English at least, the majority of phonological neighbors (similar-sounding words) are in the same neighborhood because they rhyme (De Cara & Goswami, 2002). According to Ziegler and Goswami (2005), the preliterate brain may thus depend on phonological similarity in terms of onsets, vowels, and codas for lexical restructuring. The literate brain may develop fully specified phonemic representations as a consequence of orthographic learning. According to Ziegler and Goswami’s theory, orthographic learning becomes a mechanism for the development of PA at the phonemic level.

The development of phonological awareness in early childhood is explained by Keram (1982). He states that Preschool children are able to use language very easily while communicating with their immediate surroundings. They can also create new meanings by participating in conversations in different environments. Every child of 3-4 years of age can easily understand a simple word, without being able to identify the phonemes of the word. Most children at this age have difficulty identifying the initial and
final sounds of the word. When children develop the ability of speak, they naturally concentrate on the meanings of words. For young children it is irrelevant that each word is made up of different phoneme sequences. For the development of literacy, however children have to learn to identify the letters of words and the sounds of these letters.

Assessment in phonological awareness serves essentially two purposes: to initially identify students who appear to be at risk for difficulty in acquiring beginning reading skills and to regularly monitor the progress of students who are receiving instruction in phonological awareness. The measures used to identify at-risk students must be strongly predictive of future reading ability and separate low and high performers. Measures used for monitoring progress must be sensitive to change and have alternate forms (Kaminski & Good, 1996).

Typically, kindergarten students are screened for risk factors in acquiring beginning reading skills in the second semester of kindergarten. Appropriate screening measures for the second semester of kindergarten include measures that are strong predictors of a student’s successful response to explicit phonemic awareness instruction or beginning reading acquisition. Such predictors of successful response to segmenting and blending instruction are the Test of Phonological Awareness-Kindergarten (TOPA-K; Torgesen & Bryant, 1994), a Nonword Spelling measure (Torgesen & Davis, 1996), and the Digit Naming Rate (Torgesen & Davis, 1996). Predictors of the successful acquisition of beginning reading skills include automatized naming of colors, objects, numbers, or letters (Wolf, 1991) and segmenting ability (Nation & Snowling, 1998; Torgesen et al., 1999; Vellutino & Scanlon, 1987; Yopp, 1988). Other measures used during the second semester of kindergarten to identify students at risk for not acquiring beginning reading skills include measures of phoneme deletion.

The measures appropriate for identifying first-grade students at risk for not acquiring reading skills overlap those used in kindergarten. The TOPA-K and onset-rime are no longer appropriate, as students should have developed these skills by the end of kindergarten, whereas segmenting is still an emerging skill.

‘A Test of Learning Disability in Kannada’ was developed by Deepthi (2009). It is a test for assessing different domains in children with learning disability. The test contains seven subtests including two Proformae, visual discrimination tasks, reading, writing, arithmetic (addition, subtraction, multiplication and division), reading comprehension and phonological awareness tasks. Phonological Awareness task section consists of seven subsections i.e. Phoneme Oddity, Phoneme Stripping, Syllable Oddity, Syllable Stripping, Rhyme Recognition, Clusters and Blending. To standardise the test material, 270 children were selected randomly. They were reported to have no behavioral problems and academic performance were average and above average. All the subjects were attending regular school in the Mysore district. Equal number of subjects was taken from grade II to grade X (6 years to 15 years) i.e. thirty subjects from each grade were considered for the study. The test was also administered on 30 children with Learning Disability and was reported that the test could clearly distinguish the phonological awareness skills among Children with Learning Disability and normals. (APPENDIX 2: Details on Scoring and Maximum scores achievable).

Research findings reveal that various factors affect the phonological awareness abilities in children. Some of them are age, gender, cognitive factors, emotional factors, ontogenic factors, family environment or family setting in which child lives, parental co-operation, age at school entry, presence of associated problems like hearing impairment, visual defects, behavioral problems, cultural background and so on (Huffman et al., 2000). Among all these socio economic status is an important factor which has high influence on development phonological awareness in children.

Socio-economic status is a measure of an individual’s or group’s standing in the community. It usually relates to the income, occupation, educational attainment and wealth of either an individual or a group. These types of variables are summarised into a single figure or socio-economic index. Socio economic status is an important determinant of health and nutritional status as well as mortality and morbidity. Socio economic status also influences the accessibility, affordability, acceptability and actual utilization of various available health facilities. Socio-economic status plays a large part in influencing the development of phonological awareness in children.

Emerging body of literature indicate that children...
entering school in areas of low socio-economic status (SES) have delayed written word recognition are consistent with poor phonological awareness (Bowey, 1995, Duncan & Seymour, 2000; Raz & Bryant, 1990). Such disadvantage, experienced during the first year of school, can have long-term educational implications. Socially disadvantaged children enter kindergarten from family backgrounds with one or more factors that might affect their skills and knowledge (US Department of Education, 1997). The factors include: living in a single-parent household, living in poverty, having a mother with low education, low familial literacy and poor nutrition.

Hence Social disadvantage has been reported to delay children's development of both spoken language (Locke, Ginsborg & Peers, 2002) and literacy (Bowey, 1995) skills. Locke et al. (2002) found that the spoken language abilities of preschool children reared in poverty were significantly below those of the general population, despite children's cognitive abilities being comparable.

Various researchers have reported the influence of other factors affecting phonological awareness in children. But there appears to be limited previous research on the influence of socio economic status on the phonological awareness, and comparison study between middle socio economic status and lower socio economic status in Kannada speaking children. Hence the study aimed to determine the difference in performance between children from lower and middle socio economic status for phonological awareness tasks.

**Objectives**

To study the difference in performance between children from lower and middle socio economic status for phonological awareness tasks.

**Method**

**Subjects:** A total of 20 native Kannada speaking children within the age range of 6 to 14 years were selected. All the subjects were formally screened for speech and hearing abilities by the experimenter and those who passed the screening were included in the study. All the participants had Kannada as their mother tongue. They had no behavioural problems. All the subjects had normal intelligence. For the study, the subjects were divided into 2 groups based on the 'Scale for measuring the socioeconomic status of a family' (developed by Aggarwal et al., in 2005). This scale consists of 22 questions based on which the scoring is done and the total score obtained suggests whether the subject belongs to upper high, high, upper middle, lower middle, poor and very poor/ below poverty line. Group 1 consisted of 10 normal children with poor socio economic status (scoring of 16-30 in the scale) & Group 2 consisted of 10 normal children with higher socio economic status (scoring of 61-75 in the scale).

**Materials:** 'A Test of Learning Disability in Kannada', Standardised test material to assess Learning Disability was used. The test contains seven subtests which include two Proformae, visual discrimination tasks, reading, writing, arithmetic (addition, subtraction, multiplication and division), reading comprehension and phonological awareness tasks. As the present study focused only on phonological awareness skills, only a part of this test, i.e., the section for assessing phonological awareness skills was chosen. This section consisted of seven subsections i.e. Phoneme Oddity, Phoneme Stripping, Syllable Oddity, Syllable Stripping, Rhyme Recognition, Clusters and Blending.

**Instructions:** The words were presented orally by the investigator to the subjects. The subjects were instructed as per the test material. Specific instructions were given to the subjects regarding each task (APPENDIX 1). A practice trial was given prior to the test administration. In each section words were arranged in the increasing order of complexity that is from bisyllabic to multisyllabic words. The instructions were repeated to the subjects who could not follow instructions when given once. This was followed for all the tasks.

**Procedure:** Testing was carried out in a class room of the school, which was away from the distractive environment and had a comparatively lower ambient noise level. The subjects were seated comfortably on a chair opposite to the investigator across the table and later rapport was built by speaking with the subjects, in order to get the co-operation. The test was carried out in a single sitting and the time consumed for each child was around 35 - 40 minutes. Further, the responses given by the subjects were noted by the investigator in the response sheet. The scoring of the response was done according to the instructions given in the test material, i.e., each correct response received a score of one and no score for an incorrect response. These responses were collected and calculated for both the groups and were subjected to statistical analysis.
Statistical analysis
Paired sample t test was done as a part of statistical analysis between all the three groups to find out the significant difference between each of the groups across all the eight tasks using SPSS (version 17.0).

Results
The present study aimed at finding difference in the phonological awareness tasks between children from middle socio economic status and lower socio economic status. The mean and standard deviation values for lower socio economic status and middle socio economic status in phonological awareness task is shown in the Table 1 and Graph 1.

Table 1: Showing mean, standard deviation and significance scores of Low Socio Economic Status (LSES) and Middle Socio Economic Status (MSES) groups for phonological awareness tasks.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>MSES</th>
<th>LSES</th>
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<tr>
<td></td>
<td>Mean</td>
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<td>Mean</td>
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<tr>
<td>Phoneme oddity (initial)</td>
<td>9.5</td>
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<td>8.3</td>
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<tr>
<td>Phoneme oddity[final]</td>
<td>7.8</td>
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<tr>
<td>Syllable oddity[initial]</td>
<td>8.1</td>
<td>1.2</td>
<td>7</td>
</tr>
<tr>
<td>Syllable oddity[final]</td>
<td>6.2</td>
<td>1.1</td>
<td>5.9</td>
</tr>
<tr>
<td>Syllable stripping</td>
<td>7.2</td>
<td>1.3</td>
<td>6</td>
</tr>
<tr>
<td>Rhyme recognition</td>
<td>9.1</td>
<td>2.5</td>
<td>7.8</td>
</tr>
<tr>
<td>Clusters</td>
<td>3.3</td>
<td>2.1</td>
<td>3</td>
</tr>
<tr>
<td>Blending</td>
<td>3.3</td>
<td>2.1</td>
<td>2.8</td>
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</table>
From table 1 and graph 1 it can be noticed that there was increase in mean scores among middle social economic status when compared to lower socio economic status. There was significant difference in terms of performance in all tasks except syllable oddity (final) task. The scores also showed better performance for phoneme oddity (final). Similar trend was seen in syllable oddity task, where the scores were better for syllable oddity (initial) when compared to syllable oddity (final). In Rhyme recognition tasks the scores were comparatively higher. Poor performance is seen in clusters and blending tasks. It was evident from the result that, children from low socio economic status background performed below than the children from middle socio economic status.

Discussions

The present study sought to examine difference in phonological awareness between children from lower socio economic status and children from middle socio economic status. The results indicated that the children from a low SES background had poorer skills on all tasks. These findings were consistent with results of studies indicating that children from homes of lower SES performed more poorly on measures of phonological awareness (e.g., Bowey, 1995). This is also supported from the study by (McIntosh and Liddy, 1999) who indicated that the preschoolers from a low SES background did not perform as well as their average SES peers on the total Quick Test of Language. (initial) task when compared to phoneme oddity

From the study it was also evident that children from LSES performed well below the children from MSES in phoneme stripping and rhyme recognition tasks. The findings were consistent with the study by (Dodd & Gillon, 2001), indicating that children from a low SES background performed well below the level expected for their chronological age for rhyme awareness and phoneme isolation subtests of PIPA. Consistent with prior studies, SES differences were found on most of the measures of phonological awareness and language (Bird et al., 1995). Children from higher SES background outperformed children from lower SES backgrounds.

Conclusion

The present study revealed that children from lower socioeconomic status performed poorly than the children from lower socio economic status in phonological awareness tasks. The obtained difference in performance between the two groups is supported with the review that children from homes of higher SES are more likely to have had exposure to activities that help them realize their potential; therefore, displays of lower phonological awareness most likely represent lower capacity. In contrast, children from homes of lower SES may not have had exposure to such reading-related activities, so poor performance on phonological awareness tasks (Walker et al., 1994). Therefore from the present study it is concluded that socio economic status is evident for development of phonological awareness because poorer home literacy, including limited access to reading materials or modelling of reading by adults in the home, has been cited as a main causal variable leading to reduced academic performance including reading and writing ability. Alternatively, it may reflect need for a longer time period to generalize learning in low SES children.

References


**APPENDIX 1: PHONOLOGICAL AWARENESS TASKS**

**TASK 1: PHONEME ODDITY**

This section consisted of two parts i.e. Phoneme oddity (initial) and Phoneme oddity (final). The subjects were instructed to listen to the words and to choose the one which did not belong to the set.

1. Phoneme oddity (initial): The test material consisted of fifteen sets of words. Each set consisted of four words, of which three of them begin with same sound (phoneme) and one word begin with different sound (phoneme). The subjects were instructed to listen to the words and to choose the one which did not belong to the set.

2. Phoneme oddity (final): The test material consisted of fifteen sets of words. Each set consisted of four words, of which three of them end with same sound (phoneme) and one word end with different sound (phoneme). The subjects were instructed to listen to the words and to choose the one which did not belong to the set.

**TASK 2: PHONEME STRIPPING**

This section consisted of fifteen words. The subjects were asked to listen to the words carefully and they were instructed to strip (delete) a particular sound from the word and say the rest of the word.

**TASK 3: SYLLABLE ODDITY**

The subjects were instructed to listen to the words and to choose the one which did not belong to the set. This section consists of two parts i.e. Syllable oddity (initial) and syllable oddity (final).

1. Syllable oddity (initial): This material consists of fifteen set of words. Each set consisted of four words, of which three of them begin with same syllable and one word begin with different syllable.

2. Syllable oddity (final): This material consists of fifteen set of words. Each set consisted of four words, of which three of them end with same syllable and one word end with different syllable.

**TASK 4: SYLLABLE STRIPPING**

The test consists of fifteen words. The subjects were instructed to strip (delete) a particular syllable from the word and say the rest of the word.

**TASK 5: RHYME RECOGNITION**

This section consists of fifteen pair of words, both rhyming and not rhyming. The subjects were instructed to identify whether the paired words were rhyming or not.

**TASK 6: CLUSTERS**

This section consists of fifteen words. The subjects were instructed to identify the cluster in the presented word and then were asked to simplify the cluster by naming the sounds which constituted the clusters.

**TASK 7: BLENDING**

This section consists of fifteen pair of phonemes. The subjects were instructed to combine the two sounds to make a cluster orally.

**APPENDIX 2: AVAILABLE NORMS FOR BOYS AND GIRLS FOR 'TEST OF LEARNING DISABILITY IN KANNADA' (FOR PHONOLOGICAL AWARENESS TASKS).**

**Phoneme Oddity**

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<td>Males</td>
<td>Females</td>
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<td></td>
<td></td>
<td>Mean  SD</td>
<td>Mean  SD</td>
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<td>30</td>
<td>11.66  1.81</td>
<td>11.32  1.54</td>
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<td>IV</td>
<td>30</td>
<td>12.76  2.13</td>
<td>11.98  1.38</td>
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<td>V</td>
<td>30</td>
<td>13.50  1.83</td>
<td>13.43  0.92</td>
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<tr>
<td>VI</td>
<td>30</td>
<td>14.63  0.85</td>
<td>14.62  0.81</td>
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<tr>
<td>VII</td>
<td>30</td>
<td>14.96  0.18</td>
<td>14.96  0.16</td>
</tr>
<tr>
<td>VIII</td>
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<tr>
<td>X</td>
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### Phoneme Stripping

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EVIDENCE FOR THE INHIBITORY CONTROL-BASED LANGUAGE-NON-SPECIFIC LEXICAL SELECTION IN BILINGUALS

*Gopee Krishnan, & **Shivani Tiwari

Abstract

In the context of the ongoing and overwhelming debate on the ‘language-specific’ versus ‘language non-specific’ nature of bilingual lexical selection, the current study aimed at investigating this issue using a ‘semantic relatedness judgment’ paradigm. A group of proficient Malayalam-English bilinguals were required to judge the semantic relatedness (i.e., semantically related vs. unrelated) of word pairs in two language conditions (viz. monolingual – L2-L2 & cross-lingual – L2-L1). The semantically related monolingual and cross-lingual stimuli were judged faster compared to their semantically unrelated counterparts. Monolingual word pairs were judged faster compared to their cross-lingual counterparts both in the semantically related and unrelated conditions. Findings of the present study supported the ‘language non-specific’ nature of lexical selection in bilinguals. In addition to this, it also provided evidence for the role of inhibitory control of the non-target language in bilingual lexical selection.

Key Words: Bilingualism, Language-specific lexical selection, Language non-specific lexical selection, Semantic system

One of the most remarkable abilities of bilingual speakers is that of separating their two languages during the production of speech (Costa & Santesteban, 2004). Although the speech of highly proficient bilinguals in their second language (L2) often carries traces (e.g., accent, syntactic structures) of the first language (L1), it rarely exhibits lexical intrusions (Poulisse, 1999). That is, these bilinguals are competent enough at selecting and producing words from only one of their lexicons, either from L1 or L2 according to the communicative context. The contemporary investigations of the bilingual mental lexicon focus to uncover this intricate mechanism. In the following sections, we provide a brief overview of the mono- and bilingual language production system.

Lexical selection in monolingual speech production

A central stage in language production – the lexical selection – is the process of retrieving the words from the lexicon that match the speaker’s communicative intention (Caramazza, 1997; Dell, 1986; Levelt, 1989; 2001). A selection mechanism is often believed to function as several lexical representations are activated due to spreading activation from the semantic system to the lexical level. That is, the activated conceptual node spreads a proportion of its activation to its corresponding lexical node. In this context, the semantic system activates not only the word that matches the intended meaning but also other semantically related items. For example, when naming the picture of a dog, not only the lexical node “dog” is activated, but also other related lexical nodes such as “cat” and “bark”. It is assumed that the lexical selection mechanism is in charge of deciding which of the activated lexical nodes needs to be selected for further processing. Further, it is widely accepted that the level of activation of lexical nodes is the critical variable for deciding which node is to be selected. Thus, in general, the lexical selection mechanism would pick out the node with the highest level of activation which, in the normal case, corresponds to the intended meaning. However, some models of lexical access assume that this mechanism is also sensitive to the level of activation of non-target (yet activated) lexical nodes that act as competitors (e.g., Roelofs, 1992).

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Lexical selection in bilingual speech production

Applying the lexical selection mechanism in the case of bilinguals, two questions become relevant. First, does the semantic system activate the two lexicons of a bilingual? Second, do the lexical nodes of the non-response language act as Competitors? Previous research has shown a positive answer to the first question. That is, during the course of lexicalization in one language, the lexical nodes of both languages of a bilingual receive activation from the semantic system (Colome, 2001; Costa, Caramazza, & Sebastián-Gallés, 2000; Gollon & Kroll, 2001). However, with respect to the second question, some models of lexical access assume that the lexical selection mechanism is language-specific (Costa & Caramazza, 1999; Costa, Miozzo, & Caramazza, 1999; Roelofs, 1998). That is, the lexical selection mechanism considers the activation levels of the lexical nodes in the intended language. Therefore, according to these models, the lexical intrusions from the non-response language do not occur while speaking in a given language. In contrast to this, other models of bilingual lexical access assume that the lexical selection mechanism considers the lexical nodes from both languages – i.e., language non-specific lexical selection. That is, these models assume that, following the activation of a conceptual node, multiple lexical nodes are activated in both target and non-target languages. For example, when a Malayalam-English bilingual is asked to name the picture of a cat, the conceptual node [CAT] sends activation to its corresponding Malayalam (/pattii/) and English (/cat/) as well as to several other semantically-related lexical nodes [for e.g., /patti/ in Malayalam and its translation equivalent in English /dog/]. Consequently, this mechanism requires a means by which the target item (not its semantically related items) can be selected in the target language (not in the non-target language) by creating a differential level of activation between the two lexicons of a bilingual. Here, the pertinent question is: How does the system produce an imbalance of activation between the two lexicons? Two solutions have been postulated to explain this. The first postulation assumes that both target and non-target lexical nodes are activated roughly equally – thereby arising the 'hard problem' (Finkbeiner, Almeida, Janssen, & Caramazza, 2006) – and this is overcome by an inhibitory mechanism (see below) that suppresses the activation of the lexical nodes of the non-response language (de Bot, 1992; Green, 1986, 1998; Poulisse & Bongaerts, 1994). In contrast, the second postulation assumes that there exists a differential activation of the lexical nodes in the two languages (essentially, the lexical node in the target language being activated more than those from the non-target language) (La Heij, 2005; Poulisse & Bongaerts, 1994). Therefore, according to the second assumption, the issue of 'hard problem' does not arise in bilingual lexical selection.

Green's (1986; 1998) Inhibitory Control Model (ICM) has been employed to explain the bilingual selection mechanism. According to ICM, the control of lexical representation is achieved through the language task schemas. That is, each lexical node is associated with a language tag or schema (such as L1 or L2). These task schemas are claimed to exert control over the bilingual lexicon by inhibiting or activating the lexical nodes based on the language tags they possess. Task schemas also exert control through the suppression of competing task schemas of the non-target language. An important feature of the ICM is that inhibition is proposed to be reactive in nature. That is, the more non-target lexical representations become activated initially, the stronger those representations are then inhibited.

Experimental evidences for language non-specific lexical selection

Among the proponents of the language non-specific bilingual lexical selection, Meuter and Allport (1999) provided the most crucial evidences for the language suppression hypothesis. In their study, there were two independent variables: language switching (switch vs. nonswitch) and naming (in L1 vs. L2). The results of their study revealed two significant findings. First, a main effect of switching – that is, increased latency for switch trials. Second, an asymmetry of switching cost – that is, greater switching cost for L1 responses compared to L2. These two findings have been considered as the firm evidences of language suppression in bilingual subjects.

This asymmetrical switching cost in bilinguals has been regarded as the signature finding of language suppression in bilinguals (Finkbeiner et al., 2006). The L2-L1 switching cost has always been found to be longer across the studies following the seminal study of Meuter and Allport (1999). For instance, Costa and Santesteban (2004) replicated the increased switching cost from L2 to L1, although
these authors claimed that this asymmetry arose from the language proficiency. Finkbeiner et al. (2006) replicated the findings of Meuter and Allport (1999) and claimed that the switching cost arises from the stimulus qualities (i.e., univalent versus bivalent). That is, these authors disentangled the switching cost by keeping the experimental condition constant (L2 to L1) and varied the stimulus trial. In the univalent condition, the participants were required to name the pictures only in L1 whereas in the bivalent condition, they were required to name the digits both in L1 and L2. The results of this study showed a strong asymmetric switching cost in the bivalent condition (digit naming) with no evidences of switch cost on the picture naming (univalent) task. Finkbeiner et al. (2006) claimed that the nontarget language is not completely suppressed as a whole when selecting the lexical representations in the target language.

**Experimental evidences for language-specific lexical selection**

In contrast to the language non-specific nature of lexical selection, the language-specific view assumes that the lexical selection mechanism considers only the activation of the lexical nodes of target language (Costa, Miozzo, & Caramazza, 1999; Roelofs, 1998). According to these models, the lexical selection in bilinguals proceeds the same way as in monolinguals as the nontarget language is never considered during the lexical selection process. Evidences for this proposal come from the semantic interference effect (SIE) using picture word interference paradigms.

Semantic interference effect reflects the competition of different lexical nodes at the lexical level and this has been widely employed in bilingual research (Roelofs, 1992; Schriefers, Meyer, & Levelt, 1990). Although the semantic interference effect, at first instant seems to show the language non-specific nature of lexical access, a careful interpretation questions this argument (see, Costa, Colome, & Caramazza, 2000, for a discussion). In addition, it has been repeatedly reported in different languages that the identity effect – a paradigm employed to study the semantic interference effect by presenting the distracter word either in the same language or different language – leads to faster naming latencies when the distracter word corresponds to the target word’s translation equivalent than when it was unrelated. The mechanism behind this facilitation of the target language by the non-target language distracter is that the presentation of the distracter word activates its concept which in turn activates the lexical nodes in both languages. The faster naming latency in the target language can be explained only by the language-specific view of lexical access, as the language non-specific nature should result in slower naming latency resulting from the competition between the lexical nodes in both target and non-target languages. Therefore, these evidences strongly propose the language-specific nature of lexical access in bilinguals.

**Aim of the study**

From the brief review above, it is apparent that a consensus on the nature of lexical selection mechanism is yet to emerge. In the context of such ambiguous theoretical proposals, investigations employing novel paradigms seem pertinent. The present study, therefore, aimed to determine the nature of lexical selection (i.e., language-specific vs. language non-specific) in a group of bilingual subjects using a semantic relatedness judgment task. This task requires the participants to judge the semantic relatedness of a critical stimulus (second word of the word-pair) subsequent to the presentation of the first word.

**Objective of the study**

The objective of the study was to compare the judgment time between two variables: semantics (related & unrelated) and language (monolingual & cross-lingual).

**Working hypotheses**

In the present study, we hypothesized that:

a. A faster judgment time in the case of semantically related word pairs compared to their semantically unrelated counterparts may indicate the language non-specific nature of bilingual lexical selection. This is especially relevant in the case of the cross lingual word pairs (e.g., cat – patti vs. cat – thoppi).

b. Within the semantically related word pairs, if the monolingual items (e.g., cat – dog) are judged faster compared to the cross lingual items (e.g., cat – patti), it is suggestive of a differential activation of lexical items from the two languages, with an advantage of the monolingual lexical items.
Finally, in the semantically unrelated condition, if the monolingual items (e.g., cat – hat) are judged faster compared to their cross-lingual counterparts (e.g., cat – thoppi), it would be indicative of a non-semantic-based lexical selection mechanism among the two lexicons that are activated in parallel.

Method

Participants

A group of 25 right-handed university students (Mean age – 21; SD – 2 years) volunteered to participate in the study. All participants were born and brought up in Kerala – the southwest state of India, where the dominant language is Malayalam (a Dravidian language). All had their education in English medium, starting from the kindergarten level (early sequential bilinguals) and all judged themselves to have relatively good proficiency in their second language (English) (M = 5.5 on a 7-point scale).

Stimuli

The stimuli were prepared by pooling a list of semantically related and unrelated nouns by a group of five Malayalam-English bilingual subjects. From this list, the semantic relatedness was determined by a different group of 10 subjects who wrote down the features shared by each word pair. For the semantically related stimuli, pairs that had a minimum of three or more features were selected. For the semantically unrelated item, word pairs that did not have any features in common were selected. After this procedure, to further validate the list, the entire group of related and unrelated word pairs was rated by another group of another five subjects on a 5-point rating scale on their semantic relatedness. The extreme points of the scale were ‘semantically highly related’ and ‘semantically highly unrelated’. These subjects rated all the items at either extreme. Following this, the translation equivalents of these words were developed. Care was taken to eliminate those words that had phonological similarity between the translated pairs.

The final stimuli consisted of 60 word pairs grouped under four experimental conditions. Of these 60 word pairs, 30 were semantically related and remaining items were semantically unrelated. Under these two semantic conditions, equal number of items was further grouped into monolingual and cross-lingual conditions. Thus, the final set consisted of 15 stimuli each under English-English Semantically Related (EESR) (e.g., cat – dog), English-English Semantically Unrelated (EESU) (e.g., cat – hat), English-Malayalam Semantically Related (EMSR) (e.g., cat – patti) and English-Malayalam Semantically Unrelated (EMSU) (e.g., cat – thoppi) conditions (See Appendix for the stimuli).

Procedure

The experiment was carried in a quiet and dimly lit room. The stimuli were presented through DMDX reaction time software (Forster & Forster, 2003) in a Pentium IV desktop computer. The subjects were seated in a comfortable chair and were instructed to press ‘m’ or ‘n’ button of the keyboard following the judgment of semantically related and unrelated word pairs, respectively. In addition, the subjects were instructed to rest their index and middle fingers on ‘n’ and ‘m’, respectively, to eliminate the time lag to reach the button after every trial. Before the commencement of the experiment, a set of five trial items were provided for familiarizing with the task demands. A '+' symbol was presented at the center of the screen for 500 ms followed by an equal duration of blank screen. This was followed by the prime word, which remained on the screen for 750ms. This was replaced by a blank screen for 500 ms following which the target was presented for 2000ms. The inter-trial interval (ISI) was two seconds. Each subject was tested separately and the testing time did not exceed more than 10 minutes for each subject.

The participants were required to make judgment on the semantic relatedness (i.e., whether the second word of the stimulus pair was semantically related or unrelated to the first word). The stimuli were presented in two blocks, one for each language (i.e., mono- & cross-lingual) condition. The order of presentation of the stimuli was distributed such that half of the participants performed English-English task initially whereas the remaining half performed English-Malayalam task initially. Descriptive and statistical test of significance were performed for the judgment time of correct responses using SPSS 11 for Windows.

Results

The mean judgment time of English-English Semantically Related (EESR) word pairs was 875.06 ms (SD = 85.14; % error = 5.9) and that of the English-Malayalam Semantically Related (EMSR) word pairs was 980.35 ms (SD = 54.68; % error = 12.09). Similarly, the mean judgment time of English-English
Semantically Unrelated (EESU) word pairs was 1000.79 ms (SD = 54.48; % error = 7.9) and that of English-Malayalam Semantically Unrelated (EMSU) word pairs was 1068.52 ms (SD = 40.92; % error = 6.67). Figure 1 shows the mean reaction times of these four conditions.

To test our first hypothesis, we compared the judgment times of monolingual semantically related items (EESA) to that of their semantically unrelated counterparts (EESU). The comparison showed a significant difference between the two conditions. As part of the first hypothesis again, we compared the cross-lingual semantically related word pairs (EMSA) with their semantically unrelated counterparts (EMSU) and, more importantly, this too showed a significance difference in their judgment times. Further we compared the monolingual and cross-lingual semantically associated word pairs (i.e., EESA – EMSA) to test the second hypothesis. The difference in judgment times between these two conditions was significant with monolingual word pairs revealing mean judgment time faster by 105.2 ms. Finally, we performed pair-wise comparison of the semantically unrelated mono- and cross-lingual word pairs (i.e., EESU – EMSU) to test our third hypothesis. This comparison showed that the monolingual word pairs were judged faster by 67.7 ms compared to their cross-lingual counterparts. Table 1 provides the results of the comparisons of the mean difference in judgment time, confidence intervals, t-values, and the significance levels (p) of each of the comparison.

Table 1: Paired comparisons of semantically related and unrelated mono- and cross-lingual conditions.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean Difference</th>
<th>Confidence Interval</th>
<th>t-value</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESA – EESU</td>
<td>-126.7</td>
<td>-161.04 to -92.42</td>
<td>-4.88</td>
<td>24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EMSA – EMSU</td>
<td>-81.6</td>
<td>-130.93 to -32.29</td>
<td>-4.47</td>
<td>24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EESA – EMSA</td>
<td>-105.2</td>
<td>-147.8 to -62.59</td>
<td>-5.34</td>
<td>24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EESU – EMSU</td>
<td>-67.7</td>
<td>-94.98 to -40.47</td>
<td>-5.38</td>
<td>24</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* See text for expansion.

To investigate the effects of language (i.e., monolingual vs. cross-lingual) on the semantic relatedness (i.e., semantically related vs. unrelated), the judgment time data was submitted to repeated measures ANOVA. The results (Figure 1) revealed a significant main effect for language (F (1, 96) = 75.91, p < 0.001). English-English word pairs had significantly shorter reaction times (M = 937.92 ms; SD = 95.00) than the English-Malayalam word pairs (M = 1024 ms; SD = 65.28) and this difference was large (η² = 0.844). A significant main effect was also obtained for the semantic condition (F (1, 96) = 32.08, p < 0.001) indicating that the semantically related word pairs were judged faster (M = 927.60; SD = 88.37) compared to semantically unrelated word pairs (M = 1035 ms; SD = 58.59). This difference between the two conditions was large as indicated by the partial eta squared value (η² = 0.69). However, the results did not reveal any significant interaction between language and semantic relatedness (F (1, 96) = 1.413, p < 0.24).

![Figure 1: Mean judgment time of the semantically related and unrelated word pairs as a function of language conditions.](image)

**Discussion**

The present study investigated lexical selection mechanism in a group of Malayalam-English bilinguals through a semantic-relatedness judgment paradigm. Before proceeding to the discussion of the results, a note on the task employed in the current study seems appropriate.

**Nature of the task employed in the current study**

Researchers often employ a variety of experimental tasks to investigate the underlying architectural and processing principles of the bilingual mental lexicon. The seemingly contradictory findings in bilingual research may, to a large extent, be attributed to the way the results from various experimental tasks are interpreted. As rightly opined by Marian (2008) “challenges arise not because different tasks are used, but because the different tasks often probe different phenomena, and that is not always taken into account when interpreting the findings”. One should understand the task employed
and the target processing under study in order to interpret the findings in the right direction. The current study employed a 'semantic relatedness judgment' task. Although we used words as stimuli and the visual word recognition is an essential processing component in such tasks, the emphasis in the present study was on the post-visual recognition stages of lexical processing – that is, the semantic processing. The participants of the study were provided with a word in their L2 for about 750 ms duration which was followed by a blank screen of 500 ms duration. The critical stimulus (i.e., the second word) of the word-pair was presented at the end of the 500 ms blank screen and it remained for 2000 ms. Therefore, the duration between the onset of the initial word to that of the critical word (either in L2 or L1), was 1250 ms. It is evident that the initial word recognition requires much less duration than this. In addition, the semantic knowledge of the first word is usually accessed within this time frame (Meyer & Schvaneveldt, 1971). Therefore, although the visual word recognition was involved in the early stages of the processing of the initial word of the stimulus pair, it is apparent that the participants have accessed the semantic representation of the same by the time the second word was presented. In this context, we interpret our results with respect to semantic processing rather than visual word recognition.

Returning to the findings of our study, the participants showed shorter judgment time for semantically related word pairs compared to the unrelated word pairs both in the monolingual as well as in the cross-lingual conditions (Table 1). In the monolingual literature, this finding is attributed to 'semantic priming' (Meyer & Schvaneveldt, 1971). That is, the presentation of the initial word (e.g., cat) could partially activate the semantic concept of the second word of the stimulus pair (e.g., dog), thus making the semantic relatedness judgment faster (See Krishnan & Tiwari, 2008, for a discussion). Further, the faster judgment time in the semantically related cross-lingual word pairs (e.g., cat – patti) compared to their unrelated counterparts (e.g., cat – thoppi) indicates that even L1 (e.g., patti) lexical items were activated by the initially presented L2 words (e.g., cat). That is, priming (by cat) of a semantically related monolingual (dog) as well as its translation-equivalent (i.e., cross-lingual) (patti) items indicated the possible spread of activation from the concept [CAT] to both L1 (patti) and L2 (dog) semantically related items. These findings, therefore, strongly indicate the language non-specific nature of lexical selection (La Heij, 2005; Meuter & Allport, 1999; Poulisse & Bongaerts, 1994).

A significant difference in judgment time between the semantically related mono- (e.g., cat- dog) and cross-lingual (e.g. cat-patti) further showed that within the two activated lexicons, the monolingual lexical items revealed shorter judgment time, supporting our second hypothesis that there was a differential activation of L1 and L2 lexical items following the semantic activation by an L2 word. In this context of such parallel and differential activation of L1 and L2 lexicons, additional interpretation is required to explain this intricate lexical selection mechanism. As mentioned in the introduction, there are two possible explanations (i.e., differential activation of L1 and L2 lexical items & inhibitory control of the non-target language) for the advantage of monolingual over the cross-lingual word pairs. In the following section, we argue that the mechanism behind lexical selection in bilinguals is the inhibitory control of the non-target language rather than the differential activation of L1 and L2 lexical items. To support our argument, we discuss the findings from the semantically unrelated mono- and cross-lingual conditions.

In the semantically unrelated monolingual (e.g., cat-hat) and cross-lingual (e.g., cat-thoppi) conditions, the participants exhibited a faster decision time in the former condition. Considering the fact that both conditions were not semantically mediated, the facilitation of the monolingual word pairs requires an additional mechanism (i.e., other than semantic mediation) is required. Considering the two explanatory hypotheses (i.e., Inhibitory control and differential activation), the latter (i.e., differential activation) fail to account for the observations from the semantically unrelated conditions. That is, according to the differential activation account, both L2 and L1 are activated to different levels. However, according to the activation level-based models of bilingual lexical selection, both L1 and L2 are activated only when they are semantically related to the conceptual node. Put it in a simple way, an activated conceptual node does not send its proportional activations to the semantically unrelated L1 or L2 lexical items. It is, therefore, apparent that the only explanation that could account for the facilitation of the monolingual semantically unrelated over the
crosslingual semantically unrelated word pair is the inhibitory control mechanism (Green, 1986; 1998).

The inhibitory control mechanism (ICM) hypothesizes that when a bilingual speaks in one language, inhibitory control mechanisms are called up on to suppress the non-target language. According to the tenets of ICM, in the regulation of the bilingual lexico-semantic system, a conceptualizer builds conceptual representations, which are driven by the communicative goal. These both are mediated by a supervisory attentional system (SAS) together with components of the language system (i.e., language task schemas). The language task schemas, in turn, control the output leading to the accurate selection of words in the target language. Once the target language is established, the bilingual mind will turn to language tags to help determine which non-target words will need to be inhibited. According to Green (1998), words of the non-target language are suppressed to a degree that is proportionate to the level of activation based on language tags. Applying Green’s model to the present study, it may be assumed that with the presentation of the initial L2 word, the language task schemas and tags of L2 suppress the L1 lexical items. Since the inhibitory control exerted on L1 is not semantic-based, even semantically unrelated L1 lexical items are suppressed. The results of the present study provided strong support in this regard by revealing slower judgment time in the case of semantically unrelated cross-lingual word pairs compared to their monolingual pairs. In this context, it is apparent form the current study that the bilingual lexicon employs an inhibitory control over the non-target language.

Summarizing the findings of the present study, it is apparent from the current observations that the bilingual subjects activated both L1 and L2 lexicon while processing supporting the language non-specific nature of lexical processing. Further, the study provided strong empirical evidence for the inhibitory control-based suppression of the non-target lexical items that are activated in parallel with the target lexical items.

Limitations of the study

The present study, however, had certain limitations. First, it did not incorporate the L1 monolingual condition (Malayalam-Malayalam). Second, the semantic relatedness was judged always from L2- L1 and the reverse direction was not investigated. We therefore, advocate that the future studies employing semantic relatedness judgment paradigm may consider these shortcomings.

Conclusion

In summary, the present study provided empirical evidences for the language non-specific lexical selection in bilingual lexico-semantic system using the semantic relatedness judgment paradigm for the first time. More importantly, it provided strong evidence for the role of inhibitory control mechanism (ICM) in bilingual lexical processing.

References


FAST MAPPING IN TYPICALLY DEVELOPING KANNADA SPEAKING TODDLERS

*Sushma Manjunath, **Amulya P. Rao, ***Ranjini Mohan, & ****Swapna. N

Abstract

The ability to form a ‘quick, initial, partial understanding of word’s meaning’ and thereby to learn and retain new words with only minimal exposure is known as Fast Mapping. Studies exploring fast mapping abilities especially in toddlers are limited, therefore research in this area would be highly valuable in understanding the way children accomplish the task of learning new words that add to their developing lexicon. Thus the present study was undertaken to investigate the fast mapping skills of toddlers by examining the effect of practice on the accessibility of the words in the lexical memory. Two groups of typically developing Kannada speaking children between the age of 16 to 20 months participated in the study. These children were taught the names of 24 unfamiliar objects over twelve training and testing sessions spread over a span of twenty four days. The amount of practice children had with individual words varied as a function of session. The experimental group underwent training and testing for all the sessions, while the control group were trained and tested during the first and last sessions only. The accuracy of identification, at every session was tabulated and subjected to statistical analysis. The results revealed that there was significant difference between the high practice words (words exposed to during all the sessions) of session ‘1’ and Low practice words (words exposed to during the last session) of session ‘12’ in both the groups. However, between the two groups, the performance on low practice words was not significant. Thus it can be concluded that fast mapping does occur in toddlers and learning some words primes the system to learn a novel set of words. Nevertheless, the present results should be interpreted with caution because of modest sample size considered.

Key Words: Novel words, lexical memory, comprehension.

Word learning involves learning lexical labels, which requires the ability to correctly recognize the phonemes in their proper order within a label and associate meaning with a phonetic string representing the word label. The ability to form a ‘quick, initial, partial understanding of word’s meaning’ and thereby to learn and retain new words with only minimal exposure is known as Fast Mapping (Carey & Bartlett, 1978; Rice, 1989). Fast mapping is viewed as the critical first stage of learning new words, requiring intact phonological and semantic processing skills (Ellis Weismer & Evans, 2002; Gray, 2005).

In typically developing children the initial slow, one-at-a-time word learning is followed by an apparent ‘explosion’ in the lexicon (Bloom, Lifter & Broughton, 1985). Estimates suggest that children in their preschool years may learn up to nine new words a day (Templin, 1957). Researchers hypothesize that this explosion in the lexicon occurs because of the phenomenon called Fast Mapping. According to Carey & Bartlett (1978) following a single exposure to a new phonological form that has semantic value leads to the formation of a preliminary mental recording, or form-meaning ‘map’. Carey (1987) proposed that children learn the meaning of a word in two separate phases: (a) a fast mapping phase, in which the child establishes an initial link between word and referent, and (b) a subsequent, slow mapping phase. In the fast mapping phase, the child has only partial knowledge of the meaning of the word, whereas in the second phase of acquisition, the initial word representation becomes supplemented through...
additional experience, eventually coming to resemble the adult meaning. According to Crais (1992) the greater the exposure to a word, the more complete is the map. Fast mapping has been observed in typically developing children as young as 13 months of age (Kay-Raining Bird & Chapman, 1998; Schafer & Plunkett, 1998), children between 16-18 months (Gershkoff-Stowe & Hahn, 2007) and in children between 15 to 24 months (Bates, Bertherton & Snyder, 1988).

There are several factors that influence the ability of children to learn and use lexical labels. The sequence of sound that constitutes a lexical label can directly affect processing of that label. The phonotactic probability influences children’s word learning (Strokel, 2001; Strokel & Rogers, 2000). The characteristics of the new word, characteristics of the referent, characteristics of the introducing event, mutual exclusivity, taxonomic organization, existing lexicon, word frequency and neighborhood density are some of the other factors influencing word learning.

Practice effects are also ubiquitous in learning (Newell & Rosenbloom, 1981). Word learning requires extensive practice. Although word learning involves simple acquisition of information in memory, it also importantly involves the fine-tuning of processes that enable increased accessibility to information (Rumelhart & Norman, 1978). Yet, to date, the role of practice in the lexical development of beginning word learners has received little attention. The more an item is selected for comprehension or production, the stronger the level of activation will be and hence the greater the probability of access. This suggests that practice with individual words in a rapidly expanding lexicon changes the operation of the lexicon through the accumulated activation of many items. This is accomplished through an increase in the base of lexical and semantic units and the strengthening of connections between them.

A few studies have investigated the effect of practice on the accessibility of the words in the lexical memory. One such study was carried out by Gershkoff-Stowe & Hahn (2007) who investigated mapping advantage in normally developing toddlers between 16-18 months of age. The purpose was to examine the effects of practice on the accessibility of words in lexical memory. The results showed that for the children in the experimental group, extended practice with a novel set of high-practice words led to the rapid acquisition of a second set of low-practice words, while the children in the control group did not show the same lexical advantage.

In the Indian context, a few studies have been carried out to study the fast mapping ability. One such study was by Trupthi (2009) who assessed the fast mapping skills in 60 typically developing Kannada speaking children in two age groups, viz. 2.5- 3.5 years and 3.5- 4.5 years on a naming task. The accuracy of naming unfamiliar objects was scored ten minutes after training and one week later. She found that the children in the older age group performed better than the younger group. Further, the performance of all the children on an average, reduced when tested one week after training. The results indicated that the process of fast mapping may not be adequate for the development of lexicon and a subsequent extended slow mapping would also be necessary for word learning.

**Need for the study**

Although there are a number of studies carried out in the West which investigated the fast mapping abilities in children, the studies with respect to the effect of practice on word learning, especially in toddlers are limited. The age between one to two years, which has been known to be the first fifty word stage, explores the transition and development in the mapping of words. Moreover, this period is the time when many children experience a sudden, rapid spurt in production, and studying the pattern of development then could throw light on the vocal growth (Bloom, 1973; Gershkoff-Stowe & Smith, 1997). Considering that such studies exploring fast mapping abilities in toddlers in the Indian context are scarce and that such studies would be highly valuable in understanding the way children accomplish the task of learning new words that add to their developing lexicon, this study was planned.

**Aim of the study**

The main aim of the study was to investigate the fast mapping skills of toddlers by examining the effect of practice on the accessibility of the words in the lexical memory, i.e., whether the extended practice with a set of unfamiliar words would enhance the ability to access a new set of unfamiliar words in response to system wise changes in the activation of a new item.
Method

Participants: Two groups of typically developing Kannada speaking children ranging in age from 16 to 20 months participated in the study. The experimental group comprising of 8 Kannada speaking children (5 females and 3 males) (mean age: 1.61 yrs) were compared to a control group of 8 Kannada speaking children (4 females and 4 males) (mean age: 1.66yrs) using comprehension as a measure of fast mapping. Those children without any history of language, neurological, hearing, developmental, intellectual, social, emotional or orofacial disabilities only were included in the study. The children were screened to rule out any form of language deficits using the 'WHO Ten-question disability screening checklist' (Singhi, Kumar, Malhi & Kumar, 2007) and the Three-Dimensional Language Acquisition Test (Harlekhar & Karanth, 2002). An informal hearing screening was done to rule out hearing impairment. Ethical procedures were used to select the participants. The parents of the participants were explained the purpose and the procedures of the study and an informal oral consent was taken.

Materials and design

The parents of all the participants were asked to list out all the nouns in their child’s receptive and expressive vocabulary. Due to the non-availability of standardized tests to assess the vocabulary of children below two years, the words from ‘With a little bit of help- Early Language Training Manual’ (Karanth, Manjula, Geetha & Prema, 1999) was used to assess the vocabulary of the child. Based on the above twelve familiar picturable words were selected which were used during the testing sessions for control group. Another set of picturable words which were unfamiliar to the children were prepared for the experimental group. The target words were selected based on the low incidence level in the receptive and expressive vocabulary of the child and hence assumed to be unfamiliar to the child. This was also ensured by naming it to the child and the child giving a negative response for the word. The words considered for the study were primarily ‘nouns’ since several studies suggest that majority of the children’s first words are nouns (Dromi, 1987; Gershkoff-Stowe & Smith, 2004). These words were used for training the children in both the groups to maximize the probability that fast mapping would be observed. Bisyllabic Kannada words were selected and they were matched approximately for object category. This was done based on reports from literature that semantic similarity between words is a potent force in early word learning (Baldwin, 1992; Smith, 2000; Gershkoff-Stowe, Connell & Smith, 2006). Twenty four picture cards with bright colors were prepared. The twenty four unfamiliar words were divided into four sets of six words each, the names of which were matched approximately for object category, syllable length and phonological complexity. The stimuli used for the study has been shown in the appendix.

Two of the lists were classified as 'high practice' words, considered so, as the children saw the sets during all the sessions. One list was classified as 'medium practice', which the children in the experimental group only saw during session 3, 6 and 9. The final list was classified as 'low practice' which each child saw only on the last i.e., the session 12. The medium practice and low practice words were accompanied with a set of high practice words for the purpose of counter balancing.

Procedure

A total of twelve sessions were carried out with each child in the experimental and control group. In each session, the child was shown twelve picture cards and was involved in training and testing phases. The schedule of the training and testing phases in the experimental group was as follows: The sessions 1, 2, 4, 5, 7, 8, 10 and 11 consisted of training and testing of twelve high practice words, while the sessions 3, 6 and 9 consisted of training and testing of six high practice and six medium practice words. The six low practice words were trained and tested only in the session 12 along with six high practice words. This schedule was adopted from the study carried out by Gershkoff-Stowe & Hahn (2007).

In the training phase, the parent and the experimenter together labeled each of the twelve pictured objects a minimum of six times per session. Naming occurred in an ostensive context by directly pairing the visual object with the auditory label, when both the child and adult were jointly focused on the referent (Schafer & Plunket, 1998). Ostensive learning is essentially optimal for children with smaller vocabulary who may otherwise not be able to demonstrate fast mapping (Lederberg, Preszbindowski & Spencer, 2000). This interaction was structured naturally. Words were typically
embedded in propositional statements to support the processing of word-referent pairing. Thus, the child might hear the parent/experimenter say for example- “See the bear? It lives in the forest!” No attempt was made to systematically manipulate the amount or kind of semantic information provided. The experimental words rather than the synonyms (e.g., mynah rather than bird) and the whole object rather than the part was named during training. The experimenter also requested that parents avoid deliberate attempts to name the object any time before/after the session.

Testing probes were administered immediately after training. In the testing phase, six out of twelve pictures were kept in front of the child and the child was asked to point to the correct picture as the experimenter named each object. The order and location of the picture were arranged randomly for each session and each child. The same procedure was repeated for the remaining six pictures. When errors occurred, the experimenter provided the correct name and picture.

A similar procedure was followed for the control group for the first and last session. This group was included to separate the contribution of maturity and familiarity with the procedure from the experience with learning words. They were shown two high practice sets in session ‘1’ and one set of high practice and one set of low practice in the session ‘12’. For the intervening sessions, the parents were asked to name a set of twelve pictures of common everyday objects that were familiar to the child. These set of pictures were used at each of the ten middle intervening sessions and the children were expected to identify the named picture. These children were not exposed to the medium practice words at all. This design provided a between subject control for the testing and training sessions and experience with the procedure.

The two groups differed primarily in their exposure to the word referent pairs and amount of practice with the new unfamiliar words. The experimental group was exposed to the high practice words on all twelve sessions, whereas, the control group was exposed only in the first and the last session. Fast mapping was measured for each set by measuring the number of correctly identified words, at the session ‘1’ where new words were introduced; session ‘1’ for high practice, session ‘3’ for medium practice and session ‘12’ for low practice. Hence comparison of the child’s learning of high, medium and low practice words as a function of time was done. The response of each individual child in each session was scored and tabulated. The data was subjected to statistical analysis using SPSS (version 16). Mean and standard deviation was calculated. Other statistical measures were also applied to check for any significant difference between the experimental and the control group.

Results and Discussion

The results obtained on the fast mapping abilities in both the groups from different statistical analyses have been presented and discussed:

I. Comprehension of high practice words

To analyze how well children in both the groups learnt a new set of high practice words, it was important to see the increase in proportion of high practice words correctly identified from session ‘1’ through session ‘12’. The mean and SD values of high practice words for experimental and control group are depicted in Table 1.

Table 1: Mean and Standard Deviation (SD) of identification scores in session ‘1’ and session ‘12’ of high practice words in experimental and control group

<table>
<thead>
<tr>
<th>Group</th>
<th>Session</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>S1</td>
<td>9.38</td>
<td>6.95</td>
</tr>
<tr>
<td></td>
<td>S12</td>
<td>79.17</td>
<td>14.77</td>
</tr>
<tr>
<td>Control</td>
<td>S1</td>
<td>25.0</td>
<td>19.92</td>
</tr>
<tr>
<td></td>
<td>S12</td>
<td>54.17</td>
<td>31.81</td>
</tr>
</tbody>
</table>

*S1-Session ‘1’, S12- session ‘12’

The experimental group correctly identified 9.38% of the high practice words in session ‘1’ with only minimal exposure, compared to 79.17% in session ‘12’. The mean scores obtained were subjected to Wilcoxon Signed Rank test. The results revealed that there was a statistically significant difference (z = 2.52, p < 0.05) between first and the twelfth session. This shows that the children in the experimental group showed a gradual increase in the proportion of high practice words learned during the period of twelve sessions carried out. The children in the control group correctly identified 25% of the words correctly in Session 1, but showed little gain in session ‘12’, with only 54.17% correct.

A comparison of the mean scores of identification of high practice words in session ‘12’ by the two groups of children using Mann Whitney test, however, indicated no statistical significance, although the
performance by the experimental group was better as indicated by the mean value. The Figure 1 depicts the mean proportion of high practice words comprehended by experimental and the control group between session ‘1’ and session ‘12’.

These results are not in consonance with the study by Gershkoff-Stowe & Hahn (2007) who found that children in the experimental group comprehended statistically greater number of high-practice words in the last session of testing than the control group. This could have occurred because of the difference in the duration of training. In their study, the fast mapping was measured over a period of twelve weeks, while the current study was carried out for a period of twenty four days only, i.e. there was a period of twenty two days between first and last exposure to the set of high practice words in the control group. This short time gap between the two episodes of testing could have facilitated retention of words taught in session ‘1’.

Additionally, only an informal means of assessing the vocabulary of the children before commencement of the experiment was done. Due to lack of availability of standardized tests to assess vocabulary of the children below two years in the Indian context, a sufficient and objective pre-test account of the vocabulary of the children could not be established. The children in the control group could hence have had a larger vocabulary than the experimental group to begin with. Moreover, there is evidence in the literature suggesting significant correlation between children’s fast mapping skills and their vocabulary production scores on various standardized vocabulary tests (Ellis Weismer & Evans, 2002; Gray, 2005). Markman & Wachtel (1988) also opine that the child’s existing lexicon has an effect on word learning process.

In the days between first and last session, children in the control group received training on a set of familiar words that included everyday objects. This ensured that children in both groups received equivalent exposure in the experimental task. These children identified 100% of the familiar words in session ’11’, compared to only 54% of unfamiliar words in session ‘12’. This result suggests that like the experimental group, these children are equally capable of following the word learning experiment.

II. Comprehension of Experimental low practice words

The main question in this study was whether frequent exposure to a novel set of words would facilitate learning of an additional set of words. If this was the case, children in the experimental group would be expected to show better fast mapping skills than the control group. This was assessed by comparing the identification of low practice words by both the groups in session ‘12’. The experimental group did perform better than the control group with scores of 64.58% and 50% respectively. This indicates that the training of high practice words did indeed facilitate learning of a novel set of words especially in the experimental group. This has been depicted in Figure 2 below.

Mann Whitney test of significance however, showed no statistical significance between the two
groups ($z=1.07$, $p>0.05$). Though the experimental group did perform better than the control group, the small sample size and individual variations in the lexicon of the child, especially in the control group, could have led to these results. The greater scores in the experimental group compared to the control group indicate that fast mapping did occur in this group, though to a lesser extent. Due to the lack of a standardized test of vocabulary to assess the lexical development in toddlers in the Indian context, their exact vocabulary could not be assessed and this might have had an effect on the scores during final testing. The children, who received extended training in comprehension of unfamiliar words, progressed from learning each word individually to learning many words at once. This finding could be attributed to change in the strength of lexical activation due to repeated practice. These results are in partial agreement with the study by Gershkoff-Stowe & Hahn (2007) in which they found that the performance of the experimental group was significantly better than the control group. According to them, language processing system undergoes a shift from incremental improvements on a word-by-word basis to general, system wide growth in word retrieval skills. These results imply that fast mapping did occur in the experimental group, though the strength of the mapping could not be established.

The study also lends support to the fact that the semantic neighbourhood characteristics of a word also influenced the lexical access. The words used in the study were semantically related. They formed a unique "neighborhood" gradually increasing in strength as the number and density of task-related words also increased (Charles-Luce & Luce, 1990). This implies that through associative learning processes and prior experience, words and concepts can be organized into larger units or systems that facilitate 'fast, efficient, and parallel access to a broad base of related past knowledge' (Nelson, McEvoy & Pointer, 2003). Thus a small set of contextually related words can create a structural neighborhood that facilitates the spread of activation to other newly acquired words. This is consistent with adult studies showing that networks of association affect memory performance in tasks of recognition and cued recall (Nelson et al., 2003). Having a pre-established neighborhood in which to incorporate the new words thus appeared to have a facilitating effect on rapid word learning. This finding can be interpreted within the context of a spreading activation model, i.e., broadening the base of conceptually related links within a single neighborhood produces patterns of activation that support the accessibility of individual words (Stemberger, 1989).

### III. The medium practice set as a within subject control

A Friedman test was done to compare the results of learning at first presentation for high practice (session ‘1’), medium practice (session ‘3’) and low practice (session ‘12’) among the experimental group. Table 2: Mean and Standard Deviation (SD) of identification scores in sessions experimental and control groups.

<table>
<thead>
<tr>
<th>Sessions*</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 high practice</td>
<td>9.38</td>
<td>6.95</td>
</tr>
<tr>
<td>S3 medium practice</td>
<td>27.08</td>
<td>12.40</td>
</tr>
<tr>
<td>S12 low practice</td>
<td>64.58</td>
<td>22.60</td>
</tr>
</tbody>
</table>

*S1-Session ‘1’, S12- session ‘12’

The children in the experimental group correctly identified 9.38% of high practice words in Session 1, 27.08% of medium practice words in Session 3 and 64.58% of low practice words in Session 12. The results revealed a significant difference ($\chi^2(2, N=8) = 15.54, p < 0.001$). Figure 3 depicts the improvement made by the experimental group across different conditions.

The above findings also showed that the low practice words were identified best at first exposure, followed by medium practice words and high practice words at first exposure each. This establishes that the children in the experimental group not only identified better across time, but also improved performance every time a novel set of words was introduced.

There is a possibility however, that the improved performance of the children in session ‘12’ was due to the familiarity with experimental procedure and not due to practice with learning words. If this was so, a significant increase should have occurred in the identification of words after a few days of training itself. To rule out this, a comparison of comprehension of high practice and medium practice set at second presentation was done. The children correctly identified 26.04% of high practice words at session ‘2’ and 43.8% of medium practice words at session ‘6’. The Wilcoxon Signed Rank test revealed that the
mean scores were not statistically significant ($z = 1.6$, $p>0.05$), thus indicating that the improvement was indeed due to the effect of learning and not due to familiarity with the procedure.

**Conclusion**

The present study aimed at studying the fast mapping skills in Kannada speaking toddlers. The children in the group that was provided repeated training of a novel set of words extended the learning and practice to another set of unfamiliar words i.e. fast mapping was seen in these children, although to a smaller extent. The high practice words created a neighborhood which facilitated the rapid learning of low practice words. In these children, learning of new words seemed to prime the system to knowing more words. Nevertheless, the present results should be interpreted with caution because of small sample size, but the study throws light on the importance of examining the potential changes in the strength of activation of words with repeated practice. In extending the results of this study to children who have difficulty accessing words for expressive use despite intact comprehension, it suggests that both listening to words as well as producing them influences lexical representation in memory. Though listening involves passive retrieval and expression involves active retrieval, both are mutually influential and activation in one modality would facilitate activation of units in another modality. Further research on fast mapping in a greater sample of children of various age groups and establishing norms on lexical vocabulary in children speaking Indian languages is warranted.

**Acknowledgement**

We would like to thank The Director, AIISH, Mysore, the participants of the study and the staff members, AIISH, Mysore.

**References**


Harlekhar, G., & Karanth, P. (2002). Three Dimensional Language Acquisition Test (3D-


**APPENDIX**

<table>
<thead>
<tr>
<th>Experimental condition</th>
<th>High practice</th>
<th>Medium Practice</th>
<th>Low Practice</th>
</tr>
</thead>
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<tr>
<td>/hubbu/</td>
<td>/reppe/</td>
<td>/ede/</td>
<td>/galla/</td>
</tr>
<tr>
<td>/vi:Ne/</td>
<td>/sita:r/</td>
<td>/Dho:lu/</td>
<td>/ta:La/</td>
</tr>
<tr>
<td>/pengvIn/</td>
<td>/maina/</td>
<td>/gu:be/</td>
<td>/hundza/</td>
</tr>
<tr>
<td>/kempu/</td>
<td>/ni:ll/</td>
<td>/kappu/</td>
<td>/bIL/</td>
</tr>
<tr>
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<td>/be:ll/</td>
<td>/chImnI/</td>
<td>/ba:vi/</td>
</tr>
<tr>
<td>/e:DI/</td>
<td>/to:La/</td>
<td>/me:ke/</td>
<td>/ginke/</td>
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</table>

**Control condition**

<table>
<thead>
<tr>
<th>Familiar word list</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>/kaNNu/</td>
<td>/kurchi/</td>
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<td></td>
</tr>
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<td>/mane/</td>
<td>/a:ne/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/sara/</td>
<td>/ba:ji/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ele/</td>
<td>/mu:gu/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/Chatri/</td>
<td>/ka:lu/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/tale/</td>
<td>/To:pi/</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PREVALENCE OF SEIZURE DISORDERS IN CHILDREN WITH COMMUNICATION DISORDERS- A PRELIMINARY STUDY

*Sangeetha Mahesh, & **Y. V. Geetha

Abstract

The word “Epilepsy” is derived from a Greek word which means to seize. Jackson (1931) defines, “Epilepsy as sudden, excessive, rapid and local discharge of gray matter”. Epileptic seizures are usually brief, lasting from second to minutes, and they are marked by the sudden appearance of behavioral manifestation that may be purely motor or that may affect other brain functions. It is known to co-exist or develop as a range of childhood conditions in which there is Central Nervous System (CNS) involvement. Seizures occur more frequently in children with communication disorders than in the general population. However, prevalence of epileptic seizures in children with communication disorders is not clearly understood. There is an urgent need for studies regarding prevalence of epileptic seizures in communication disorders. Hence the present study was planned. The subjects considered in the study included children below the age of 12 years, who had visited AIISH with the complaint of speech, language and hearing problems over a period of two years (Jan 2007- Dec 2008). Case files of these children were reviewed for the presence or absence of seizures and type of associated communication disorders. Results revealed that out of 6,101 children with communication disorders, who were registered during the period, 730 children had positive history of seizures. A total percentage of communication disorder having positive history of seizures was 11.96% whereas in general population it is about 3-5%. The gender wise distribution revealed that boys had 74.1% (541/730) and girls had 25.9% (189/730) history of seizures. It was noted that epileptic seizures are one of the most common neurological disorders occurring in children with communication disorders. The prevalence figure varied widely across the clinical population. These findings suggest measures to control seizures in the subgroups of communication disorders as the presence of seizures is a deterrent to physical and mental progress.

Key Words: Prevalence, Epileptic seizures, Communication disorders.

Epilepsy is an enduring condition or rather a group of conditions, in which epileptic seizures occur repeatedly without a detectable extracerebral cause (Gastaut, 1973). According to the Epilepsy Foundation of America (2010), Epilepsy is a physical condition that occurs when there is a sudden and brief change in how the brain works. When brain cells are not working properly, a person’s consciousness, movement or actions may be altered for a short time. These physical changes are called epileptic seizures. Epilepsy is therefore sometimes called a seizure disorder. The epileptic discharge is a complex phenomenon resulting from the interaction of excitatory and inhibitory influxes network formed by multiple diverse neuronal sources. The main characteristics of the epileptic discharge are its high amplitude and its rhythmicity, both caused by the excessive synchronization of an abnormal number of potentials in a neuronal aggregate (Fenwick, 1983; Aird, Masland, & Woodbury, 1989). In the epidemiologic studies the occurrence of two seizures is accepted as the operational definition of epilepsy (eg., Sander & Sillanpaa, 1998). This definition, though convenient, is obviously arbitrary. In other studies (eg., Todt, 1984) the threshold for a diagnosis of epilepsy was about three attacks. It is
recommended that the guidelines established by the International League against Epilepsy (ILAE) commission in epidemiology and prognosis be followed in epidemiologic studies of epilepsy. According to these guidelines, a person with active seizures is one who has had at least one epileptic seizure in the previous five years, regardless of antiepileptic drug treatment.

a. Incidence & prevalence of epileptic seizures in general population

Epileptic seizures affect people in all nations and of all races. It is the second most common chronic neurological condition seen by neurologist. It is estimated that there are 55,00,000 persons with seizures in India, 20,00,000 in USA and 3,00,000 in UK. Three to five per cent of the population have active seizures (Sridharan, 2002). About two million Americans have seizures. Of the 125,000 new cases that develop each year, up to 50% are in children and adolescents (Freeman, Vining, & Pillas, 1997).

The prevalence figures of seizures among the general population (Indian data) per 1000 population ranged widely from as low as 1.28 in Baroda (Issac, 1987) to 11.92 in rural Bangalore (Sathishchandra, Gururaj, Devi, & Subbakrishnan, 1996). As India is a large country with diverse cultures and food habits, local figures for prevalence and incidence should not be extrapolated for the rest of the prevalence rates across the country.

b. Prevalence of epileptic seizures in children with communication disorders

Seizures occur more frequently in children with communication disorders than in the general population (Stephenson, 1999). The frequency and the severity of the epileptic syndrome are related more to the primary cause of communication disorder. In United states, the prevalence of mental retardation is approximately 0.3-0.8%, but 20-30% of children with mental retardation have seizures. Approximately 35-40% of children with seizures also have mental retardation (Alvarez, 1998). Rodin (1968) found a low intelligence in children with brain lesions whereas, in “pure” seizures, the Intelligence quotient (IQ) was within normal limits, although the curve of IQ was shifted to the left. In the whole group, a mild irregular downward trend was present and significant loss was seen in only some cases. Sillanpaa (2000) found some deterioration in IQ among 11% of the children.

Saemundsen, Ludvigsson, and Rafnsson (2007) suggested that the estimated prevalence of autistic spectrum disorders (ASD) is higher in children with history of seizure in the first year of life than in the general population. Thompson and Wasterlain (1997) found 25-35% of children with cerebral palsy having seizures and those with spastic hemiparesis and quadraparesis had the highest frequency. The study by Kudrjveev, Schoenberg, Kurland, and Grouver (1985) in Minnesota between 1950 and 1976, found 52% of those with severe cerebral palsy had developed seizures.

Broeders, Geurts, and Jenneke Schinkel (2009) explored pragmatic language deficits in children with seizures and if present, are discrete or associated with general intellectual functioning. Of children with seizures, 23% had pragmatic deficits, whereas only 3% of the children with various other neurological disorders and none of the typically developing children had these deficits. Van Riper (1971) found greater prevalence of stuttering among patients with seizures. These findings suggest a link between stuttering and seizures but do not enable one to specify the nature of the link. Review of literature indicates that the epileptic seizures are one of the most common neurological disorders occurring in children with communication disorders. It also suggests that the prevalence figure varied widely across the clinical population.

India has a large number of differentially abled population numbering about 100 million. The number is expected to increase substantially every year in view of the rapid changing demographic profiles and morbidity patterns. It is axiomatic that the coexistence of seizures and few types of communication disorders is usually not coincidental, but that both result from some underlying brain disorder. Speech language pathologists and Audiologists come across many children and adults with various communication disorders having a history of seizures or seizure disorders. Epileptic seizures consist of various types of clinical seizures and epileptic syndromes. The appearance rate or distribution of various types of epilepsies and epileptic syndromes in communication disorders has not been explored much. Hence there is need for studies regarding prevalence of epileptic seizures in communication disorders. The epidemiological findings are important not only for the public health but also for clinical practice. It would also be interesting to know the role of seizure disorders...
disorders in different clinical population in order to take suitable preventive measures and to provide rehabilitation. Since there is only limited Western data and no Indian data about the prevalence of epileptic seizures in children with communication disorders the present study was planned.

The objective of the study was to determine the prevalence of epileptic seizures in different subgroups of children with communication disorder.

**Method**

The study was planned as a retrospective analysis of case file data of children below the age of 12 years with the complaint of speech, language and hearing problems, who were registered at AIISH OPD during Jan 2007 to Dec 2008.

**Materials:**
1. Case files of children registered at AIISH as mentioned
2. A checklist to collect relevant information
3. SPSS software for the analysis of the data

**Procedure:** Case files of children were reviewed for the presence or absence of seizures. A checklist was prepared to collect the demographic data and other relevant information from the case files of children, selected as participants of the study. Demographic data included age, gender, contact address, socioeconomic status and education. Other relevant information included history of seizures like age of onset, associated speech, language, hearing and other disorders, family history, causes, type of seizure, frequency of occurrence, type and duration of medication and whether the seizures is under control with medications in children with communication disorders. The data was analyzed using SPSS software and equality of proportions to study the research objective.

**Results**

**A. Prevalence of epileptic seizures in different subgroups of children with communication disorders**

Children below the age of 12 years who visited AIISH over a period of two years (Jan 2007- Dec 2008) with the complaint of speech, language and hearing problems were found to be 6,101. Out of 6,101 children with communication disorders, 730 children had positive history of seizures. The total percentage of communication disorder having positive history of seizures was 11.96%. The prevalence of epileptic seizures in different subgroups of children with communication disorders are depicted in the following table 1 and figure 1.

<table>
<thead>
<tr>
<th>Disorders</th>
<th>Clients registered at AIISH (2 years)</th>
<th>Clients with +ve history of seizures</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borderline intelligence</td>
<td>34</td>
<td>25</td>
<td>73.53%</td>
</tr>
<tr>
<td>Speech regression</td>
<td>30</td>
<td>20</td>
<td>66.6%</td>
</tr>
<tr>
<td>Hearing loss with Cerebral palsy and Mental Retardation</td>
<td>29</td>
<td>17</td>
<td>58.62%</td>
</tr>
<tr>
<td>Mental Retardation and Cerebral palsy</td>
<td>332</td>
<td>170</td>
<td>51.20%</td>
</tr>
<tr>
<td>Development delay</td>
<td>78</td>
<td>24</td>
<td>30.76%</td>
</tr>
<tr>
<td>Mental retardation</td>
<td>1276</td>
<td>271</td>
<td>21.23%</td>
</tr>
<tr>
<td>Pervasive developmental disorders</td>
<td>162</td>
<td>32</td>
<td>19.75%</td>
</tr>
<tr>
<td>Apraxia</td>
<td>11</td>
<td>2</td>
<td>18.18%</td>
</tr>
<tr>
<td>Mental retardation and Hearing Loss</td>
<td>133</td>
<td>23</td>
<td>17.29%</td>
</tr>
<tr>
<td>Attention deficit hyperactivity disorder</td>
<td>69</td>
<td>8</td>
<td>11.69%</td>
</tr>
<tr>
<td>Hearing loss and cerebral palsy</td>
<td>65</td>
<td>9</td>
<td>13.48%</td>
</tr>
<tr>
<td>Cerebral palsy</td>
<td>210</td>
<td>28</td>
<td>13.33%</td>
</tr>
<tr>
<td>Delayed speech and language</td>
<td>867</td>
<td>31</td>
<td>3.53%</td>
</tr>
<tr>
<td>Hearing Loss</td>
<td>1595</td>
<td>42</td>
<td>2.63%</td>
</tr>
<tr>
<td>Learning disability</td>
<td>195</td>
<td>5</td>
<td>2.56%</td>
</tr>
<tr>
<td>Cleft lip and palate</td>
<td>104</td>
<td>2</td>
<td>1.92%</td>
</tr>
<tr>
<td>Dysarthria</td>
<td>134</td>
<td>2</td>
<td>1.49%</td>
</tr>
<tr>
<td>Misarticulation</td>
<td>302</td>
<td>3</td>
<td>0.99%</td>
</tr>
<tr>
<td>Stuttering</td>
<td>426</td>
<td>4</td>
<td>0.09%</td>
</tr>
</tbody>
</table>

Table 1: Prevalence of epileptic seizures in different subgroups of children with communication disorders.
The percentage of seizures in different subgroups of children with communication disorders are as follows. Higher prevalence rate (73.53%) of seizures was noticed in children with borderline intelligence and lowest prevalence rate was noticed in children with stuttering (0.09%). 20 children (66.6%) had speech regression due to epileptic sequelae. 17 children (58.62%) with multiple disability i.e., hearing loss with cerebral palsy and mental retardation had positive history of seizures.

In general, the percentage of seizures in children with borderline intelligence was 73.53%, followed by speech regression (66.6%), hearing loss with cerebral palsy and mental retardation (58.62%), mental retardation with cerebral palsy (51.20%), developmental delay (30.76%), mental retardation (21.23%), pervasive developmental disorders (19.75%), apraxia (18.18%), mental retardation with hearing loss (17.29%), cerebral palsy with hearing loss (13.84%), cerebral palsy (13.33%), attention deficit hyperactivity disorder (11.69%), delay in speech and language (3.53%), hearing loss (2.63%), learning disability (2.56%), cleft lip and palate (1.92%), dysarthria (1.49%), misarticulation (0.99%) and stuttering (0.09%).
B. Prevalence of epileptic seizures across gender in children with communication disorders

The percentage of seizures across gender was analyzed in children with communication disorders. Out of 730 children with positive history of seizures, 541 (74%) were boys and 189 (25.9%). The prevalence of epileptic seizures across gender in different subgroups of communication disorders are depicted in the following table 2.

<table>
<thead>
<tr>
<th>Disorders</th>
<th>Boys with + ve history of seizures</th>
<th>Girls with + ve history of seizures</th>
<th>z values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of children</td>
<td>Percentage</td>
<td>No. of children</td>
</tr>
<tr>
<td>Borderline intelligence</td>
<td>22</td>
<td>4.06</td>
<td>3</td>
</tr>
<tr>
<td>Speech regression</td>
<td>15</td>
<td>2.77</td>
<td>5</td>
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<tr>
<td>Hearing loss with Cerebral palsy and Mental retardation</td>
<td>11</td>
<td>2.03</td>
<td>6</td>
</tr>
<tr>
<td>Mental retardation and Cerebral palsy</td>
<td>122</td>
<td>22.5</td>
<td>48</td>
</tr>
<tr>
<td>Development delay</td>
<td>15</td>
<td>2.77</td>
<td>9</td>
</tr>
<tr>
<td>Mental retardation</td>
<td>206</td>
<td>38.07</td>
<td>65</td>
</tr>
<tr>
<td>Pervasive developmental disorder</td>
<td>22</td>
<td>4.06</td>
<td>10</td>
</tr>
<tr>
<td>Apraxia</td>
<td>2</td>
<td>0.36</td>
<td>0</td>
</tr>
<tr>
<td>Mental retardation and Hearing loss</td>
<td>15</td>
<td>2.77</td>
<td>8</td>
</tr>
<tr>
<td>Attention deficit hyperactivity disorder</td>
<td>7</td>
<td>0.29</td>
<td>1</td>
</tr>
<tr>
<td>Hearing loss and Cerebral palsy</td>
<td>5</td>
<td>0.82</td>
<td>4</td>
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<tr>
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<td>17</td>
<td>3.14</td>
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</tr>
<tr>
<td>Delayed speech and language</td>
<td>24</td>
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<tr>
<td>Hearing loss</td>
<td>30</td>
<td>5.54</td>
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<tr>
<td>Learning disability</td>
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<td>0.92</td>
<td>0</td>
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<tr>
<td>Cleft lip and palate</td>
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<td>0</td>
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<tr>
<td>Dysarthria</td>
<td>2</td>
<td>0.36</td>
<td>0</td>
</tr>
<tr>
<td>Misarticulation</td>
<td>3</td>
<td>0.55</td>
<td>0</td>
</tr>
<tr>
<td>Stuttering</td>
<td>4</td>
<td>0.73</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2: Prevalence of epileptic seizures across gender in children with communication disorders and results of equality of proportions
In general, the percentage of seizures among boys was maximum of 206 (38.07%) in children with mental retardation and minimum of 2 (0.36%) in cleft lip & palate and apraxia. Similarly, the percentage of seizures among girls was maximum of 65 (34.39%) in children with mental retardation and minimum of 1 (0.52%) in children with attention deficit hyperactivity disorder. The present study revealed no history of seizures among girls in subgroup of communication disorders like learning disability, stuttering, misarticulation, dysarthria, cleft lip & palate, apraxia and in boys also it was <1%.

The percentage of seizures among boys and girls in subgroups of communication disorders was compared using the test of equality of proportions. There was no significant difference across gender at 95% confidence interval except for children with mental retardation ($z = 2.96$, $p > 0.05$). The results indicated that the frequency of occurrence of seizures across gender was not significantly different from each other. However, only among children with mental retardation boys had significantly higher frequency of occurrence of seizures than girls.

**Discussion**

In the present study it was noted that epileptic seizures were one of the most common neurological disorders occurring in children with communication disorders. The percentage ranged from as high as 73.53% in children with mental retardation to as low as 0.09% in stuttering group. Findings suggest that the prevalence rate of seizures was more in children with brain damage as in borderline intelligence, cerebral palsy, mental retardation, developmental delay and pervasive developmental disorders.

**A. Prevalence of Seizures in subgroups of children with communication disorders**

1) **Seizures in children with mental retardation**

In the present study, the maximum percentage of seizures ranged from 73.56% to 21.23% in children with mental retardation indicating brain damage as the major cause for seizures. Children with developmental disabilities are at higher risk for seizures than the general population (Walsh, 1999). The frequency and the severity of the epileptic syndrome are related more to the primary cause of mental retardation than to the severity of mental retardation. However, there is a direct relationship between severity of intellectual disability, frequency and severity of chronic epileptic seizures. In United states, the prevalence of mental retardation is approximately 0.3-0.8%, but 20-30% of children with mental retardation have seizures. Approximately 35-40% of children with seizures also have mental retardation (Alvarez, Carvajal, & Begaud, 1998). Rodin (1968) found a low intelligence in children with brain lesions whereas, in “pure” seizures, the IQ was within normal limits, although the curve of IQ was shifted to the left. In the whole group, a mild irregular downward trend was present and significant loss was seen in only some cases. Sillanpaa (2000) found some deterioration in IQ among 11% of the children. The results of the present study indicate a much higher percentage of seizures in children with mental retardation compared to other studies.

2) **Seizures in children with speech regression**

Speech regression due to seizures was found to be 66.6% in the present study. This indicates that there might be greater amount of detrimental effects in children due to presence of seizures. Acquired epileptic aphasia (AEA) typically develops in healthy children who acutely or progressively lose receptive and expressive language ability coincident with the appearance of paroxysmal EEG changes. Population-based epidemiologic data related to AEA are limited. Many reports describe no correlation between EEG abnormality and language dysfunction (Menezes, 2010).

Those with neurological involvement and hence at risk for developing seizures constitute the tip of the iceberg. Frequent causes of seizures in young children are central nervous system (CNS) malformation, CNS injury from infection or accident and CNS malfunction caused by a metabolic error (Singh & Mehta, 1987). Seizures and speech regression may occur together and both may result from same underlying brain disorder. However, the causal association between seizures and language impairment is poorly documented due to constraints in epidemiological methods. The present study is a retrospective analysis and hence most of the information were considered from the casefiles as reported by the parents. Majority of the time information collected would depend on the type of understanding the parents have regarding the condition. The first epileptic seizure that involves abnormal body movements for a short duration may have greater significance for parents. Hence, there
is higher probability of parents to report as seizures being the causative factor for communication disorder.

3) Seizures in children with Pervasive developmental disorders (PDD)

In the present study the frequency of overt seizures among patients with Pervasive developmental disorders (PDD) was 19.75%. Tuchman and Rapin (2002) found that seizures was present in 14% of autistic children after they excluded patients with Rett’s syndrome. Al-Salehi, Al-Hifthy, and Ghaziuddin (2009) examined a sample of 49 children (37 males and 12 females) diagnosed with an autistic spectrum disorder at a tertiary referral center in Saudi Arabia. They found 11 clients with a history of seizure disorder and one had chromosome abnormality. Saemundsen, Ludvigsson, and Rafnsson (2007) described autistic spectrum disorders (ASDs) in a cohort of children with history of unprovoked seizures other than infantile spasms in the first year of life. Eighty-four children (82.4%), 28 boys and 56 girls, participated in the study and 36.9% (31/84) were investigated for possible ASD. Twenty-four (28.6%) had at least one neuro-developmental disorder, 14.3% had mental retardation (MR) and six (7.1%) were diagnosed with ASD, all of whom also had MR and three of whom had congenital brain abnormalities. The results suggested that the estimated prevalence of ASD is higher in children with history of seizure in the first year of life than it is in the general population. The results of the present study are in agreement with other studies.

4) Seizures in children with multiple disability

The present study found children with multiple disabilities i.e., Hearing loss with Cerebral palsy and Mental retardation, Mental retardation and Cerebral palsy, Mental retardation with Hearing loss and Cerebral palsy with Hearing loss had prevalence rate of seizures of 58.62%, 51.20%, 17.29% and 13.84% respectively. This indicates that more the number of disabilities found, more prone the children are for epileptic seizures or its co-existence. This finding is in agreement with findings in many other studies. An association of mental retardation with cerebral palsy is also common in those with seizures. Earlier studies have investigated the prevalence rate of seizures in children with cerebral palsy and mental retardation. In a group of non institutionalized individuals, the prevalence of seizures was 20%, seizures and mental retardation was 43% and seizures associated with cerebral palsy was 33% (Hauser, Annegers, & Kurland, 1991).

5) Seizures in children with Cerebral Palsy (CP)

The present study found that children with cerebral palsy (CP) had 13.33% and Hearing loss with cerebral palsy (HLCP) had 13.84% of prevalence rate of seizures. Thompson and Wasterlain (1997) found 25-35% of children with cerebral palsy having seizures and those with spastic hemiparesis and quadriparesis had the highest frequency which support the results of the present findings. The dual handicap of seizures and cerebral palsy occurs in 1 in 1,000 live births. When the two disorders coexist, it is reasonable to assume that the etiology also is related that is, that the same brain injury responsible for causing cerebral palsy also has caused the seizures. Davis (1977) reported seizures rates as high as 55-72% in cases of spastic hemiplegia to about 23% in the choreoathetotic or ataxic forms. The population-based study in Sweden by Hagberg, Hagberg, Olow, and Wendt (1996) found that 28% of people with CP also had seizures. An update of this study published in 2003 reported that 38% (55/146) developed seizures by 6 to 14 years of age (Carlsson, Hagberg, & Olsson, 2003). Similarly, the Danish cerebral palsy register reported that 27.1% of patients born with cerebral palsy between 1979 and 1986 also had seizures (Topp, Uldall, & Roos, 1997). Data from Western Australia (Stanley, Alberman, & Blair, 2000) from 1975 through 1994 record the incidence rate of seizures to be 37% (618 of 1,664). The rate of combined seizures and CP of 0.8 per 1,000 live births has remained constant over 25 years. The improvements in neonatal care during the last 20 years, the number of surviving premature and low birth weight babies has been increased with a concomitant increase in the rate of CP (Camfield, Camfield & Watson, 2001).

The study by Kudrjeev, Schoenberg, Kurland, and Grouver (1985) in Minnesota between 1950 and 1976, found 52% of those with severe cerebral palsy developed seizures. Conversely, seizures was present in 23% of those with mild to moderate CP. Watson and Stanley (as cited in Camfield et al., 2001) found that 65% of children with severe cerebral palsy born between 1975 and 1994 developed seizures, as compared with 24% of children with minimal, mild or moderate cases of CP. Hence it is concluded that children severely affected by cerebral
palsy seem to be more likely to develop seizures. However, the present study did not attempt to correlate the prevalence with severity of CP.

6) Seizures in children with other subtypes of communication disorders

The lowest prevalence rate of seizures was found in clients with speech and language delay (3.53%), hearing loss (2.63%), learning disability (2.56%), cleft lip and palate (1.92%), dysarthria (1.49%), misarticulation (0.99%) and stuttering (0.09%). Findings are probably because these communication disorders are not caused due to serious brain damage.

Broeders, Geurts, and Jennekens Schinkel (2009) explored pragmatic language deficits in children with seizures and if present, are discrete or associated with general intellectual functioning. They concluded that the pragmatic composite score distinguished between the two neurologically impaired groups, even after controlling for full-scale intelligence quotient (FSIQ). Of children with seizures, 23% had pragmatic deficits, whereas only 3% of the children with various other neurological disorders and none of the typically developing children had these deficits. When compared scale by scale with typically developing children, children in both clinical groups showed more structural language problems and problems of language use, but these differences disappeared when FSIQ was controlled for. Pragmatic deficits in communication are present in children treated for various neurological impairments, but more so in children whose seizures necessitate referral to a tertiary hospital.

Learning disabilities can be caused by damage to the brain. This damaged part of the brain can then become irritable and provide a focus for epileptic seizures. The resulting seizures, however, may not appear until many years after the damage occurred. Usually seizures does not cause learning disabilities. However, having many and/or severe seizures over a length of time can cause damage to the brain. This in turn can lead to learning disabilities. Learning difficulties of variable severity are present in 5% to 50% of children with seizures (Schoenfeld, Seidenberg, & Woodard, 1999). Oromotor apraxia and speech problems may be congenital or they may develop or worsen with episodes of sustained spike and wave discharges during sleep (Scheffer, Jones, & Pozzebon, 1995).

Van Riper (1971) found greater prevalence of stuttering among patients with seizures. These findings suggest a link between stuttering and seizures but do not enable one to specify the nature of the link. There is an apparent relationship between stammering and seizures in the abnormality of the brain wave tracings. Interestingly brain wave tracings suggest that persons with stuttering may be functioning in a state of reduced consciousness (Lebrun & Fabbro, 2002).

B. Prevalence of seizures in children across gender in subtypes of communication disorders

The prevalence of epileptic seizures across gender revealed higher percentage of 74.1% among boys and lower percentage of 25.9% among girls. The present study considered prevalence rates of seizures in subtypes of communication disorders. The prevalence of seizures in Rochester, Minnesota was higher for males than females (Hauser et al., 1991). Among the Indian studies, Das and Sanyal (1996) found crude prevalence rate for seizures per thousand population was 3.06 in rural areas of Malda district, West Bengal. The age specific prevalence rate for males aged above 14 years was 3.75 and for 14 years and below was 2.60, corresponding figures for females being 3.53 and 1.94, respectively. Musa, Shon, and Kulkarni (2010) made a prospective and retrospective observational, cross sectional study involving data collection on a specially designed proforma with respect to seizure diagnosis, duration, co-existing medical conditions, precipitating factors if any, along with details of drug treatment. Data from a total of 336 patients with the diagnosis of seizures was collected and recorded over a period of one year of the study. Analysis of the data for gender wise distribution showed a distinct predominance of males (62%) over females (38%). The results of the present study are in consensus with the earlier studies.

The most profound difference between girls and boys is not in any brain structure per se, but rather in the sequence of development of the various brain regions. The different regions of the brain develop in a different sequence in girls compared with boys. This is the key insight from the past five years of neuroscience research in brain development. A most comprehensive study demonstrated that there is no overlap in the trajectories of brain development in girls and boys (Lenroot, Gogtay, & Greenstein, 2007). The study of epidemiology of seizures in communication
disorders is of immense value in understanding the prevalence, causes, gender difference, outcome and its prevention. It is also useful in planning proper services for clients with seizures and improving their quality of life. Since there is only limited data about the prevalence of seizures in children with communication disorders with reference to Indian context, the present study was planned. However, the long term effects of epileptic seizures in children with communication disorders are unknown. Future epidemiological research needs to be addressed on the characteristic features of seizures in children with communication disorders.

Conclusions

The present study was a retrospective analysis to determine the prevalence of epileptic seizures in children with communication disorders. It was noted that epilepsies are one of the most common neurological disorders occurring in children with communication disorders. The prevalence figure varied widely across clinical population. These findings determine the importance of identifying seizures in children. It also suggests measures to control seizures in the subgroup of communication disorders as the presence of seizures is a deterrent to overall development of the child.

References


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Twins are one of the integral members in the society. It is generally accepted that the physical characteristics of the laryngeal mechanisms are genetically determined. Since Lung volume and air flow are the source of voice production, it is wise to investigate the similarity of respiratory parameters (voice source). Slow vital capacity (SVC) and Mean air flow rate (MAFR) was investigated using Spirometer (RMS Helios 501). 17 monozygotic twins (MZ) pairs (11 F and 6 M pairs) with mean age of 22.1 yrs and age and gender matched normal subjects were participated in the study. Pearson within pair correlation should high positive coefficient value. Only SVC showed gender differences for raw scores. No influence of age and gender on respiratory similarity. But, male showed less similarity than female. Discriminant analysis showed separation of twins group from the normal; separation was greater for absolute differences score. In conclusion present study showed similarity in SVC and MAFR of monozygotic twins. It supports the theory of genetic influence on respiratory functions.

Key Words: Vital capacity, Mean airflow rate, Discriminant analysis, Genetic.
Above recent studies shows that researchers were interested in investigating the voice similarity in twins or genetic contribution towards voice. The physiology of voice production is remarkably complex. The production of voice is dependent on three primary factors, (a) pulmonic air pressure, (b) laryngeal vibration, and (c) transfer function of vocal tract, with each of these factors having measurable parameters. It shows that respiratory system or lung volume and the airflow has great importance in voice production and the modulation of voice. Hence before going detailed investigation in to the production and the perception aspect of voice similarity in twins, it is vice to investigate the similarity of voice sources parameters in twins. Also, there is dearth of studies in respiratory functions similarity twins. Few earlier studies suggest that lung volume in terms of alveolar and airway development was majorly influenced by the genetic influences rather than environmental influences on pulmonary function (Hubert, Fabsitz, Feinleib & Gwinn, 1982; Chatterjee & Das, 1995) but some study shows till the adolescence the pulmonary functions were majorly influenced by genetic, but later on it is influenced by the environmental influence (Kawakami, Shida, Yamamoto, Yoshikawa, 1985).

In this context the present study was conducted with interest in investigating lung volume and airflow similarity and influence of age and gender on similarity in monozygotic twins. Secondly, the above studies investigated monozygotic twins without any evidence of genotype similarity; Recent studies have suggested that phenotype some time misleads even in monozygotic twins (St. Clair, St. Clair, Swainson, Bamforth & Machin 1998). DNA fingerprint is a recent genotype analysis, which gives DNA sequence that is different for each individual except the monozygotic twins.

**Method**

Subjects: Fifty one subjects were participated in the study. Subjects were divided in to two groups. Group I consist of 17 monozygotic twins pairs (11 female and 6 male pairs) in the age range of 18 years to 26 years (mean age 22.1 year) 9 pairs were = 21 yrs and 8 pairs were > 21 yrs. Group II consist of equal number (17 subjects) of age and gender matched normal control subjects. Criteria for selecting monozygotic twins include (a) they should be same in gender, (b) Should have approximately similar height and weight. (c) Should have same blood group. (d) DNA fingerprint pattern should be same. Subjects having any unstable voice, voice disorder, speech disorders, neuro-motor disorder, endocrinal disorders and/or hearing disorder will be excluded from the study. A screening tool was used to rule out other disorders and ling (consisting of seven speech sounds) test will be used for hearing screening.

**Procedure:** Initially subjects were contacted over phone and explained about the study, roles and responsibilities of participants. Once they/ their Parents/Guardian gave their oral willingness to participate in the study, they were directly contacted with the purpose of sample collection and their written consent was obtained. The study was cleared by the AIISH ethical committee. Most of the respiratory samples were collected from the house of the participants using potable Spirometer (RMS Helios 501). Subjects were in standing position during the time of measurement and they were tested individually.

**Parameters and procedure:** To access the respiratory system, slow vital capacity and mean air slow rate parameters were taken

Slow vital capacity (SVC-CC): It is the total volume of air that can be exhaled after deep inhalation. Subjects were instructed to take a deep breath and blow out as long and hard as possible into the Spirometer (RMS Helios 501) mouthpiece (Awan, 2001). It was ensured that there was no air escape. Upon completion of the task, the mouth piece was closed to avoid any other environment air flow to happen which may affect the estimation. Subjects repeated the task thrice. The readings on the Spirometer were noted down.

Mean air flow rate (MAFR CC/sec): It is the average volume of air that passes through the vocal folds per unit time and depends on stiffness, sub glottal pressure, and levels of adduction of the vocal folds. Subjects were instructed to sustain vowel /a/ at habitual pitch and comfortable loudness with nasal occlusion after taking a deep inspiration (Baken, & Orlikoff, 2000) in to the mouth piece of the Spirometer (RMS Helios 501). It was ensured that there was no air escape. Upon completion of the task, the mouth piece was closed to avoid any other environment air flow to happen which may affect the estimation.
Subjects repeated the task thrice. The total amount of volume of air expired while sustaining vowel /a/ and the total duration of sustaining the vowel were recorded using Spirometer and stop watch, respectively. Mean air flow rate was calculated by using the formula $\text{MAFR} = \frac{\text{Total amount of volume of air expired (CC)}}{\text{Total duration of vowel sustained (sec)}}$

**Analysis:** In each of the twin pairs (group I) first of the twin was called twin1 (T1). The co-twin was called twin2 (T2). Group II which had age and gender matched normal subjects of each twin pairs was called normal group (N). To understand the extent of the similarity or closeness between twins, and twins and non twins, the absolute differences were calculated between T1 and T2 (T1-T2). Similarly T1-N and T2-N was calculated. Using absolute differences values the influence of age and gender on respiratory similarity was analyzed.

Statistical analysis: To understand the similarity between monozygotic twin Pearson's correlation and the discriminate analysis was used. Discriminant function analysis is used to predict group membership from a set of predictors. The characteristics of predictors are related to form groups based upon similarities of distribution of dimensional space which are then compared to groups. To find significant difference between gender and age group and to know the effect of age and gender on vocal similarity, Mann Whitney U test was used.

**Results**

**Respiratory similarity in MZ twins**

(i) **Mean, SD and correlation**

The results indicated that SVC and MAFR values were similar in T1 and T2. But group II showed higher values than group I. Results of Pearson’s correlation indicated high positive correlation between the respiratory measures of T1 and T2 ($P = 0.01$); low positive correlation on slow vital capacity between group I and group II ($P = 0.05$) and no correlation on MAFR between group I and group II. Tables 1 and 2 show the mean, SD, and correlation in group I and group II.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I (MZ)</th>
<th>Group II (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVC (ltr)</td>
<td>2.25 (0.53)</td>
<td>2.25 (0.53)</td>
</tr>
<tr>
<td>MAFR (CC/sec)</td>
<td>139 (15.2)</td>
<td>137 (20.2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I (MZ)</th>
<th>Group II (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVC (ltr)</td>
<td>0.926**</td>
<td>0.529*</td>
</tr>
<tr>
<td>MAFR (CC/sec)</td>
<td>0.925**</td>
<td>0.097</td>
</tr>
</tbody>
</table>

(ii) **Discriminant function analysis for monozygotic**

The Respiratory data of monozygotic twins and age and gender matched normal subjects of study was subjected to discriminant function analysis. From the analysis two discriminant functions were obtained. The first function (DF1) accounts for 99% of the total variability. The second function (DF2) accounts for the remaining 1% (table 3). For the first function DF1, Wilks Lambda showed significance in the functions of the data that was analysed for separating twins from normals (table 4). DF2 was not found to be statistically significant for the grouping the MZ twins data. Further to interpret the first discriminant function DF1, standardized discriminant function coefficients were considered (Table 5). DF1 was found to be most heavily weighted on respiratory related measures.

<table>
<thead>
<tr>
<th>Function</th>
<th>Eigenvalue</th>
<th>% of Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.214</td>
<td>99.0</td>
</tr>
<tr>
<td>2</td>
<td>0.002</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 4: Wilks’ Lambda value for absolute difference score.

<table>
<thead>
<tr>
<th>Test of Function 1 through</th>
<th>Wilks’ Lambda</th>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.822</td>
<td>9.292</td>
<td>4</td>
<td>0.05</td>
</tr>
</tbody>
</table>

| 2 | 0.998 | 0.098 | 1 | 0.75 |

Table 3: Eigenvalues and variance value for raw score.
Table 5: Function coefficient, Structure Matrix and centroids for groups for raw scores of respiratory measures.

<table>
<thead>
<tr>
<th></th>
<th>Standardized canonical discriminant function coefficient</th>
<th>Structure Matrix</th>
<th>Centroids for groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Function 1</td>
<td>Function 2</td>
<td>Function 1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SVC</td>
<td>1.067</td>
<td>-0.214</td>
<td>0.978*</td>
</tr>
<tr>
<td>MAFR</td>
<td>-0.225</td>
<td>1.065</td>
<td>0.197</td>
</tr>
</tbody>
</table>

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions

Variables ordered by absolute size of correlation within function.

* Largest absolute correlation between each variable and any discriminant function.

**Canonical Discriminant Functions**

Figure 1: Canonical discriminant functions for twin1, twin2 and Normal.

Discriminate analysis showed twins1 and twin 2 is closer than normal subjects. Slow vital capacity (DF1 function) had significant importance than MAFR (DF2) in grouping these subjects. 47% of original grouped subjects correctly classified by Discriminant function using DF1 and DF2.

(III) Discriminant function analysis for Absolute differences value in monozygotic twins

The result indicated that first function (DF1) accounts for 100% of total variability. The second function (DF2) accounts for the remaining 0% (Table 6). DF1 is significant at p<0.001 and DF1 is more important than DF2.

Table 6: Eigenvalues and variance value for raw score.

<table>
<thead>
<tr>
<th>Function</th>
<th>Eigenvalue</th>
<th>% of Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.654</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>0.000</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 7: Wilks’ Lambda value for absolute difference score.

<table>
<thead>
<tr>
<th>Test of Function</th>
<th>Wilks’ Lambda</th>
<th>Chi-square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 through 2</td>
<td>0.604</td>
<td>23.912</td>
<td>4</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>1.000</td>
<td>.008</td>
<td>1</td>
<td>0.927</td>
</tr>
</tbody>
</table>
Table 8: Function coefficient, Structure Matrix and centroids for groups for absolute differences scores of respiratory measures.

<table>
<thead>
<tr>
<th>Function coefficient</th>
<th>Structure Matrix</th>
<th>Centroids for groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discriminant function</td>
<td>Function</td>
<td>Function</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SVC</td>
<td>0.781</td>
<td>-0.693</td>
</tr>
<tr>
<td>MAFR</td>
<td>0.439</td>
<td>0.947</td>
</tr>
</tbody>
</table>

Discriminant analysis showed T1-T2 was well separated from T1-N and T2-N. T1-N and T2-N was closer in comparison with T1-T2. Slow vital capacity (DF1 function) showed had importance than MAFR (DF2). 62% of original grouped subjects correctly classified by Discriminant function using DF1 and DF2.

Effect of Gender and age

(i) Gender differences

SVC showed significant difference between gender in group I and group II. Mean and SD of SVC was lower in females, and males of group I compared to those in group II. Since SVC showed gender difference, the correlation was calculated for male and female separately. Results of Pearson’s correlation indicated high positive correlation between the SVC of T1 and 2 (P = 0.05) and no correlation between T1 and N, and T2 and N. Tables 9 and 10 show the mean, SD, and correlation in group I and group II.

Table 9: Mean, SD and Z values for gender difference of respiratory measures in group I and group II using raw score. (**p<0.005 *p<0.01)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I (MZ) (Male = 6, Female =11)</th>
<th>Group II (Normals)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male T1 Mean (SD)</td>
<td>Female T1 Mean (SD)</td>
</tr>
<tr>
<td>SVC</td>
<td>2.81 (0.52)</td>
<td>1.95 (0.16)</td>
</tr>
<tr>
<td>MAFR</td>
<td>141 (18.6)</td>
<td>138 (15.6)</td>
</tr>
</tbody>
</table>
Table 10: Correlation of respiratory measures between MZ-female twins and normal subjects

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Females (n = 11)</th>
<th>Males (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 vs T2</td>
<td>T1 vs N</td>
<td>T2 vs N</td>
</tr>
<tr>
<td>SVC (litr)</td>
<td>0.638*</td>
<td>-0.117</td>
</tr>
</tbody>
</table>

Result of Mann-Whitney U test significant difference between gender on MAFR for T1-N and T2-N. SVC for T1-N male showed greater absolute differences compared to female. Table 11 shows the Mean, SD and gender difference of respiratory measures using absolute differences value.

Table 11: Mean, SD and Z values for gender difference of respiratory measures using absolute differences value. P<0.05

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
<th>Z - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVC</td>
<td>0.22 (0.12)</td>
<td>0.14 (0.07)</td>
<td>1.514</td>
</tr>
<tr>
<td>MAFR</td>
<td>7.88 (4.74)</td>
<td>5.87 (3.5)</td>
<td>1.106</td>
</tr>
</tbody>
</table>

(ii) Age group differences

No significant difference was observed between age groups in group I for group II for SVC and MAFR. SVC and MAFR were lower in age groups of group I compared to those in group II. Since there was no significant difference, age group correlation was not calculated separately. Tables 12 show the mean, SD and Z value for age group difference between group I and group II.

Table 12: Mean, SD and Z value for age group difference of respiratory measures in subgroup I and group II using raw scores.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I (MZ)</th>
<th>Group II (Normals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 21 y T1</td>
<td>&gt; 21 y T1</td>
<td>= 21 y T2</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>SVC</td>
<td>2.24 (0.48)</td>
<td>2.27 (0.61)</td>
</tr>
<tr>
<td>MAFR</td>
<td>142 (15.37)</td>
<td>137 (17.9)</td>
</tr>
</tbody>
</table>

Both SVC and MAFR did not show significant difference between age groups in all the conditions. T1-T2 condition had lower mean value than other two conditions. Table 13 shows the Mean, SD and Z value for age group difference using absolute differences value.

Table 13: Mean, SD and Z value for age group difference of respiratory measures using absolute differences value using absolute difference scores.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>= 21 y T1-T2</th>
<th>&gt; 21 y T1-T2</th>
<th>= 21 y T1-N</th>
<th>&gt; 21 y T1-N</th>
<th>= 21 y T2-N</th>
<th>&gt; 21 y T2-N</th>
<th>Z - Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVC</td>
<td>0.14 (0.09)</td>
<td>0.19 (0.11)</td>
<td>1.01</td>
<td>0.79 (0.47)</td>
<td>0.68 (0.42)</td>
<td>0.48</td>
<td>0.81 (0.56)</td>
</tr>
<tr>
<td>MAFR</td>
<td>6.25 (4.0)</td>
<td>6.95 (4.1)</td>
<td>0.00</td>
<td>24.6 (15.3)</td>
<td>28.2 (24.1)</td>
<td>0.38</td>
<td>21.6 (14.3)</td>
</tr>
</tbody>
</table>
Discussion

The present study was aimed to investigate the respiratory similarity in monozygotic twins. Also the researchers were interested to know whether age and gender has any effect on the degree of similarity. Result showed that there is significant high positive correlation between MZ twins on SVC, MAFR. It indicates that, a good similarity between twin’s respiratory parameters (table 2). Low positive correlation was noticed between twins and normal on SVC and no correlation was shown between twins and normal on MAFR. This result is inconsonance with study by Wu, Boezen, Postma, Los, Postmus, Snieder and Boomsma (2010) showed good correlation between twin pairs on forced vital capacity and its related measurements. This similarity respiratory similarity can be attributed to the genetic similarity of the monozygotic twins. Chatterjee and Das (1995) investigated the relative contributions of genetic and environmental components in the variability of lung function measurements in 30 MZ and 24 DZ twin pairs. From the Spirometer measurement (like Inspiratory capacity, slow vital capacity, forced vital capacity), within pair variance was significantly lower in MZ than DZ. The result data showed major lung function measurements are possibly influenced more by genetic than environmental factors. Genetically influenced measurements show higher levels of heritability estimates and suggest that genetic determination of lung function is possibly independent of the influence of physical characteristics. Hubert, Fabsitz, Feinleib and Gwinn, (1982) analyzed 127 MZ and 141 DZ twins in the age range of 42 to 56 yr on forced vital capacity and its related measures. Twin analyses showed significant genetic variance (p < 0.001) for Forced Vital Capacity. The findings of this study are also, consistent with theories of genetic influences on alveolar and airway development and argue in favor of early as well as adult environmental influences on pulmonary function. Sataloff (1997) said that the physical characteristics of the laryngeal mechanism, such as vocal fold length and structure, size and shape of the supraglottic vocal tract, and phenotypic similarities elsewhere in the vocal mechanism are genetically determined. This study shows that similarity not restricted to vocal mechanism but even source mechanism for the vocal production.

The discriminate analysis for raw score showed the difference between twins (T1 and T2) was less compare to difference between one twin and normal subject (Figure 1 and table 5). SVC had significant important role in differentiating twin from the normal in comparison with MAFR. But this function was able to classify correctly for nearly 50% of the subjects. Similarly, The discriminate analysis for absolute differences score showed the difference between twins (T1-T2 vs T1-N, T2-N) was less compare to difference between one twin and normal subject (Figure 2 and table 8). This showed good separation compare to the raw score. Even for this functions SVC had important role in differentiating twin from the normal in comparison with MAFR. Also, this function was able to classify correctly for nearly 62% of the subjects. Discriminant analysis shows that from the respiratory parameters nearly two third of twins can be identified correctly.

Gender comparison for raw scores showed significant difference between gender for SVC and no significant difference for MAFR (table 4). This was supported by early literatures saying broad difference between male and females in terms of lung capacities especially vital capacity measurement. Gender comparison for respiratory similarity was analysed using absolute differences score; it showed no significant difference for SVC but, MAFE showed significant different for T1-N and T2-N (table 5). Overall male showed less similarity than females for both the respiratory measures. This can be attributed due to the dynamic range difference in lung volume for male and females. Since male showed greater lung capacity the possibility for variability is more. Second the same lung capacity variation might have effect in the airflow and the pressure between the vocal fold. Age group comparison for raw scores and for absolute difference score did not show any significant differences. But early study by Kawakami, Shida, Yamamoto, Yoshikawa (1985) showed age group differences in respiratory similarity in monozygotic twins. They examined in 20 adolescent MZ twins, 11 adolescent DZ twins, and 20 adult MZ twins. Within pair variability analysis indicate that small airway dynamics are influenced in larger part by genetic factors in adolescence as well as adulthood, whereas lung volumes in terms of forced vital capacity are controlled by genetics only in adolescence.

Conclusion

The present study was design to investigate the respiratory similarity in monozygotic twins using slow vital capacity and mean airflow rate. Result showed that high positive correlation between twins for SVC
and MAFR and poor correlation between twins and normal. SVC showed gender differences for raw scores. The influence of age and gender on respiratory similarity was analysed using absolute differences between twins and normal, which showed there was no effect of age and gender on respiratory similarity, but males showed less similarity in twins as well as for normal comparison, although it was not significant. Discriminant analysis showed separation of twins group from the normal; separation was greater for absolute differences score. In conclusion present study showed a similarity in monozygotic twins of respiratory measurements. It supports the theory of genetic influence on respiratory functions.

References

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SPEECH INTELLIGIBILITY IN (3-4 YEARS OLD) TYPICALLY DEVELOPING CHILDREN

*Sishira S. Bharadwaj, **Sushma S., & ***Sreedevi N.

Abstract

Speech intelligibility is an index of overall speech adequacy. It reflects the child's verbal communication competence and is vital in determining the need for intervention. Intelligibility data for young children with typical as well as disordered phonologies are lacking, even though they are critical for clinical decisions. The present study aimed at tracking the developmental progress in speech intelligibility with increasing age in two tasks: spontaneous speech and sentence imitation. The study included 16 kindergarten (3-4 years) typically developing Kannada speaking children as participants who were divided into four age groups: a) 3-3.3 years b) 3.3-3.6 years c) 3.6-3.9 years d) 3.9-3.12 years. The speech samples were recorded using a digital recorder. These were played to 12 unfamiliar and untrained adults within 35 years of age who served as the judges for the study. Three judges were assigned to each age group and were played the first hundred utterances of the spontaneous speech and sentence imitation samples for verbatim transcription. The verbatim transcription of each subject was evaluated and percent speech intelligibility was obtained using the key developed by the researcher for each subject's utterances per se. Mean, standard deviation and range of percent intelligibility were obtained for each age group and for the two tasks separately. Appropriate statistical analysis was carried out using SPSS package, the results revealed a statistically significant difference across the age groups for spontaneous speech task and not for the sentence imitation task. However, there was no significant difference across the two tasks. The study indicated a linear progress in intelligibility with increasing age especially in spontaneous speech. The findings show that, by 3.3 years, normal children achieve 85% intelligibility and near 100% intelligibility by four years of age itself. This finding has important clinical significance for assessment of intelligibility in children with communication disorders.

Key Words: Spontaneous speech, Sentence imitation, verbatim transcription
another consideration regarding the sequence of phonetic development, but is also a true measure of articulatory proficiency i.e., how the child uses the speech sounds or the phonemes acquired in contextual speech.

The speech sounds of the child may be correctly articulated in isolation and the child may have acquired these in his or her verbal repertoire, but these may not be clear to the listeners in conversational speech. When comparing a child's articulation with the developmental norms of speech sounds, one may find articulation on target, yet the speech of the child may be very difficult to understand, suggesting that factors other than the normal phonetic and phonemic development influence intelligibility. Intelligibility metrics are often affected by articulation and phonological aspects including adventitious sounds on one hand and by a number of other factors such as communicative developmental dysfluencies of the child, inflection, juncture, mean length of utterance, morphology, morphophonemics, physical posture, pitch, pronunciation, speaking rate redundancy, resonance, rhythm, semantics, stress, syntactic level of the child, voice quality, vocal loudness, pragmatics (Bernthal & Bankson 1998; Shriberg & Kwiatkowski, 1982; Weiss, 1982) on the other.

The above mentioned factors influence speech intelligibility perception from the perspective of the child's verbal productions. There are also certain factors which can influence speech intelligibility perception which can be attributed to be emerging from the listener's side. Some of these include sophistication of the listener as well as listener familiarity with the stimuli being used to asses speech intelligibility, the type of stimulus material and the context in which the speaker's verbal productions are presented to the listeners.

Unlike the articulatory development, the development of speech intelligibility is less orderly and less systematic due to the influence of many variables affecting it adversely. Linguistic aspects such as the size of the child's vocabulary, length of the utterance and familiarity of the word can influence intelligibility to a large extent. Larger the vocabulary, the longer the child's utterance and longer and less familiar the word, greater are the chances of having poorer intelligibility.

The construct of speech intelligibility has important clinical applications including assessments and determination of intervention if needed, setting intervention goals and evaluating the effectiveness of intervention (Bernthal & Bankson, 1998). According to parent's reports, normally developing two year old subjects can be understood by a stranger 50 % of the time (Coplan & Gleason, 1988). Vihman and Greenlee, (1987) studied 10 three year old subjects from well educated families and revealed an average of 70 % intelligibility in conversation. Gordon-Brannan (1994) reported a mean intelligibility of 93 % with normally developing 4 year old subjects. Shipley and Mc Afee (1998) reported varied percentages of intelligibility for different age groups which are: 19-24 months: 25-50%; 2-3 years: 50-75; 4-5 years: 75-90 %; 5 years and above: 90-100 %. Chin, Tsai, and Gao (2003) studied 47 normal hearing English speaking children and found that children reached adult like or near adult like intelligibility around the age of 4 years. Baudnoock, Buekers, Gillesbert, and Van Lierde (2009) reported percent speech intelligibility of 90 % in children between 4-5 years having Flemish as their mother tongue. It is generally recognized that a 3 year old child who is unintelligible is a candidate for treatment.

As per the literature reports, there are three general approaches for measuring intelligibility. They are: open set word identification, closed set word identification and rating scale procedures (Gordon-Brannan, 1994). The first two methods yield intelligibility percentages. Open set methods are based on the listener identification through orthographic or phonetic transcription of words spoken by the participant. Closed set methods involve the listener selecting words from a pool of word choices while rating scales involve equal appearing rating scales and direct magnitude rating scales.

Currently most practicing speech-language pathologists make impressionistic estimates of speech intelligibility. These intelligibility estimates which often turn out to be inaccurate can influence the course of intervention for these subjects (Kent, Miolo & Bloedel, 1992). The method that is considered most valid for measuring intelligibility involves calculating the percentage of words understood from a continuous speech sample (Kent et al., 1992; Kwiatkowski & Shriberg, 1992). The procedure involving determining the percentage of words understood is most objective than estimation.

Need for the study: Most of the research on speech intelligibility has focused on individuals with
hearing loss, or neurological impairments or on adults who are alaryngeal speakers (Yorkston & Buekelman, 1981). Intelligibility data for young children with typical phonologies are lacking, especially in the Indian context, even though critical clinical decisions often are dependent on the normal aspects of speech intelligibility. Hence there is a need for studies to emerge regarding the speech intelligibility scores of typically developing children.

Objectives of the study are

· Primarily to obtain speech intelligibility scores from typically developing young Kannada speaking children.

· Secondly, to verify if any significant difference existed in intelligibility percent across spontaneous speech and sentence imitation tasks.

Method

Subjects: Sixteen normal Kannada speaking kindergarten subjects ranging between 3-4 years of age were considered as subjects for the study. The subjects were divided into 4 trimesters according to their chronological ages (3-3.3 years, 3.4-3.6 years, 3.7-3.9 years, and 3.10-3.12 years). Each group included four subjects respectively. These subjects were selected on the criteria that they had Kannada as their mother tongue and had normal speech, language, hearing and cognitive function with no history of any developmental delay.

Tasks: The subjects were required to perform on two verbal tasks: a) Spontaneous speech and b) Sentence imitation.

Stimulus for spontaneous speech: Attractive pictures of zoo and park were used for picture description. The subjects were encouraged to speak more on these topics through prompts provided by the researchers whenever required.

Stimulus for sentence imitation: Five sentences from Kannada story books appropriate for children of 3-4 years age group were selected. The mean length of utterance of the target sentences were 4-5 words (Appendix A). These sentences were presented auditorily to the subjects one at a time and their responses were recorded in a quiet room with a high signal to noise ratio.

Instrumentation: A digital voice recorder (Olympus W-100) with a sampling frequency of 16 KHz was used to record the speech samples. The samples were then digitized for audio recording using audio editing software (Cool Edit Pro version 2.00).

The edited sample contained only the subject’s speech and was completely devoid of the researchers utterances.

Selection of the judges: 12 judges were selected for the purpose of verbatim transcription. They were selected based on the following criteria:

- within the age range of 20 - 35 years
- minimum qualification of Pre University
- Kannada as their mother tongue
- Absence of physical ailments or auditory deviancies
- minimum or limited exposure to children’s speech

Perceptual judgment: Three judges were assigned to each group. Judges were presented first with each child’s spontaneous speech samples followed by sentence imitation samples. In the spontaneous speech sample the first 100 verbal productions of the child were presented. For verbatim transcription of spontaneous speech, the samples were played as many times as needed and on a basis of three words at a stretch so that the judges had the opportunity to transcribe the perceived words immediately. Later the percentage of intelligibility for each child was calculated by comparing the verbatim transcription of the judges with a key which the researcher had developed for each child separately depending upon the child’s actual utterances.

Statistical analysis: Appropriate statistical analysis was carried out using the SPSS (Ver 16) package.

Results and Discussion

The main aim of the study was to track the developmental progress in speech intelligibility in typically developing Kannada speaking toddlers. Various statistical tools were utilized in arriving at the results. The Reliability coefficient alpha test was used to determine the inter judge reliability for each age group. It ranged from 75% to 90% indicating fair interjudge reliability.

Using descriptive statistics mean standard deviation and ranges of intelligibility scores were obtained for each of the four age groups and for the two tasks separately (Table 1). As is evident from Table 1, there is an increment in percent intelligibility in both the speech tasks with increase in age with the youngest age group having 86% and 85% in spontaneous speech and sentence imitation tasks respectively.

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The oldest group scored 96% intelligibility in spontaneous speech task and 94% intelligibility in sentence imitation task. This observation is much in accordance with the results of the previous Western studies which have reported a linear development in intelligibility with increasing age (Bowen, 2002; Shipley & Mc Afee, 1998; Gordon-Brannan, 1994; Baudnock et al; 2009). This is because, as children develop in their phoneme acquisition, they become more intelligible. Recent study by Pratima (2009) indicated that all the phonemes in Kannada are mastered by 3.5 years except phonemes /r/ and /h/ in the initial position. Another interesting fact was that the children were 85% and above intelligible within 3.3 years itself and nearing 100% by 4 years whereas some of the previous authors have reported only 75% intelligibility by 4 years. Graph 1 indicates the linear increase in intelligibility with increase in age.

In this study two comparisons were made:
- Speech intelligibility across the four age groups using the statistical measures Kruskal Wallis and Mann Whitney tests for the two tasks
- Speech intelligibility across the two tasks for each age group using Wilcoxon signed ranks test.

### Table 1: Mean, Standard deviation and Range of percent intelligibility for the two tasks.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Spontaneous speech</th>
<th>Sentence imitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean%</td>
<td>SD</td>
</tr>
<tr>
<td>3.0 - 3.3</td>
<td>86.00</td>
<td>5.60</td>
</tr>
<tr>
<td>3.4 - 3.6</td>
<td>88.00</td>
<td>2.12</td>
</tr>
<tr>
<td>3.7 - 3.9</td>
<td>91.91</td>
<td>1.34</td>
</tr>
<tr>
<td>3.10 - 3.12</td>
<td>96.41</td>
<td>2.21</td>
</tr>
</tbody>
</table>

Graph 1: Mean % of intelligibility in different age groups across tasks.
Age wise comparison

The Kruskal-Wallis test revealed that there was an overall significant difference across the age groups in the spontaneous speech task at .05 level of significance (p=.013). Therefore Mann Whitney test was run to detect the presence of significant difference across the age groups. The results revealed that there was a significant difference in intelligibility across some of the groups which are shown in Table 2.

Table 2: Shows significant difference for across age group comparison for spontaneous speech task. +/-: Significant Difference present/absent

<table>
<thead>
<tr>
<th>Across age group (years) comparison</th>
<th>‘p’ value</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-3.3 vs 3.4 - 3.6</td>
<td>.386</td>
<td>-</td>
</tr>
<tr>
<td>3-3.3 vs 3.7 - 3.9</td>
<td>.191</td>
<td>-</td>
</tr>
<tr>
<td>3-3.3 vs 3.10 - 3.12</td>
<td>.021</td>
<td>+</td>
</tr>
<tr>
<td>3.3-3.6 vs 3.7 - 3.9</td>
<td>.043</td>
<td>+</td>
</tr>
<tr>
<td>3.3-3.6 vs 3.10-3.12</td>
<td>.021</td>
<td>+</td>
</tr>
<tr>
<td>3.7-3.9 vs 3.10-3.12</td>
<td>.021</td>
<td>+</td>
</tr>
</tbody>
</table>

However, as Kruskal-Wallis test did not reveal any significant difference across age for sentence imitation task, Mann-Whitney test was not performed for this task. This lack of significance could be possibly because the subjects received a model from the researcher in the imitation task, which provided visual and auditory cues thereby aiding in their correct production irrespective of their age.

Task-wise comparison

The Wilcoxon Signed Ranks test was run to compare the percent intelligibility difference across the two tasks in each age group. The results revealed that there was no significant difference in the percent intelligibility across the two tasks. The most acceptable explanation for this finding is that despite receiving a model while imitating the target sentences, there could be certain words which are totally new to the child or even when present in the expressive vocabulary, they are sparingly used. This is supported from the earlier reports that familiarity with the words is also a major factor influencing speech intelligibility (Baudnock et al; 2009). However, it is suggested that the validity of this finding be explored further with more number of subjects.

Conclusions

The present investigation was an attempt to track the developmental progress in speech intelligibility in Kannada speaking toddlers. The study revealed that there is a significant linear progress in intelligibility with age in spontaneous speech task but not in sentence imitation task. The results indicate that by the age of 3.3 years itself, typically developing children attain 85 % intelligibility, and by four years of age near 100 % intelligibility is present even to strangers. This finding has important clinical implications for speech language pathologists in their diagnostic as well as therapeutic procedures.

References


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Appendix:
Target sentences for the task of sentence imitation.

1. /nange ais krim jumba: i\n
2. /nam manje ne\n3. /bekku bista\n4. /ra\n5. /ame molakke sparde/
A COMPARISON OF ACOUSTIC CHARACTERISTICS OF SPEECH IN YOUNG COCHLEAR IMPLANT AND BTE USERS WITH NORMAL HEARING AGE MATCHED INDIVIDUALS

*Anusha Saju, *Varsha Jevoor & ** Sreedevi N.

Abstract

A major consequence of hearing impairment in children appears to be a reduced repertoire of sound segments mainly consonants which results in place, manner and voicing errors leading to poor communication. With advancement in technology (cochlear implants and programmable digital behind the ear devices), significant progress have been made by children with profound hearing impairment. Cochlear implant (CI) aims to improve the speech perception and production abilities in individuals who receive limited gain from the conventional amplification devices. The primary aim of the present study was to compare selected acoustic speech parameters (lead and lag Voice Onset Time, word and vowel duration and second formant frequency) of children with hearing impairment using cochlear implants, Behind The Ear (BTE) hearing aids with those of age matched normal hearing peers. Results indicated that, the mean lead Voice Onset Time (VOT) in CI and BTE users was longer compared to normal hearing individuals, though not statistically significant. Results of lag VOT indicate that mean values for the CI and BTE groups were shorter than normal hearing individuals. Measures of F2 revealed that CI group had higher F2 where as the BTE users had lower F2 values compared to normal hearing individuals. Among the duration measures only vowel duration was significantly different between normal hearing individuals and CI. Though several studies report that acoustic measures of the speech of cochlear implantees approximate normal values, similar findings were not obtained in the present study, probably because the cochlear implantees in this study were implanted only six months prior to data collection.

Key Words: Voice Onset Time (VOT), word and vowel duration, fundamental frequency (F2)

A major consequence of hearing impairment in children appears to be a reduced repertoire of sound segments mainly consonants leading to poor communication. The speech of children with profound deafness is characterised by numerous segmental errors, including vowel neutralisation, omission of word-final consonants, confusion of voiced voiceless cognates and errors of manner and place of articulation (Levitt & Stromberg, 1983 and Smith, 1975). Speech of children with deafness has been studied for many years (Tobey, Geers & Brenner, 1994) and continues to be studied. These reports have examined aspects such as, errors in their speech production; differences in their speech as a function of hearing loss and /or perceptual abilities; differences in their speech as a function of hearing device used and; deviations in their speech acoustics.

Voicing, place and manner of articulation errors are common in individuals with hearing impairment. Perceptually consonant errors include substitution and omission and vowels include substitutions, neutralisation and diphthongization. Acoustically, voicing errors (Calvert, 1961); reduced VOT (Gilbert & Cambell, 1978); prolongations of vowels (Calvert, 1961; Shukla, 1987); and abnormal formants (Angelocci, Kopp & Holbrook, 1964; Vasantha, 1995; Nataraja, Sreedevi & Sangeetha 1998) have been reported.

Children who make proficient use of hearing aids develop a predominantly auditory/vocal style and go on to acquire good understanding and use of spoken
language (Tait & Lutman, 1994). Speech language pathologists are trying their best to increase the verbal productions of the child with hearing impairment who have been rehabilitated with either digital hearing aids or more recently cochlear implants. Cochlear implants have made a tremendous influence in the last decade not only on individuals with profound deafness but on the entire health care profession. Many factors have contributed to the rapid growth and success of cochlear implants. The most significant factor is the benefit received by the hearing impaired individual. They have obtained high levels of word recognition without lip reading (Dorman, Hannley, Dankowski, Smith & Mc Candless, 1989). Children who receive cochlear implant by 5 years of age are presented with auditory information at the crucial time for speech and language development. Children vary in the amount of speech information they obtain from a cochlear implant. Duration of deafness and age of implantation might be expected to have an influence (Fryauf-Bertschy, Tyler, Kessay, Gantz & Woodworth, 1997).

Children using cochlear implants, who have good speech perception skills, may be the ones who are able to use auditory feedback effectively to assist in the development of their speech production skills. Multichannel cochlear implants are the products of recent technology in the field of assistive listening devices. The primary aim is to improve speech perception abilities in children who have limited gain from the conventional amplification method. It promotes the speech production skills in mainly prelingually impaired individuals and improves their capacity to produce vowels, consonants and suprasegmental aspects of spoken language.

A clinically significant increase in the size and diversity of imitative and spontaneous phonetic repertoires after one to two years of CI use has been reported (Osberger, Robbins, Berry, Todd, Hesketh & Sedey, 1991; Tobey & Hasenstab, 1991). Others have reported improved production of vowels (Ertmer, Kirk, Todd & Riley, 1997) and consonant features (Kirk & Osberger, 1995) after 24 to 36 months of implant experience. Tait and Lutman (1997) say that the benefits of implantation appeared to be showing one year after implantation in the prelinguistic measures.

Dawson et al. (1995) and Sehgal, Kirk, Svirsky, Ertmer and Osberger (1998) indicated that children who use cochlear implants produced labial consonants correctly more often than consonants with other places of articulation. Affricates were produced correctly less often than consonants with any other manners of articulation. Osberger et al. (1991) found that children who had used cochlear implants for one year produced bilabial stops and nasals /m/ often followed by velars and alveolar stops, then fricatives, liquids and lastly glides.

As the acoustic features in the speech of the hearing impaired are characterized by several segmental and suprasegmentals errors, speech and language clinicians increasingly have been confronted with children who exhibit hearing impairment and are not clear about the parameters that should be manipulated in order to improve their speech intelligibility. Literature is abundant with studies on the acoustic characteristics of speech of analog hearing aid users, whereas such studies on subjects using cochlear implants and digital BTE hearing aids is relatively sparse at least in the Indian context. Therefore the present study is planned to compare a few acoustic parameters of speech across CI users, digital BTE users and age matched normal hearing individuals.

Method

Subjects: Subjects considered were divided into three groups: cochlear implant users, BTE users and normal-hearing age-matched children. Each of the above three groups consisted of three participants, (total number of subjects were 4 males and 5 females) and all of them were in the age range of 4 to 4.5 years with Kannada as their native language. Inclusion criteria for normal hearing age mates were normal speech, language, hearing, cognitive, neurological and physiological development, and that for the hearing impaired group was that they have congenital hearing loss and normal developmental domains except for speech and language. The language age of these children were also matched using a screening tool, Receptive Expressive Emergent Language Scale (REELS) and their language age was of 42 to 48 months for both reception and expression. The children wearing BTE were rehabilitate for two years on an average and those using CI (Freedom Nucleus with ACE coding strategy) had been implanted six months ago with two of the children having used digital BTE amplification device (Electone
Eclipse 2SP) in both the ears for a period of two years prior to implant. Their aided performance was 10 – 15 dB below the speech spectrum. Only one child had not been using conventional amplification device prior to implantation. All the rehabilitated children with hearing impairment were attending listening training for a duration of 45 minutes thrice a week.

**Speech stimulus:** Three meaningful simple bisyllabic Kannada words were considered incorporating the phonemes /k/ and /g/ and vowels /a/ /i/ and /u/. All the children were able to produce the selected phonemes at word level. The target words were /kanna/ (eyes), /kuri/ (sheep) and /gili/ (bird). The parameters measured from the waveform display are:

1. **VOT** (for the plosives /k/ and /g/ in the initial position of words ( /gili/ and /kuri/) (VOT is defined as the time difference between the articulatory release and the onset of vocal fold vibration (Lisker & Abramson, 1964)

2. **Word duration** (measured as time difference between the onset and offset of the target word) for all the three words.

3. **Vowel duration** (measured as time difference between the onset and offset of target vowel in a word) of /a/, /i/, and /u/ in the above three words respectively.

4. **The single spectral parameter considered is the second Formant Frequency (F2) of vowels /a/, /i/ and /u/. F2 was measured at the centre of the steady portion of the target vowel.**

**Procedure:** The speech sample was recorded in quiet room for one subject at a time. Recording was done using COOL EDIT PRO VERSION 2. The speech utterances were digitized at a sampling rate of 44100 Hz with 16 bit resolution. The subjects uttered the target words into a microphone (Smart-Stereo headphones SH-03). For all the three groups speech was elicited with the help of colourful, average sized flashcards or by imitation. Three productions of each word were obtained and the best production was for further acoustical analysis which was carried out using speech analysis software PRAAT (Ver.5114).

**Statistical Analysis:** A non parametric test, Kruskal Wallis was applied to compare the parameters across the cochlear implantees, BTE users and normal hearing age peers. All statistical analysis was carried out using “SPSS” (Ver. 16).

**Results and Discussion**

Descriptive statistics consisting of mean, standard deviations, minimum and maximum values were obtained for all the parameters as depicted in Table 1. The statistical analysis revealed some salient features of interest (Table 2). The results of lead VOT indicated that the mean values for the cochlear implantees and BTE users were longer as compared to normal hearing subjects as shown in Graph 1. This finding can be explained on the basis that there is an increase in VOT values as the place of articulation moved back in the oral cavity as also explained by Lisker and Abramson (1964) and Gilbert and Cambell (1978). Similar finding was reported by Ravishankar (1981) in Kannada citing the same reason. It is highly probable that for producing a velar sound the children with hearing impairment would have possibly made a much more posterior place of articulation because of the exaggerated visual demonstrations to them during training. The standard deviation was the highest in the BTE group followed by CI and then normal hearing individuals as shown in Table 1.

The results of lag VOT indicate that there was no significant difference between the mean values of all three groups with the mean value for the hearing impaired group (CI and BTE) being shorter than normal hearing individuals as seen in Graph 1. The reduced positive VOT value in the speech of the hearing impaired may be attributed to the reduced oral breath pressure in them (Gilbert, 1978; Hutchinson & Smith, 1976). Standard deviation for the normal hearing individuals was comparatively higher as compared to the hearing impaired group as depicted in Table 1.
Table 1: Mean and Standard deviations for lead and lag VOT, F2, word and vowel duration for the three groups.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Normal Mean(SD)</th>
<th>CI Mean (SD)</th>
<th>BTE Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOT (in ms)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead VOT for /g/</td>
<td>91.33 (16.86)</td>
<td>103 (21.37)</td>
<td>135 (56.82)</td>
</tr>
<tr>
<td>Lag VOT for /k/</td>
<td>56 (41.67)</td>
<td>25 (13.11)</td>
<td>34.67 (20.03)</td>
</tr>
<tr>
<td>Word and vowel duration (in ms)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/kannu/ (W1)</td>
<td>460.66 (166.4)</td>
<td>765.33 (193.14)</td>
<td>755.67 (70.5)</td>
</tr>
<tr>
<td>/gili/ (W2)</td>
<td>431.67 (52.93)</td>
<td>695.33 (113.07)</td>
<td>655 (77.17)</td>
</tr>
<tr>
<td>/kuri/ (W3)</td>
<td>389.66 (72.05)</td>
<td>677.66 (231.53)</td>
<td>642 (76.54)</td>
</tr>
<tr>
<td>/a/ (V1)</td>
<td>99.33 (26.72)</td>
<td>290 (105.35)</td>
<td>94 (29.46)</td>
</tr>
<tr>
<td>/i/ (V2)</td>
<td>82 (19.46)</td>
<td>328 (60.1)</td>
<td>170 (69.29)</td>
</tr>
<tr>
<td>/u/ (V3)</td>
<td>82 (7.81)</td>
<td>263.33 (221.32)</td>
<td>127.33 (17.9)</td>
</tr>
<tr>
<td>Spectral parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formant frequency (F2) in Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/a/</td>
<td>1955 (296.5)</td>
<td>2032 (369.26)</td>
<td>1498 (184.27)</td>
</tr>
<tr>
<td>/i/</td>
<td>2684 (124.5)</td>
<td>3343 (453.24)</td>
<td>2632 (319.67)</td>
</tr>
<tr>
<td>/u/</td>
<td>1568 (123.92)</td>
<td>1791 (420.29)</td>
<td>1091 (365.44)</td>
</tr>
</tbody>
</table>

Table 2: Results of Kruskal Wallis Test

* : significant at 0.05 level

The present study indicates that both CI and BTE groups had word duration almost twice that of the normal group as shown in Graph 2.

Graph 1: Mean lag and lead VOT values for the three groups.

Graph 2: Mean word duration values for the three target words.

Many earlier studies have reported similar results in the hearing aid users (Shukla, 1986 & Vasantha, 1995; Calvert, 1961; Monsen, 1974 and Osberger & Levitt, 1979). Monsen (1974) states that deaf subjects production of vowels were longer by one and a half times when compared to normal hearing individuals.
The standard deviation for word duration was maximum for the CI group followed by normal hearing individuals and lastly BTE group as seen in Table 1. A puzzling finding was that the CI group had longer vowel duration as compared to BTE users and normal hearing individuals.

Graph 3: Mean vowel duration in the three groups

Vowel duration is found to be longer in the CI and BTE group and one possible reason for the prolongation of vowels and consonants is that they heavily depend on vision and vision simply does not operate in as rapid a time frame as audition. Another possibility is that auditory feedback is necessary for rapid smooth production of complex motoric sequences of speech and hearing impairment limits the required information too severely. It could also be reasoned out that vowels are much easier to produce as compared to the consonants and hence the hearing impaired group compensate for the inability of producing a consonant by prolonging the vowel. One more probable reason is that training given to the hearing impaired group is exaggerated to obtain a better production from the client which in turn leads to a prolongation of vowels in them.

Several studies (Uchanski & Geers, 2003; Dawson et.al, 1995) have reported that the acoustic measures of the speech of the CI users are expected to approach normal values compared to the BTE users. However in the present study, the CI values did not vary significantly with those of the BTE users. It can be supported by the fact that the cochlear implantees taken up for this study have been implanted for duration of 6 months only at the time of data collection.

With respect to vowel duration, the results illustrate a significant difference between normal hearing individuals and the CI group at 0.05 level of significance using Mann Whitney test. Vowel duration of the CI group is thrice that of the normal hearing individuals and that of the BTE group is twice that of normal hearing individuals.

The second formant frequency (F2) pattern of vowels is an important acoustic correlate of the vowels phonetic quality and its phonemic identity. It was observed that the CI group had higher F2 for the vowels /a/, /i/, /u/ as compared to normal hearing age matched individuals, whereas the BTE users had lower values than the normal hearing individuals for these vowels as depicted in Graph 2. The finding is in consonance with the study done by Angelocci et.al, 1964; Monsen, 1976 who report that deaf talkers formant frequencies often deviate from those of normal hearing talkers. It has also been supported by Monsen (1976) who reported that in the speech of the hearing impaired subjects (using BTE) the second formant transitions may be reduced both in time and frequency. BTE users probably had lower F2 formant values because of the neutralisation of the vowel and also tongue raising is insufficient in contrast to what is required for the accurate production of /i/ and the hearing impaired children usually produce vowel /i/ with an open jaw which lowers F2. The front back position of the tongue is primarily responsible for the second formant, which is not easily visible and hearing impaired individuals have difficulty in maintaining proper position of the tongue (Monsen, 1976) during vowel production.

Graph 4: Mean F2 values for the vowels /a/, /i/ and / u/.

A salient observation was that F2 for /i/ is relatively higher for the cochlear implant user
compared to the BTE users. Except for the formant frequency for the vowel /i/, the values of the CI users are approximating that of the normal hearing individuals as opposed to the BTE users. The F2 of the CI group is approaching the normal values probably because the former have a better speech perception in the F2 region which can be one of the important advantages of CI implantation.

Also one of the CI subject was directly implanted without any prior amplification. The present finding is also in consonance with the report of Tait and Lutman (1997) which states that the benefits of implantation appears only one year after implantation in the pre-linguistic measures.

Conclusions
Describing the speech of the individuals with hearing impairment acoustically not only has the advantage of an objective measurement but it also sheds light on the probable reasons for the poor intelligibility in them, which in turn may help in developing effective therapeutic procedures. The present study made an attempt to compare a few acoustic parameters across cochlear implanteees, BTE users and normal hearing subjects. The findings revealed that there was significant difference only for vowel duration across CIs and normal hearing subjects where as no evident difference was seen in lead and lag VOT, second formant frequency and word duration across the three groups. This is probably because the cochlear implantees in this study were implanted only six months prior to data collection. In view of the small group studied, findings need to be ascertained by expanding the study on a larger number of cochlear implantees and BTE users.

References


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We thank the Almighty, for the successful completion of our first research paper. The authors also wish to sincerely thank Dr. Vijayalakshmi Basavaraj, Director, AIISH, Mysore, for permitting us to carry out the study. We would also like to acknowledge Mrs. Vasanthalakshmi, Lecturer in Biostatistics, AIISH, Mysore for the statistical analysis and representations.
ACOUSTIC ASPECTS OF SENTENCE STRESS IN CHILDREN WITH COCHLEAR IMPLANT

*Gouri Shanker Patil, **Yamini Sindhura G., & ***Madhusudarshan Reddy B.

Abstract

The study intended to examine the acoustic features of stress F0, duration, and intensity in children using cochlear implants and compare these features with those in normal hearing children. Seven children with congenital profound hearing impairment fitted with multichannel cochlear implants and equal number of normal hearing children participated in the study. The participants narrated a picture depicting a ‘living room’ for about 2-3 minutes. The utterances were classified into separate intonation units and primary stressed syllable identified in each intonation unit. The stressed syllables were acoustically analyzed to measure duration, F0, and intensity using Praat software. The statistical analysis was carried out using SPSS version 12.0. The mean duration of primary stressed syllable in children with cochlear implant was 0.32 s (SD = 0.11) and in normal hearing children it was 0.19 s (SD = 0.08). The mean F0 in children with cochlear implant was 339.89 Hz (SD = 56.14) whereas in normal hearing children it was 306.37 Hz (SD = 51.21). The mean intensity was 80.83 dB (SD = 5.49) in children with cochlear implant and 83.51 dB (SD = 5.17) in normal hearing children. The independent samples t-test revealed significant difference between the two groups of participants for all acoustic measures. The results of the current study seem to suggest that children with cochlear implant distinctly produced sentence stress but the acoustic correlates of stress are significantly different from those produced by individuals with normal hearing. Hence, the results emphasize the need to consider inclusion of suprasegmental aspects in the speech-language rehabilitation of children with cochlear implant.

Key Words: - F0, duration, intensity, hearing impairment

The sentence stress refers to the prominence given to any particular syllable in a sentence. The prominence is brought about by increased duration, F0, and intensity compared to other syllables in a sentence (Cruttenden, 1997). Inappropriate stress patterns have been described as "typical" of individuals with hearing impairment (Hargrove, 1997). Ando and Canter (1969) reported that individuals with hearing impairment produced only stressed syllables. They did not distinguish between stressed and unstressed syllables (Osberger & Levitt, 1979). Similarly, Nickerson (1975) reported that individuals with hearing impairment tend to vary pitch less often resulting in excessive stress on all syllables or a flat monotone stress pattern throughout the utterance. Many investigators reported consistent errors in acoustic measures of stress in children with hearing loss. McGarr and Harris (1983) demonstrated variable use of F0, amplitude, or duration to signal stress contrasts with no stereotypic acoustic pattern in a client with hearing loss. These individuals used excessively high pitches (Angelocci, Kopp & Holbrook, 1994; Martony, 1968), abnormal temporal patterns such as smaller proportional shortening of unstressed syllables with respect to stressed syllables (Stevens, Nickerson & Rollins, 1978; Osberger & Levitt, 1979) i.e., deaf children uttered stressed and unstressed syllables with less of a difference in duration than children with normal hearing. Tye-Murray (1987) observed speakers with hearing impairment intentionally lengthened stressed vowels relative to unstressed vowels, but the intended stress
patterns were not always correctly perceived by listeners.

It is of interest to consider whether deaf speakers problems in producing stress patterns are due to impaired motor control of speech or to linguistic factors. To answer this question, Tye-Murray and Folkins (1990) asked deaf and hearing participants to speak sets of homogenous syllable strings which they could tap out with a finger, and hence could understand. Strain gauges monitoring lower lip and jaw movements revealed that deaf and hearing participants produced different durations and displacements for stressed and unstressed syllables. There was no evidence that motor abilities affected the production of stress patterns in the deaf speakers. Thus, when the deaf participants understood a given stress pattern they could speak it, even when they did not articulate the correctly. This outcome showed that the deaf participants were not aware of phonemic distinctiveness via stress.

Measurements of speech fundamental frequency (F0) in hearing impaired people, however, have presented mixed and conflicting results. Horii (1982) reported higher than normal F0 values for 12 speakers with hearing impairment aged 16-19 years. Leder, Spitzer and Kirchner (1987) found recently that F0 was significantly higher in individuals with profound post lingual hearing impairment than in hearing persons. Children with severe to profound prelingual hearing loss reportedly exhibit particular problem in learning to coordinate control of their breath in producing speech. Without experience to guide them they may attempt to speak on inspiration as well as expiration, using ingressive as well as egressive airstreams. They tend to produce short bursts of speech and then run out of breath because they do not take sufficient breath before beginning to speak. Their spoken sentences are thus broken up by pauses, which interfere with the speech flow (Leder et al. 1987). The pauses make their speech stressful to listen to and understanding of their message difficult (Hudgins & Numbers, 1942; Calvert & Silverman, 1975; Forner & Hixon, 1977). These problems of coordinating breathing and phonation compound their errors in the articulation of vowels and consonants and difficulties with suprasegmental features.

Data on speech production of individuals using cochlear implant suggests that suprasegmental and segmental properties of speech are influenced by the auditory feedback provided by the implants. Qualitative and quantitative changes in speech production skills are evident in a large number of deaf children using cochlear implants (Te, Hamilton, Rizer, Schatz, Arkis & Rose, 1996). Although suprasegmental performance tends to be higher following implantation, it appears to plateau after implantation and no further improvement is observed in individuals with post lingual deafness (Tobey et al., 1991).

It has been reported that cochlear implant users show improvement in voice quality, intonation pattern, volume control, and intelligibility. Iler-Kirk and Edgerton (1983) examined voice parameters in 4 cochlear implant users - 2 male and 2 female. They found that in the implant-on condition, the fundamental frequency of 2 male participants decreased and the variability in intensity also decreased. The 2 female participants also showed improvement but, in their case, fundamental frequency and variability in intensity increased in the direction of normal. Leder, Spitzer and Kirchner (1987) also found that fundamental frequency decreased in male cochlear implant users and that this change was noticed almost immediately. The use of contrastive stress patterns has also been examined. It has been observed that cochlear implant users show an improvement in the use of contrastive stress patterns (Waters, 1986). Leder, Spitzer, Milner, Flevaris-Phillips, Richardson and Kirchner (1986) reported decreased variability in acoustic measures of stress post-implantation compared to non-stereotypical acoustic pattern prior to implant in an adventitiously deaf individual. The more recent study by Lenden and Flipsen (2007) examined longitudinally the prosody and voice characteristics of 40 conversational speech samples obtained from 6 young children with prelingual severe to profound deafness who had been fitted with multichannel cochlear implant devices. The samples were obtained at 3-month intervals over 12-21 month periods and analyzed using the Prosody Voice Screening Profile (Shriberg, Kwiatkowski & Rasmussen, 1990). The most problematic aspects of prosody and voice for these children appeared to be the use of stress (lexical, phrasal, and/or emphatic). However, children with cochlear implant demonstrated significant improvements in the use of stress over a period of time.

The previous research relating to prosodic aspect of stress in individuals with cochlear implants primarily
focused on the qualitative aspects of stress. The acoustic correlates of stress in children with cochlear implant were little addressed. Thus the current study examined the acoustic parameters of F0, duration, and intensity in the spontaneous monologue speech samples obtained from 7 young children with prelingual profound deafness who were fitted with multichannel cochlear implant devices and compare these features with those in normal hearing children.

Method

Participants

Seven right handed congenital and profoundly hearing impaired children fitted with multichannel cochlear implants participated in the study. The demographic and clinical details of the participants are given in Table 1. The participants included 3 male and 4 female children. The age range of the participants varied from 6.4-8.4 years with the mean age of 7.5 years. All the participants were native Telugu speakers who could speak in simple sentences. All children with cochlear implant were fitted with multichannel Nucleus 24 with ACE signal processing strategy and were attending speech therapy based on the Auditory Verbal Therapy (AVT) framework for about 6 months to 3 years post-implantation at the same speech rehabilitation centre. Although the therapy duration was variable, all children could speak in at least simple sentences. The language skills of the participants at the time of recording the speech sample were measured using Receptive and Expressive Emergent Language Skills (Bzoch & League, 1971) test. Prior to implantation they had attended speech therapy based on multisensory approach for about 1-2 years. They were fitted with analog behind-the-ear hearing aid before implantation. None of the participants had any associated problems.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Implantation age (years)</th>
<th>Language age (months)</th>
<th>Implant type</th>
<th>Processing strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI1</td>
<td>F</td>
<td>6.1</td>
<td>5.0</td>
<td>33-36</td>
<td>35-33</td>
<td>Nucleus 24</td>
</tr>
<tr>
<td>CI2</td>
<td>F</td>
<td>6.4</td>
<td>5.5</td>
<td>33-36</td>
<td>27-30</td>
<td>Nucleus 24</td>
</tr>
<tr>
<td>CI3</td>
<td>F</td>
<td>7.2</td>
<td>6.0</td>
<td>27-30</td>
<td>27-30</td>
<td>Nucleus 24</td>
</tr>
<tr>
<td>CI4</td>
<td>F</td>
<td>7.2</td>
<td>6.0</td>
<td>27-30</td>
<td>27-30</td>
<td>Nucleus 24</td>
</tr>
<tr>
<td>CI5</td>
<td>M</td>
<td>5.6</td>
<td>7.0</td>
<td>27-30</td>
<td>27-30</td>
<td>Nucleus 24</td>
</tr>
<tr>
<td>CI6</td>
<td>M</td>
<td>5.5</td>
<td>5.0</td>
<td>27-30</td>
<td>24-27</td>
<td>Nucleus 24</td>
</tr>
<tr>
<td>CI7</td>
<td>M</td>
<td>5.4</td>
<td>5.5</td>
<td>27-30</td>
<td>24-27</td>
<td>Nucleus 24</td>
</tr>
</tbody>
</table>

In order to draw comparison with the speech of non-hearing impaired individuals, 7 age and gender matched normal hearing children were recruited for the study. The participants did not present any previous history of speech, language or hearing deficits as ascertained by the information provided by their parents or guardians. All the participants were native speakers of Telugu.

Stimulus

The stimulus constituted a single comprehensive picture card that depicted a 'Living Room' of general Indian household. Some of the events that constituted the picture card were a woman playing with her daughter, a man on a sofa reading a newspaper, a baby playing with toys on the floor, a television set in a corner of a room, a painting hung on a wall, a cat under the table, among others. Initially, a pilot study was carried out to confirm:

(a) that expressive speech of minimum 3 minutes could be elicited from the participants.
(b) the possible occurrence of different grammatical classes in Telugu.

Five normal hearing participants aged 6-8 years narrated the events related to the selected picture stimuli. Analysis of the discourse content revealed that the participants described the picture for about 2-3 minutes and there was sufficient scope for use of various grammatical classes such as nouns, verbs, adjectives, pronouns, postpositions, and conjunctions. There was also scope for repeated use of some of the grammatical categories. More importantly, the chosen stimulus facilitated generation of a significant number of sentences thus enabling collection of a large corpus of speech sample.

Procedure

Recording procedure

Prior to recording of speech sample, informed consent in writing for participation in the study was obtained from the parents/guardians of all participants. Prior to the actual recording of speech sample of participants, the principal investigator demonstrated narration of picture using another stimulus to each participant. All the participants were given sufficient time to formulate the utterances and get familiarized about the picture to be narrated. The picture was placed in front of participants and they were instructed to observe and verbally describe as many events, things, activities etc. about the picture. The speech sample was recorded in a single trial in a quiet environment. The duration of recording ranged
between 2-3 minutes across participants. The participants' utterances were recorded using Transcend digital voice recorder with a uni-directional microphone placed at a distance of about 10 cm from the mouth.

**Analysis**

**Perceptual analysis**

The basis for perceptual analysis was to identify the intonation units and to determine the primary stressed syllable in each of these intonation units. The perceptual identification of intonation units and primary stressed syllables was necessitated because they were fundamental to acoustic analysis of features of stress. The recorded utterances were transcribed by the principal investigator using The International Phonetic Alphabet (revised to 1993, updated 1996). This is done identify the speech sounds in each utterance. The utterances were classified into separate intonation units by the principal investigator. An intonation unit (IU) was operationally defined as 'a sequence of words combined under a single, coherent intonation contour' (Chafe, 1987). The perceptual criteria adopted for demarcating intonation units were: presence of at least one stressed syllable, significant pause between intonation units, phrase final lengthening, anacrusis, and pitch reset (Cruttenden, 1997). Another judge who was a qualified speech-language pathologist with experience in analysis of prosody also identified the intonation units independently. The item-by-item inter-judge reliability coefficient 'Alpha' for identification of intonation units was found to be 0.9404. The judgment task was repeated after 2 weeks time by the principal investigator and other judge to establish intra-judge reliability. The item-by-item intra-judge reliability coefficient 'Alpha' for the principal investigator was found to be 0.9804 and for another judge it was 0.9702. Later, 3 speech-language pathologists independently identified the primary stressed syllable in each intonation unit. The item-by-item inter-judge reliability coefficient 'Alpha' was found to be 0.9904. The judgment task was repeated after one week to establish intra-judge reliability. The item-by-item intra-judge reliability coefficient 'Alpha' for the 3 judges were 0.9905, 0.9503, and 0.9802 respectively.

**Acoustic analysis**

The utterances of participants recorded on a digital voice recorder were transferred to a computer for the purpose of acoustic analysis using Praat software. The speech signal was digitized at a sampling rate of 22000 Hz. The F0 and intensity range was set between 75-500 Hz and 40 to 90 dB respectively while the window frame length of analysis was 25 ms. The pitch analysis was done using autocorrelation method. The F0 and intensity related measures were read directly from the pitch and intensity contours. The duration of the primary stressed syllable was measured as the time difference between onset and offset of stressed syllable in intonation unit. In order to obtain accurate duration measurements and facilitate discernible boundaries of stressed syllables, the utterances were displayed on a wide-band spectrogram. The spectrographic analysis was done using the Fourier method and involved Gaussian window weighting. The pre-emphasis level was set at 6.0 dB/octave. The acoustic measurements of temporal, F0, and intensity cues to stress were carried out by the principal investigator. To check for the reliability of measurement of temporal, F0, and intensity parameters, about 20% of the speech sample was measured independently by another speech pathologist. The inter-judge reliability coefficient ‘Alpha’ for measurement of acoustic features was found to be 0.9604. The data obtained for duration, F0, and intensity was statistically analyzed using SPSS 12.0 software.

**Results**

A total of 251 intonation units were observed in children with hearing loss where as children with normal hearing demonstrated significantly lower intonation units of 76 only. In each intonation unit one primary stressed syllable was identified perceptually. The ear marked primary stressed syllable was acoustically analyzed by Praat software to obtain the measures related to duration, F0, and intensity.

**Duration of primary stressed syllable**

The mean duration of primary stressed syllable in intonation units of speech of children with cochlear implant was 0.320 ± 0.11). It ranged from 0.06 s to 0.72 s. In children with normal hearing, the mean duration of primary stressed syllable was 0.19 s (SD = 0.08) and ranged from 0.07 s to 0.35 s (see Table 2, Figure 1). To determine the difference in mean duration of primary stressed syllable between the two groups of participants, independent samples t-test was used. The results revealed highly significant difference, $t(324) = 4.5, p < .000$. 

97
Figure 1: Mean duration of primary stressed syllable in children with cochlear implant and children with normal hearing.

Table 2. Mean duration of primary stressed syllable in children with cochlear implant and children with normal hearing.

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>N</th>
<th>Minimum (Hz)</th>
<th>Maximum (Hz)</th>
<th>Mean (Hz)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochlear Implant</td>
<td>7</td>
<td>251</td>
<td>159.43</td>
<td>491.23</td>
<td>339.89</td>
<td>56.14</td>
</tr>
<tr>
<td>Normal hearing</td>
<td>7</td>
<td>76</td>
<td>214.40</td>
<td>457.20</td>
<td>306.37</td>
<td>51.21</td>
</tr>
</tbody>
</table>

F0 of primary stressed syllable

The mean F0 of primary stressed syllable in intonation units of speech of children with cochlear implant was 339.89 Hz (SD = 56.14) with a range of 331.80 Hz. In children with normal hearing, the mean duration of primary stressed syllable was 306.37 Hz (SD = 51.21) and ranged from 242.80 Hz (see Table 3, Figure 2). The independent samples t-test was administered to examine the significance of difference in the mean duration of primary stressed syllable between the two groups of participants. The results revealed highly significant difference, t(324) = -3.8, p < .000.

Figure 2. Mean F0 of primary stressed syllable in children with cochlear implant and children with normal hearing.

Figure 3. Mean F0 of primary stressed syllable in children with cochlear implant and children with normal hearing.

Table 3. Mean F0 of primary stressed syllable in children with cochlear implant and children with normal hearing.

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>N</th>
<th>Minimum (Hz)</th>
<th>Maximum (Hz)</th>
<th>Mean (Hz)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochlear Implant</td>
<td>7</td>
<td>251</td>
<td>159.43</td>
<td>491.23</td>
<td>339.89</td>
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<tr>
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<td>76</td>
<td>214.40</td>
<td>457.20</td>
<td>306.37</td>
<td>51.21</td>
</tr>
</tbody>
</table>

Intensity of primary stressed syllable

The mean intensity of primary stressed syllable in intonation units of speech of children with cochlear implant was 80.83 dB (SD = 5.49). It ranged from 64.60 dB to 89.53 dB. In children with normal hearing, the mean duration of primary stressed syllable was 83.51 dB (SD = 5.17) and ranged from 65.50 dB to 88.82 dB (see Table 4, Figure 3). The independent samples t-test was administered to examine the significance of difference in the mean duration of primary stressed syllable between the two groups of participants. The results revealed highly significant difference, t(324) = -3.8, p < .000.

Figure 4. Mean intensity of primary stressed syllable in children with cochlear implant and children with normal hearing.

Table 4: Mean intensity of primary stressed syllable in children with cochlear implant and children with normal hearing.

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>N</th>
<th>Minimum (dB)</th>
<th>Maximum (dB)</th>
<th>Mean (dB)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochlear Implant</td>
<td>7</td>
<td>251</td>
<td>64.60</td>
<td>86.53</td>
<td>80.83</td>
<td>5.49</td>
</tr>
<tr>
<td>Normal hearing</td>
<td>7</td>
<td>76</td>
<td>65.50</td>
<td>88.82</td>
<td>83.51</td>
<td>5.17</td>
</tr>
</tbody>
</table>
Discussion

A certain degree of homogeneity in terms of age of onset of hearing loss, type of cochlear implant, and speech therapy technique used was maintained across participants with cochlear implants. The homogeneity is also reinforced by the standard deviation scores of all the three acoustic parameters investigated. The standard deviation values in children with cochlear implants were similar to those found in children with normal hearing for the acoustic parameters of duration, F0, and intensity. The homogeneity facilitated group comparison of data between the two groups of participants.

As evident from the results, the children with cochlear implant presented higher number of intonation units (251 intonation units) relative to children with normal hearing (76 intonation units). In other words, although they described the picture in simple sentences, they did not produce the sentence in one single utterance. They inserted frequent and lengthy pauses between the words in a sentence that resulted in frequent F0 resettings and hence more number of intonation units. Whereas, children with normal hearing narrated the picture in lengthier utterances and hence longer and lesser number of intonation units.

Although they produced, greater number of intonation units, the utterances of children with cochlear implant may not be labeled monotonous. They could produce both stressed and unstressed syllables i.e. They could bring distinction between stressed and unstressed syllables. The results are in sync with those of Lenden and Flipsen (2007), and Waters (1986) who found significant improvement in the use of stress over a period of time in children with cochlear implant. However, for the stressed syllables, the acoustic correlates of duration and F0 were found to be significantly higher than normal hearing individuals where as the intensity was significantly lesser in children with cochlear implant.

Conclusions

The results of the current study seem to suggest that children with cochlear implant distinctly produced sentence stress but the acoustic correlates of stress for all 3 parameters of duration, F0, and intensity are significantly different from those produced by individuals with normal hearing. The mean duration and F0 were higher in children with cochlear implant compared to children with normal hearing. However, the mean intensity was relatively lower in children with cochlear implant than children with normal hearing.

The children with cochlear implant produced shorter intonation units compared to individuals with normal hearing. The results of the current study bear implications on the need to include suprasegmental aspects in the speech-language assessment and treatment of children with cochlear implant. Since the prosodic correlates of speech vary across languages, it would be interesting to replicate the study in children with cochlear implant speaking other languages.

References


LATERAL ASYMMETRY IN SPEECH PROCESSING AT THE BRAINSTEM: EVIDENCE FROM SPEECH EVOKED ABR

*Sujeet Kumar Sinha, & **Vijayalakshmi Basavaraj

Abstract

Asymmetrical function of the left and right cerebral cortices is well documented. Rapidly changing auditory signals (including speech) are primarily processed in the left auditory areas while tonal stimuli are preferentially processed in the right hemisphere. Some studies suggest that response asymmetries in subcortical auditory structures do exist and may contribute to cerebral lateralization. However, the role of the subcortical auditory pathway in lateralized processing needs to be further established. 40 normal hearing subjects participated in the study. Click evoked auditory brainstem response (ABR) and speech evoked ABR were recorded. Speech evoked ABR was elicited using a synthesized /da/ stimulus. The two measures of speech evoked ABR the onset response (consist of wave V) and the frequency following responses (consist of wave D, wave E, and wave F). Additional, a fast fourier transform (FFT) of FFR also gives information regarding the amplitude of fundamental frequency of sound, the amplitude of first formant of the sound and higher harmonics of the speech sound. Results revealed that there was no difference between wave V of click evoked and speech evoked ABR for the left and the right ear. But the mean latency of wave D, E, F and O were shorter for the right ear as compared to that for the left ear. Also, the frequency following responses (FFR) revealed that mean amplitude of fundamental frequency and harmonics were larger for the right ear as compared to the left ear. The present study suggests that the right ear advantage for speech stimulus could be preserved at the brainstem level. The study adds new information in the role of auditory brainstem processing of speech sounds. These results may open up new area of research in clinical population such as learning disabled children and also the older individuals.

Asymmetrical function of the left and right cerebral cortices is well documented. Rapidly changing auditory signals (including speech) are primarily processed in the left auditory areas while tonal stimuli are preferentially processed in the right hemisphere (Zatorre, 2001). Kimura (1969) has reported that speech stimuli presented to the right ear, contralateral to the hemisphere best suited to process rapid stimuli, are preferentially processed over competing speech presented to the left ear. The cortical asymmetry of language processing has been determined by using functional imaging, electrophysiological responses, and performance on dichotic listening tasks.

The role of the subcortical auditory pathway in lateralized processing is not yet well understood. Studies of brainstem auditory evoked potentials, (Levine & McGaffigan, 1983; Levine, Liederman & Riley, 1988) reported a rightward asymmetry for monaural click-train stimulation. Stimulation of the right ear elicited larger brain stem responses than stimulation of the left ear suggesting an increased number of active neurons or increased firing synchrony in the brain stem structures along the afferent auditory path from the right ear to the left auditory cortex. The authors related the rightward asymmetry in the brain stem responses to the left hemisphere dominance for speech processing.

Smith, Marsh & Brown (1975) and Hoormann, Falkenstein, Hohnbein & Blanke (1992) have studied subcortical lateralization of spectral encoding. It is reported that tonal (and other highly periodic) stimuli elicit a frequency following response (FFR) in which the periodicity of the response matches the periodicity of the stimulus. The FFR is thought to be generated by a series of brainstem nuclei, including the inferior
colliculus and lateral lemniscus, and represents the temporal coding of frequency through neural phase locking. Normalized amplitude of the FFR region in adults was reported to be significantly different for the left and right ear presentation of tone bursts (Ballachanda, Rupert & Moushegian, 1994). In comparing the right- and left-ear contributions to the binaural response to the tonal stimulus, the magnitude of the binaural response was found to be attenuated more when the left ear responses was subtracted than the right ear response, suggesting that the left ear contributed more to the binaural response for the tonal stimulus (Ballachanda et al., 1994).

Asymmetries in peripheral auditory structures have also been reported. Magnitude of active cochlear amplification, assessed by click-train--evoked Otoacoustic emissions, is reported to be greater in the right than in the left cochlea (Khalfa & Collet 1996; Khalfa, Micheyl, Veuillet & Collet, 1998). This peripheral asymmetry is also considered as an indicator of speech related asymmetries in the cerebral hemispheres.

Thus, previous studies which have reported a lateral asymmetry of the auditory brainstem responses and the otoacoustic emissions have used non speech stimulus. Subcortical laterality of speech has also been reported for a few parameters of speech using speech evoked ABR (Hornickel, Skoe & Kraus, 2009). But the study of Hornickel et al. (2009) studied a small sample of 12 normal subjects and they found significant difference for the latency two peaks of speech evoked ABR. For rest of the peaks in speech evoked ABR it reached to significance level but failed to show a significant difference. The findings of Hornickel et al. (2009) study may be due to a small sample size.

Speech evoked auditory brainstem responses consist of a transient and a sustained portions that mimics the acoustic signal (Galbraith et al., 1995). The sustained portion is also known as frequency following response (FFR). The speech evoked auditory brainstem response is considered to provide a direct electrophysiological measure of sensory processing in the auditory brainstem (Galbraith et al., 2000). More research is indicated to strengthen the evidence regarding the contribution of the subcortical auditory pathway to the cerebral asymmetry in processing speech.

Thus, limited information available in the literature shows a rightward asymmetry for non speech stimulus using a non speech stimulus such a click, at the subcortical level. However, the studies regarding the speech laterality at the subcortical level is very less. Thus, there is a need to study how speech is coded at the subcortical level (brainstem) as well, using a large data sample. The present study was undertaken with the aims of studying the right ear and left ear advantage, if any, for the speech evoked ABR to understand lateral asymmetry, if any, in speech processing at the brainstem.

Method

I. Participant

Forty student subjects (20 females, 20 males) in the age range of 18 to 30 years, with a mean age of 22 years, participated in the study. All were right-handed by self-report and as determined by the Edinburgh Handedness Inventory (Oldfield, 1971). All participants had pure tone thresholds of <20 dBHL from 250 Hz to 8000 Hz for air conduction and from 250 Hz to 4000 Hz for bone conduction in both the ears. A normal middle ear function was for all the subjects were determined by tympanometry and reflexometry evaluations. Prior to the study, consent was obtained from all the participants.

II. Test Stimulus:

The test stimulus which was used for speech evoked ABR in the present study was a synthesized /da/ syllable (King, Warrier, Hayes & Kraus, 2002). The stimulus available in BIOLOGIC NAVIGATOR PRO evoked potential system with the BioMARK protocol was used. The /da/ stimulus available with the BioMARK protocol is a 40 ms synthesized speech syllable produced using KLATT synthesizer (Klatt, 1980). This stimulus simultaneously contains broad spectral and fast temporal information's characteristic of stop consonants, and spectrally rich formant transitions between the consonant and the steady-state vowel. Although the steady-state portion is not present, the stimulus is still perceived as being a consonant-vowel syllable. The fundamental frequency (F0) linearly rises from 103 to 125 Hz with voicing beginning at 5 ms and an onset noise burst during the first 10 msec. The first formant (F1) rises from 220 to 720 Hz, while the second formant (F2) decreases from 1700 to 1240 Hz over the duration of the stimulus. The third formant (F3) falls slightly from 2580 to 2500 Hz, while the fourth (F4) and fifth formants (F5) remain constant at 3600 and 4500 Hz, respectively. Figure-1 shows the time domain waveform of the stimulus used in the present study.
III. Instrumentation:
A calibrated (ANSI S3.6-1996), two channel clinical audiometer Madsen OB922 with TDH-39 headphones housed in Mx-41/AR ear cushions were used for pure tone audiometry. Radioear B-71 bone vibrator was used for measuring bone conduction threshold. A calibrated middle ear analyzer, (GSI Tymstar) using 226 Hz probe tone was used for tympanometry and reflexometry. BIOLOGIC NAVIGATOR PRO evoked potential instrument was used for recording click evoked and speech evoked auditory brainstem responses.

IV. Procedure:
All the participants underwent puretone audiometry and tympanometry to ensure the subjects selection criteria. Participants were also subjected to click evoked auditory brainstem responses (ABR) and Speech evoked ABR. Click evoked ABR and Speech evoked auditory brainstem responses were recorded with the protocol shown in table-1

Table 1: Recording parameters for the click and speech evoked auditory brainstem responses.

<table>
<thead>
<tr>
<th>Stimulus parameter</th>
<th>Click</th>
<th>/da/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>0.1 msec</td>
<td>40 msec</td>
</tr>
<tr>
<td>Intensity</td>
<td>80 dB SPL</td>
<td>80 dB SPL</td>
</tr>
<tr>
<td>Polarity</td>
<td>Alternating</td>
<td>Alternating</td>
</tr>
<tr>
<td>Repetition rate</td>
<td>11.1/sec</td>
<td>9.1/sec</td>
</tr>
<tr>
<td>Total no. of stimulus</td>
<td>2000</td>
<td>3000</td>
</tr>
<tr>
<td>Analysis time</td>
<td>10 msec</td>
<td>74.67 ms time window that included 15 ms of pre-stimulus activity, and 59.67 ms of post-onset activity.</td>
</tr>
<tr>
<td>Filter setting</td>
<td>100 to 3000 Hz</td>
<td>100 to 3000 Hz</td>
</tr>
<tr>
<td>Electrode</td>
<td>Noninverting(+ve): Vertex,</td>
<td>Noninverting(+ve): Vertex,</td>
</tr>
<tr>
<td>Montage</td>
<td>Inverting(-ve): Test ear mastoid, Ground: Non test ear mastoid</td>
<td>Inverting(-ve): Test ear mastoid, Ground: Non test ear mastoid</td>
</tr>
<tr>
<td>Transducer</td>
<td>Biologic Insert</td>
<td>Biologic Insert</td>
</tr>
</tbody>
</table>
ABR were recorded twice for both the ears to ensure the reliability of the waveforms and also to get a weighted add waveform for the speech stimulus. For the speech stimulus the two waveforms was added together using weighted add option in the BIOLOGIC EP instrument. This waveform was converted to ASCII format using the software called ‘AEP TO ASCII’. ASCII format data was then analyzed using ‘BRAINSTEM TOOLBOX’ developed at Northwestern University. This software runs on MATLAB platform and does the FFT of the waveform and analyses the FFR.

V. Data analysis

Data analysis was done as described by Russo et al. (2004), Wible et al. (2004). The seven peaks of the response to /da/ (V, A, C, D, E, F, O) were identified. Frequency following response for frequency encoding was analyzed using a Fourier analysis 11.4–40.6 ms time window. To increase the number of sampling points in the frequency domain, the time window was zero-padded to 4096 points before performing a discrete Fourier transform. Average spectral amplitude was calculated for three frequency ranges: fundamental frequency (F0) 103–120 Hz, first formant (F1) 455–720 Hz, and high frequency (HF) 721–1154 Hz.

Table-2: Mean and standard deviations (S.D) of the wave V latency (msec) of click evoked ABR

<table>
<thead>
<tr>
<th>Latency (msec)</th>
<th>Left ear</th>
<th>Right ear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.75</td>
<td>5.70</td>
</tr>
<tr>
<td>S.D</td>
<td>0.11</td>
<td>0.12</td>
</tr>
</tbody>
</table>

The first formant of the stimulus ramps from 220 to 720 Hz over the 40-ms syllable. The F1 frequency range used for FFR analysis accounts for the time lag and the corresponding F1 frequency ramping between the onset of the stimulus and the periodic formant transition that elicits the FFR. The HF range corresponded to the 7th through 11th harmonics of the F0 of the stimulus, a frequency range between the first and second formants. All the analysis for the FFR was computed with “brainstem toolbox”.

Statistical analyses:

Statistical analysis was done using SPSS software version 15. Descriptive analysis was carried out to obtain the mean and the standard deviation of (i) latencies of peaks V of click evoked ABR and wave V, A, C, D, E, F & O of speech evoked ABR (ii) amplitude of F0, F1 & HF of speech evoked ABR only. Paired ‘T’ test was applied to analyse the significance of difference between the latencies of peak V for the left and the right ear for the click evoked ABR and also to find out a Significance of difference between the latencies of peak V, D, E, F & O for the left and the right ear for the speech evoked ABR. Paired T test was also applied to find out a significance of difference between the amplitude of F0, F1 & HF for the left and the right ears.

Results

I. Descriptive analysis of click ABR responses:

The click ABR was recorded reliably for all the 40 subjects. Since speech evoked ABR were available only for 34 subjects, the data of click ABR of only those 34 subjects were considered for analysis. Table-2 shows the mean and standard deviation (S.D) of the latency of click evoked ABR for the left and the right ear presentations.

Paired 't' test revealed no significant difference between the left and the right ear peak V latencies for speech evoked ABR.

II. Descriptive analysis of speech evoked ABR

Speech evoked ABR could be recorded reliably in 34 out of 40 subjects for the left and the right ear. In 6 subjects in the recorded waveform at around 10 msec had a large positive peak either in one or both the ears which is consistent with the latency of post-auricular muscle artifact. Hence the data of these subjects were not considered for analysis. An example of such a waveform is shown in figure-2.
The peak 'C' was not included for analysis as it was present in only 60% of the subjects. Figure-3 shows speech evoked ABR sample.

Table-3 represents the mean and standard deviations of the latencies (msec) of wave D, E, F and O and amplitude(µv) of fundamental frequency, first formant frequency, and high frequency. The 't' values and the level of significance of right and left ear comparisons are also shown in table-3. As it can be seen from table-3 that mean latencies for wave D, E, F and O were longer for the left ear as compared to that of the right ear. It can also be seen that mean amplitudes of the fundamental frequency, first formant frequency, and high frequency were smaller for the left ear as compared to that of the right ear.
Figure 4 represents the data of 34 subjects in error bar graph. It can be seen from figure -4 that there is no much difference in the latency of wave V for the left versus the right ear, however, the latencies of peaks D, E, F are shorter for the right ear as compared to that of the left ear.

![Error bar graph showing latency for wave V, D, E, F](image)

Table 3: Mean and Standard deviations (S.D) of latency (msec) of wave V, D, E, F, O and amplitude (µv) of F0, F1 and HF

<table>
<thead>
<tr>
<th></th>
<th>Left Ear</th>
<th>Right Ear</th>
<th>‘t’ Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Latency (msec)</strong></td>
<td>Mean</td>
<td>Mean</td>
<td>S.D</td>
</tr>
<tr>
<td>Onset response</td>
<td>V</td>
<td>6.54</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>7.39</td>
<td>0.35</td>
</tr>
<tr>
<td>Frequency</td>
<td>D</td>
<td>22.68</td>
<td>0.58</td>
</tr>
<tr>
<td>Following responses</td>
<td>E</td>
<td>30.94</td>
<td>0.55</td>
</tr>
<tr>
<td>Offset response</td>
<td>O</td>
<td>47.90</td>
<td>0.57</td>
</tr>
<tr>
<td><strong>Amplitude(µv)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fundamental Frequency(F0)</td>
<td>4.28</td>
<td>1.45</td>
<td>5.24</td>
</tr>
<tr>
<td>First Formant Frequency(F1)</td>
<td>0.86</td>
<td>0.55</td>
<td>1.06</td>
</tr>
<tr>
<td>High Frequency(HF)</td>
<td>0.31</td>
<td>0.16</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Figure 4: Shows the error bar graph of latency for [a] wave V [b] wave D [c] wave E, [d] wave F of speech evoked ABR
Discussion

The aim of the present study was to explore any indications for subcortical lateralization, if any, for processing the speech. The speech evoked ABR was recorded reliably in 33 subjects. In 6 subjects there was a positive peak present in the wave form at around a mean latency of 10 msec. This positive peak was suggestive of post auricular muscle response as described by Purdy, Agung, Hartley, Patuzzi & O’Beirne (2005), who reported a mean latency of 10.31 msec for the post auricular muscle response. Hence the 6 subjects were excluded from the data.

The onset response (i.e. wave V) did not show any significant differences for the left and the right ear presentations for both the click as well as speech stimulus. The result of the present study in consonance with the study by Hornickel et al. (2009), where they also did not get the significance difference for the wave V for the click and speech stimulus. The similarity between the two studies is because an identical protocol was used in both the studies. Also, Song, Banai, Russo & Kraus, (2006) have reported that peak V of click evoked and speech evoked ABR are highly correlated with each other. Thus, it may be hypothesized that the auditory system processes the speech as well as the non speech stimulus similarly with respect to the onset response. In the present study the latency differences attained statistical significance for the frequency following responses (i.e. for the waves D,E and F) and also the offset response, were longer for the left ear presentation as compared to the right ear presentation, suggesting that the frequency following responses (FFR) may be encoded earlier at the brainstem for the right ear presentation compared to that of the left ear presentation. It may be noted that this asymmetry in FFR is evident even when there is no difference in the onset response for the speech evoked ABR. It is possible that brainstem processes the onset of the stimulus differently and the periodicity of speech stimulus differently. This is supported by the reports which suggest that FFR to speech operate via different mechanisms/pathways than the onset response (Hoormann et al., 1992; Kraus & Nicol, 2005; Song et al., 2006; Akhoun et al., 2008). It is also possible that the right-ear/le f t hemisphere pathway contains a more efficient phase locking network that results in interaural latency differences during the FFR region but not for the onset or click responses (Hornickel et al.2009).

The results of the present study showed that the amplitude of the fundamental frequency was larger for the right ear presentation as compared to that of the left ear presentation. The larger fundamental frequency representation for the right ear has also been reported by Hornickel et al. (2009). This is in contrary to the reports that there is left ear advantage for tonal perception (i.e of F0) which is crucial for pitch perception. Scheffers (1983) hypothesized that the auditory system extracts the pitch of a sound on a moment-to-moment basis and uses the pitch value to direct voice segregation. Thus, the duration of the stimulus might play an important role in pitch encoding. Since the stimulus used in the present study was of only 40 msec duration, it is possible that it was too transient to enable a valid pitch encoding, and therefore the amplitudes were better for the right ear as compared to that of the left ear.

Another important finding was that the amplitude of the harmonics (first formant and the high frequency harmonics) was more for the right ear presentation as compared to the left ear. This may be expected as these two are very important aspect of speech and thus simply may be processed better through the right ear as compared to the left ear. One more observation to be noted here is that the amplitude for the high frequency harmonics is less as compared to that of the first formant frequency. The lesser amplitude of the high harmonics can be justified as the efficiency of the brainstem structures to phase locking better for the low frequencies compared to that for high frequencies (Rose, Hind, Anderson & Brugge, 1971).

Conclusions

The present study suggests that the processing of speech is faster through the right ear as compared to the left ear. Frequency following responses specially shows a faster processing through the right ear compared to the left ear. The results of present study are encouraging as it may open up new areas of research in clinical population. These findings suggest lateralization of speech processing in the auditory brainstem for selective stimulus components and support the existence of right ear advantage for speech and speech-like stimuli. These results may have clinical implications in studying children with language based learning disorders, who tend to have particular difficulty with phonemic contrast since they have delayed brainstem responses relative to their normal learning peers (Banai et al., 2005; Wible et
al., 2004). The study may also have clinical implications in older individuals, as Bellis, Nicol and Kraus (2000) have reported that there is a lack of typical hemispheric asymmetry in the neural representation of speech sounds in older individuals at the cortical level. It would be interesting to see whether such a decrement in speech processing occurs at the level of brainstem also in older individuals.

References


RELATIONSHIP BETWEEN OAES AND BEHAVIOURAL DISCRIMINATION ABILITY OF NORMAL HEARING INDIVIDUALS

*Varun Uthappa A. G., **Priyanka Shailat, & ***Animesh Barman

Abstract

Frequency selectivity and Otoacoustic emissions (OAEs) have been shown to exhibit some relationship, which may explain the psychoacoustics of the ear on peripheral testing. The current study attempts to find the relationship between the amplitudes of OAE and frequency discrimination abilities across frequencies within an individual. The amplitudes of Transient Evoked Otoacoustic Emissions (TEOAE) (signal to noise ratio - SNR), TEOAE (absolute amplitudes) and Distortion Product Otoacoustic Emissions (DPOAE) were measured at 1, 1.5, 2, 3 and 4 kHz respectively in ten ears with normal hearing. Difference Limen for Frequency (DLF) and Frequency Modulated Difference Limen (FMDL) were measured at ten and forty dBSL at the frequencies at which maximum and minimum TEOAE / DPOAE amplitudes were obtained. The difference limens were compared across the frequencies at which maximum and minimum TEOAE / DPOAE amplitudes were obtained. There was no significant difference between frequency discrimination abilities at frequencies with maximum and minimum OAE amplitudes. The results showed that within an individual, the OAE amplitudes might not give information regarding the frequency discrimination abilities. The OAE amplitude not only depends on the status of the outer hair cells. The amplitude also varies with several other factors like the resonance properties of the middle and external ears. Hence, no one to one correlation was obtained. OAEs may not give reliable measures to draw information about the behavioral discrimination ability of individuals.

Key Words: DLF, FMDL, TEOAE, DPOAE

Otoacoustic emissions (OAEs) that arise from the most vulnerable cellular mechanism in the cochlea, which is of fundamental importance to hearing: the outer hair cell (OHC) population; are used to evaluate the OHC functioning. These may also reflect the active biological mechanisms in the cochlea (Brownell, 1990; Norton & Stover, 1994; Zwicker, 1986). The cochlea is the centre for any entering sound to be subjected for frequency analysis. Frequency analysis refers to the ability of the auditory system to separate or resolve (to a certain extent) the components in a complex sound. It does depend to a large extent on the filtering that takes place in the cochlea. The OAEs may provide useful information in this area of frequency selectivity and sensitivity.

With reference to the frequency selectivity and sensitivity and their relationship with frequency discrimination abilities, several studies have been done since the 1990s. A relationship has been shown between physiologic measures [(Spontaneous Otoacoustic Emissions - SOAEs) and [Transient Evoked Otoacoustic Emissions]] and psychoacoustic measures (psychoacoustic tuning curves) in normal hearing subjects by Micheyl and Collet in 1994. The results revealed significant differences at 2 kHz in the quality of Psychoacoustic Tuning Curves (PTC) between subjects with and without SOAEs. This study indicates that the frequency analysis is better in the ears with better OHC functioning. However, in the same study larger Transient Evoked Otoacoustic Emissions (TEOAE) was associated with poorer frequency selectivity, whereas smaller TEOAEs were associated with better frequency selectivity at 2 kHz. The differences in the results may be attributed to the type of emission measured, stimulus levels and method differences. Sridhar K. (2000) found that the
ears with larger Distortion Product Otoacoustic emissions (DPOAE) had better Frequency Modulated Difference Limens (FMDL) compared to the ears with smaller DPOAEs at 2 kHz. These results supported the relationship between electro physiologic and psychoacoustic measures in normal hearing subjects.

Therefore, it is not clear if the different types of OAEs show the same characteristic in representing the functioning of OHCs and also if OAEs are reliable tools to assess frequency selectivity of these cells. The current study uses three kinds of OAE measures: TEOAE (signal to noise ratio - SNR), TEOAE (absolute amplitude), and DPOAE, and compares the physiological measures with two kinds of frequency discrimination measures. The minimum difference in frequency to differentiate one from the other are calculated using Difference Limen for Frequency (DLF) and Frequency Modulated Difference Limens (FMDL) procedures at two sensation levels to rule out the masking effect of higher amplitude signals on frequency discrimination.

The major difference though in the earlier studies and this one is that the comparisons are made across frequencies with in subjects. The study hence, seeks to find out if frequency selectivity can be measured as a function of OAE amplitudes with in an individual across frequencies from 1 kHz to 4 kHz. The aims of the study are as follows:

1. To find the relationship between frequency discrimination using DLF/ FMDL and TEOAE on signal to noise ratio (SNR) amplitudes/ absolute amplitudes at those frequencies with maximum and minimum amplitudes respectively.
2. To find the relationship between frequency discrimination using DLF/ FMDL and DPOAE amplitudes at those frequencies with maximum and minimum amplitudes respectively.
3. To find the effect of sensation levels on frequency discrimination using DLF/ FMDL at those frequencies with maximum and minimum OAE amplitudes.

**Method**

Ten ears (eight males & two females) were taken for the study. The age range was from 18 to 24 years. They all had their pure tone thresholds from 1 kHz to 4 kHz with in 15 dB HL. Thresholds were estimated using OB-922 version 2 clinical audiometer with TDH-39 headphones. They all had ‘A’ type tympanogram. None of them had any history of a neural problem.

Transient Evoked Otoacoustic Emissions (TEOAE) of subjects was obtained at 1 kHz, 1.5 kHz, 2 kHz, 3 kHz & 4 kHz in two ways respectively. ILO 292 was used to measure the Transient Evoked Otoacoustic Emissions (TEOAE). The SNR values and absolute amplitude values were taken at each of the frequencies. The two frequencies in both the conditions with maximum and minimum intensities were considered respectively. Distortion Product Otoacoustic Emissions (DPOAE) was administered in the same ear as the TEOAE using the same instrument, and the amplitudes were taken at each of the 5 frequencies: 1 kHz, 1.5 kHz, 2 kHz, 3 kHz & 4 kHz respectively. The frequencies with maximum and minimum amplitudes were noted. The Difference Limen for Frequency (DLF) and Frequency Modulation Difference Limens (FMDL) were found in each of the ears at all frequencies at which any of the three tests revealed maximum and minimum OAE amplitudes. To obtain Just Noticeable Difference (JND) for frequencies, the OB-922 version 2 clinical audiometer was used in the advanced mode.

To obtain difference limen for frequency, two tones were presented for durations of 500 ms each with an inter pair gap of 200 ms, the tones were such that, one of them was a frequency considered after the OAE tests. It was kept constant and the other tone was varied in 1 Hz steps. Ex.: 1000 Hz and 1001 Hz, 1000 Hz and 1002 Hz etc. The subjects were instructed to say if the tones presented were same or different. Subjects were given tones of the same frequency and two tones with a large frequency difference to familiarize them to the task. Then the bracketing method was used to establish the DLF at each frequency. The minimum difference in the tones at which the subjects indicated a difference for 75% of the times was considered as Just Noticeable Difference (JND). The other parameters of the signals were kept constant. This test was done at both 40 and 10 dBSL.

Frequency Modulation Difference Limens was obtained using the same audiometer. The subjects were first trained to listen to two tones with widely differing modulations such as 0% and 7.5% frequency modulated (FM) tones to familiarize them.
to the task. The actual test began with the presentation of a tone with high modulation. The subjects were instructed to say whether the tone presented was modulated or continuous. For every three consecutive positive responses to the modulated signal, the percentage of modulation was reduced. This was continued till one negative response was obtained i.e. when the subject said that there was no more modulation in the tone. That minimum modulation of frequency at which the subjects indicated the last three positive responses was taken as the FMDL. The test was done at both 40 and 10 dBSLs at the same frequencies as tested for OAEs. The modulations given were in these steps: 7.5%, 5%, 2.5%, 1.0%, 0.5%, 0.2% and 0%.

The analysis of the numerical data was done using SPSS (version 10) software. The values of DLF were obtained in hertz (Hz) called delta ‘f’ (df). FMDL values were obtained in terms of percentage. Hence, to make a comparison across the two methods of obtaining difference limens the delta ‘f’ (df) values were converted as relative percentages according to the formula (df / f * 100) where ‘f’ refers to the frequency tested for DLF. These relative values were tabulated. Wilcoxon Signed Ranks test was used to compare the DLF and FMDL at 40 and 10 decibels above the pure tone thresholds at each frequency. The results showed no significant differences across the difference limens at frequencies with maximum and minimum amplitudes in all the tests. The frequencies with maximum and minimum amplitudes in TEOAE or DPOAE did not have better and poorer frequency discrimination scores respectively in either DLF or FMDL methods at the two sensation levels of 40 and 10 dBSL.

### Results

The study compared 2 variables in 2 conditions each with respect to 3 testing procedures. The mean values and standard deviations of difference limens in percentage in each of the parameters were computed. They include the values of DLF and FMDL at 40 and 10 dBSLs at those frequencies with maximum and minimum amplitudes as obtained on the TEOAE (SNR), TEOAE (absolute amplitude) and DPOAE. These are shown in Tables 1, 2 and 3 respectively.

The Wilcoxon Signed Ranks Test was done to find the differences in difference limens (DLF & FMDL) with respect to the frequencies with maximum and minimum amplitudes as obtained by the three OAE procedures at 40 and 10 decibels above the pure tone thresholds at each frequency. The results showed no significant differences across the difference limens at frequencies with maximum and minimum amplitudes in all the tests. The frequencies with maximum and minimum amplitudes in TEOAE or DPOAE did not have better and poorer frequency discrimination scores respectively in either DLF or FMDL methods at the two sensation levels of 40 and 10 dBSL.

<table>
<thead>
<tr>
<th>Test for DL</th>
<th>Max/ Min</th>
<th>Mean (df/f*100)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLF/ 40 Max</td>
<td>0.3640</td>
<td>0.395592</td>
<td></td>
</tr>
<tr>
<td>DLF/ 40 Min</td>
<td>0.4520</td>
<td>0.454045</td>
<td></td>
</tr>
<tr>
<td>DLF/10 Max</td>
<td>0.6240</td>
<td>0.573860</td>
<td></td>
</tr>
<tr>
<td>DLF/10 Min</td>
<td>0.5505</td>
<td>0.503408</td>
<td></td>
</tr>
<tr>
<td>FMDL/ 40 Max</td>
<td>1.3500</td>
<td>0.818196</td>
<td></td>
</tr>
<tr>
<td>FMDL/40 Min</td>
<td>1.2500</td>
<td>0.677003</td>
<td></td>
</tr>
<tr>
<td>FMDL/ 10 Max</td>
<td>1.4700</td>
<td>0.923821</td>
<td></td>
</tr>
<tr>
<td>FMDL/10 Min</td>
<td>1.7000</td>
<td>0.856349</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Mean and SD values of the difference limens in percentage at 40 and 10 dBSLs at frequencies where amplitudes of TEOAE (SNR) were maximum or minimum.

<table>
<thead>
<tr>
<th>Test for DL</th>
<th>Max/ Min</th>
<th>Mean (df/f*100)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLF/ 40 Max</td>
<td>0.3645</td>
<td>0.463318</td>
<td></td>
</tr>
<tr>
<td>DLF/40 Min</td>
<td>0.5960</td>
<td>0.678597</td>
<td></td>
</tr>
<tr>
<td>DLF/10 Max</td>
<td>0.4325</td>
<td>0.526526</td>
<td></td>
</tr>
<tr>
<td>DLF/10 Min</td>
<td>0.6245</td>
<td>0.670806</td>
<td></td>
</tr>
<tr>
<td>FMDL/ 40 Max</td>
<td>1.4000</td>
<td>0.774597</td>
<td></td>
</tr>
<tr>
<td>FMDL/40 Min</td>
<td>1.2000</td>
<td>0.714920</td>
<td></td>
</tr>
<tr>
<td>FMDL/ 10 Max</td>
<td>1.5500</td>
<td>0.831665</td>
<td></td>
</tr>
<tr>
<td>FMDL/10 Min</td>
<td>1.7000</td>
<td>0.856349</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Mean and SD values of the difference limens in percentage at 40 and 10 dBSLs at frequencies where amplitudes of TEOAE (absolute amplitude) were maximum or minimum.
Table 3: Mean and SD values of the difference limens in percentage at 40 and 10 dBSLs at frequencies where amplitudes of DPOAE were maximum or minimum.

<table>
<thead>
<tr>
<th>Test for DL</th>
<th>Max/Min</th>
<th>Mean (df*/100)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLF/40</td>
<td>Max</td>
<td>0.5160</td>
<td>0.376186</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>0.4620</td>
<td>0.461009</td>
</tr>
<tr>
<td>DLF/10</td>
<td>Max</td>
<td>0.7130</td>
<td>0.548696</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>0.5080</td>
<td>0.502080</td>
</tr>
<tr>
<td>FMDL/40</td>
<td>Max</td>
<td>1.3500</td>
<td>0.818196</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>1.2500</td>
<td>0.677003</td>
</tr>
<tr>
<td>FMDL/10</td>
<td>Max</td>
<td>1.6200</td>
<td>0.960093</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>1.4000</td>
<td>0.774597</td>
</tr>
</tbody>
</table>

Discussion

The results of the current study show no relationship between the amplitudes in OAEs across frequencies and the just noticeable difference for frequencies within an individual. Earlier studies have dealt with the relationship between amplitude of OAE and DLF/FMDL at particular frequencies in a group of subjects. They have shown that a positive relationship does exist when compared with a frequency. Sridhar (2000) found that the ears with larger DPOAEs had better frequency discrimination at 2 kHz. However, it is now found that the relationship does not remain the same across frequencies. The frequencies, at which the OAE amplitudes are better, need not have the smallest DLF or FMDL. The findings in the paper can be attributed to the following reasons.

Otoacoustic emissions may not be good indicators of the actual functioning of the outer hair cells across the wide range of frequencies. But, OAEs have been relatively successfully used in threshold estimation with the assumption that they provide frequency specific information.

Secondly, the spectrum of OAE not only depends on the integrity of the outer hair cell functioning, but also depends on the resonance properties of the middle ear and the external ear. It is more likely that larger OAE amplitudes can be seen either at the middle ear resonance frequency or at the external ear resonance frequency, thus reducing the sensitivity of assessing the actual integrity of the outer hair cell functioning.

However, the amplitudes of OAE are also extremely variable with in an individual over time. Wit & Dijk (1979) found that the magnitudes of the responses measured in OAE were also influenced by the stimulus frequency and that the higher frequency stimuli generated smaller emissions than the lower frequencies. This may also be accounted for the differences in the actual functioning and the measured values. On the other hand Norton & Neely in the year 1987 said that the spectra of TEOAEs resemble those of the evoking stimuli. But, the amplitude of the evoking signal may not be the same across frequencies. Therefore, studies in the past have shown both sides of the same tests.

We may also speculate that it is not a possibility to draw comparisons of DLF/FMDL across frequencies. Researchers in the past have found values of DLF at various frequencies, though the comparisons were not made across frequencies. To make the comparisons meaningful, the values in the current study were converted into percentages. Yet, differences couldn't be seen in the study. What is even more interesting is that even a negative trend is not being seen.

Based on the results obtained, we can confirm that the outer hair cells may only have the function of separating the speech input grossly, and may not have much of a role in further analysis of the signal. Even if it does participate in more complex processes the OAEs may fail to detect it. The amplitude measured in the OAEs may not be the sound transduced into the auditory pathway.

On the basis of the results of the current study, we may say that the level of presentation of the stimulus has no effect on the relationship between the frequency discrimination abilities and OAE amplitudes. Therefore, we may suppose that the OAEs are not reliable measures of OHC functioning as they are influenced by other physiological factors. Thus it fails to correlate the physiology of the OHCs with the perceptual ability of the individual. Hence, the scope of OAEs in indicating the psychoacoustic characteristics may well be limited.

Conclusions

Previous studies have shown different patterns of relationship between OAE amplitudes and
frequency discrimination, the frequencies being considered across individuals. The results of the present study, which compared the relationship across frequencies within the same individual, do not reveal any such pattern. A relationship followed well across ears at a frequency doesn’t hold well across frequencies within an ear. Hence, interpretation of the amplitude differences across frequencies in the OAEs of an individual should be made with caution.

References

Acknowledgements
We thank God Almighty for giving us the strength and support throughout our lives in all that we have done. We wish to thank our respected Director, Dr. Vijayalakshmi Basavaraj for providing us the opportunity to conduct this research. Our special thanks are to Mrs. Vasanthalakshmi, Lecturer in Biostatistics, for helping us carry out the statistical analysis. We are grateful to Mr. Baba Fakruddin, Dept. of Audiology for helping us through our research and lending his valuable time for us. We extend our special thanks to Ms. Mamatha, Mrs. Devi, Mr. Sujith, Mr. Praveen and Dr. Vijay, (faculty members) Dept. of Audiology, for their timely help. We are thankful to the library and its staff for their consistent support.
THE EFFECT OF FILTERED SPEECH ON SPEECH IDENTIFICATION SCORES OF YOUNG NORMAL HEARING ADULTS

*Vijay Kumar Yadav Avilala, **Prashanth Prabhu P., & ***Animesh Barman

Abstract

Filtered speech material would help to understand the importance of different spectral energy in perception of speech. Spectral energy of different speech sounds varies due to variation of the fundamental frequency (F0), first formant (F1) and second formant (F2) values. These are essential cues to understand speech. The F1 and F2 values are determined by the tongue height and tongue advancement respectively. These formants can alter due to the change in volume or size of the oral structures and also the language used. Hence, the present study aimed at assessing the speech identification scores for four low-pass (800, 1200, 1500 & 1700 Hz) and four high-pass (1700, 2100, 2500 & 3000 Hz) cut off frequencies filtered speech in 30 young normal hearing adults in the age range of 17-25 years. The spectral modifications were done using Adobe Audition Software for the phonemically balanced words in Kannada developed by Yathiraj and Vijayalakshmi (2005). The speech identification scores were determined at all the eight cut off frequencies. Results revealed that there is lowering of the cut off frequencies at which 70% speech identification scores are obtained for low-pass filtered stimuli in Kannada compared to English (Bornstein, Wilson & Cambron, 1994). This difference could be because of the low F1 values and higher low frequency spectral energy in Kannada spoken language compared to English language. There is no difference in high-pass cut off frequency filtered speech. The results suggested that the spectral information between 1200 Hz and 2100 Hz is more important in perception of speech in Kannada language and also highlight the selection of appropriate cut off frequency for filtered speech for clinical use.

Key Words: High-pass cut off frequency, Low-pass cut off frequency, Spectral Modifications.

Speech is a complex signal which encompasses spectral information in the frequency range of 300 to 3000 Hz. Speech consists of different classes of speech sounds like vowels and consonants. Spectral energy of vowels is more concentrated at low to mid-frequencies, whereas consonants have spectral energy at wide range frequencies. Within the consonants, nasal speech sounds are more of low frequencies, plosives usually have more spectral energy at mid frequencies and fricatives usually have high frequency spectral energy concentration.

Due to the spectral variations of speech sounds, speech materials have become an indispensable tool in clinical evaluation. They could be used to determine the extent to which a person has disruption in the perception of complex signals like speech (Wilson & Margolis, 1983). Speech materials are also being used in selection and prescription of amplification devices and in rehabilitation (Risberg & Martoni, 1972). Beattie, Edgerton and Svhovec (1977) compared the slopes of performance intensity function of NU No. 6 and CID W-22 speech materials and reported that the slope was 4.2% and 4.6% respectively. It suggests that the different test materials can also yield different performance-intensity functions.
Speech contains both spectral and temporal information that is important for perception of speech. However, there are variations across languages in the way these spectral/temporal cues contribute in perception of speech. There are spectral variations like differences in formant frequencies and temporal variations like changes in speaking rate across languages. However, it might be complicated to study the influence of this information in speech identification scores by varying both the parameters. Hence, a systematic study is required to see the spectral or temporal influence on speech identification scores by keeping one parameter unaltered. Thus, by varying the spectral properties of speech (like use of filtered speech material) one can determine the contribution of different spectral energy in perception of speech in different languages.

Spectrally modified speech stimuli like filtered speech have been used as a monaural low redundancy test to assess Auditory processing disorder (Bocca, Calearo & Cassinari, 1954). Filtered speech helps to understand the contribution of different frequencies in perception of speech (Bornstein, Wilson & Cambron, 1994). The degradation of the speech signal that is produced by filtering is affected by the cut-off frequency of the filter and also by the rejection rate of the filter. Bornstein et al. (1994) reported that, (1) for low-pass filtered speech materials, the word recognition performance decreased with the lowering of the cut off frequencies; (2) for high-pass filtered speech materials, the performance decreased as the high pass cut-off frequency increased, and (3) for both low-pass and high-pass filtered speech material, the word recognition performance decreased as the steepness of the rejection rate of the filter increased.

Bornstein et al. (1994) observed that individuals with normal hearing could obtain 70% correct scores with low-pass cut-off frequencies of 1500 Hz and high pass cut off frequency of 2100 Hz. These results suggest that frequencies between 1500 Hz and 2100 Hz are more important in perception of speech. The spectral information above 2100 Hz and below 1500 Hz though important but may not provide adequate information for the perception of speech. The effect of cut-off frequency mainly depends on the spectral energy of the speech sounds and it might change with the language used.

The variations in spectral energy might alter due to the structural variations of the oral cavity. These could lead to the variations in first formant (F1) and second formant (F2), as F1 is determined by the frontal volume of the oral structure and F2 is by the volume of the back cavity. Savithri, Jayaram, Venugopal and Rajasudhakar (2007) have reported the mean F1 (497 Hz) and F2 (1596 Hz) values for vowels in Kannada language. Peterson and Barney (1952) have observed the mean F1 (538 Hz) and F2 (1560 Hz) values for vowels in English language. The comparison of F1 and F2 values reported in both the studies shows that the mean F1 of vowels in Kannada are lower in frequencies than the English language. The mean F2 of vowels is higher in Kannada compared to English language. Sairam (2002) reported that the Indian languages like Kannada have more energy in the low frequency region, compared to the western spectrum. Most of the studies reported in the literature regarding spectral variations of speech on speech perception (filtered speech) have used English language and those results cannot be adapted directly to other languages, especially Indian languages like Kannada. There is a need to develop data base for filtered speech stimuli in Indian languages as well. Hence, the current study aimed to observe how different spectrally varied speech stimuli can affect the speech identification scores.

Objectives of the Study: The main objective of this study was to determine the effect of spectrally modified speech (filtered speech) on the speech identification scores in normal hearing adults. The second objective was to find out the cut-off frequencies at which young normal hearing adults can obtain 70% speech identification scores for both low- and high-pass cut off frequency filtered speech.

Method

Participants: Thirty young adults (mean age 21.5 years) having normal hearing (hearing sensitivity less than or equal to 15 dB HL) participated in the study. The participants had no history of any otologic and neurologic symptoms. The participants had 100% speech identification scores (SIS) in quiet for monosyllables (Mayadevi, 1974) presented at most comfortable level. They had normal tympanogram with presence of acoustic reflexes at normal levels. Speech perception in Noise (SPIN) test was administered to rule out Auditory Processing Disorder and all the participants had speech identification scores greater than 60% at 0 dB SNR (Orchik & Burgess, 1977).
Stimuli: In the present study, phonemically balanced word lists developed by Yathiraj and Vijayalakshmi (2005) in Kannada were used for spectral modification to determine speech identification scores in young adults having normal hearing. The Yathiraj and Vijayalakshmi (2005) test material in Kannada has a total of four lists having 25 words in each list. These materials were standardized on young normal hearing adults. Each list was filtered using low-pass cut-off frequencies of 800, 1200, 1500 and 1700 Hz; and high-pass cut-off frequencies of 1700, 2100, 2500 and 3000 Hz using adobe audition software and the attenuation rate of 115 dB/octave using Butterworth filters. Each unmodified word was selected and filtered separately for each cut-off frequency. These four lists were further randomized using random table to make eight lists, to avoid any practice effect.

The words lists were recorded by a native Kannada female speaker. The recording was done on a Pentium Dual Core laptop using a unidirectional microphone kept at a distance of 10 cm from the speaker's mouth for recording. The recording was done using Adobe audition software (Version 2) using a 32-bit analog-to-digital converter at a sampling rate of 44.1 kHz. The recorded signal was normalized so that all the words had the same intensity. A calibration tone of 1 kHz was recorded prior to the list.

Procedure: To estimate the pure tone thresholds and speech identification scores, a calibrated dual channel diagnostic audiometer GSI-61 with TDH-39 headphones housed in MX-41/AR ear cushions was used. A Radio ear B-71 bone vibrator was used to estimate the bone conduction thresholds. Pure tone testing was done using Modified Hughson and Westlake procedure (Carhart & Jerger, 1959). Speech identification scores of these participants were determined using the monosyllables developed by Mayadevi (1974). Speech identification scores were obtained at most comfortable level. Immitance evaluation ( tympanometry and acoustic reflex testing) was carried out using 226 Hz probe tone. A calibrated Middle ear Analyzer (GSI-Tymppstar V 2.0) was used for the same. Acoustic reflexes were checked at 500, 1000, 2000 and 4000 Hz tone for both ipsilateral and contralateral. Speech Perception in Noise test was administered at 0 dB SNR using monosyllables developed by Mayadevi (1974). The speech material recorded for the study was played using Adobe Audition (Version 2.0) software. The signal was routed through a Core 2 Duo Computer to the tape and auxiliary input of a clinical audiometer through TDH-39 headphones with MX-41/AR cushions. The intensity of the presentation level was controlled from the audiometer.

The individuals were instructed to give a written response and the speech identification scores were determined for each cut-off frequency. The participants were also informed that they could guess the test items in case they were not very clear. Half of the participants were tested in right ear first and for the remaining participants were tested in left ear to avoid ear effect. The presentation of the stimuli was randomized for all the eight lists to avoid practice and order effect. The number of corrected responses was calculated. The speech identification scores were calculated using the formula given below:

\[
SIS = \frac{\text{Optained number of responses}}{\text{Total number of responses}} \times 100
\]

Results

The speech identification scores obtained for different filtered speech was noted. The mean and standard deviation of the speech identification scores were calculated. The results obtained at different cut-off frequencies for 30 individuals (60 ears) with normal hearing are depicted in Table 1. It is evident from the table that there is an increase in speech identification scores with increase in low-pass cut-off frequency and with decrease in high-pass cut off frequency. The participants obtained greater than 70% scores for low-pass cut-off frequency of 1200 Hz or higher and high-pass cut off frequency of 2100 Hz or lower. The scores gradually decreased from 1700 to 800 Hz low-pass cut off frequency. However, there is a gradual decrease in speech identification scores from 1700 to 2500 Hz high-pass cut off frequency and then the scores sharply deteriorated for 3000 Hz high pass cut off frequency.

<table>
<thead>
<tr>
<th>Cut-off frequency</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Range (Min - Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 Low-pass</td>
<td>60</td>
<td>65.9</td>
<td>5.64</td>
<td>52-72</td>
</tr>
<tr>
<td>1200 Low-pass</td>
<td>60</td>
<td>75.88</td>
<td>3.71</td>
<td>72-88</td>
</tr>
<tr>
<td>1500 Low-pass</td>
<td>60</td>
<td>64.9</td>
<td>3.26</td>
<td>85-92</td>
</tr>
<tr>
<td>1700 Low-pass</td>
<td>60</td>
<td>90.9</td>
<td>2.76</td>
<td>85-96</td>
</tr>
<tr>
<td>1700 High-pass</td>
<td>60</td>
<td>90.4</td>
<td>3.15</td>
<td>89-92</td>
</tr>
<tr>
<td>2000 High-pass</td>
<td>60</td>
<td>77.86</td>
<td>4.42</td>
<td>73-88</td>
</tr>
<tr>
<td>2500 High-pass</td>
<td>60</td>
<td>65.73</td>
<td>7.02</td>
<td>40-76</td>
</tr>
<tr>
<td>3000 High-pass</td>
<td>60</td>
<td>36.4</td>
<td>4.49</td>
<td>24-48</td>
</tr>
</tbody>
</table>

Table 1: Mean, standard deviation and range of SIS obtained for filtered speech stimuli at different cut off frequencies obtained from 60 ears of 30 individuals with normal hearing.
A repeated measures ANOVA was carried out to test whether the speech identification scores were significantly different across different low and high cut-off frequencies. The results of repeated measures ANOVA shows that there was significant difference in speech identification scores across low cut off frequencies \([F (3, 177) = 395.83, p < 0.01]\) and high cut off frequencies \([F (3,177) = 924.67, p < 0.01]\).

A test of Bonferroni’s multiple pair-wise comparison was carried out to determine between which two cut off frequencies the speech identification scores differed significantly from each other. The results of the Bonferroni’s test revealed that the scores of all the cut-off frequencies for both low-pass and high-pass words differed significantly from each other at level of significance of \(p < 0.01\) as depicted in Table 2 and 3.

### Table 2: Bonferroni’s multiple comparison of filtered speech for low-pass cut off frequencies.

<table>
<thead>
<tr>
<th>Cut off frequency</th>
<th>1200 Hz low-pass</th>
<th>1500 Hz low-pass</th>
<th>1700 Hz low-pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 Hz low-pass</td>
<td>Significant ((p &lt; 0.01))</td>
<td>Significant ((p &lt; 0.01))</td>
<td>Significant ((p &lt; 0.01))</td>
</tr>
<tr>
<td>1200 Hz low-pass</td>
<td>-</td>
<td>Significant ((p &lt; 0.01))</td>
<td>Significant ((p &lt; 0.01))</td>
</tr>
<tr>
<td>1500 Hz low-pass</td>
<td>-</td>
<td>-</td>
<td>Significant ((p &lt; 0.01))</td>
</tr>
</tbody>
</table>

### Table 3: Bonferroni’s multiple comparison of filtered speech for high-pass cut off frequencies.

<table>
<thead>
<tr>
<th>Cut off frequency</th>
<th>2100 high-pass</th>
<th>2500 Hz high-pass</th>
<th>3000 Hz high-pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1700 Hz high-pass</td>
<td>Significant ((p &lt; 0.01))</td>
<td>Significant ((p &lt; 0.01))</td>
<td>Significant ((p &lt; 0.01))</td>
</tr>
<tr>
<td>2100 Hz high pass</td>
<td>-</td>
<td>Significant ((p &lt; 0.01))</td>
<td>Significant ((p &lt; 0.01))</td>
</tr>
<tr>
<td>2500 Hz high pass</td>
<td>-</td>
<td>-</td>
<td>Significant ((p &lt; 0.01))</td>
</tr>
</tbody>
</table>

**Discussion**

The results of the present study show that the speech identification scores improved with increase in low-pass cut off frequencies and with decrease in high-pass cut off frequencies. The subjects obtained speech identification scores of 70% at low-pass cut off frequency of 1200 Hz and at high-pass cut off of 2100 Hz.

Bornstein et al. (1994) reported that individuals with normal hearing obtained 70% speech identification scores for 1500 Hz low-pass and 2100 Hz high-pass cut-off frequencies. In the present study, it was found that the speech identification scores reached 70% at 1200Hz low-pass cut-off frequency itself and at 2100 Hz for high-pass cut-off frequency. This difference is mainly due to the difference in languages used. The discrepancy in the low-pass cut-off frequency for Kannada (1200 Hz) in comparison with English (1500 Hz) could be due to the predominance of low frequency information in Kannada language. Sairam (2002) reported that the spectral energy concentration of speech sounds in Kannada is more at the low frequency region compared to Western speech spectrum. This was attributed to the frequent occurrence of long vowels in Kannada which carries more of low frequency information. The decreased low-pass cut off frequency in Kannada could also be because of lowered F1 values in Kannada compared to English which is important for consonant perception as observed by Savithri et al. (2007) in Kannada and Peterson and Barney (1952) observed in English language. The variation in F1 values could be because of changes in tongue position and volume of the back cavity (Savithri et al., 2007).
The present study shows that there was no difference in high-pass cut off frequency between Kannada and English reported by Bornstein et al. (1994). The mean F2 values for vowels in Kannada (Savithri et al., 2007) are higher than the F2 values for English reported by Peterson and Barney (1952). The mean F2 values for both Kannada and English were less than 1700 Hz. The high-pass cut off frequencies used in the present study is greater than 1700 Hz. Thus, the variation in F2 between the languages may not have affected the high-pass cut off frequencies. The result of the present study suggests that spectral energy information greater than 1200 Hz and lesser than 2100 Hz along with their auditory closure abilities used to obtain 70% speech identification scores. This suggests that the energy concentration between 1200 Hz and 2100 Hz are essential to perceive speech in Kannada language.

Conclusions

The present study made an attempt to find out the effect of spectral variations on perception of speech in young normal hearing adults. The study showed that the spectral information between 1200 Hz and 2100 Hz are important for perception of speech in Kannada. It was also found that slightly lower low cut off frequency is important to perceive the speech in Kannada compared to English language.

Implications of the study

This data can be used to carry out further studies in perception of filtered speech. It highlights the importance of studying filtered speech in different languages as the present study shows difference in lower cut-off frequencies compared to English languages. It also suggests the lowering of cut off frequency in filtered speech of Kannada language might be used to assess auditory processing disorders.

References


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Abstract

Speech language pathology has largely been viewed as a 'woman's profession'. Support for this view is found in the fact that women form the majority of field workers in the profession. Yet the prevalence and impact of women, be it in positions of power within the field, or as speech language pathology scientists, has been negligible. The paper explores the possible reasons for the same and how this needs to be and can be changed in the future.

Friends,

It is indeed a pleasure to be presenting this plenary note in the area of Speech and Language, at this prestigious congress on 'Women in Science' and my sincere thanks to the organizers for having invited me to do so. The gender bias in the professional arena even in one in which the number of women has consistently outnumbered men, has been a matter of concern through out my professional career and I am indeed delighted that I now have a platform to voice these concerns, not only with reference to my own personal experiences and sphere of activities, but with reference to the larger scope of the profession of Speech Language Pathology across the globe.

In my four decade long career as a Speech Language Pathologist (SLP) in India, I have often experienced and witnessed, how gender has been an unwarranted factor in both my own professional trajectory as well as the many women colleagues and the even more women students that I have had the privilege of knowing and training. Over the years there has been many a bright eyed, sharp minded, aspirant female SLP with excellent academic credentials, getting into the profession largely on the basis of her academic strengths and continuing to fare similarly in the profession. A few years down the line many of them are not to be seen or heard from and in the professional arena the markedly skewed gender divide seen in the student population reverses itself. While admittedly some of this is due to already acknowledged contributory factors of attrition such as marriage and childbirth, there are also other insidious factors that have and continue to operate, factors that need to be recognized and acknowledged in order that women in the science of speech-language pathology rightfully gain their due.

Traditionally, the speech-language pathology profession has been viewed as a 'woman's profession'. The number of women enrolling for courses in speech-language pathology across the world is decidedly tilted in favor of women and women represent a majority of the field's total workers. According to a recent report by Forbes, the profession is reported to be among the top ten highest paying jobs for women in countries like the US; after pharmacists, women physicians and surgeons, and women human resource managers, but ahead of women systems analysts and computer programmers (forbes.com, 2009 based on a U.S. Department of Labor Women's Bureau 2008 analysis).

Impressive as this may seem at first glance, it is important to note that the list compiles the top ten paying jobs for 'women', not 'the' top ten paying jobs. So it really doesn't say much about women's position in the world's top paid jobs and professions. If one looks closely at this list of professions in which women earn the maximum as compared to other professions that other women are employed in, it appears that the key factors that influence the choice of these jobs by women are high-paying work (relatively that is) and flexibility with manageable schedules indicators of the many other demands that women have to accommodate, while choosing jobs.
What is it that contributes to the perception of SLP as being a profession that is suited for women? The following are a few possibilities -

1) Rehabilitation in India and elsewhere has, until recently, developed under the 'charity model' and was primarily non-paying/poorly paying charitable work. Therefore a woman's job?

2) SLP is among the caring, clinical professions therefore for women?

3) The practice of SLP requires patience and is slow to show results ideally suited for women?

In short, the perception is that, the profession of speech language pathology is ideally suited for women because it is nurturing in nature, requiring loads of patience, economically unimportant with final outcomes that are not too dramatic and therefore feminine in nature! Within the profession anyone who disagreed or failed to fall in line with these socio cultural perceptions were seen as those who are loud and aggressive unwomanly characteristics most women are culturally trained not to want to be identified with. Interestingly within the broader combined field of Speech & Hearing Sciences, speech (SLP) was perceived to be the 'soft science' more suited for women and hearing (Audiology) the 'hard science' for men.

Further, while speech-language pathology is universally acknowledged as a 'woman's profession' and is dominated by women in terms of numbers, this has not necessarily converted into a dominance of women in the profession, in terms of their professional status. The ratio of women to men in the higher rungs of the profession progressively declines. One of the reasons for the same is that as in many other professions a sizeable number of the female work force cannot or do not persist in the workforce because they are tradition-bound and opt out of the workforce to dedicate themselves to the role of home makers. However it is also a fact that selections of women to higher positions are not only suppressed on the assumption that women can't multi-task but are often influenced by considerations of the husband's job and or location, not by the woman herself but by the selectors and administrators. This despite the fact that the academic and professional record of the woman candidate is more often than not superior to that of her male colleague and the fact that she has chosen to apply for the job knowing fully well the requirements of the position as also presumably her particular circumstances in terms of family needs!

There is a further gender divide, the divide of the 'upstairs' and 'downstairs' people. While the 'upstairs people' carried out the more onerous work of teaching, research and administrative positions, the 'downstairs people' consisting of clinicians carried out the more 'mundane' or 'routine' clinical work, the unwritten and unspoken rule being that the former was essentially to be peopled by men and the latter by women. It is needless to point out that the pay packets, domination and 'prestige' of the former is considerably higher than that of the latter. On a concessional note, there was a feeble attempt at creating positions of 'clinical lecturer' and 'clinical readers'. The fact that in its nearly 5 decade history the current Director of AIISH is only the second lady to occupy this position stands testimony to the above. Even a cursory look at the academic records of the male and female students that have passed through the institution would clearly throw up how disproportionate the ratio is in comparison to the relative ratio of 'promise of academic excellence' across the genders in their student days.

The situation in the more advanced / western countries, was no different until recently.

Despite their higher numbers on ground, women speech language pathologists remain under-represented in science and in decision-making bodies concerned with scientific issues, as in many other disciplines in which women are not predominant. That, things are a changing is evident in that, Speech-Language Pathology is singled out in the Forbes list as the only occupation that currently showed no gender pay gap (forbes.com, 2009). It is equally gratifying to observe that many of the professors and teaching faculty of AIISH today are women, reflecting the gender bias in the proportion of men and women who take up this profession.

And what of science and women scientists in the field of speech language sciences and pathology in India? While in the west there is an increasing presence of women scientists in the field, this is not true of India, as yet. Regrettably, as in many other scientific and clinical disciplines in India, speech language pathology too has borne the brunt of the phenomenon of brain drain, perhaps even more so
since it is a science in its nascent stage. Scientific research and development in the field has barely begun and is yet to take root, despite the enormous potential that our socio cultural and linguistic milieu holds for such research. Much of the research that has been carried out so far has been in the nature of fulfilling requirements for obtaining degrees and jobs. Long term research positions and grants have neither been readily available nor sought after. It is only in the last decade or so that a handful of scientists have emerged in the field, with a serious commitment to science and research.

It would not be amiss to observe that the reason why we are only now beginning to see some serious attention, being paid to sustained research in the discipline, could also be linked partially at least, if not totally, to the predominance of women in the discipline. As in most other professions, women in SLP too end up having checkered career graphs, because of the prioritization of marriage, family and children. It is not until her forties, if then, that the woman professional pursues her career more single mindedly and in the absence of readily accessible research positions or funds, a larger commitment to science and research becomes the last priority. The absence of any real presence of scientists among us should therefore be seen in the context of the short history of SLP in this country as well as the predominance of women in the workforce.

The decreasing number of women, from enrolment in undergraduate courses to PG courses and research programs contributes and strengthens the identification of science with masculinity. Nevertheless it is noteworthy that as in other areas, the young woman SLP of today takes a more informed decision on her choice of career and in charting the course of her career vis a vis her personal life. Even so there are aspects of a career in speech language pathology that can be turned in to an advantage and a basis for good science, with some thought and preplanning.

The potential that clinical practice holds for science in SLP is one such. Given the largely unexplored course of scientific investigation in SLP, because of its very brief existence as an independent scientific discipline; it is the clinical work that will provide the questions and pointers for further research, provided that one approaches the clinical work within this scientific perspective. Research and science in the discipline has to stem from clinical work and feed back into it. Given the nascent stage of the discipline good clinicians could well be among our best scientists. The challenges of clinical work and results are in my personal experience and opinion, far more than those in teaching and ‘pure research’ in this applied clinical discipline. And it is time that we broke the myth of the superiority of teaching and research over clinical work.

Good science in speech language pathology does not require one to be wearing a white coat and sitting in a laboratory. Child rearing which is so much a part of a woman’s preoccupation and takes up so much of her time, for instance, could easily provide a unique opportunity for providing a basis for good science in this discipline. There is so much that awaits scientific investigation in the science of child language acquisition and disorders. Incidental science and scientific thinking during the long years of child rearing, within the vantage position of a ringside look, can lead to the very questions that need to be looked in to empirically in controlled studies at a later date. Provided of course there is a scientific mind and scientific framework for your thoughts and ideas and the scientific discipline and drive to take it further, subsequently.

Speech-language pathology is expected to grow faster than average through the year 2014 (ASHA website) and there is room for many a woman scientist within this growth. To go by this years Nobel Prize list for science, the abysmal ratio of outstanding women to men scientists, shows signs of changes. Differences across boys and girls in performance on math whizzes and other traditional ‘masculine subjects’ are reported to have declined to 1 to 1 in gender equal countries. Leading scientists such as Stanford University neurology professor Robert M. Sapolsky, the author of “A Primate's Memoir,” among other works; emphasize how ‘the brain is constantly reshaped by environment and as we contemplate findings like these, it’s worth appreciating how powerfully the brain is sculpted by society’s values and beliefs”. A reaffirmation of our belief in us and our honing of our capacities as rational thinkers and scientists will augur well for women among the speech language scientists of the future.

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BOOK REVIEW
AUDIOLOGY IN DEVELOPING COUNTRIES

Editors: *Bradley McPherson & **Ron Brouillette

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New York

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The book AUDIOLOGY IN DEVELOPING COUNTRIES has 12 chapters written by chosen authors from the area of public health, audiology or education and who are from or have worked in developing countries. Chapter 1 is Introduction to the book written by the editors which outline the design and coverage of the book.

Chapter 2 is on AUDIOLOGY: A developing country context: is written by Bradley McPherson, University of Hong Kong, China and describes various definitions of the developing countries from different parameters as delineated by UN authorities and WHO based on the criteria like mostly agriculture based with less industrial income, more rural population than urban, less homogenous in terms of factors of ethnicity, multi lingual & socio-cultural diversity, multi community with unequal wealth distribution etc. In the view of the authors, economic difficulties force governments in developing countries to give no or less priority to hearing health care. Thus the primary audiologic services are nonexistent or insufficient in these countries. Table on development indices of selected developing countries shows India at 73rd position in terms of quality of life index. Not much on current practices in audiology in India is included and most of the discussion is based on developing countries from Africa. However WHO initiatives on hearing healthcare have been well summarized.

Chapter 3 is on Demographics of Hearing loss in developing countries written by Andrew Smith of London School of Hygiene and Tropical Health. This provides a world view on burden of hearing impairment. Accordingly 278 million people across the world are affected by hearing loss and hearing impairment ranks 3rd according to Years Lived with Disability (YLD) by individuals, which is a component of Global Burden of Disease. Included in this chapter are WHO estimates of HI in various countries, methods used for estimation, difficulties encountered in estimation, role of practicing Audiologist and researchers in audiology. On the whole this chapter presents a global view of hearing impairment though quoted studies from India are limited to only 3. Thus graduate students in Speech and Hearing in India gain valuable information on demography and other issues as required to be discussed in their course work on “community based professional practices”, even though information on prevalence across countries is very limited.

Chapter 4, Education and Practice of Audiology Internationally: Affordable and sustainable education models for developing countries by Helen Goulios and Robert Patuzzi enlists need of audiologists at different levels in various set ups, tries to work out a world wide requirement of Audiology professionals and personnel by gathered information on available training programs from certificate, diploma, degree, post graduate and doctoral levels. Provide their own model for training and recommend that a strong alliance with in and between countries involving governments, private industries, educational institutions, professional bodies and wherever possible consumer organizations must be considered. Not much is reflected on audiology training in India.

Chapter 5 on Screening for Hearing loss in developing countries is written by Bradley McPherson and Bolajoko O. Olusanya of Department of Community Health and Primary Care, University of Lagos, Nigeria. In this chapter, the importance and need for hearing screening as a priority component of primary health care/screening is stressed and recommended that all governments should promote this. They discuss the basic requirements for infant and other hearing programs especially in situations where limited financial and technical personnel & resources are available. Importance of School based hearing screening specially at entry points in countries where a significant proportion of births occur outside regular hospital facilities are stressed. Most of what is discussed in this chapter is part of curriculum of

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courses in speech and hearing in India and thus should interest the reader.

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Chapter 6 on Providing Diagnostic audiology services in Economically challenged regions is by Jackie, L. Clark and Valerie Newton, from University of Texas at Dallas, USA and University of Manchester, UK respectively. They discuss the limited facilities that may be available in developing economically challenged countries for audiology assessment and diagnosis and further on problem faced by them in terms of absence or limited facilities for calibration and/or repair of diagnostic equipment. To overcome above problems the authors recommend certain steps to be strictly followed by professionals. Also high light WHO recommended guidelines on awareness creation in the community and on training of supportive staff. Nothing new will be gained from this chapter for a trained professional in audiology.

Chapter 7 is on Rehabilitation of Hearing Loss: Challenges and Opportunities in developing countries by Ron Brouillette, Director of primary and mass education, Dhaka, Bangladesh. It provides information on innovative aural rehabilitation alternatives to meet hearing health care as used in 149 lower and lower middle income group nations following the guidelines of WHO. Anecdotal information gathered from different countries is discussed.

Chapter 8 on Hearing Aid Provision in Developing Countries: An Indian case study, written by Vijayalakshmi Basavaraj, Director: All India Institute of Speech and Hearing, Mysore, India, makes a very good and interested reading on provision of hearing aid and its development in the country. Further the chapter depicts contribution of various agencies like Government, institutions, industries and professionals in the development and building of a viable and largely sustained hearing aid distribution facility in India. The author has rightly pointed to the paucity of systematic demographic information on Hearing impairment in the Indian population and that the existing facilities to cater to this large number of population with hearing impairment in the country is limited. Existing infrastructure of 2 national institutes with their branches, 150 Government aided organizations, 5000 and odd private clinics, 130 DDRc’s, 5 CRC’s and 270 medical colleges have been sited as having audiological diagnostic and rehabilitative facilities. Majority of the available facilities are in cities. The manpower and professional development in the country has been slow and gradual, starting from two institutions in 1967 till mid 80 have there were hardly any private or voluntary agencies involved in speech and hearing training. Now there are 30 institutions accredited and listed by RCI as providing Speech and hearing training at graduate or post graduate levels. The author has explained at length the efforts of AIISH on providing distance mode education at DHLS level at various remote places with the help of virtual classes and study centers as addition to existing training programs at graduate, PG and doctoral levels. However, the author is mostly silent on details of teacher training programs and the role of NGO organizations involved in training and other activities like creation of awareness in community on education of the HI, etc. Under the section on status of hearing aid provision in India, the author explains at length the distribution of hearing aid under Government schemes. She estimates that 100,000 to 125,000 hearing aids as being manufactured in India and about 50 to 60,000 hearing aids are said to be imported from other countries as against an the requirement of about 30 million persons with hearing impairment. Thus there is a huge gap in the need and availability of aids. A detailed account of past and present scenario specially after 1980’s is presented and discussed. The author estimate the cost of hearing aid in India to vary between Rs 500 to 10,000 (10 to 250 $) & Rs 2500 to 80,000 (US $ 50 to 1600) for BTE’s depending upon whether they are Digital or analog Aids. Mention on availability of hearing aid at subsidized rate at Alish and free & subsidized hearing aid distribution system through many Government and voluntary agencies under ADIP scheme has been explained. Further it comes out clearly while discussing prescription of hearing aids that probably audiologists are not the first but last professional to...
be contacted in prescription and dispensing of the aids. Depending upon the set up procedure of prescription varies and by and large procedure followed for prescription is not satisfactory. Quite a lot of information on batteries for hearing aids, ADIP scheme implementing agencies, has been provided. A separate section on ear moulds and facilities to promote use and maintenance of hearing aids is provided. Some information on assistive listening devices has also been included. Some recent developments regarding National Program of Prevention and Control of Deafness (NPPCD) and other Government initiatives are discussed. By and large the author has succeeded in presenting an objective picture of facilities available and their limitations for provision of hearing aid to individuals with hearing impaired in India. However, it would have been apt to have included role of NGO institutions in a wider perspective, specially in reaching rehabilitation to rural people at primary levels. This chapter should make the reader know the difficulties encountered in audiology practices in developing countries and this book can be recommended as one of the texts for paper on Community based professional practices of BASLP course in India.

Chapter 9 is on Educational Audiology in Developing Countries written by Susie Miles and Wendy McCracken of University of Manchester, UK. Explains how schools for the children with hearing impairment having audiology services can help in providing hearing aid guidance to children with HI in the absence of audiology clinics. School based audiology service can take care of hearing health care and hearing assessment services effectively. Authors recommend educational and school based audioligic facility as alternate to clinical facility wherever they are not available. The chapter discusses the challenges faced in setting up such facilities in schools as gathered from a range of audiology practitioners in developing countries.

Chapter 10 on Audiological Counseling in developing countries: A journey through Guatemala is written by Patricia Castellanos de Munoz and Sandra E. Sosa, Guatemala. The authors explain the progress made despite sever restriction of finance, lack of encouragements and potential obstacles, proactive measures taken, some amount of success in providing cultural sensitive family counseling and improved healthcare facilities to persons with hearing problems in Guatemala. The description depicts some resemblance to the Indian scenario.

Chapter 11 on Occupational Hearing Loss in developing Countries, authored by Geoffrey K. Amedofu and Adrian Fuente from Ghana and Chile makes an interesting reading on noise and its effects on health specially sensorineural hearing loss. Noise is also recognized to be a preventable cause. Studies have shown that industrialization not only brings noise but also chemicals and other pollutants/solvents as causative agents of hearing loss. Exposure to solvents such as toluene, xylene, styrene and n-hexane are expected to be very high in developing countries due to laxity of control in industrial work place. This accompanied by exposure to noise will have the combined effect of increased chances of hearing loss and found to be higher than in the developed countries. Similarly the authors note that there is large scale and uncontrolled use of pesticides, herbicides, insecticides for agriculture purposes in developing countries which are also known to have effect on nervous and auditory systems. Thus this chapter which discusses thread bear issues related to occupational hearing loss become very meaningful in Indian context as industrial pollution, environmental pollution and recycling of industrial waste and world scrap in India have all increased substantially the chances of workers to develop occupational hearing loss. Thus this chapter makes a good reading for graduate students.

Chapter 12 on Resources for Audiologists in Developing Countries written by the editors give a list of sources from where practicing audiologists and interested readers can access information and help on hearing loss and also funding information.

This book on Audiology in developing countries is a very useful source for information on audiological practice and other issues like diagnosis and assessment, school based audiological services, hearing screening and occupational hearing loss, Noise control and hearing conservation. This is recommended for all libraries and institutions conducting training courses in the area of speech and hearing.

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CLINICAL AUDIOVESTIBULOMETRY FOR OTOLOGISTS AND NEUROLOGISTS (4TH EDITION)

*Dr. Anirban Biswas

Published by: Bhalani Publishing House
Mumbai

The first edition of this book came in print almost 2 decades ago and is one of the various publications from the prolific pen of Dr. Anirban Biswas. Dr. Biswas's reputation in the field of Neuro-otology remains unparalleled in South-East Asia, and indeed his writings have become the standard and preferred texts in the subject of Neuro-otology. The current edition is the fourth edition of an established book and seeks to supplement itself with the recent developments in the subspecialty since the last edition in 2002.

The book is an easy read on a difficult and challenging subject which unfortunately is made even more challenging to most professionals in otology and neurology because of the lack of many comprehensive and contemporary texts on the subject. The subject is presented from the standpoint of a medical practitioner and covers a fair amount of the relevant basic sciences of physics, audiology, otology and neurology which are essential to the understanding of the subject. These are presented not as dry, stand-alone chapters, but are integrated into the text with the relevant sections so as to hold the reader's interest and to provide the reader with the theoretical basis for the clinical tests and their applications. The author's facility with words ensures that even difficult concepts are presented in a facile and easy to comprehend manner.

The book covers two distinct aspects- one of audiological assessment and another of vestibular assessment. The focus is primarily on a detailed description of how to do each test followed by a discussion on the interpretation of each finding. Practical difficulties encountered, and tips and nuggets for each procedure are suggested amidst the text, and testify to the author's practical experience in undertaking each of the described tests. The entire gamut of available tests is covered in a comprehensive way. The audiological testing procedures covered include pure tone audiometry, tympanometry, behavioral audiological testing, speech audiometry, tests for central deafness, evoked response audiometry, auditory steady state response testing, evoked response audiometry and assessment of a deaf child. The vestibular tests covered include a very detailed and comprehensive discussion on Electronst agmography, and further descriptions on the battery of vestibulo-spinal tests inclusive of cranio-corpography and posturography and the recently made available test of vestibular evoked myogenic potentials (VEMP). An additional section presents an overview of the available test battery and tries to place into perspective the benefits and limitations of each test in the overall assessment of the dizzy patient.

The audiological community would certainly have encountered more comprehensive texts on the subject of audiological testing. This particular book however stands out in presenting all the requisite, relevant and practical information in a concise and readable form, and in detailing the perspective of the clinicians who may order these tests. Audiologists shall also greatly enjoy going through the very balanced section on vestibular testing. The book as suggested in the title- is however aimed primarily at otologists and neurologists; and to this group of professionals it comes across as a comprehensive text which covers its subject in a complete and inclusive manner such that no reference to any other text is deemed necessary.

Excepting for the excellent section on electro-nystagmography authored by Professor M V Kirtane who pioneered this technique, all other sections have been written up by Dr. Anirban Biswas. The single author nature of the book has advantages as it avoids repetition. The book is well indexed and the index section allows for quick references to any topic. The index also allows for the busy clinician to nevertheless make full use of the contents by short and comprehensive reads.
I personally have enjoyed previous editions of this textbook. It occupies a permanent place on my bookshelf and is often thumbed through. The current edition has further additional sections including but not limited to the ASSR, Video-Nystagmography, and Genetic testing for hearing loss. This new edition shall continue to provide me with a guide to the subject which is both useful and enjoyable, and a quick reference for some of the complexities of audiology and vestibulometry.

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INTRODUCTION

Handling children during their early years continues to challenge caregivers across all countries. Earlier notions viewed children as miniature adults. It was thought that they required no special understanding or treatments during their growth or development. They could be pushed, pulled, punished or reared in any way so long as they got shaped into responsible adults. These ancient notions on child psychology are now challenged and changed. Children are now viewed on a life cycle approach as passing through early developmental stages characterized by unique needs, abilities, progressive tasks, critical events and age graded activities. Many times the completion of activities at a lower level is seen as mandatory to successfully negotiate next oncoming ones.

Based on the above preamble, and guided by a strong understanding that very young children require functional, informal, play based, activity oriented and individualized education in place of formal, classroom based, didactic, curriculum based teaching; several proponents have carved guidelines, programs, packages or modules on these lines. Examples are the Headstart Preschool Program (2008), Denver Preschool Program (2006), Colorado Preschool Program (2005), California State Preschool Program (2006), Perry Preschool Program (Schweinhart and Weikart, 1988), Home Preschool Program (1979), Abbot Preschool Program (2009), Kidcrafters Preschool Program (2006), Berry Best Preschool Program (2005), Wisconsin Model Early Learning Standards (2008), etc. The list can be endless. There are also such programs tailored for children with special needs.

THE PORTAGE GUIDE

The Portage Guide to Early Education (originally started as a demonstration project funded by the U.S. Department of Education in 1969) was pioneered as a home based parent empowering developmental stimulation program. David E. Shearer was in the Chair along with several associates at that time for the program. Since then, the Portage Guide has undergone several reviews and re-revisions until its last and latest electronic version made available in 2003. The kit covers developmental areas: communication/language/literacy, social emotional development, exploration approaches to learning, purposeful motor activity, and sensory organization.

The portage package includes training manuals and materials, family services and even online updates. These materials have now been translated and validated across several countries or cultures (Alan and Oakland, 2001; Cameron, 1997; Oakland, 1997; Sturmet et al, 1992; Thorburn, 1992).

INDIAN SCENE


Not withstanding all of this, the presently 'authored' book tabled as an official document of the CBR Network (South Asia) is simply a reprint of the original and international 'Portage Guide' already available in the international market. The book can
be commended, if at all, for the low cost print; and probably, for being made available at an affordable yet not printed price to the poor Indian rural masses. However, unfortunately, the copyright details are blatantly missing in the usual third page details of the book.

Another positive feature of this book, unlike its original clone from the Portage Team of 1992, is the addition of low cost black and white photographs with seemingly half visible south Indian mothers and their children in this edition. Wherever, for certain activities, no matching photographs were probably available; the publishers have opted for drawings by black Indian ink. However, there are also many pages without illustrations.

The behavioral domains and individual items under them are exact replicas of the original portage. At least, the authors could have modified items to make them appropriate for the local culture and practice. It makes no sense to expect a typical rural Indian child to 'reach or operate spoons, knives or forks', 'put on zipped shoes, boots and zippers', or 'scooping with fork', 'puts on mittens', 'using knife for spreading soft topping on toast', 'preparing own sandwich', etc. If this version is to be credited as an appropriate cultural adaptation, the only common sense window dressing changes that have been made are related to changing a 'penny, nickel or dime' to 'two rupee, one rupee and fifty paise coins'. This is also in spite of the fact that even the last currency is currently out of circulation! A card-by-card comparison of contents between the original Portage and those printed in the book under review shows several goof-ups. For example, item C-104 has swapped place with item C-105. It is not clear whether such changes are intentional or unintended.

On the whole and in short, the whole exercise of publishing this book is to be taken as a low cost paper back cheaper edition of a monumental and copyrighted original work already carried out in the west several decades ago.

References


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Greeting from AIISH, Mysore! Wish you a very happy & fruitful 2011!!

The Journal of All India Institute of Speech and Hearing (JAIISH) which was resumed as an indexed journal with the ISSN No. 0973-662X in the year 2007 is publishing its annual volumes regularly. E-format of the Journal is also accessible in the portal http://aiish.ac.in directly or through the AIISH website www.aiishmysore.in.

There was overwhelming response in terms of the number of papers submitted for publication this year. In view of this, hereafter, each volume of Journal of AIISH will be brought out biannually as two numbers. Vol. 29, No.1 was released on 9th August 2010. I am happy to put before you No.2 of the 29th Volume of Journal of AIISH for the year 2010.

The present volume has certain special features. The authors/editors of three books consented for publication of the review of their book in JAIISH. Three book reviews have been included in this volume namely: Audiology in Developing Countries edited by Mc Pherson, B., Brouillette, R; Portage Guide to Early Childhood Education edited by Indumathi Rao, CBR Network (South Asia) and Clinical Audio-Vestibulometry for Otologists and Neurologists (IV Edition) by Anirban Biswas. These are published in the first number of this Volume. Our sincere thanks to them for consenting to offer their books for review. The book review section was started in the year 2009 with the intention of sharing information regarding the published books, particularly in India, for the benefit of the readers. The eminent reviewers of the books namely Dr. M. N. Nagaraja, Dr. S. Venkatesan, and Dr. Alok Thakar are sincerely acknowledged for providing their valuable opinion regarding the book. Vol. 29, No.1 also carried a write up by Dr. Prathibha Karanth titled "Women in Science". This is the plenary address she delivered on the theme of "Speech Language Hearing Sciences and Disorder" at the Second National Women’s Science Congress hosted by the All India Institute of Speech and Hearing in November 2009.

The present Volume 29 (2) has 13 articles in the area of Speech and Language; 4 in the area of Hearing; one in the area of Special Education and one paper regarding the process evaluation of the much talked about DHLS program. The articles under the Speech Language section cover a wide range of topics. It has a couple of articles on much published topics under stuttering, speech rhythm and voice. It also has some interesting articles on acoustic patterns in honey bees; phonological similarity effect; vocabulary development and memory; swallowing disorders; TBI and high risk factors for Learning disability. These articles indicate the new domains of research our Speech Language Pathologists are exploring which is very encouraging. These are the proactive steps taken in to contributing to Speech Language Sciences not restricting themselves only to the areas of speech language disorders. The contribution to Speech Language Sciences will be even better if we start working with a multidisciplinary team.

The section on hearing has two articles on speech evoked ABR which is a potential area to understand the contribution of Auditory brain stem in speech processing and perception. With the medical fraternity depending on MRI for quite a few types diagnosis, the article on the side effects (of noise) of MRI is a welcome research. The steadily prospering India has made the life expectancy longer. In this context, a report on presbyacusis in India is useful. The lone article in the area of special education deals with the academic issues of children with hearing impairment.

The initiation of the quasi distance mode Diploma in Hearing Language and Speech (DHLS) with 12
The study centers across the country in the year 2007-08 onwards has drawn a lot of attention and discussion amongst the speech and hearing fraternity in India. All of us are rightly concerned about the quality of education / training imparted through this novel strategy adopted for manpower development. We are also interested in knowing whether the program meets its objectives. The article on process evaluation of DHLS program reports the pilot data on this issue. I would request the readers to go through this article and give their feedback / suggestions to improve on this program. JAIISH is thus providing a professional platform to express opinion, criticism and give suggestions by all concerned. This endeavor, I believe, will show ways to promote ethical professional practices amongst us.

It is proposed to include a new section on "case reports" in the forthcoming volumes. It is proposed that a case report each in the area of Speech, Language, Hearing and one in the area of other related topics be chosen for publication. Students are encouraged to prepare the case reports based on their presentations, along with their guides, made at their in house clinical conferences conducted as a part of their training program. I look forward to your feedback and suggestions on this.

The 19 articles included in this volume were reviewed by 5 guest editorial members apart from the designated editorial members of the journal. Their contribution is sincerely acknowledged. Our appreciation to all the members of the Editorial Board for meeting our deadlines in reviewing the articles. Ms. K. Yeshoda, Lecturer in Speech Sciences who is the Coordinator for the journal has put in a lot of effort getting this publication through and this is sincerely appreciated and acknowledged.

I look forward to your continued support in contributing your valuable research publications in the Journal of All India Institute of Speech and Hearing. You may please email your suggestions regarding improving the standard of the journal to director@aiishmysore.in

Dr. Vijayalakshmi Basavaraj
Director & Chief Editor
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AGE AND GENDER DIFFERENCES IN PERSONS WITH STUTTERING

*Nisha Sudhi, **Merin John, ***Y.V Geetha

Abstract

Gender difference in stuttering is a much talked debated issue. A lot of studies have been done on this, mostly in the western countries. Stuttering is not only reported to be less common in females compared to males, with a 1:4 ratio, but its onset, development and recovery characteristics are more in favour of females. The present study is aimed to explore the similarities and differences in nature of disfluencies, if any, in male and female persons with stuttering, across the age groups in the Indian context. A retrospective analysis of 132 case files of all clients registered with the complaint of stuttering over a period of 6 months was made. The data was analyzed in terms of age of onset, nature and type of onset, associated problems and etiology of stuttering, across the gender and age groups. Across gender, significant differences have been obtained in most of the parameters under study and across the age and within gender too significant findings have been observed. The study confirms many of the earlier findings by other authors with regard to gender differences in stuttering. Female PWS are different in the onset, nature, development, severity characteristics of stuttering compared to male PWS.

Key words: Stuttering, nature of disfluencies, gender difference

Stuttering is a disorder of fluency, onset of which in majority of the individuals is in the preschool years. Despite decades of research it has evaded the researchers in understanding its onset, development, nature and management issues. Gender difference in stuttering has provoked the interests of many researchers but conflicts still exist regarding the differences in them. A look into the gender ratio in stuttering thoroughly documents an unequal sex distribution. Stuttering has been indicated as a male predominate disorder time and again in the literature. Early reports indicated that stuttering takes place more often in boys than girls (Blanton, 1916; Milisen & Johnson, 1936). Further research into this ratio was carried out. Yairi and Ambrose (1992) reported the male to female ratio to be 2.1:1. More recently, Van Borsel, Moeyart, Mostaert, Rossel, Loo and Renterghem (2006), in agreement with past studies reported stuttering prevalence to be higher in males than females. The tendency for stuttering prevalence to decrease with increasing age was confirmed too. The ratio is almost 4:1 in older children and adults as reported by many. This indicates that many female children recover while male children persist in stuttering. Many different aspects of the nature of disfluencies and the association with the gender reveal substantial information.

The onset of stuttering in males and females has been widely investigated and there are several contradictory evidences. Andrews, Craig, Feyer, Hoddinott, Howie and Neilson (1983) reported the age of onset to be same across gender and did not consider that males have an earlier age of onset of stuttering than females. However, more recent data indicate that girls begin to stutter a little earlier. Manssson (2000) in a study of incidence and development of stuttering reported that boys tended to have later onsets than girls (34 months for boys and 31 months for girls).

Research into the nature and development of stuttering in boys and girls reveals significant findings too. Historically, development of stuttering problems were typically reported to be a gradual process with easier more variable forms of stuttering followed by increasing fragmentation and tension. More recent reports (Yairi, Ambrose & Nierman, 1993) however,

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suggest that a significant number of preschool children exhibit a sudden onset of moderate to severe stuttering. Buck, Lees and Cook (2002) found that 53 percent of their cases had onsets reported as sudden. Yairi, and Ambrose, (2003) reported that 41% of the preschool age children had sudden onset (1-3 days), 32% intermediate onset (1-2 weeks) and the remaining 27% of the children were reported to have a gradual onset of stuttering.

One consistent finding in the literature on stuttering is that a small but significant percentage of children who stutter exhibit concomitant speech/language disorders in addition to their stuttering. Children who stutter typically achieve lower scores than their peers on measures of receptive vocabulary, the age of speech and language onset, MLU and receptive and expressive syntax. Few studies have explored the difference in terms of gender also. Healey and Reid (2003) noted that an increasingly large number of children who stutter are being diagnosed with attention deficit hyperactivity disorder (ADHD). Also, boys are classified four times more emotionally disturbed than girls (Stout & Conoley, 1992).

The question of why there is a sex ratio in stuttering has been subject to almost as varied speculation as the cause of stuttering itself. In the past, the difference in incidence between males and females was explained in a number of different ways including cultural differences in child rearing practices, (Johnson 1955), different societal stress levels on boys and girls etc. Later theories tried to explain the disparity in sex ratio in stuttering based on biological and genetic differences between the sexes. Geschwind and Galaburda (1985) considered that sex ratio in stuttering is due to higher levels of testosterone in the male foetus than in the female. Testosterone retards the development of the left cerebral hemisphere, thus increasing the risk of speech and language disturbances including stuttering. Recent neuro-imaging studies have shown increased bilateral speech and language representation in females compared to males. The males are more likely to have a strong left hemisphere lateralization for speech and language (Shaywitz et al., 1995).

According to Kidd, Kidd and Records (1978) and Kidd (1983, 1984), stuttering genotypes are expressed as different susceptibilities based on sex. As the 'stuttering threshold' is hypothesized to be higher for females, it is assumed that more precipitating (genetic or environmental) factors that contribute to stuttering would have to be present for females to cross the threshold and manifest the disorder. Regarding the family history of stuttering, Andrews and Harris (1964) found that female probands have a higher frequency of affected relatives of both sexes than do the male probands. Kidd’s (1984) study showed there was the highest risk for male relatives of females who stutter. However the data by Yairi and Ambrose (1996) indicated that the highest risk is for male relatives of males who stutter. More recently, Gupta (2001) reported that females had higher percentage of affected relatives than males. Anjana (2004) found that the first degree relatives have a higher percent of stuttering compared to second degree relatives.

**Need for the study**

There is a lot of debate about the onset, nature, development, type, associated problems and cause of stuttering in males and females with stuttering. Valuable opinion is available in scattered texts but these available information need to be compiled and a comprehensive comparison is necessary to give a better picture of the differences, if any, in the nature of disfluencies in them. This in turn may help in understanding their problems in a better way, finding out the prognosis and help in early intervention and serve better in treating the males and females persons with stuttering (PWS). The outlook towards the females with stuttering, their characteristics and needs can be understood better. In addition, most of the studies regarding gender and stuttering have been conducted in the Western countries and such intensive studies have not been conducted in India. Further investigation into the cause of the condition will also be possible.

**Aims of the study**

1. The present study aims at finding out the difference in nature of disfluencies if any in males and females with stuttering with regard to:
   - The age and nature of onset, development of stuttering
   - The severity of stuttering
   - The associated problems if any
   - The etiological factors if any in terms of family history/genetic factors, etc.
2. To compare the results obtained across age groups in each gender.

**Method**

**Subjects**

132 case files of PWS registered over a period of six months (from March to August 2009) at the All India Institute of Speech and Hearing were reviewed. 132 PWS were classified into four groups based on age and gender. Case files of 57 adult males, 46 male children, 10 adult females and 19 female children were considered for the study (see Table 1).

**Procedure**

The retrospective design was used in the present study. A total number of 132 case files of individuals who were registered with a complaint of stuttering were reviewed. They were evaluated by qualified professionals who consisted of speech language pathologists and psychologists. The case files with complete fluency evaluations were considered for the present study. Table 1 depicts the details of the subjects considered for the present study.

Parameters, namely the age and nature of onset, development of stuttering, severity, associated problems and the etiological factors were closely addressed, across age and gender.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children (0-12 years)</td>
<td>46</td>
<td>19</td>
<td>65</td>
</tr>
<tr>
<td>Adults (12 years and above)</td>
<td>57</td>
<td>10</td>
<td>67</td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>29</td>
<td>132</td>
</tr>
</tbody>
</table>

Table 1: Details of the subjects selected for the study

**Results**

The purpose of the study was to evaluate the similarities and differences in the nature of disfluencies if any in males and females and to compare it across adults and children within the same gender. The results have been described under each category.

**a) Age of onset of stuttering**

The data collected were grouped into 5 age groups, 3 years and below, 3.1 to 5, 5.1 to 10, and 10.1 to 20 and above 20 years for the analysis of age and onset, based on the information in the literature with regard to nature of onset. The results are shown in Table 2.

In terms of age of onset of stuttering, females were found to have an earlier age of onset (3.1-5 years) compared to males who had later onset of stuttering (5.1-10 years). This is in agreement with the literature which suggests early onset and recovery for females. Further, male to female ratio in the study is around 3:1 which is slightly higher probably because of inclusion of more children in the younger group.

**b) Nature and development of stuttering**

The nature of onset was categorized into two types as sudden and gradual onset. Sudden onset included all responses that fell into one of three subcategories describing onset to occur within 1 day, 2-3 days and 1 week. Gradual onset included responses that fell into one of three subcategories describing onset to occur within 2 weeks, 3-4 weeks and more than 5 weeks. The current status of the condition was classified as progressive, static and regressive in nature. Graph 1 shows the nature of onset and Graph 2 depicts current status of the condition.

With regard to the nature and development of stuttering, females were found to have a sudden onset which was progressive in nature in most whereas in few of the females it was of a static nature. Males were found to have more gradual onset of stuttering which was progressive in 33%, static in 12% and regressive in very few (2%). Both male and female CWS were found to have a progressive nature of stuttering compared to adult male and female PWS.

Based on the data available, and as depicted in Table 3, associated problems were divided into persons having Learning Disability (LD), Mental
AF - adult female, AM - adult male, CF - child female, CM - child male

Graph 1: Nature of onset of stuttering across age and gender groups

Graph 2: Current status of the condition across age and gender groups

c) Associated problems

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>LD (%)</th>
<th>MR (%)</th>
<th>MA (%)</th>
<th>Structural (%)</th>
<th>DSL (%)</th>
<th>Medical (%)</th>
<th>Nil (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td>F</td>
<td>3 (30)</td>
<td>1 (10)</td>
<td>0 (0)</td>
<td>2 (20)</td>
<td>1 (10)</td>
<td>0 (0)</td>
<td>3 (30)</td>
<td>10</td>
</tr>
<tr>
<td>Adult</td>
<td>M</td>
<td>2 (3.57)</td>
<td>0 (0)</td>
<td>2 (3.57)</td>
<td>2 (3.57)</td>
<td>2 (3.57)</td>
<td>2 (3.57)</td>
<td>47 (82.45)</td>
<td>57</td>
</tr>
<tr>
<td>Child</td>
<td>F</td>
<td>0 (0)</td>
<td>1 (5.26)</td>
<td>0 (0)</td>
<td>1 (5.26)</td>
<td>1 (5.26)</td>
<td>16 (84.2%)</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Child</td>
<td>M</td>
<td>5 (10.86)</td>
<td>3 (6.52)</td>
<td>5 (10.86)</td>
<td>5 (10.86)</td>
<td>4 (8.69)</td>
<td>22 (47.82)</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>

LD - Learning Disability; MR - Mental Retardation; MA - Misarticulation; DSL - Delayed Speech & Language

Table 3: Associated problems with stuttering across gender

problems like head injury, accidents etc. The occurrence of most of the associated problems with stuttering was found to be greater in females.

In females, adults had more history of learning disability, mental retardation, structural defects and delayed speech and language problems, whereas, in males, children had history of learning disability, mental retardation, misarticulation, structural deficits,
speech and language delay and medical problems. Therefore, the associated problems were reported more in adult females with stuttering whereas the opposite was observed in male children with stuttering.

(d) Severity of stuttering

Based on the scores and classification on Stuttering Severity Index (SSI), persons with stuttering have been grouped under the categories of very mild, mild, moderate, severe and very severe. The results are shown in Graph 3.

The graph clearly shows that in the category of severe and moderate stuttering, males outnumber females, whereas, in very mild, mild, very severe and Normal Nonfluency condition it is females who are more in number. Most of the female children with stuttering were found to be categorized under the mild degree of severity. Adult females with stuttering were categorized almost equally under all levels of severity.

In males most of the adults were categorized under moderate and severe stuttering, with one very severe adult case reported. 26% of both adults and children were categorized under mild category. There were six children who were diagnosed as NNF.

Majority of female CWS were categorized under mild severity of stuttering compared to adult females. Adult females with stuttering were categorized almost equally under all levels of severity. The severity of stuttering was found to be more in adult males compared to male children with stuttering.

e) Causative factors

From the case history collected, the reported causes have been grouped into 3 main categories namely, family history/genetics, environmental and others as shown in Table 4. Family history has been further divided into maternal and paternal, and then again sub divided into first degree and second degree. Mother, father and siblings belong to first degree and other paternal and maternal relatives belong to second degree. The environmental causes include history of contact with another person with stuttering. The others category include stuttering caused due to fear, pressure at home, change in language, change in place etc.

Regarding the etiological factors, in both male and female PWS, family history of stuttering seem to rule over the other probable etiologies of stuttering, with females showing a stronger genetic basis of stuttering. From table 5, it may be seen that females had more maternal and paternal 1st degree relatives who stuttered compared to male PWS.

Results indicate that 90% of adult females presented with a family history/genetic etiology and 42% of female children with stuttering had reported to have genetic causes. Two female children had contact with PWS and 3 each in both adults and children group were reported to have other causes like change of place, fear etc. In males around 52% of children reported to have genetic cause. Six adults and four children had contact with stutterer.

Discussion

This study was an exploration into the age and gender differences in PWS. Male and female PWS were compared in terms of important parameters such as age of onset of stuttering, the nature and development of stuttering, the causal factors behind the condition, the severity levels and the associated problems with the condition. The results obtained are in support of earlier studies published in western literature.

Considering the age of onset of stuttering, Yairi & Ambrose (1992) had reported that the onset of stuttering in males is 40.56 months and in females it is 34.21 months. The present study too supports the findings that females had an earlier age of onset compared to males. This finding could be accounted to the fact that more females than males spontaneously recover. Geschwind and Galaburda (1985) have suggested that young male speakers may have greater difficulty in achieving or maintaining fluency. Boys may be less able to adapt to communicative stress than their female counterparts. The speech language development of girls is also earlier when compared with boys. It has been well established now that during the period of acquiring speech and language, the disfluencies tend to occur.

Exploring deeper into this area, there is a sex related genetic influence too that can account for this. Yairi and Ambrose (1999) in their study have found that young females who stutter are much less likely to persist in stuttering than young males. This phenomenon suggests that males are more likely to continue to stutter than females.
Moreover, etiological factors leading to the condition has received much attention. During the past few decades, the research conducted in this area has revealed a strong genetic component in PWS. Andrews and Harris (1964) found that female probands have a higher frequency of affected relatives of both sexes than do the male probands. The present study too supports these findings. The chance of getting stuttering is more for a female child with male relatives with stuttering. This is especially true in relatives of the first degree.

Stuttering has also been reported to be progressive or increasing in its development across age and gender. This progressive nature was more in children compared to adults wherein female CWS reporting this more than male CWS. Females reported more of a progressive development than males.

Significant differences across the gender have also been reported in terms of associated problems with stuttering. Blood, Ridenour, Qualls, and Hammer (2003), in their study found that children with learning disability made up to 15% of their large sample of children who stuttered. The present study too reports similar findings. Learning related problems are seen most associated with stuttering across age and gender, with females exhibiting a greater percentage of the same. The occurrence of most of the associated problems with stuttering, were found to be greater in females.

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>Genetics</th>
<th>Environmental</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td>F</td>
<td>9 (90%)</td>
<td>0 (0%)</td>
<td>3 (30%)</td>
</tr>
<tr>
<td>Child</td>
<td>F</td>
<td>8 (42.10%)</td>
<td>2 (10.52%)</td>
<td>3 (15.7%)</td>
</tr>
<tr>
<td>Adult</td>
<td>M</td>
<td>15 (26.31%)</td>
<td>6 (10.52%)</td>
<td>5 (8.7%)</td>
</tr>
<tr>
<td>Child</td>
<td>M</td>
<td>24 (52.17%)</td>
<td>4 (8.69%)</td>
<td>4 (8.69%)</td>
</tr>
</tbody>
</table>

Table 4: Causative factors across age and gender groups

<table>
<thead>
<tr>
<th>Gender</th>
<th>1st degree</th>
<th>2nd degree</th>
<th>1st degree</th>
<th>2nd degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>16 15.53%</td>
<td>19 18.40%</td>
<td>6 5.84%</td>
<td>11 10.67%</td>
</tr>
<tr>
<td>Female</td>
<td>7 24.13%</td>
<td>4 13.79%</td>
<td>3 10.34%</td>
<td>3 10.34%</td>
</tr>
</tbody>
</table>

Table 5: Proximity of relationship in paternal and maternal sides under genetic factor
Summary and Conclusions

This study is aimed to explore the similarities and differences in nature of disfluencies, if any, in male and female persons with stuttering. It is also aimed to compare the nature of disfluencies across the age and gender groups. The review of the case files of 132 PWS, gender difference in stuttering was done. The study confirms many of the earlier findings by other authors with regard to gender differences in stuttering. Female PWS are different in the onset, nature, development, severity characteristics of stuttering compared to male PWS.

References


Acknowledgements

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ANALYSIS OF ACOUSTIC PATTERNS IN HONEY BEES- AN INVESTIGATION

*Bijoyaa Mohapatra, **Nisha Sudhi, ***Liveem M. Tharakan, ****Sri Pallavi M., *****Anil Kumar & ******Yeshoda K.

Abstract

‘Communication’ is believed to be the exchange of information between two partners. The broad field of animal communication encompasses most of the issues in ethology. Honey bee communication has been of special interest to ethologists. The purpose of this study is to determine the acoustic characteristics of the honey bees buzz in a species of Apis dorsata in natural and induced environmental conditions. The results revealed that change in the external conditions led to characteristic changes in the acoustic properties of the sounds produced by the honey bees. The mean fundamental frequency of bee buzz increased in the induced conditions compared to natural condition whereas amplitude variations were not consistent across conditions. These variations in communication patterns in honey bees across different conditions (pleasant or threatening situations) gives us good reason to call the communication pattern in honey bees as ‘language’.

Key words: Ethology, honey bee, communication

Every living being in this universe communicates as a quest for its survival. ‘Communication’ is believed to be the exchange of information between two partners. The Universal Communication Law as posited by Scudder (1980) rightly, states that, “All living entities, beings and creatures communicate”, i.e. all the living bodies in this universe communicate through sounds or movements, reactions to physical changes, verbal language or gestures, breath, etc. Thus, ‘communication’ proves as a means of survival.

Communication as of is not restricted to human beings only. All the information exchange between any living organism i.e. transmission of signals involving a sender and receiver-can be considered a form of communication. There is the broad field of animal communication, which encompasses most of the issues in ethology. ‘Zoosemiotics’, the study of animal communication, has played an important part in the development of ethology, sociobiology, and the study of animal cognition. Further, the ‘biocommunication theory’ investigates communicative processes within and among non-humans such as bacteria, animals, fungi and plants i.e. intraspecies or interspecies communication. These various kinds of animal communication are intended for agonistic interactions, territorial invading/ownership, alarm calls and/ or for metacommunications. Ethologists and sociobiologists have discretely analyzed animal communication in terms of their automatic responses to stimuli, ignoring the fact whether the animals concerned, understand the meaning of the signals they emit and receive.

Honey bee communication has been of special interest to ethologists, in particular the apiologists.

A honeybee colony is a marvelously compact community of around 50,000 individuals, its members are highly social and cannot survive without constant intercommunication, and the more one looks into their methods of conversation, the more remarkable they are found to be. Unlike human voice production, the bee does not have any structures as vocal cords to produce sound. In fact, there have been various postulations regarding the origin of the production of

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sound in the honey bees. The fact that bees make sound by ejecting air through their spiracles is refuted by various experiments. The more pronounced possibility of the bee sound is the wing-vibration theory that is put forth which states that the vibration of the bees wings are responsible for the production and amplification. Both, sounds made by wing vibrations as well as the tail wagging, seem to be used to communicate distance and direction of feeding sites.

Bees communicate by performing dance patterns to direct their hive mates to a source of food. The dance pattern types performed by honey bees are the waggle dance and round dance. These vary based on the location (distance) of the food source, (Wenner, 1964). Further, it has been proved that they also transmit information by means of sound. The earliest work done on bee communication by Charles Butler (1609) has been registered in his book the “Feminine monarchy” where he describes two sound patterns produced by the bees. Huber (1972) named these sound patterns as the tooting (produced by the first/head queen bee) and the quacking (produced subsequently by the younger ones). Together these honeybee sounds are called as ‘queen piping’ (tooting and quacking) which are broadcast in the bee’s nest as vibrations of the combs. The temporal patterns and a frequency spectrum of these signals reveal that these are more or less pure tones at low frequencies equal to 400 Hertz. (Michelsen, Kirchner & Lindauer, 1986). These were produced by rapid contractions of the thoracic muscles, and transmitted directly to the substratum of the honey bee. Thus, the foraging bee’s communication to its fellows in the hive are made up of two elements: the dance patterns and the accompanying sounds.

An experiment by Wenner (1964) indicated a strong correlation between the rate of pulse production and the strength of the sugar concentration in a food source. It may turn out that the foraging bee’s entire message is carried by the sound signals. Broadbent (1962) in his article on “Attention and Perception of Speech” have compared the bee sound with that of human speech in terms of the varying emphasis and overlay of overtones in the sound produced by both. Nieh (1993) has even opined that human like stop sounds are also emitted by the tremble dances of honeybee which again forms a part of their communication system.

The review article by Kirchner (1993) traced the research works of different authors in the field of honey bee communication between 1774-1993. His work gives an account of communication patterns in honey bees, specifically among the members of the colony. It also explains the significance of sound signals in dance communication.

Various studies on bee buzz have revealed the fact that a bee’s buzz is not simply a noise rather it constitutes of modulations and variations. And the pattern varies based on the environmental conditions- when attacked by intruder, near a source of food, exposure to intoxicating fumes, inside the hive etc. When an individual bee is aroused to attack, its buzz rises in pitch and fluctuates in intensity. Even the sound produced by different species of bees has been noted to be different in its frequency and intensity. As well, the acoustic patterns of a queen honey bee will differ from that of younger bees or from that of a virgin queen bee (Wenner, 1964).

These very interesting information and facts motivated us to study the acoustic characteristics of the honey bees buzz in a species of Apis dorsata in natural and induced environmental conditions.

**Aims of the study**
1. To analyse the acoustic parameters of sounds produced by honey bees (Apis dorsata) in different conditions.
2. To compare the recordings of acoustic parameters obtained across different conditions (natural and experimental/ induced).

**Method**

**Species of bees included for the study: Apis dorsata**

The hive in one of the campus buildings which was closer to the lab in Speech Language Sciences department of the institute was chosen. The pictures of the hive with honey bees were sent to the Entomologist to ascertain the species of the bees. **Site:** The audio recording of the honey bees was made in a quiet condition close to the hive.
**Timings:** Recordings were done twice in a single day. Trial 1: between 12 am to 12:30 am, Trial 2: between 4:30 am to 5 am.

**Procedure**

**Conditions**

**Condition 1:** Natural condition- swarm of bees hovering near a light source (tube light)

**Condition-2:** Induced-environmental conditions-

(a) Swarm of bees when presented with concentrated sugar syrup.

(b) Swarm of bees disturbed when exposed to fumes from incense sticks.

**Audio Recordings:** Instrument used: Sony mini IC recorder (Sony Corp, China) Model No. ICD-UX71F. The audio recordings were obtained in the following two conditions:

**Condition 1:** The audio recordings of the bee buzz were done when a group of about 100 honey bees were gathered around a tube light (natural condition). Three recordings of 5 minutes each were obtained.

**Condition 2a:** Food / Concentrated sugar syrup was placed in a bowl at a distance of 2 meters from the swarm of bees. Three recordings of 5 minutes each was done after the bees settled. The microphone was positioned at a distance of 5cms from the swarm.

**Condition 2b:** Incense sticks were lighted close to the swarm of bees settled on the bowl of sugar syrup. The buzz of the swarm was immediately recorded when the bees began moving away from the bowl.

**Data Analysis**

The recorded samples were transferred onto the computer memory. Cool edit pro version 2.0 software was used to convert the MP3 files to wave files for further analysis. Real Time Pitch analysis software of CSL Model 4500 was used for acoustic analysis. The recorded samples were line fed into the CSL module with a sampling rate of 44100 Hz (16 bit resolution). Eleven acoustic parameters were extracted and they were as follows:

**Pitch parameters**

1. Mean fundamental frequency (MF0-Hz)
2. Minimum Frequency (Min-Hz)
3. Maximum Frequency (Max-Hz)
4. Standard Deviation of F0 (S.D of F0)
5. Variation Fundamental frequency (vF0)
6. Relative Amplitude Perturbation (RAP)

**Energy Parameters**

1. Mean Amplitude (Mean dB)
2. Minimum Amplitude (Min dB)
3. Maximum Amplitude (Max dB)
4. Standard Deviation of Amplitude (S.D of Amplitude)
5. Shimmer (Shim %)

**Results and Discussion**

The acoustic data obtained from the honey bees across various conditions were analyzed and extracted using Real Time Pitch Analysis and CSL 4500. Table 1 gives results based on the conditions.

1. **Natural Condition**

   The mean fundamental frequency in the natural condition when the swarm of bees started to hover around the light source was recorded to be 189 Hz with minimum and maximum varying from 125 to 334 Hz (SD of 92.69 Hz). The vF0 was found to be 0.41, and RAP 2.92. The mean energy of the buzz was 66.36 dB, with mean minimum and maximum mean varying from 62.95 to 70.77 (SD of 92.69 Hz). The mean shimmer value was 1.81dB.

2. **Induced Condition**

   2a) **Concentrated sugar syrup condition:** The buzz of the swarm when near the concentrated syrup was found to be 268 Hz, range varying between 200 to 393 Hz (SD of 64.38). The vF0 and RAP were found to be 0.23 and 0.91 respectively. The mean energy of the buzz was 69.88 dB, with minimum and maximum mean varying from 66.89 to 72.30 (SD of 1.81 dB). The mean shimmer was 1.60dB.

   2b) **Incense stick fumes condition:** In this condition, the mean F0 was 336.32, ranging from a minimum mean 302.05 to a maximum of 397.30Hz (SD of 37.14). vF0 was 0.11, RAP 4.41. The mean energy was found to be 63.32 dB. Minimum energy was 61.91 dB, with the maximum energy being 65.67 dB (SD of 1.20 dB). The mean shimmer value was 2.10 dB.

**Comparison across conditions**

**Natural Vs concentrated sugar syrup**

When conditions 1 & 2a were compared, it was
observed that for the frequency parameters, there was an increase in mean F0, mean minimum and mean maximum F0, but SD of F0 reduced in the induced condition (2a) compared to natural condition. vF0 and RAP also decreased in induced condition (2a). Among the energy parameters, there was an increase of mean energy, mean minimum and mean maximum energy in 2a condition. However, the SD and shim% values reduced in 2a compared to natural condition. The characteristic 'hum' of a swarm of bees is of low frequency, estimated to be having a basic frequency of 250 Hz and is often associated with overtones (Kirchner, 1993; Wenner, 1964). But in the present study the Mean F0 was lower in natural condition, and then increased when food source was located.

The range of fundamental frequency was highest in the natural condition (209 Hz), followed by 2a (193 Hz) and 2b (95 Hz). Location of food resulted in an increase in the Mean F0 in 2a when compared to natural condition. Even in human voices, emotions like fear and anxiety may increase the habitual frequency of voice. The disturbance in honey bee has been manifested in the form of an increase in frequency and slight increase in loudness (from 66 to 69 dB), probably due to the enhanced wing vibrations by the bees. However, though these values are slightly more than the frequency produced in the natural condition, it is still comparable with the earlier estimations by Wenner (1964).

### Table 1: Mean, Standard Deviation of the Frequency & Amplitude parameters for different conditions

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Parameters</th>
<th>Natural condition - 1</th>
<th>Induced condition (Concentrated sugar syrup - 2a)</th>
<th>Induced condition (Incense stick fumes - 2b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean F0</td>
<td>189.02</td>
<td>268.90</td>
<td>336.32</td>
</tr>
<tr>
<td>2</td>
<td>Min</td>
<td>125.28</td>
<td>209.45</td>
<td>302.05</td>
</tr>
<tr>
<td>3</td>
<td>Max</td>
<td>334.09</td>
<td>393.75</td>
<td>397.30</td>
</tr>
<tr>
<td>4</td>
<td>S.D of F0</td>
<td>92.69</td>
<td>64.38</td>
<td>37.14</td>
</tr>
<tr>
<td>5</td>
<td>vF0</td>
<td>0.41</td>
<td>0.23</td>
<td>0.11</td>
</tr>
<tr>
<td>6</td>
<td>RAP</td>
<td>2.92</td>
<td>0.91</td>
<td>4.41</td>
</tr>
</tbody>
</table>

### Energy parameters

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>SD of Ampl</th>
<th>Shim %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66.36</td>
<td>69.88</td>
<td></td>
<td>2.19</td>
<td>1.81</td>
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<td>2</td>
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<td>1.60</td>
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<td>3</td>
<td>61.91</td>
<td>65.67</td>
<td></td>
<td>2.10</td>
<td></td>
</tr>
</tbody>
</table>

Concentrated sugar syrup Vs Fumes of Incense stick

In 2b condition, the mean F0, mean minimum and mean maximum F0, RAP was greater than 2a condition. SD of F0, and vF0 were lesser in 2b condition. There was a decrease in all energy parameters (mean, minimum, maximum intensity, SD), except shimmer which increased in 2b condition.

The present study revealed that, the buzz frequency of the honey bee increased maximally under conditions of threat, with variations in energy parameters. This observation is further strengthened by the findings of Wenner (1964) wherein the F0 of honey bees buzz varies depending on different environmental conditions (such as inside a hive, near a source of food, exposure to intoxicating fumes etc).

### Conclusion

The present study is a preliminary attempt in documenting the acoustic characteristics of bees buzz (in a species of *Apis dorsata dorsata*) in different environmental conditions, some of which were induced artificially. The study documents that change in the external conditions led to characteristic changes in the acoustic properties of the sounds produced by the honey bees. The mean fundamental frequency of bee buzz was highest in the induced condition 2b (fumes from incense sticks) followed by induced condition 2a (concentrated sugar syrup)
and the natural condition (1). The relative amplitude perturbation also varied similarly. The above finding could be attributed to the very reason that animal behavior is likely to change depending on the environmental conditions. Reflecting while discussing in reference to the present context, it was noticed that when a bee was aroused to attack, or harmed, its buzz is likely to rise in pitch and fluctuate in energy unlike to that of a pleasant condition, where, the bee produces a comparatively lower pitch and intensity when a source of food is being introduced to it. These facts give us strong indication to call this communication system of the honeybee ‘a language’. The existence of a true language in honeybees in the form of a symbolic arbitrary one has also been proved by Gould & Gould (1988). Human communication is primarily verbal, whereas bee communication is acoustical in nature (at times chemical or pheromonal also). The use of verbal or acoustic mode for communication is immaterial of the fact that they are different, rather highlight on the importance of use of complex ways to ensure the exchange of information among organisms of the same group. Therefore, such a study is expected to throw some light in unraveling the mysteries of the communication patterns of these creatures. Further research would help understand various interesting facts regarding the complex yet fascinating communication system and strategies of such organisms in a variety of behavioral context.

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AWARENESS OF STUTTERING AMONG PROSPECTIVE TEACHERS OF MYSORE

*Jocine Gloria Chandrabose, **Kenneth O. St. Louis, ***Pushpavathi M. & ****Shabina Raoof

Abstract

The study is an attempt to explore the awareness and attitude of prospective teachers towards stuttering in Mysore city, conducted as a part of International Stuttering Awareness Day. As stuttering exists worldwide, among different cultures it is essential to pay considerable attention in identifying and comparing attitudes, knowledge and beliefs of different cultural groups. Attitudes of 64 educators toward stuttering were studied using the questionnaire developed with few statements adapted from POSHA (consisting of eight domains such as nature, concern, attitude, causes, treatment, awareness, characteristics and occurrence of stuttering). Results indicated that their awareness on stuttering is less on some domains but also reflected positive attitude on some domains. Some of the results of this study are similar to those of other comparable studies conducted in other countries and cultures including Belgium, Brazil, Shanghai and China suggesting that most of the community has poor knowledge on stuttering. Public ignorance may be one of the factors of the mental and emotional complexities of stuttering (Blood, 1999). The results of the present study indicate that there is a need for SLPS to provide teachers with more information about stuttering. Hence, this study also helps SLPS to understand the environment of PWS which play a significant role in the onset and maintenance of stuttering.

Key words: Stuttering, prospective teachers

Stuttering is a communication disorder that disrupts the smooth, forward flow of speech but it also creates negative emotions and reactions by both the speaker and listener (Guitar, 2006). People who stutter (PWS) experience disruptions in their speech fluency as well as adverse affective, cognitive and behavioural reactions that stem from these disruptions (Bennett, 2006). The negative feelings that a person who stutters, experiences related to speaking are usually compounded by negative reactions expressed by listeners and the anticipation of negative reactions (Hult & Wirtz, 1994; Silverman, 1996; Yaruss & Quesal, 2004). Thus, "stuttering is apparently as much a disorder of communication as it is of speech; the receiver (listener) is at least as important as the sender (person who stutters) in the interchange" (Van Riper, 1982).

Listener reactions to stuttering have been considered important for many decades. Johnson (1934) surveyed PWS and found that stuttering in front of a close friend or family member was perceived as less embarrassing than stuttering in front of strangers. Johnson (1934) concluded that listener reactions influence PWS in a variety of ways and that listeners should make PWS feel as comfortable as possible by acting and speaking so that the stutterer will feel secure in one's presence and will feel that he is being accepted as an individual, and will feel that he has nothing to lose by stuttering. Classroom teachers, speech clinicians, parents and society in general should apply this knowledge at every opportunity. This suggests that there are

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appropriate and beneficial communication strategies that listeners should employ in their interactions with PWS. Yet, awareness of stuttering among teachers is a topic that has received little attention in the speech pathology literature. The non-professionals awareness, attitude towards stuttering has not been subjected to systematic investigation.

**Importance of teachers’ attitudes**

Teachers carry a large share of the responsibility for the educational development of children. This responsibility is perhaps even greater when children with a disability are concerned. Teachers have an important part to play in the educational development of CWS (Children with stuttering) and their beliefs and attitudes can significantly affect the management of CWS in the classroom, as well as their progression (Lass et al., 1992; Stewart & Turnbull, 2007). In addition, the behaviour of teachers can influence the attitudes and actions of school children and in turn have impact on the self-image and peer relationships of children who stutter (Turner & Helms, 1995). It is, then, particularly worrying to find that the majority of teachers have negative perceptions of people who stutter (PWS) and typically associate negative personality traits with PWS (Lass et al., 1992; Dorsey & Guenther, 2000).

**Procedures for measuring attitudes, knowledge and beliefs about stuttering**

In the early years quite a number of surveys have also been used to elicit knowledge, attitudes and beliefs. These include the Parental Attitudes toward Stuttering Inventory (PATS; Crowe & Cooper, 1977), The Alabama Stuttering Knowledge Test (ASK; Crowe & Cooper, 1977) and the Clinicians Attitude toward Stuttering Inventory (CATS; Cooper, 1975). The scope of these surveys varies with topics ranging from studying parental attitudes and knowledge of stuttering, to sampling a variety of professional views regarding the nature of stuttering, its treatment and Speech Language Pathologists’ (SLPs’) competence and effectiveness in working with the disorder.

Emerick (1960) explored the relationship between elementary school teachers’ ability to count or tally instances of stuttering and their attitudes toward stuttering. The Iowa Scale of Attitude toward Stuttering was administered to 21 male and 127 female teachers. A speech stimulus consisting of a 3.5 minute audiotaped recording of a male who stutters was made (the types and amount of disfluencies were not disclosed by the author). Participants were instructed to keep a count of the amount of stuttering they heard as the speech sample was played. The order in which participants completed the attitude scale or heard the speech sample varied. Participants who had a more tolerant attitude toward stuttering tend to observe more disfluencies. This trend applied most particularly to those teachers who had taken at least one course in speech pathology as compared to teachers with no formal training. Thus the author suggested that training in speech pathology might result in more tolerant attitudes toward stuttering while at the same time decreasing tolerance for speech nonfluencies (e.g., typically occurring disfluencies that are not generally considered to be core stuttering behaviors).

Crowe and Walton (1981) studied attitudes of 100 elementary school teachers toward stuttering using the Teachers Attitudes toward Stuttering Inventory and results indicated that significant positive correlations existed between teacher attitudes and knowledge of stuttering.

Yeakle and Cooper (1986) discussed attitudes of 521 teachers in the Tuscaloosa, Alabama City School (82% of the teacher population) toward stuttering were assessed using the Teachers’ Perceptions of Stuttering Inventory (TPSI). Results indicated that a significant number of teachers hold unsubstantiated beliefs concerning the etiology of stuttering and the personality characteristics of stutterers. Teachers having experience with stutterers or having had course work in speech disorders indicated more realistic attitudes toward stutterers and expressed more demanding attitudes toward stutterers in the classroom situation.

A series of studies conducted by Lass, Ruscello, and colleagues (Lass et al., 1992, 1994; Ruscello, Lass, Schmitt, and Pannbaker, 1994) involved elementary and secondary school teachers, school administrators, and special education teachers were asked to provide adjectives that describe four hypothetical people who stutter, including a female child, male child, female adult and male adult.
Elementary and secondary school teachers provided a total of 287 adjectives to describe PWS of which 66.9% were negative in nature, 20.2% were positive and 12.9% were neutral (Lass et al., 1992).

A replication of this study by Silverman and Marik (1993) found similar results. School administrators provided a total of 197 adjectives to describe PWS of which 72.6% were negative in nature, 19.8% were positive and 7.6% were neutral (Lass et al., 1994). Special educators provided a total of 241 adjectives to describe PWS of which 67.2% were negative in nature, 17.4% were positive and 15.4% were neutral (Ruscello et al., 1994). Thus, professionals involved in education are likely to provide adjectives that are primarily negative in tone, suggesting that educators, like SLPs, may be more tolerant of PWS (Lass et al., 1989). Thus, with few exceptions (e.g., Silverman & Paynter, 1990), it appears that educators and administrators in school and university settings hold negative attitudes toward PWS. Even when educators report knowing students who stutter (e.g., Crowe & Walton, 1981; Lass et al., 1992), the negative stereotype of PWS persists. It is not well understood how teachers’ perceptions of PWS influence their behavior toward students who stutter in the classroom. More research is needed that provides a more in-depth exploration of teachers’ attitudes toward PWS and correlates teachers’ attitudes with their behavior toward students who stutter in their classrooms.

Despite the availability of stuttering information through leaflets and websites it does not appear from the literature that teachers’ opinions have been sought regarding the precise information they would find helpful. In 1999, a Task Force consisting of research and policy-oriented SLPs, people who stutter and an epidemiologist (Ken St. Louis, Bobbie Lubker, Scott Yaruss, Jaan Pill, and Charles Diggs, respectively) convened to develop the first prototype of a questionnaire to measure attitudes toward stuttering known as the Public Opinion Survey of Human Attributes (POSHA-E). The Public Opinion Survey of Human Attributes (POSHA-E) by St. Louis (2005) is perhaps one of the most well developed scales which is designed to measure the attitudes, knowledge and beliefs toward stuttering among the general public in different cultural groups. The POSHA-E has been translated into and administered in several languages in various countries around the world (St. Louis, Andrade, Georgieva, & Troudt, 2005) and also considerable attention has been paid to the validity, reliability and standardization of the instrument. The inventory is unique in that it is designed to elicit attitudes toward stuttering and other human attribute and reduce response bias by not stating specifically that stuttering (or any of the other attributes) is the targeted attribute.

Since 1999, the POSHA-E has been revised three times. Like most other measures of attitudes, the POSHA-E samples a variety of beliefs, reactions, behaviors, and emotions that would identify societal ignorance, stigma, and/or discrimination (e.g., Blood et al., 2003; Gabel, Blood, Tellis & Althouse, 2004; Hulit & Wertz, 1994; Klein & Hood, 2004). These survey questions have been asked to more than 1,200 adult respondents in 27 nonprobability (nonrandom) pilot study samples in 11 countries (Brazil, Bulgaria, Cameroon, Canada, Denmark, Nepal, Nicaragua, Macedonia, South Africa, Turkey, and the U.S.). Respondents completed questionnaires in either English or one of six other languages (Bulgarian, Macedonian, Portuguese, Turkish, French, and Spanish).

The lack of awareness in teachers about PWS appears to be reflected in the findings by Crichton-Smith, Wright, and Stackhouse (2003). They reported that a large majority of SLPs in UK expressed the view that teachers do not have sufficient knowledge to manage CWS at school.

Studies have been attempted by (Abdalla & Saddah, 2009) to survey attitudes, knowledge and beliefs of Arab teachers in Kuwait and results revealed teachers in Kuwait require awareness and information about stuttering and how to deal with PWS. 60% of teachers responded that they feel uncomfortable when confronted with a PWS. Also, over 50% of the teachers responded that they would fill in words for the PWS.

The research focusing on the attitudes of the prospective teachers are limited. Therefore, to understand their attitudes, knowledge and beliefs about stuttering this study has been initiated involving prospective teachers in Mysore.
Purpose of the study

As stuttering exists worldwide, (Bloodstein & Ratner, 2008) among different cultures it is essential to pay considerable attention in identifying and comparing attitudes, knowledge and beliefs of different cultural groups. Blood, Blood, Tellis and Gabet (2003) reported that PWS live in an environment in which general public have negative attitude / stereotype attitude towards PWS or the disorder. Various studies have been conducted to assess the awareness of public towards PWS and the stuttering disorder. These studies have considered wide range of subjects which included store clerks (Mc Donald & Frick, 1954), college students (Silverman, 1982), public school teachers (Horsley & Fitzgibbon, 1987), vocational rehabilitation counsellor and employers (Hurst & Cooper 1983a), speech language pathologist (Lass et al., 1989) and general public. Even though the different groups were considered the findings are consistent related to the attitude towards PWS. Hence this study attempts to fill this void by exploring knowledge and beliefs about stuttering in teachers in the Indian scenario. This study explores the attitude of prospective teachers towards stuttering.

Objectives of the Study

• To estimate the awareness of teachers on domains such as nature, concern, attitude and cause of stuttering
• To estimate the awareness of teachers on domains, such as, occurrence, characteristics, knowledge and treatment of stuttering.

Method

Subjects

Subjects consisted of 64 participants (39 females and 25 males in the age range of 19 to 22 years) studying for diploma in education. The study was conducted as a part of orientation program on International Stuttering Awareness Day. The participants were fluent in Kannada and had the knowledge of reading and writing in Kannada.

Questionnaire

A questionnaire was developed by a qualified speech language pathologist having experience in assessment and management of fluency disorder. The questionnaire was developed in Kannada language. Few items were adapted from POSHA (St. Louis, 2005) and the same was translated to Kannada. The questionnaire consisted of eight domains such as nature, concern, attitude, cause, occurrence, characteristics, knowledge and treatment of stuttering. Each domain had ten statements. Each statement had three options (yes, no, I don’t know). Participants responded to each statement by marking any one option.

Data Collection

The participants were given questionnaire and were briefed about the marking for each statement. Participants were told to ask for clarification if any and to be filled by each participant. The data was collected prior to the orientation program on stuttering.

Statistical Analysis

The data from the questionnaire of the 64 participants were coded on the basis of the scale 0 to 3 and entered into an SPSS database. The responses were analysed separately for each domains. Data was analysed using SPSS (version 10 and 16). The response for each domain was analysed from percentage of subjects.

Results & Discussion

a) To estimate the awareness of teachers on domains such as nature, concern, attitude and causes of stuttering

Figures 1 and 2 depict the responses of subjects for domain on nature and concern of stuttering. Among the domain on nature of stuttering, 9.4% of participants believed that person with stuttering hide their speech problem, 23.4% responded that IQ is less in PWS, 89.1% of them felt that PWS usually have fear, 81.3% felt that they are shy in nature, 78.1% felt that they blame themselves for their problem, 71.9% felt that they can have friends and 60.9% responded that they can lead normal life. 51.6% felt that they have capacity to carry out all the activities while 67.2% felt that they have inferiority complex and 65.6% felt that they prefer to stay alone. The participants had a positive attitude on aspects like PWS do not hide their speech problem, have normal IQ and can lead normal life. But they also responded that PWS are shy, have inferiority complex.
and prefer to stay alone.

The second domain aimed to find the participants' concern towards stuttering. In general, 60% to 82% of the participants responded that they have concern towards anyone affected with stuttering. These participants showed more concern to family members compared to neighbors and doctors. But, 20% of the participants responded that they are not concerned and 15% of the participants did not answer.

Figs. 3 and 4 depict the participants' response towards attitude and causes of stuttering. The analysis of third domain indicated that the participants had positive attitude on PWS such as 60.9% of the participants responded that they behave normally with PWS, 93.8% of them responded that they help them by providing the word when they struggle 92.2% of them responded that they help them to speak slowly and 84.4% of them responded that they give them support and encourage them while speaking and 42.2% ignore the stuttering problem. However the negative attitude was very less as 10 to 15% responded on issues like they lose patience (10.9%), make fun of PWS (9.4%), avoid speaking to PWS (12.5%) and do not give them opportunity to speak (14.2%). 42.2% of them also expressed sympathy towards the problem.

Figure 4 depicts that a relatively high percentage of teachers believe that stuttering is caused by problem related to the tongue (82.8%) and a genetic inheritance (68.8%). Approximately 7-15% of the participants responded that they do attribute the causative factor to the influence of black magic/ghost or a curse by god. 56.3% of the participants felt that stuttering is caused due to accidents and pressure from the environment (40.6%). A few participants responded that they think that a virus/ bacteria (37.5%) or lack of blood supply (62.5%) and due to imitation (53.1%) can cause stuttering while 5% of the subjects were not aware that if it's caused by any causative agents listed in the questionnaire.

b) To estimate the awareness of teachers on domains, such as, occurrence, characteristics, treatment and knowledge of stuttering

Figure 5 and 6 depicts the response of the participants towards occurrence and characteristics of stuttering. The domain on occurrence of stuttering had statements related to the age of onset of stuttering and variation across gender. The participants responded that stuttering is seen during developmental period (60.9%), puberty (59.4%), only in adults (46.9%), only in children (43.8%) and 32.8% responded that it is seen only in geriatrics (32.8%). Among the differences across gender, 35.9% reported more in males while 18.8% felt more in females. 21.9% responded that it is seen in some specific races and 12.5% felt that it is a season specific. These results indicate that the majority of the participants were much aware of stuttering.

The domain on characteristics of stuttering also revealed interesting facts. 71.9% of participants felt that the PWS have stuttering in some situations, 65.6% felt that it is specific to individuals, 82.8% felt that they try to avoid the difficult words, 85.9% had secondaries, sweating, fast rate of speech (63.1%) and use synonyms (67.2%). But awareness was less on problems faced by PWS on difficulty with specific words (21.9%), less problem with family members and friends (29.7%). Participants also felt that PWS have fewer problems while reading (59.4%) and singing (43.8%).

The participants' response on domains regarding the knowledge and treatment options is depicted in Figure 7 and 8. The domain on knowledge aimed at knowing the source of awareness of stuttering. 67.2% responded that their awareness of this problem comes from family members, friends, famous personality who stutter (67.8%), school (68.8%), doctors and nurse (62.5%), mass media (57.8%), cinema (51.6%), personal experience (53.1%) and newspapers (45.3 %).

The awareness regarding the treatment options were familiar to participants which are reflected in their response. 85.9% of the participants had felt that PWS are treated by doctors, speech language pathologists (84.4%), teachers (85.9%), psychologists (76.6%), spiritual leaders (57.8%), physiotherapists (50%) and family members of PWS (84.4%). 23.4% of them felt that stuttering cannot be cured and 57.6% of them felt that it is cured gradually.
Even though research and mass media has paid considerable attention towards educating public about stuttering and the extensive review which has proved that PWS are normal, reasonably well adjusted and has a normal capacity on all dimensions the stereotype behaviour of the public still persists. The present study is an attempt to explore the awareness and attitude of prospective teachers towards stuttering in Mysore city. This study is conducted as a part of International Stuttering Awareness Day highlighting the eight domains of stuttering. In general, the results indicated that their awareness on stuttering is less on some domains but also reflected positive attitude on some. The present study did not reveal only negative attitude on all domains.

Since the different studies conducted in this line have used different questionnaires, comparing the present study in each domain with other studies was not been attempted. But in general since few of the statements were similar an attempt is made to compare with the earlier studies. Some of the results of this study is similar to those of other comparable studies conducted in other countries and cultures including Belgium, Brazil, Shanghai and China (Bebout & Arthur, 1992; De Britto Perira et al., 2008; Mayo et al., 2004), as well as Bulgaria, Cameroon, Canada, Denmark, Nepal, South Africa, Turkey and US (St. Louis et al., 2005). These studies suggest that most of the community has poor knowledge on stuttering. Public ignorance may be one of the factors of the mental and emotional complexities of stuttering (Blood, 1999). Klompas and Ross (2004) suggested that there is a need for SLPs to provide teachers with more information about stuttering.

The literature also indicates that the clients families as well as the client’s community towards the cause, effects and management of speech language disorders is important to the speech language pathologists work and vital to the therapeutic process (Bebout & Arthur, 1992). Therefore further studies looking into the validity, reliability, number quality, relevance and comprehensiveness of the attitude statements in some of these inventories are necessary. It is the responsibility of all the speech language pathologists to utilize all the opportunity to convey the information related to stuttering disorder and to help in building the positive attitude and acceptance of PWS and stuttering disorder. The positive attitude of the public helps PWS to combat their disorder and improve their quality of life.

Lass et al. (1992) recommended that teachers should receive training prior to practice and as part of their continuing professional education development (CPD) to increase their awareness of stuttering. In particular Lass et al., (1992) suggested teachers should learn to see CWS as whole people and not just in terms of their stuttering behaviour. A number of programs to train teachers specifically about stuttering and to encourage joint working between teachers and SLPs are suggested (Bennett, 2003; Gottwald & Hall, 2003; Stewart & Turnbull, 2007). There is a lack of evidence concerning feedback from teachers attending these training programs and no detail about the effectiveness of the training in terms of improving teachers’ knowledge of stuttering and fostering links between the teacher and the clinician.

**Conclusion**

The result of the present study adds to the established results of the previous studies and explores the attitudes of prospective teachers of Mysore. This warrants the SLP to develop more systematic programs towards creating awareness on stuttering in various culture and communities. The programs should be conducted in all possible environments in which PWS spends most of their time (School, college, office, hospitals, public places like shop, bus stand). It is also important for speech language pathologists to have knowledge about teacher’s awareness on stuttering, as teachers play an important role in identification and management of PWS. This study also helps SLP to understand the environment of PWS which play a significant role in the onset and maintenance of stuttering.

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BILINGUAL VOCABULARY DEVELOPMENT AND MEMORY AS A FUNCTION OF AGE
*Mansi Mathur, **Shivani Tiwari, & ***Rajashekar Bellur

Abstract

Working memory like in first language acquisition plays a crucial role in learning the second language also. However, the role of different memory measures in vocabulary development for bilinguals as a function of age is not known. In this context, the present study aimed at investigating and comparing the relation of different memory measures (phonological, verbal working, and semantic) with vocabulary in younger and older Hindi-English sequential bilingual children. Sixty children in the younger bilingual group (5 to 7.11 yrs) and forty in the older bilingual group (8 to 10.11 yrs) participated in the study. Nonword repetition, digit span, and word span tasks as memory measures and category generation as vocabulary measure were administered separately in the two languages (L1-Hindi, L2-English) of the participants. The results showed a similar pattern of performance on memory in relation to vocabulary development in the two languages across age. These findings thus maintain the view of interdependent development of the two languages in bilinguals. The association between the memory performance and vocabulary was found to be significant for the younger but not older bilingual group. Thus, the findings support the literature on memory role in early vocabulary development in bilingual children. Future research is needed to examine these memory aspects at different stages of bilingual development in typical as well as clinical population to better understand the interaction between the two.

Key words: Working memory, sequential bilingual, category generation

The development of language in children exposed to two or more languages has been a topic of growing interest in past few decades. Research data has demonstrated that bilingualism enhances the cognitive flexibility (Cummins, 1976; Diaz, 1983). Children as young in the preschool stage learn contextual use of languages (Lanza, 1992). The two languages in bilingual children can be learned either simultaneously from infancy (simultaneous bilingualism) or sequentially, when a second language is introduced after the first language is well established (McLaughlin, Blanchard & Osonai, 1996; Watson, 1996).

Most bilingual children make unequal progress in acquiring the two languages. This depends on several factors as what language is being spoken to the child, how often it is being spoken and by whom, and on the opportunities the child has to use one language or the other (Goodz, 1994). Thus, bilingualism in children is complex and highly individual.

Vocabulary development in bilinguals

Studies examining lexical development in bilingual children report similar patterns and rate of vocabulary acquisition as that of monolingual children (Genesee, 2003; Patterson & Pearson, 2004). The relative vocabulary size in each language of a bilingual is dependent on the relative amount of time spent in each language (Pearson, Fernandez, Lewedag & Oller, 1997). The similarity in acquisition of the two languages in bilinguals could be explained in terms of the linguistic interdependence principle (Cummins, 1979, 2001).

This principle postulates that linguistic proficiency is common and interdependent across languages. As a result, cross-language transfer of these skills is expected. Peña, Bedore and Zlatic-Giunta (2002) investigated the lexical-semantic
organization in Spanish-English bilingual children of 4 to 7 yrs old using the category generation paradigm (Nelson & Nelson, 1990). Similar to monolingual peers, the bilingual children showed a shift in productivity from script-based (slot-filler) condition to a taxonomic condition. Moreover bilingual children generated a comparable number of category exemplars in each language (Spanish, English) under each condition (slot filler, taxonomic) and for each category (animal, food, and clothing), indicating similarity in rates of semantic development between the two languages.

Working memory (a temporary processing and storage of information) plays a crucial role in learning a second language. Research suggests that verbal working memory tasks may be useful to predict L2 acquisition (Service, 1992). For instance, the ability to repeat words in an unknown language has been observed to predict success in learning that language (Ardila, 2003). On the other hand, decreased digit span and inability to repeat pseudowords have been related to failure in L2 acquisition (Ganschow, Sparks, Javrosky, Pohlman & Bishop-Mabury, 1991). Further, word span and semantic span have also been implicated in learning the second language. However, these measures have seldom been studied in developing bilinguals.

Thus, present study aimed at examining the memory measures in relation to vocabulary (category generation task) in the two languages of Hindi-English bilingual children. This particular association between memory and vocabulary was measured as a function of age across younger and older bilingual children.

**Method**

**Participants**

A total of 100 children participated in the study. 60 children of age 5 to 7.11 yrs comprised the younger bilingual group and another 40 children of age 8 to 10.11 yrs comprised the older bilingual group. All children were early sequential bilinguals with Hindi as their mother tongue and English as the second language, with minimum age of exposure in L2 being 3-4 yrs. All children were recruited from schools with English as the medium of instruction. Participants obtained a score of 3 and higher for the two languages on a 5-point language proficiency rating scale given by Gutierrez-Clellen and Krieter (2003). All participants were screened for any complaints of hearing loss, cognitive deficits and/or history of speech and language problems.

**Test measures**

Memory measures such as phonological memory (non word repetition), verbal working memory (digit span test) and semantic memory (word span test) were studied in relation to vocabulary (using a category generation task) in the two languages of the participants.

**Non word repetition:** This test was used as a measure of Phonological Memory. A list of 9 non words were used in the study comprised of three 1 syllable, 2 syllable and 3 syllable words each. In English, the word list was adapted from non words developed by Hoff and McKay (2005). In Hindi, the word list was generated with the help of a linguist and fellow speech-language pathologists. A pronunciability check was done by three native Hindi speakers for the various non words in Hindi based on a 3-point rating scale from 0-2 and words rated as pronounceable by all three speech language pathologists were chosen for the study. These non words were audio recorded and presented to the children using the laptop computer using speakers. Participants were instructed to repeat the stimulus after every presentation. The syllables correctly repeated for every nonword by participants was given a score 1. The maximum score for the task was 18.

**Digit span test:** This test was used as a measure of Working Memory. This measure of randomized digit test used in the study is an adaptation from Binet-Kamath Test (Venkatesan, 2002). The children were presented with a recorded list of numbers. The length of the digits increased from 3 to 9 and the numbers ranged from 1-9. The digits were audio recorded and presented through laptop to the children. Participants were instructed to repeat the numbers in the same order after each presentation. The score given was the maximum span of digits which were correctly produced by the child in the correct order. The maximum score for this task was 9 and the minimum score was 3.

**Word span test:** This test was used as a measure of Semantic Memory. A list of semantically unrelated words was presented to the children and they were asked to repeat it in the respective order. English words were taken from Hoff and McKay (2005). Hindi word list was generated with the help of a linguist and fellow speech language pathologist. A familiarity check was done by three native Hindi speakers for
the various words in Hindi on the basis of a 3-point rating scale from 0-2. Words rated as familiar by three speech language pathologists were included in the list. The length of the words increased from 3 to 9 in the list. These words were also audio recorded and presented through laptop to the children. The children were instructed to repeat the words in the same order after each presentation. The score was the maximum span of words which was correctly produced by the child in correct order. The maximum score was 9 and the minimum score was 3.

**Category generation task**: This task was used as a measure of vocabulary in the two languages. In this task the children were instructed to give the names of as many items in one category as possible. Five different categories were used for this task namely animals, fruits, vegetables, common objects and vehicles. Every item produced in a category was given 1 point each. Individual points of each category were summed up to obtain the total score for category generation task.

**Procedure**

The testing was carried out in a quiet situation. The stimuli were presented through laptop computer using speakers. The responses obtained from the participants were recorded on paper and were scored according to each task.

**Results**

This study aimed at examining and comparing the relation between memory and vocabulary measures in younger and older Hindi-English sequential bilingual children. Table 1 provides the descriptive statistics for performance on memory measures and the vocabulary task across the two languages of the participants.

Figure: 1 depicts the performance trend of participants on memory and vocabulary measures in the two languages. The older bilinguals over performed the younger bilingual group in terms of memory measures. It was observed that performance on nonword repetition task reached the maximum level for the older bilingual group. Further performance on digit span and word span tasks also improved with age, though did not reach the maximum level. The performance on vocabulary measure (category generation) however did not show a significant improvement with increasing age.

Participants from younger bilingual group showed superior performance on various memory measures in English than in Hindi language. However, their performance on those memory measures was similar for the older bilingual group across the two languages. Further the association between performances on memory and vocabulary tasks in Hindi and English languages for the two groups of participants was tested using a Spearman correlation.

The results of correlation analysis between the memory measures (nonword repetition, digit span and word span) and vocabulary task (category generation) showed significant positive correlation in Hindi and English languages for the younger bilingual group. However no correlation was observed for the older bilingual group in either language (Table 2).

<table>
<thead>
<tr>
<th>Language</th>
<th>Task</th>
<th>Younger bilinguals</th>
<th>Older bilinguals</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>Inter-quartile range</td>
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<tr>
<td></td>
<td></td>
<td>Median</td>
<td>Inter-quartile range</td>
</tr>
<tr>
<td>Hindi</td>
<td>Memory measures</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Nonword repetition</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Digit span test</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Word span test</td>
<td>4</td>
<td>2</td>
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<tr>
<td></td>
<td>Vocabulary measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category generation</td>
<td>38</td>
<td>21.25</td>
</tr>
<tr>
<td>English</td>
<td>Memory measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nonword repetition</td>
<td>14</td>
<td>4.75</td>
</tr>
<tr>
<td></td>
<td>Digit span test</td>
<td>5</td>
<td>1</td>
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<tr>
<td></td>
<td>Word span test</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Vocabulary measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category generation</td>
<td>37</td>
<td>21.25</td>
</tr>
</tbody>
</table>

Table 1: Descriptive statistics of the performance on memory and vocabulary measures in the two languages
Figure 1: Performance trend on memory and vocabulary tasks

Table 2: Correlation of memory measures with vocabulary task in two languages

<table>
<thead>
<tr>
<th>Group</th>
<th>Language</th>
<th>Nonword repetition</th>
<th>Digit span test</th>
<th>Word span test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger</td>
<td>Hindi</td>
<td>0.58*</td>
<td>0.61*</td>
<td>0.67*</td>
</tr>
<tr>
<td>bilingual</td>
<td>English</td>
<td>0.56*</td>
<td>0.57*</td>
<td>0.64*</td>
</tr>
<tr>
<td>Older</td>
<td>Hindi</td>
<td>0.05</td>
<td>-0.10</td>
<td>-0.14</td>
</tr>
<tr>
<td>bilingual</td>
<td>English</td>
<td>0.23</td>
<td>0.06</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

Discussion
Adequate and appropriate development of language in children is one of the key features which accounts for their normal development. Many factors are responsible for language to develop adequately in a child. One such factor is cognition. In the field of bilingualism, researchers have proposed that the cognitive development in bilingual children is different from those of monolinguals, though the research has been limited in this regard. More elaborately, memory
is one such cognitive feature which is responsible for language development in children (Baddeley, 2003). Literature indicates that various components of memory are important for second language development, like, phonological memory (Thorn & Gathercole, 2001; Service, 1992), working memory (Service, 1992) and semantic memory (Ardila, 1995).

The present study thus aimed at investigating the performance trend on different memory measures like phonological memory, working memory, semantic memory and vocabulary (category generation) in younger and older Hindi-English bilingual children and to find the association between different memory measures on vocabulary in these children. Non word repetition, Digit span test and Word span test were used as measures of phonological memory, working memory and semantic memory respectively. Category generation task was used as a measure of vocabulary. The performance on memory and vocabulary tasks was compared for younger and older bilingual children across the two languages. Results indicated that older bilingual participants outperformed younger bilingual participants on all memory measures as nonword repetition, digit span and the word span tasks. However, participants in both groups demonstrated comparable performance on memory measures across the two languages.

Our study findings showed a developmental trend in participants' performance on phonological memory task across age. Durgonoglu, Naggy and Bhatt (1993) reported that phonological memory is dependent on phonological awareness ability. The better performance obtained by older bilinguals in our study thus indicate that their phonological awareness skills are more developed in comparison to younger bilinguals, who are still developing their phonological awareness skills. Also, participants’ performance being similar across the languages by both groups suggest that phonological awareness skill is a cognitive skill that develops simultaneously in children regardless of their monolingual or bilingual oral development (English, Leafstedt, Gerber & Villaruz, 2001). A similar trend was observed for participants’ performance on digit span task wherein older bilinguals performed better on digit span task indicating better working memory skills. The performance on working memory measures is mostly dependent on the demands placed on the central executive system (Baddeley & Hitch, 1974). Superior performance by older bilingual group thus suggests their central executive system works in a more developed manner as compared to younger bilinguals. Further, digit span performance in English (L2) being similar to that observed in Hindi (L1) language indicates that the processing of L2 might share the same executive system of working memory as the processing of L1 (Harrington & Sawyer, 1992). Children’s performance on semantic memory measure was also found to be parallel other memory measures. Older bilinguals performed better in comparison to younger group. These findings collectively suggest that semantic memory is more developed in older than younger bilinguals. The developmental trend reflected in participants’ performance suggests their ability on semantic memory was still developing. This finding is line with the available literature, wherein Cohen and Stewart (1982) also found that older children had improved ability to correctly recall presented words, as compared to younger children. These observations thus imply that bilingualism facilitates increased recall outputs, and that benefits are associated with age. Similar performance by the participants on semantic memory task in two languages further support parallel development in bilinguals’ first and second language lexical-semantic skills (Sheng, McGregor & Marian, 2006).

Participants from both group performed similarly on category generation task in the two languages. This is in accordance with findings of PenPa et al. (2002). It can be attributed to the fact that sequential bilingual children are at an advantage at learning second language. This finding could be explained by Cummins’ (1976) notion that a native language foundation can serve as a support for learning English as a second language and also helps in making the learning process easier and faster. According to Cummins (1979) the amount and quality of first language use in the home have been shown to be associated with student readiness for the academic demands of schooling and continued primary language development in the school. The findings that both the groups of participants had a low mean score of their total vocabulary skills may be accounted for the limited exposure to a rich and varied vocabulary (Epinosa, 2006). If the children speak one language in the home and are learning English at preschool, the child may also know some
words in one language and not the other.

Our study results also showed significant correlation of memory measures with vocabulary task for the younger bilingual group, though such a correlation was not observed for the older bilingual group. The role of phonological memory in vocabulary development is well established in the literature. The link between vocabulary knowledge and non word repetition is typically strongest during the early stages of acquiring a particular language (Gathercole, 2006). Vocabulary and non word repetition scores were found to be highly correlated with one another in 4-8 years old children (Gathercole & Baddeley, 1989; Gathercole, Willis, Emslie, & Baddeley, 1992). Non word repetition ability has been shown to be an excellent predictor of language learning ability in children learning English as a second language (Service, 1992; Service & Kohonen, 1995). Thus the positive correlation found between the nonword repetition and vocabulary task for the younger bilingual subjects in the two languages (Hindi and English) in our study could be explained on these grounds.

A similar performance trend was observed for digit span and word span in relation to vocabulary for the younger bilingual group. Considerable evidence is available indicating short term working memory plays a crucial role in supporting the long-term learning of the sound patterns of new words involved in the acquisition of both native and foreign languages (Baddeley, Gathercole & Papagno, 1998). Lanfranchi and Swanson (2005) showed that children with higher English and Spanish vocabulary had higher scores on English and Spanish working memory measures respectively, when compared to those with lower vocabulary. The authors justified their findings as: a better working memory will result in better vocabulary development. Also, Harrington (1991) and Harrington and Sawyer (1992) in their study reported a moderate relationship between working memory performance in a second-language (English) reading span test and the second-language proficiency of Japanese children. The significant association observed between memory measures and the vocabulary task in our study thus support the fact that memory has a crucial role to play in vocabulary development (known in monolingual children) in both the languages of bilingual children. Furthermore, this association is prominent during the early years of the language development.

**Summary**

To summarize, findings of this study show that the performances on memory improved with age in bilingual children. Parallel trend observed in the development of memory and vocabulary skills in the two languages of Hindi-English early sequential bilingual children, thus support the interdependent development of two languages in bilinguals. Further, the association between memory measures and category generation was found to be significant in younger but not older bilingual children thus indicating the significance of memory in early vocabulary development.

**References**


Education.


CORRELATION OF VOICE HANDICAP INDEX SCORES WITH CLIENT PERCEPTIONS OF SEVERITY IN MALES V/S FEMALES WITH VOICE DISORDER

*Ms. Pallavi Sovani, **Mrs. Vinaya Keer, ***Mrs. Maya Sanghi

Abstract

Voice is the mirror of personality, and an indispensable ingredient for effective communication. A person with dysphonia would thus be affected functionally and emotionally. The Voice Handicap Index (VHI) measures these effects of a voice disorder. The present study aimed at making the VHI more usable in India, and finding the correlation of VHI scores with clients' self-perceived severity of the voice disorder. The VHI was translated to Hindi and Marathi languages. Back-translation of these versions and test-retest reliability was done before administering them to one of two groups (Hindi and Marathi) of 30 typical individuals. 11 males and 21 females with dysphonia were then given the VHI in their language of choice, and finally asked to rate the severity of their disorder. Spearman's rank correlation coefficient and t-test were used. Frequency of distribution of scores was also analyzed for the entire sample of 92 individuals. The mean VHI scores of the normative sample and pathological samples were significantly different. Test-retest reliability was >0.9 for both Indian versions. There was a moderate correlation between VHI scores and client perceptions of severity. It was moderate for males, poor for females, and poorest for working women. In cases with a discrepancy between VHI scores and self-perceived severity, at least one subscale score correlated well with the client's perception. The results suggest that Hindi and Marathi versions may regularly be used for assessment. Correlation analysis shows that persons with dysphonia give more priority to only one of the three aspects of the disorder (functional, physical, emotional). Males view their problem more holistically while females tend to underestimate their problem, perhaps a salient characteristic of the Indian woman. The study was a pilot attempt at validating the VHI in Indian languages, and gave valuable information for assessment and therapy planning.

Key words: Voice Handicap Index, Indian, perception

Voice is an attribute which is unique in every individual. It is one of the major characteristics which distinguish one individual from another. Naturally, it holds an important position in a person's life, and in case it is disrupted in any way, it directly or indirectly affects the person functionally, socially and emotionally. This explains why persons with dysphonia report symptoms of psychosocial distress as a direct consequence of their dysphonia. These consequences of dysphonia are measured using quality-of-life measures.

Quality of life measures provide insight into what the person has experienced and recognize the centrality of his/her point of view. Typically, they have been in the form of questionnaires. An important contribution to these was the development of a standardized self-assessment ordinal scale, the Voice Handicap Index (VHI) by Jacobson et al. (1997). The VHI (Jacobson et al., 1997) is a question and answer tool to subjectively assess the amount of handicap a voice disorder is causing. It consists of 30 questions representing several different problems in speaking situations, and the person has to rate the frequency of the problem on a 5-point scale where: 0=never; 1=almost never; 2=sometimes; 3=Almost always; 4=always. Each question tests one of three aspects- functional, physical and emotional. The letters “F, P, E”
respectively precede each question number. There are thus three subscales and 10 questions belonging to each subscale.

Thus a VHI score from 0-30 represents a low score, and most likely there is a minimal amount of handicap associated with the voice disorder. A score of 31-60 represents moderate handicap, as is seen in people with vocal fold injuries, nodules, polyps or cysts. A score from 61-120 represents a serious amount of handicap due to a voice problem, and is often seen in patients with new onset vocal cord palsy, vocal cord scarring, etc. (Jacobson et al., 1997). The VHI has various uses ranging from assessing the impact of voice disorders, to measurement of functional outcomes and treatment efficacy (Rosen, Murry, Zin, Zullo & Sonbolian, 2000) in behavioral, medical and surgical treatments of voice disorders.

In Jacobson et al.'s (1997) study, an 85-item version of the VHI was administered to 65 consecutive patients seen at the Voice Clinic at Henry Ford hospital. The data was subjected to measures of internal consistency reliability and the 85-item version was reduced to a 30-item questionnaire, which had strong internal consistency reliability and test stability. Construct validity though was not fully evaluated here. Relationships between functional, emotional and physical subscales were moderately strong with Pearson product-moment correlation coefficients ranging from 0.70 to 0.79. In the same study, relationship between VHI score and voice disorder severity was studied. Results indicated a moderate relationship between the two self-assessment measures.

This was followed by studies comparing the VHI to other quality of life measures. Benninger, Ahuja, Gardener and Grywalski (1998) compared a general quality-of-life measure- Medical Outcomes Trust Short Form 36- Item (SF-36) and a voice-specific instrument, i.e., the VHI. They found that the two correlate with each other in the domains of social functioning, mental health and role function-emotional.

VHI scores have also been compared to other subjective voice-related measures like the Voice Symptom Scale (VoiSS) by Wilson, Webb, Carding, Steen, MacKenzie and Deary (2006), and Voice Related Quality of Life measure (V-RQOL) by Portone, Hapner, McGregor, Otto and Johns (2006). Portone et al. (2006) concluded that the VHI and V-RQOL are highly correlated but not interchangeable measures. Murry, Medrado, Hogikyan and Jonathan (2004) had explored the relationship between trained listener ratings of voice quality and patients’ ratings of V-RQOL, and found that there is a moderate correlation, though each scale appears to provide unique information.

Krichke et al., (2005) tried to find if changes in Health Related Quality of Life (HRQL) depend on the kind of voice disorder, and the gender of the person, but concluded that they did not. Although it is perceived that women tend to perceive a disease in a different manner than do men, this study shows no significant difference in HRQL between men and women.

VHI results were also correlated by some researchers, with other tools like Voice Lab Measurements (Hsiung, Pai & Wang, 2002; Woisard, Bodin, Yardeni & Puech, 2006), and specific acoustic measures (Wheeler, Collins & Sapienza, 2006). These studies reveal poor correlation between VHI and objective/ acoustic parameters and conclude that they give independent information in practice.

The VHI has also been used to monitor treatment efficacy for voice disorders (Rosen et al., 2000). Roy et al., (2002) used the VHI as one of the measures to quantify benefit with voice amplification v/s vocal hygiene instruction for teachers with voice disorders. They also used the severity rating scale that has been used in the present study. In contrast to VHI results, data from the severity rating scale suggest the vocal hygiene group did not perform significantly better than the control group. The amplification group showed a decrease in mean VHI scores in contrast to the control group showing increases scores. Similar studies by other authors (Behrman, Rutledge, Hembree & Sheridan, 2008; Hall, 1995; Wolfe, Long, Youngblood, Henry & Olson, 2002) have used the VHI as one of the means to measure a dependent variable.

Certain specific populations have also been studied in detail using the VHI. Smith, Taylor, and Mendoza (1998) studied functional impact of nodules using the VHI, and found that the incidence of voice problems was more in females, and that females were affected more in areas like work and communication due to their voice disorder. A recent
A retrospective study along similar lines was by Bouwers and Dikkers (2009) who concluded that the VHI was a good reflection of the psychosocial impact of voice disorders. The VHI has extensively been used to study the population of singers (Murry, Zschommler & Prokop, 2009; Rosen & Murry, 2000). Wingate et al. (2005) studied the population of older patients with adductor spasmodic dysphonia with reference to the VHI. Other populations that have been studied using the VHI include laryngectomees (Kazi et al., 2007) and teachers (Kooijman, Thomas, Graamans & De Jong, 2007) and student-teachers (Thomas, Kooijman, Donders, Cremers and De Jong, 2007). However, there was no normative data available to describe expected VHI scores from adults with healthy voices. Hence Behrman et al. (2008) considered the upper limit of 11.5 as a cut off for a VHI score expected from a person without a voice disorder.

The VHI has been translated and validated in languages like Portuguese (Guimaeas & Aberton, 2004) and Hebrew (Amir, Ashkenazi, Leibovitzh, Michael, Tavor & Wolf, 2006). It has also undergone modifications, a recent one being the Pediatric Voice Handicap Index (pVHI) (Zur, Cotton, Kelchner, Baker, Weinrich & Lee, 2007). However, no study regarding the translation and validation to Indian languages has been published till date. The VHI would be much more useful clinically if translated and validated in Hindi and Marathi, especially Hindi being the national language of India. Thus there may be a large portion of the population of India that might not know English, but would be well-versed with these languages.

Hence the present study was aimed at making the VHI more usable in India and also measuring the correlation of VHI scores with clients’ perception of severity of the voice disorder. The extent of correlation has further been compared across males and females and also across males and working women in particular.

**Methods**

**Participants**

The sample for the study included:

- Two groups of 30 symptom-free (as regards voice problems) age matched adults (21-60 years) who were proficient in Hindi (Khariboli dialect) and Marathi languages respectively who consented to participate in the study;

- A purposive sample of 32 persons with dysphonia (11 males, 21 females) referred for voice therapy from the Otorhinolaryngology department of B.Y.L. Nair Hospital who were included in the study after viewing their Indirect Laryngoscopy findings and obtaining their informed consent. Only persons with hyper functional dysphonia and dysphonia due to neurological causes were included in the study. Subjects above 60 years and below 21 years of age were excluded, as voice anomalies in these age groups may be attributed to organic changes- hormonal, mucosal, or changes due to aging. The time period between age of onset of dysphonia and initiation of therapy was not held as a control variable for two reasons. Firstly, for two individuals with identical time elapsed between appearance of symptoms and therapy, their VHI scores may vary. Secondly, the study dealt with comparing correlation coefficients (and not absolute VHI scores) of males and females with dysphonia. However all the data was collected at the onset of therapy since therapy was a variable that could influence the correlation between VHI scores and client perceptions of severity.

**Tools and procedure**

The tools used were the Voice Handicap Index (VHI) (Jacobson et al., 1997) and its translated versions whose equivalency to the original English version was established as described below.

The VHI was first translated to Hindi (Khariboli dialect) and Marathi languages by native speakers of those languages who were also well versed with English. Back translations were then performed by a clinical psychologist and a social worker, both of whom were experienced translators. On back-translation, statements 11, 17 and 23 underwent minor grammatical changes. However, all the statements conveyed the same meaning as the original English version. Each of these two translated versions was administered to one of the two groups (Hindi and Marathi) of 30 symptom-free adults. To check the test-retest reliability, the VHI was administered twice to 7 randomly selected subjects each in Hindi and Marathi (5 symptom-free individuals and 2 persons with dysphonia).

Once the equivalency of the translated versions was thus established, all the three versions of the
VHI were then used for collection of data from persons with dysphonia.

The persons with dysphonia were given the VHI in a language which they were most comfortable with, out of English, Hindi and Marathi. They were given the following instructions:

“This questionnaire helps us to see the difficulties you face due to your voice problem. Answer the questions by marking the appropriate option, to let us know how frequently you encounter that situation. (An example was given using the first question.) Rate the frequency of the situation on a five-point scale where 0=never; 1=almost never; 2=sometimes; 3=Almost always; 4=always.”

Table 1: Reliability coefficients

<table>
<thead>
<tr>
<th></th>
<th>Marathi</th>
<th>Hindi</th>
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<tbody>
<tr>
<td>Overall test-retest reliability</td>
<td>0.96</td>
<td>0.92</td>
</tr>
<tr>
<td>Functional subscale</td>
<td>0.91</td>
<td>0.95</td>
</tr>
<tr>
<td>Physical subscale</td>
<td>0.87</td>
<td>0.84</td>
</tr>
<tr>
<td>Emotional subscale</td>
<td>0.94</td>
<td>0.98</td>
</tr>
</tbody>
</table>

The person was asked to rate, in his/ her opinion, how severe the problem was, on this scale. No specific instruction was given regarding the meaning of "severity".

Scoring and statistical analysis

The score obtained on VHI was put into one of the three categories- mild (0-30), moderate (31-60) and severe (61-120). These categories were then given ranks, such that: 1=mild, 2=moderate and 3=severe. The last question too yielded a rating of "mild", "moderate" or "severe" for all the persons with dysphonia. Spearman's rank correlation coefficient was computed for the entire sample (N=32) of persons with dysphonia. Separate correlation coefficients were also computed for males (N=11) and females (both working women and housewives, N=21), and compared. Further the correlation coefficient for only working women (N=14) was computed and was compared with that of males. The data was analyzed using the GraphPad Instat software.

Results

Indian versions of the VHI

As stated above, the back-translations yielded questions which conveyed the same meaning as the original English version. The test-retest reliability (using Pearson’s Product-Moment correlation coefficient) was good for both the Hindi and Marathi versions, for the total and subscale scores. The precise values are given in Table 1.

The mean VHI scores of the normative samples in Hindi and Marathi were compared to the mean VHI scores of the dysphonia samples in the respective languages that were obtained in the second part of the study. On applying the unpaired t-test, there appeared to be a significant difference between the means of the normal and pathological population. The means and SDs (standard deviations) are seen in Table 2.

Correlation of VHI scores and self-perception

When Spearman’s rank correlation coefficient was applied, the correlation between the clients' perception of voice disorder severity and VHI scores appeared to be 0.41, implying moderate correlation. The correlation coefficient for males was 0.65 (moderate correlation) while that for females was 0.21 (poor correlation). When only working women were included for analysis, the correlation was found to be very poor, i.e. 0.018.

To investigate the nature of the relationship between VHI scores and self-perceived severity, the means of total VHI scores (ranks) and self-perception (ranks) were compared. The trend seen was that in males the mean rank of the VHI scores was approximately the same as that of self-perceived severity, but for females, whether it was women in general or working women, the mean rank of VHI scores was always higher.

On observing individual data, it was seen that in persons in whom there was a discrepancy between VHI scores and self-perceived severity, at least one of the three subscale scores was seen to correlate well with the client's perception of severity. (For the
purpose of this comparison, the subscale scores too were categorized such that 0-10=mild, 11-20=moderate, 21-40=severe, in proportion with the categories of the total scores.)

Finally, an analysis of the frequency of distribution of the scores was also done which revealed that

- Ratings of symptom-free individuals were frequently ‘0’ or ‘1’, while those in patients range from ‘0-5’.
- Most symptom-free individuals rated statement F-1 and F-3 (which pertained to the voice not being heard in general and in noise) as ‘1’.
- More than 50% of the persons with dysphonia answered “never” for questions E-9, E-25, P-26 and E-27 to E-30, most of which pertain to the extreme effects of voice problems, e.g.: “My voice ‘gives out’ on me” or “My voice makes me feel handicapped”.
- Patients with vocal cord palsy gave most ratings in the range of 2-4, while those with dysphonia due to vocal abuse gave most ratings on the range of 1-3.

**Discussion**

The fact that the meaning of the statements was unchanged in the back-translations and that the test-retest reliability was good suggests that the Indian versions may be appropriate for use clinically.

Further a significant difference in the means of the normative and pathological samples for both the Indian versions of the VHI implies that the questionnaire even in its Indian version, is correctly measuring what it is intended to measure. The means of the normative sample are also well within the range of 0-11.5 suggested by Behrman et al. (2008). Thus, the study may later be replicated with a larger sample size to validate the VHI in Indian languages, following this preliminary attempt.

None of the persons with dysphonia selected the option of “normal” to describe their voices, suggesting that they all were aware of their voice problem. The clients' perception of severity of the voice problem correlates moderately with the VHI, a finding that agrees with those of Jacobson et al. (1997) but disagrees with Carding (2000) who stated that there is a good correlation between the two measures.

One reason for the moderate correlation may be that the person might be giving a higher priority to one of the three factors- functional, physical or emotional, to judge his problem. Between the two measures, at least one subscale score correlates well with self-perception of severity. In this case, giving the client a holistic view of his problem could be one of the goals in therapy. Another reason could be that there are other factors at play which are not included in the VHI, e.g. personality, status within the family and society, etc. Both these possibilities should be carefully explored in therapy.

These factors which may influence a person's self-perception of severity of the voice problem may work both ways, i.e., may worsen his/ her impression of the problem or make it better than what it actually is. Some of these factors may be:

- Biases due to inadequate information obtained from the wrong sources
- Occupational demands, i.e., whether or not the voice needs to be used extensively at the workplace
- Social status and power: This refers to the importance or status given to the person within the family or within society. E.g.: An influential person may feel that his/ her voice problem is more severe as against a person perceived as insignificant by society.
- Personality traits like introversion or extroversion will determine the degree to which a voice problem will limit functioning. Further, an introvert may also want to keep back information while filling up the questionnaire.

<table>
<thead>
<tr>
<th>Marathi</th>
<th>Hindi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normative sample</td>
<td>Dysphonia sample</td>
</tr>
<tr>
<td>Mean</td>
<td>S.D</td>
</tr>
<tr>
<td>6 16</td>
<td>5 23</td>
</tr>
<tr>
<td>t = 6.14 with 13 degrees of freedom</td>
<td>t = 7.30 with 9 degrees of freedom</td>
</tr>
</tbody>
</table>

Table 2: Means and SDs of VHI Scores of normative and dysphonia samples
Significant other people’s opinion of the person’s problem may also influence his/her self-perception.

Vulnerability of the person will determine the extent to which he/she is influenced by other people’s opinions.

Perception of the voice problem in contrast to others: This means that if the person with a voice problem is surrounded by a lot of people with voice disorders or voices with a poor quality, his/her self-perception of the problem will be different from what it would have been, had he/she been surrounded by people with excellent voices.

Finally, the person’s literary skills and understanding may also lead to a poor correlation between the two measures, as the answers depend on what meaning is derived out of the question. Thus poor literary skills may lead to a wrong interpretation of the statement that is read.

The correlation coefficients show that males’ perception of the severity of the disorder may be slightly more holistic and rational than females in general and working women, in whom the correlation of VHI scores and self-perceived severity is poor. Also, means of ranks obtained from VHI scores were always higher than means of ranks given to self-perceived severity for both the groups of women (all women and working women). This finding suggests that most Indian women tend to underestimate their problem, and hence perceive the severity as less in spite of the large number of limitations in function that the VHI might actually show.

Finally the analysis of the frequency distribution of scores reveals that:

- Most symptom-free individuals too face difficulties with volumes of their voices.
- The rating of “never” for questions 9 and 25-30 may either mean that most persons with dysphonia do not face so severe a problem, that they have not come to terms with it, or that they do not wish to admit to strong statements like feeling “embarrassed, angry, incompetent, or ashamed” due to their voice problems.
- Persons with vocal cord palsy face more severe problems, and thus higher VHI scores than those with hyper functional dysphonia, a finding that supports those of Jacobson et al. (1997).

An interesting fact which was also noted in a study by Guimaeaes and Abberton (2004) was that responses to statements P-5 (calling people around the house) and P-6 (use of a phone) would differ not only due to the severity of the voice problem but also due to a person’s socioeconomic status. In fact, these are the only two questions where “because of my voice” is not stressed.

These findings on frequency distribution suggest that in future, the VHI may well be modified. Statements that elicit high ratings even in symptom-free individuals; or those that depend on socioeconomic status, etc. may be excluded. The VHI could also be made more sensitive to the factors other than the voice problem that exacerbate or reduce the limitations in function, in line with the recent International Classification of Functioning, Disability and Health (WHO, 2001).

**Conclusion**

The VHI is already an invaluable tool in the field of voice therapy and research. Its translation to Indian languages would make it even more applicable and useful to the vast Indian population. Its moderate correlation with client self-ratings of severity leads to many possible conclusions. Firstly, that the person is probably giving relatively greater priority to one of the areas affected by the problem, an important clue for the clinician for where to start therapy in order to have a well-motivated client. Secondly, that there might be areas the person is unaware of, or does not want to look at (i.e., underestimation, especially in case of women). In such a case it would help to counsel the client to come to terms with these areas and deal with the problems.

One might also want to explore and try to modify the factors discussed above (e.g. excessive vulnerability) which might influence self-perception of the problem. This, in other words, implies that the VHI has scope for expansion to include these “other relevant factors” that contribute to the problem.

The study also opens doors to future research with a larger sample size, or controlling for the factors like socioeconomic status, age, occupation, etc. which may yield information specific to certain subgroups of people. Validation of the VHI in other Indian languages may also be considered.
Finally, the study supports the fact that a subjective measure or a discrepancy in two findings does not complicate results, but gives us valuable new insights that can help us solve the problem more efficiently, ultimately leading to a better prognosis.

References


Thomas, G., Kooijman, P.G., Donders, A.R., Cremers,


CROSS LINGUISTIC STUDY ON PHONOLOGICAL SIMILARITY EFFECT

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Abstract

The phonological similarity effect (PSE), poor retention of order for lists of similar-sounding items is a benchmark finding in the short-term memory literature. While the models of PSE have been investigated after extensive studies on monolinguals, the bilingual population would serve as a potential platform to examine PSE from cross linguistic perspective. The main aim of the study is to examine the PSE in Malayalam – English bilingual speakers and to find out a) The factors that facilitate serial recall b) Whether phonologically similar words have a detrimental effect on serial recall task c) Whether lexicality plays a role on PSE d) Whether the PSE on item recall is crucially affected by lexicality. Ten typical Malayalam-English bilinguals in the age range of 20-25 years were selected for the study. Stimuli were categorized into five different lists, namely rhyming words list, alliterative words list, rhyming non-words, alliterative non-words and simple non-word list in both English and Malayalam. The audio recorded stimuli were presented through the DMDX program. Subjects were instructed to recall maximum number of items in the serial order. The superior performance on rhyming words and alliterative words over simple non-words is in consonance with the lexicality effect reported in the literature. Consistent with the existing literature, our results also confirmed the categorical cueing effects which are responsible for better performance in recall of rhyme nonword over simple nonwords and alliterative nonwords over simple nonwords which in turn supports feature based model.

Overall the results show similarities in PSE between Malayalam and English thus suggesting that the PSE construct employed to propose short term memory models for English language would also explain PSE in Malayalam though the two languages are from different families.

Key words: Rhyme, Alliteration, Feature Based Model, Lexicality Effect, Category Cueing Effect

A robust finding in working memory research is that to recall a set of phonologically similar words is much more difficult than to recall a set of phonologically dissimilar words, which is the well-known phonological-similarity effect (Conrad & Hull, 1964). This finding points out that the capacity of information retention in our working memory store more or less depends on the phonological nature of the to-be-memorized information. The more similar (phonologically) the to-be-memorized item, the more difficult it is to retain in the working memory store.

Watkins, Watkins & Crowder (1974) compared serial recall of phonologically similar and phonologically dissimilar lists. Performance was assessed using the strict serial recall measure and it was found that the performance was better for the phonologically distinct lists, demonstrating the classic Phonologic Similarity Effect (PSE). However, no difference in performance in item recall measure was found for the phonologically similar versus dissimilar lists. Similarly, Gathercole (1982) compared serial recall of phonologically similar and phonologically dissimilar lists. Using the strict serial recall measure, performance was better for the phonologically distinct lists; however, item recall was actually better for the phonologically similar lists than for the phonologically dissimilar lists. Besner and Davelaar (1982) demonstrated that the phonemically similar lists were less accurately recalled than lists of phonemically distinct items, irrespective of the word likeness of...
the visually presented materials.

Poirier and Saint-Aubin operationally defined phonological similarity as lists of rhyming words while other studies have used lists of single syllable words with a common vowel and some overlap in the consonants (Coltheart, 1993). A study by Poirier and Saint-Aubin (1996) examined serial recall of lists of 2-syllable words. Strict serial recall was better for the phonologically distinct lists, but item recall was no different for the phonologically similar versus dissimilar lists. Some studies have obtained classic PSE that is PSE has been found in both item and serial recall. Drewnowski (1980) Coltheart (1993), found that recall was better for phonologically dissimilar than for phonologically similar lists in terms of both the strict serial recall and item recall measures.

Lian and Karlsen (2004) showed a significant interaction effect between lexicality and phonological similarity, indicating in their case that the phonological similarity factor affected words but not nonwords.

Roodenrys and Stokes (2004) found that there is a positive effect of word likeness on nonwords regardless of task. Non words of high word likeness appear subject to redintegration leading to errors in serial recall task or position accuracy (Fallon, Mak and Tehan, 2005).

Fallon, Groves, and Tehan (1999) reported that both the rhyming and the phonemically similar condition showed impaired order memory compared to a dissimilar condition, the recall of item information was actually enhanced in the rhyming condition albeit in the wrong order than in phonologically dissimilar condition. They suggested that the rhyming similarity can act as an effective category cue, and therefore facilitates item recall; but the phonological overlap without rhyme does not provide an effective category cue, and therefore does not facilitate item recall. However, the rhyming-non rhyming manipulation in their experiments was confounded with a difference in the degree of within-list phonological overlap. Each member of similar rhyming lists shared two phonemes, whereas each member of similar non rhyming lists such as shared on average only one phoneme. The difference in item recall for these two types of lists could therefore have been due to cueing by the degree of phonemic overlap rather than by rhyme category.

Theoretical account that has been proposed for the above observation is based on the feature model. The feature model of Nairne (1990) incorporates representations of this type. In this model, the effect of phonological similarity in serial memory arises from overlap of the feature vectors that represent the phonologically similar list items. Phonological similarity makes it difficult to recover an item's correct position within a list because there are overlapping features; however, common phonological features among list items can be used to discriminate the list as a whole from other lists, thus aiding item recall which is termed as category cue (Nairne & Kelley, 1999). The feature model would therefore predict that item recall for lists comprised of phonologically similar rhyming stimuli should be equivalent to that for lists comprised of phonologically similar non-rhyming stimuli such as alliterative lists, if the degree of phonological overlap is controlled which is referred to as feature account.

According to Baddeley's phonological loop model which comprises of two components, the phonological short-term store and the sub vocal rehearsal process, the source of PSE in immediate serial recall is the phonological store. It is argued that memory items that share a similar phonological structure will become more rapidly indiscriminable from one another due to decay than items with non-overlapping phonological structures (Baddeley, 1966).

Most of the studies regarding PSE have been carried out in English language. Cross-language investigations on PSE would be necessary to understand the influence of linguistic / structural differences in language processing. PSE on span of verbal short term memory in Persian language (Jahana, Baratzadeh & Nilipour, 2008) has been done using three different lists, namely rhyming words list, alliterative words list and dissimilar words list. The results showed significant difference between rhyming, alliterative and dissimilar words. There was no difference between rhyming and alliterative lists. They concluded that in rhyming and alliterative words, vowel, because of higher sonority (rather than the consonants) enhances the memory span as a cueing feature.
differences, especially in phonemes sonority level may cause different phonological similarity effects among languages. Since verbal short term memory is sensitive to vowel in words, it seems that the verbal short term memory is linguistic in nature.

In English, rhyming words (similar final syllable) and alliterative words (similar initial consonant or syllable) have different significance since each syllable is stressed differently. Studies on PSE have not been conducted in Malayalam language, the language spoken in the state of Kerala. English is a phonemic or stressed language while Malayalam is considered as a syllabic language with equal stress. Therefore there would not be much difference with regard to position of stress. That is, both rhyming words and alliterative words will have the same effect provided the degree of overlap of the similar feature is constant.

Study of phonological similarity effect (PSE) in immediate serial recall (ISR) has produced a conflicting body of results. No studies have been able to distinguish both the influence of segmental as well as prosodic feature in PSE. Cross-language studies would help to understand the role of linguistic features in processing the phonological elements of language. No attempts have been made in Indian context to address this issue and to integrate linguistic research to short term memory models. The aim of this study is to examine PSE in cross-language context on span of verbal short term memory in Malayalam and English.

Aims of the study
The main objective of the study is to examine the PSE in Malayalam-English bilingual speakers. The study also aims to find out a) The factors that facilitate serial recall b) Whether phonologically similar words have a detrimental effect on serial recall task c) Whether lexicality plays a role on the order of detrimental PSE d) Whether the PSE on item recall is crucially affected by lexicality, a finding less well explained by the feature based model which is a prominent model of PSE.

Method
Participants: Ten typical Malayalam-English undergraduate students (females) in the age range of 20-25 years with no history of neurological or psychological illness were selected for the study. All the participants were early bilinguals studied in English medium school since preschool. All participants were self rated as highly proficient in both the languages based on their proficiency in reading, writing, and speaking in both the languages. No particular proficiency rating scale was used because of the nonavailability of standardized proficiency rating scale in the year of the study. The same group of subjects participated in all the experiments designed for the study.

Material and procedure: Stimuli were categorized into five different lists, namely rhyming words list (RW), alliterative words (AW), rhyming non-words (RNW), alliterative non words (ANW) and simple non-word (NW) list in both English (E) and Malayalam (M). Ten seven-item list were created for the five different categories of words. All to-be-recalled words were bisyllables. The stimuli were audio recorded in an adult female voice using Praat software sampling rate of 44.1 kHz on a Lenovo Y430 Idea pad computer. The audio recorded stimuli were presented through the DMDX2 program. DMDX software was used to maintain uniform presentation time and response time. The subjects were seated comfortably in a quiet room and were instructed to listen to the stimuli presented through a headphone. Prior instructions were given to the subjects to serially recall (serial recall) the presented stimuli once each seven item list is heard. They were also asked to recall the maximum number of items (item recall) possible. Each sequence of items in the list was followed by a signal to indicate the participant to respond with recall of wordlist. There was a 4 second interval between words in each sequence. Two practice items were given prior to the test stimuli. The responses were recorded onto the system and verbatim transcription was done. The accuracy of the serial recall and number of items accurately recalled were checked. The time taken for each participant to complete the testing is approximately 40 minutes. Counter balance design was used where among the 10 subject’s five subjects received stimuli in the order of Malayalam-English and 5 subjects in the order of English-Malayalam. Rhyme and nonwords were used to maintain the effect of prosodic feature and study the effect of semantics.
Non words were considered to family the effect of meaning in PSE. Alliterative words were used to study the effect of segmental feature. The degree of phonemic overlap was not consistent across the word list.

**Results and Discussion**

Statistical analysis was done for both item recall and serial recall tasks to examine the effects of wordlist across and within languages. One-way repeated measure ANOVA with wordlists as independent variable was carried out and the results revealed a significant main effect. Paired t-test was done to compare the performance for each wordlist within language. The results are discussed under three phases.

**Phase I:** This phase compares the performance on item and serial recall for rhyming words and alliterative words within languages. This is done in order to determine the feature responsible for PSE in both languages (Table 1).

<table>
<thead>
<tr>
<th>Language &amp; task</th>
<th>Word list</th>
<th>&quot;t&quot; value</th>
<th>Sig (2tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Recall (SRM)</td>
<td>RW-AW</td>
<td>1.590</td>
<td>.146</td>
</tr>
<tr>
<td>Serial recall (SRE)</td>
<td>RW-AW</td>
<td>.730</td>
<td>.484</td>
</tr>
<tr>
<td>Item recall (IRM)</td>
<td>RW-AW</td>
<td>.037</td>
<td>.971</td>
</tr>
<tr>
<td>Item recall (IRE)</td>
<td>RW-AW</td>
<td>6.263</td>
<td>.000*</td>
</tr>
</tbody>
</table>

*significant at .05 level of significance

Table 1: T Values and Significance

In Malayalam language results of performance on serial recall and item recall for rhyming and alliterative words, shows no significant difference. This is attributable to the syllabic script of Malayalam in which rhyme and alliteration has the same effect.

In English serial recall of rhyme and alliterative words were not significantly different. This is probably because the category cueing effects of rhyming words were not strong to overcome the strict demands placed by the task. The rhyming words had consonantal overlap but the following vowel overlap was not present. This would have led to inadequate category cueing for serial recall also reported by Fallon, Groves and Tehan (1999). Results of item recall of rhyming and alliterative words in English show significant difference in accordance with the categorical cueing effect of the rhyme. This can also be in concordance with the findings of Poirier and Saint-Aubin (1996) where they found that there is no significant difference between phonologically similar versus dissimilar list in item recall.

**Phase II:** Phase two compared the performance of subjects in item recall and serial recall on rhyming words and alliterative words versus corresponding nonwords i.e. rhyming nonwords and alliterative nonwords, rhyming words versus nonwords and alliterative words versus nonwords within languages. In first two comparison features, which is rhyme and alliteration are kept constant and lexicality changes. In next two comparison both feature and lexicality changes. This was carried out to exclude the influence of word meaning (lexicality effect) and to study only the effect of features. If lexicality has a significant role in serial recall, rhyming and alliterative words must have larger scores compared to nonwords.

The results revealed significant difference between rhyme and simple nonword, alliteration and simple nonword, alliteration and alliteration nonword, rhyme nonword and alliteration nonword in both the languages for both item and serial recall task. The superior performance on rhyming words and alliterative words over simple nonwords is in consonance with the lexicality effect consistent with the findings of Lian and Karlsen (2001) where they showed a significant interaction effect between lexicality and phonological similarity. Consistent with the existing literature, our results also confirmed the categorical cueing effects which are responsible for better performance in recall of rhyme nonword over simple nonwords and alliterative nonwords over simple nonwords. This shows that PSE is not only due to category cueing but also due to lexicality effect. The superior performance of rhyme words and alliterative words over simple nonwords in both the languages also in turn supports feature based model (Nairne, 1990). There was no significant difference between rhyme words and rhyme nonwords. This may be dues to the word likeness of the rhyme nonwords and redintegration as supported by Roodenrys and Stokes (2004).

**Phase III:** Phase III compared the performance on item and serial recall for the entire lists across language (graph 1). This is done for a cross linguistic comparison of PSE. Performance across all the wordlists were compared and analyze.
Table 2: T Value and Significance between Rhyming and Alliterative Words and Non Words

<table>
<thead>
<tr>
<th>Language &amp; task</th>
<th>Word list</th>
<th>&quot;t&quot; value</th>
<th>Sig(2tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial Recall (SRM)</td>
<td>RW-RNW</td>
<td>1.132</td>
<td>0.287</td>
</tr>
<tr>
<td></td>
<td>RW-NW</td>
<td>3.647</td>
<td>.005*</td>
</tr>
<tr>
<td></td>
<td>ALW-NW</td>
<td>3.679</td>
<td>.005*</td>
</tr>
<tr>
<td></td>
<td>ALW-ALNW</td>
<td>3.234</td>
<td>0.010*</td>
</tr>
<tr>
<td>Serial recall (SRE)</td>
<td>RW-RNW</td>
<td>1.700</td>
<td>.123</td>
</tr>
<tr>
<td></td>
<td>RW-NW</td>
<td>.728</td>
<td>.485</td>
</tr>
<tr>
<td></td>
<td>ALW-NW</td>
<td>1.879</td>
<td>.095</td>
</tr>
<tr>
<td></td>
<td>ALW-ALNW</td>
<td>1.933</td>
<td>.085</td>
</tr>
<tr>
<td>Item recall (IRM)</td>
<td>RW-RNW</td>
<td>.158</td>
<td>.878</td>
</tr>
<tr>
<td></td>
<td>RW-NW</td>
<td>9.646</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>ALW-NW</td>
<td>8.94</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>ALW-ALNW</td>
<td>1.776</td>
<td>.109</td>
</tr>
<tr>
<td>Item recall (IRE)</td>
<td>RW-RNW</td>
<td>1.693</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>RW-NW</td>
<td>5.416</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>ALW-NW</td>
<td>11.279</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>ALW-ALNW</td>
<td>10.036</td>
<td>.000*</td>
</tr>
</tbody>
</table>

*significant at .05 level of significance

Graph 1: Comparison of two languages in both SR and IR

Statistical analysis using one-way repeated measure ANOVA revealed that there was a significant main effect on all the type of tasks – item and serial across language (F (3, 36) = 7.354, p<0.001). Bonferroni multiple comparisons were done to find the word list that showed a significant difference.

The result showed a significant difference between non words (NW) (p<.05) across language. This can be explained by the word likeness of the words in the English non word list compared to Malayalam non words used in the study (Roodenrys & Stokes, 2004). Comparison of performance for rhyming words, alliterative words, rhyming nonwords and alliterative nonwords did not show a significant difference. This indicates that the PSE is similar in both the languages except in case of simple nonwords. This can be attributed to the word likeness of the English nonwords when compared to those in Malayalam which is in consonance with the study by Roodenrys and Stokes (2004) where they found that there is a positive effect of word likeness on nonwords regardless of task. The similar results for PSE observed in both the languages for item and serial recall suggests close proximity of the two languages as though being on a continuum.

Conclusion

This study aimed to examine the phonological similarity effects between different word lists in
Malayalam-English bilinguals. From the first experiment it was found that performance for both item and serial recall tasks varied only for simple nonwords between the two languages. Performances on other wordlists were similar across both English and Malayalam. This shows the close proximity between these two languages. The superior performance on words over nonwords irrespective of the feature in both languages shows the effect of lexicality in both languages on both item recall and serial recall. The superior performance of rhyme words and alliterative words over simple nonwords in both the languages supports the premise that category cues for better recall which in turn supports feature based model (Nairne, 1990). Overall the results show similarities in PSE between Malayalam and English thus suggesting that the PSE construct employed to propose short term memory models for English language would also explain PSE in Malayalam though the two languages are from different families. This findings inturn suggest the need for incorporating the linguistic researches in short term memory models to verify the models as well as to consider the findings when adopting test materials from developed for western population. This should also be taken into account while developing test stimuli for assessing the short term memory as well as presenting stimuli during intervention.

References

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The authors wish to express their gratitude to Dr. Vijayalakshmi Basavaraj, Director, AIISH for permitting to carry out this study. They also thank all the subjects for their cooperation for the study.
DEVELOPMENT OF SPEECH RHYTHM IN KANNADA SPEAKING CHILDREN

*Savithri S. R., **Sreedevi N., ***Jayakumar T., ***Kavya V.

Abstract

Rhythm in speech is the systematic organization of speech units in time, such as syllables and vocalic intervals. Language of the world has been organized under stress-timed, syllable – timed and mora-timed, depending on the type of syllables used in a language. The present study is initially output of large scale study which to investigated the development of speech rhythm in typically developing Kannada speaking children by using the pair-wise Variability Index (PVI). Total of 15 boys, were divided in to three age groups (4-5, 8-9 and 11-12 years) with an equal number of participants. A five-minute of narrated speech sample of each child was elicited using cartoons or Panchatantra pictures. All the samples were audio-recorded using Olympus digital voice recorder at a sampling frequency of 16 kHz. Each speech samples were audio listened carefully removed the pauses manually. The Vocalic (V) and Intervocalic (IV) durations were measured in the samples using PRAAT software. The duration difference between successive vocalic and intervocalic segments was calculated and averaged to get the normalized Pair-wise Variability Index (nPVI) and raw Pair-wise Variability Index (rPVI), respectively. The result indicated that segmental timing showed a developmental trend in children and the boys begin to adult-like rhythm at around 11-12 years. Due to the high nPVI and low rPVI values the rhythmic pattern remains unclassified and cannot be placed in any of the rhythmic classes. The findings reveal that the syllabic structure used by children is different (prolonged vowel duration) from the adults.

Key words: Speech rhythm, Vocalic duration, Intervocalic duration, Pair wise Variability Index.

Rhythm, a prosodic feature, refers to an event repeated regularly over a period of time. Rhythm in speech is the systematic organization of prominent and less prominent speech units in time, such as syllables and vocalic intervals (Abercrombie, 1967). Rhythm varies with languages and depends on the types of syllables used in a language. Languages differ in characteristic rhythm, and with respect to adult speakers, they have been organized under stress-timed, syllable-timed and mora-timed, based on the Rhythm Class Hypothesis (Abercrombie, 1967). The Rhythm Class Hypothesis states that each language belongs to one of the prototypical rhythm classes known as stress-timed, syllable-timed or mora-timed (Ladefoged, 1975).

When a language has simple syllabic structure, for e.g. VC or CCV, the durational difference between the simplest and most complicated syllable is not wide. This durational difference may be less than 330ms. Under these circumstances, the rhythm of the language is said to be a fast syllable-timed rhythm. If the syllabic structure is still simpler, for e.g. VC or CV, then the durational difference between syllables is negligible and it is called a mora-timed language. When a language has complex syllabic structure, for e.g. V and CCCVC, the difference between syllables can be very wide. In such a condition one has to use a slow stress-timed rhythm (Abercrombie, 1967).

The development of concept on rhythm measurement was started with the concept of isochrony- i.e. each syllable has equal duration or the occurrence of regular stress beats. The first attempt to test Rhythm Class Hypothesis (Grabe &
Low, 2002) by using the average syllable duration (ms), but was not found to be effective in classifying rhythm types. Roach (1982) used a different measure – inter-stress interval (ISI). However, ISI also does not seem to classify all languages on the basis of rhythm. Ramus, Nespor and Mehler (1999) measured and found that a combination (vector) of vocalic durations (%V) and SD of consonant intervals (ΔC) provided the best acoustic correlate of rhythm classes. These measures reflected rhythmic differences as continuum, but not classes.

The Pair-wise Variability Index (PVI) was developed by Low (1998) for rhythmic analysis. This is a quantitative measure of acoustic correlates of speech rhythm and it calculates the patterning of successive vocalic and intervocalic (or consonantal) intervals, showing how one linguistic unit differs from its neighbor. The normalized Pairwise Variability Index (nPVI) and raw Pairwise Variability Index (rPVI) was developed by Low, Grabe and Nolan (2000). nPVI is used for rhythmic analysis of vocalic durations and rPVI is used for rhythmic analysis of intervocalic durations. Since it is a ratio it does not have any unit. Using the nPVI and rPVI value majority of the languages was classified successfully in comparison with other measures of rhythm. The classification of languages according to nPVI and rPVI is based on the following pattern shown in Table 1. Classifying the rPVI and nPVI value as high or low is in comparison with each other.

<table>
<thead>
<tr>
<th>Rhythm Type</th>
<th>rPVI</th>
<th>nPVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress-timed</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Syllable-timed</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Mora-timed</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 1: Classification of rhythm patterns based on the Vocalic and Intervocalic intervals.

In the Indian context, the research done so far is mostly on adults and much needs to be done on speech rhythm in children. Savithri, Sanjay Goswami and Kedarnath (2007) investigated rhythm in Kannada speaking adults and results showed that Kannada is a mora-timed language (low rPVI and nPVI). The rPVI values for the reading sample ranged between 35.90 and 52.10 with a mean of 46.18 and nPVI values ranged between 41.80 and 54.36, with a mean of 46.95.

With respect to children, few studies have been carried out recently. Subhadra, Das and Singh (2009) examined the rhythmic features of speech in 70 bilingual children speaking English and Hindi between 5 and 8 years. They found that at around 7 years of age, the durational variability for English became significantly larger than that of Hindi and suggested that children learning two languages exhibit characteristic speech rhythm around 7 years of age. A study by Savithri, Sreedevi and Kavya (2009) investigated the type of speech rhythm in typically developing 8-9 year old Kannada speaking children. The rPVI values for these children ranged between 44.97 to 78.17 with a mean of 65.90 and the nPVI values ranged between 80.10 to 122.75 with a mean of 96.06.

The results of above studies reported high nPVI and low rPVI values for adults as well as for children in Kannada language and therefore the rhythmic pattern remained unclassified. The results also showed that syllabic structure used by the children was simpler than adults. These reports give interest in investigating the trend of change in the rPVI and nPVI values across age groups. This intern will help to in known the syllabic structure changes in the spoken language across age groups which will help in assessment and management of children with arrhythmia. Hence there is a need to investigate the development of speech rhythmic pattern in children. In this context the present study was undertaken. The present paper is a part of the DST project and investigated the development of speech rhythm in typically developing Kannada speaking children across the age and gender in large samples. The present study shows the result of three age groups of participants.

**Method**

**Participants:** A total of 15 boys participated in the study. Participants were divided into three groups according to their age. Group I consisted of 5 boys in the age range of 4-5 years; Group II consisted of 5 boys in the age range of 8-9 years and Group III consisted of 5 boys in the age range of 11-12 years. All the participants were screened by the speech-language pathologist for speech and hearing problem. Ling test was used for hearing screening and the standardized questioner developed by department of Prevention of communication disorder.
All India Institute of Speech and Hearing was used to screen the speech and language problem.

**Material:** Cartoons developed by Indu (1990) were used for children of Group I. Children in Group II and III described Panchatantra pictures developed by Rajendra Swamy (1992).

**Procedure:** Speech samples were collected in quiet room of schools in Mysore. A five-minute of narrated speech sample of each child was elicited using cartoons or Panchatantra pictures. From Group I children speech was elicited using prompts and repetitions. All the samples were audio-recorded using Olympus digital voice recorder at a sampling frequency of 16 kHz.

**Analyses:** Speech samples were displayed as waveform using the PRAAT software (Boersma & Weenink, 2004, version 5.0.34). They were heard carefully to identify pauses which were removed manually. This was done in order to get an appropriate measure of the vocalic and non-vocalic segments. The Vocalic (V) and Intervocalic (IV) durations were measured in the samples using PRAAT software. Vocalic measure refers to the duration of vowel/ semivowel/ diphthong that will be measured as the time duration from the onset of voicing to the offset of voicing for that vowel/ semivowel/ diphthong. Intervocalic measure refers to the duration between two vocalic segments. It was measured as the time duration between the offset of the first vocalic segment to the onset of the second vocalic segment. Figure 1 shows the illustration of vocalic and intervocalic measures in the sentence [ondu:ralli ondu ka:ge ittu].

The duration difference between successive vocalic and intervocalic segments was calculated and averaged to get the nPVI and rPVI, respectively. Pairwise Variability Index developed by Low, Grabe and Nolan (2000) was used as a measure of rhythm. The rPVI and nPVI were measured using the following formulae:

\[ rPVI = 100 \times \frac{\sum_{k=1}^{m-1} |d_k - d_{k+1}|}{(m-1)} \]

\[ nPVI = 100 \times \frac{\sum_{k=1}^{m-1} |d_k - d_{k+1}|}{(m-1)} \]

where, \( m \) is the number of intervals and \( d_k \) is the duration of the \( k \)th interval.

**Statistical analysis:** Microsoft Office Excel program was used to generate the formula and calculate the difference between successive vocalic and intervocalic segments and to obtain the nPVI and rPVI values. Mann Whitney-U test was used to obtain the significant differences between the groups.
Results and Discussion

The mean rPVI of Group I ranged between 49.75 to 92.58 and the mean nPVI ranged between 83.41 to 119.5. The mean rPVI of Group II ranged between 48.0 to 66.57 and the mean nPVI ranged between 83.72 to 112.8. The mean rPVI of Group III ranged between 36.63 to 46.64 and the mean nPVI ranged between 67.52 to 78.8. The mean nPVI was found to be higher than the mean rPVI in all the three groups. Table 2 and the figure 2 shows the rPVI and nPVI values of all the subjects.

Results of Mann Whitney-U test indicated no significant difference between group I and II for rPVI \(|Z| = 0.94, p > 0.01\) and nPVI \(|Z| = 0.52, p > 0.01\). Significant differences between group II and III for rPVI \(|Z| = 2.61, p = 0.01\) and nPVI \(|Z| = 2.61, p = 0.01\) and between group I and III for rPVI \(|Z| = 2.61, p = 0.01\) and nPVI \(|Z| = 2.61, p = 0.01\) were found. The results revealed several points of interest. First, the results indicated that nPVI was higher than the rPVI values in all the three groups. This is in not consonance with the findings by Savithri, Sanjay Goswami and Kedarnath (2007) where they have used reading task for speech rhythm analysis in adults speaking Kannada. Current study showed high value of nPVI value which may be because of of longer durations of vocalic segments. This implies that children (boys) in the present study tend to prolong the vowel to a greater extent, which had effect on nPVI compared to adults. Another reason can be the difference in the task one being reading and another being narration. Narration of pictures requires more time (to form a sentence) which might have caused lengthening of vowels in children's speech.

Second, the results of the present study revealed no significant difference between 4-5 years and 8-9 year old children. But there was a significant difference between 8-9 years and 11-12 year old children. The nPVI and rPVI were shorter in boys in the age range of 8-9 years compared to 11-12 year old boys. The nPVI value of boys in the age range of 11-12 years was closer to adults (Savithri, Sanjay Goswami & Kedarnath, 2007). This shows that the boys begin to acquire an adult-like rhythm at around 11-12 years. These findings support the results of several studies by Smith (1978), Lee, Potamianos and Narayanan (1999), Smith and Kenney (1999) which indicate that segmental timing shows a developmental trend in children and that the children start to develop speech rhythm as early as 15 months, which continues till the age of 12 years.

Table 2: Mean rPVI and mean nPVI of the five male subjects across three age groups.

| Sub. No. | Group I (4-5 yrs) | Group II (8-9 yrs) | Group III (11-12 yrs) |
|---------|-----------------|-----------------|-----------------|-----------------|
|         | rPVI | nPVI | rPVI | nPVI | rPVI | nPVI |
| 1.      | 51.55 | 119.5 | 62.13 | 91.22 | 46.64 | 68.2 |
| 2.      | 49.75 | 96.07 | 48   | 96.4  | 36.63 | 74.02 |
| 3.      | 92.58 | 86.92 | 66.57 | 112.8 | 37.88 | 78.8 |
| 4.      | 74.34 | 92.46 | 63.21 | 108.24 | 42.04 | 67.52 |
| 5.      | 66.74 | 83.41 | 63.22 | 83.72 | 41.63 | 71.11 |
| Median  | 66.74 | 92.46 | 63.21 | 96.4  | 41.63 | 71.11 |
| (SD)    | (17.63) | (14.18) | (7.25) | (11.99) | (3.94) | (4.62) |
| Confidence Interval (95%) | 45-88.8 | 78-113.2 | 51.6-96.6 | 83.5-113.3 | 36-45.8 | 66.1-77.6 |

Figure 2: Mean of nPVI and rPVI values for children of the three age groups vs. adults.

(Agent data is from Savithri, Sanjay Goswami and Kedarnath, 2007)
Third, the rhythm in boys in the present study showed high nPVI value and Low rPVI value which remains 'unclassified'. This is not in consonance with the results of the study in Kannada speaking adults by Savithri, Sanjay Goswami and Kedarnath (2007) which indicated that Kannada was a mora-timed language. This result generated doubts whether rhythm needs to be classified under the three types. Probably, there may be many more types of rhythm. Also, should the measurement of rhythm needs to be further investigated or whether the rhythm measurements should be based only on durations or should it be based on other acoustic correlates of prominence, namely increased F0, increased amplitude and changed vowel quality. Kohler, 2009 reported that rhythm is not a fixed typological prominence pattern for groups of language but is variable within each language. However it is also determined by the language in that the potential rhythmical patterns of F0, syllabic duration, energy and spectral patterning over time.

Fourth, it was observed that the PVI variability (SD) was larger in the younger age groups compared to the older age group and it decreased from 4-5 years to 11-12 years of age. Most of the time the variability was higher in nPVI compared to rPVI. These results support the findings of Lee, Potamianos and Narayanan (1999), who report that between the ages 9 and 12, both magnitude and variability of segmental durations decrease significantly and rapidly, converging to adult levels around age 12.

The study intends to investigate the development of speech rhythm in typically developing Kannada speaking children from 3 to 12 years of age. Hence, it is anticipated that a picture of emerging rhythm will appear when the study is complete.

Conclusions
Speech rhythm refers to the alternation of timing and the perceived regularity of prominent units in speech, and its acquisition provides valuable insights into how children learn their languages. The present study investigated the development of speech rhythm in typically developing Kannada speaking children by measuring the vocalic and intervocalic intervals. The results of the present study indicated that children appear to produce durational and other prosodic differences as early as 4-5 years, but their productions are characteristically variable until much later, stabilizing to more or less adult-like rhythmic patterns around 11-12 years of age. This study reveals that the syllabic structure used by children is different from the adults and there is a need to develop normative data to map the pattern in which they acquire adult-like speech rhythm.

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DISCOURSE IN TRAUMATIC BRAIN INJURY

*Hema N. & **Shyamala Chengappa

Abstract

Analysis of discourse production can be chosen as a means for testing cognitive-linguistic abilities of individuals with traumatic brain injury (TBI). The aim of the present study was to assess the cognitive-linguistic abilities in terms of discourse analysis in participants with traumatic brain injury and to compare them with discourse of neurologically intact individuals. The participants included 20 individuals with TBI (closed head injury) and 20 healthy talkers. The task involved use of a conversational topic, “family”. Conversation was audio recorded using computer software and speech sample was transcribed verbatim using IPA and analyzed for discourse parameters using a discourse analysis scale. The results of this study showed a significant difference between the participants with TBI and healthy talkers. Participants with TBI were deficient on certain parameters of discourse. The details are discussed.

Key words: Discourse analysis scale, traumatic brain injury, cognition, linguistic ability

Discourse can be defined broadly as language use “in the large”, or as extended activities that are carried out via language (Clark, 1994). It is a unit of language longer than a single sentence for verbal exchange and conversation. Discourse is a broad term used to describe four forms of connected speech (Rosenbek, LaPointe & Wertz, 1989): Procedural discourse deals with describing the procedures involved in performing an activity. Expository discourse deals in conveying information on a single topic by a single speaker. Conversational discourse is the one which conveys information between a speaker and listener or among speakers and listeners. And narrative discourse is a description of events. According to Brown and Yule (1983), discourse can be studied at comprehension level where it checks the ability to establish relationships within and between sentences by using context as the foundation for comprehension to form a coherent representation.

At expressive level, it can be transactional discourse which checks for the ability to express content and have interactional discourse which deals with the expression of personal attitudes and social relationships. Conversation is fundamental for socializing and strengthening interpersonal relationships through good comprehension ability and expressive skills. Individuals with TBI show poor conversational competence due to their verbosity, inappropriate responses to social communication, poor topic maintenance and reliance on additional conversational prompting. Thus, it is not surprising that their conversations have been described as less enjoyable, interesting or rewarding (Coelho, Youse & Le, 2002; Godfrey & Shum, 2000; Paterson & Stewart, 2002).

Discourse can be analyzed at microlinguistic and macrolinguistic levels (Ulatowska, North & Macaluso-Haynes, 1981; Ulatowska, Freedman-Stern, Doyle & Macaluso-Haynes, 1983; Glosser & Deser, 1990; Cannizzaro & Coelho, 2002): At microlinguistic level the processing of phonological, lexical-semantic and syntactic aspects of single words and sentences can be analyzed. Measures of syntactic complexity and production at the single word level are often used here. At macrolinguistic level, the ability to maintain conceptual, semantic and pragmatic organization at the suprasentential level can be analyzed.

Coherence and cohesion are often used as measures of macrolinguistic abilities (Halliday &
Hasan, 1976). It relies on the interaction of both linguistic in terms of comprehension and expression and non-linguistic knowledge, especially the non-linguistic systems of executive control and working memory (Cannizzaro & Coelho, 2002). Competent speakers use a range of discourse levels in their daily communication to meet the demands of situations and partners (Bloom, 1994; Coelho, Liles & Duffy, 1994; Togher, 1998).

Finally, the discourse can be examined via a text, viewing it as a product or as a joint activity of discourse as a process. Because of its inherently dyadic nature, Clark (1994) suggested to view discourse as a joint and more meaningful activity, referring to interactional conversation as well as to stories told to others by single narrator.

Ehrlich (1988) has indicated that examination of communication skills of persons with TBI should always include assessment at the discourse level, particularly because these deficits on traditional linguistic tests are more subtle than what is observed for aphasia and/or other adult communication disorders. Discourse analysis has been widely used by psychologists, speech pathologists, and other professionals to analyze everyday language interactions (Stubbs, 1983). Discourse elicited from monologues and narrative tasks does not always represent interactional communication of everyday and therefore may not capture true communicative competence or incompetence of individuals with TBI (Snow, Douglas & Ponsford, 1995; Snow & Douglas, 2000). These tasks are used as controlled elicitation tasks mostly for research purposes.

Conversation and “social chat” have been recognized as important communication genres for individuals with TBI (Davidson, Worrall & Hickson, 2003; Larkins, Worrall & Hickson, 2004). It is well documented that individuals with TBI do not always produce proficient conversational discourse because they have difficulty in maintaining appropriate pragmatic and social skills. They may also have difficulty producing proficient discourse due to impaired attention, planning, organization, and self-regulation processes (Bond Chapman, Levin, Matejka, Harward & Kufera, 1995; Cherney, Shadden & Coelho, 1998). Previous research on conversational discourse of individuals with TBI has depicted their incompetence and communication difficulties. Conversations with individuals with TBI have been described as more effortful and less enjoyable because their partners are required to use “additional” prompting to maintain the topic and flow of conversation (Coelho, Youse & Le, 2002). Conversational interaction between friends, parents and siblings of individuals with TBI has been occasionally included in clinical studies, and it is difficult to identify if discourse performance of individuals with TBI may be improved in the presence of people who share meaningful (social) relationships with them. But this causes bias in choosing discourse partners and does not provide an accurate judgment of TBI individuals’ discourse ability. So, discourse studies in the TBI literature have focused on “conventional” genres such as monologues, narratives, procedural texts and structured conversations to make the task more controlled from a research point of view.

Many investigators have also made incidental comments on the salient impairments in conversation exhibited by participants with TBI. Coelho, Liles, Duffy and Clarkson (1993) examined conversations of five individuals with TBI, five individuals with aphasia, and five non-brain-injured controls using Blank and Franklin’s (1980) procedure for evaluating appropriateness within a conversation. Results indicated that the individuals with TBI had more turns, shorter utterances, decreased response adequacy, as well as difficulty initiating and sustaining topics. These findings suggested such analysis to be promising for delineating distinctions in conversational performance across groups. Functional communication requires language competence in a variety of settings ranging from informal social interactions to formal educational or work-related tasks (Snow, Douglas & Ponsford, 1997).

Recent investigations have demonstrated that individuals with TBI experience difficulty with communicative effectiveness across a number of discourse production genres. In various other studies (Allen & Brown, 1976; Milton, 1984; Mentis & Prutting, 1991), TBI patients were found to be lacking in many areas of conversational discourse like interactional/ non-propositional aspect and propositional aspect of conversation. The discourse abilities of adults who have suffered TBI have revealed that although these
individuals display “normal” or “near normal” language on traditional aphasia tests, they demonstrate varying levels of impairment in the coherence, cohesion, and informational content of their extended verbal production (Hagen, 1984; Ylsivaker & Szekeres, 1989, 1994; Hartley & Jensen, 1991; Coelho, Liles & Duffy, 1994).

The present study sought to validate a comprehensive discourse analysis using “Discourse Analysis Scale” (Hema & Shyamala, 2008) for conversation task in Kannada language. The scale consists of conversation parameters categorized under two headings. The propositional aspect deals with how discourse is organized with respect to overall plan, theme or topic and how individual utterances are conceptually linked to maintain unity. And the non-propositional aspect deals with the important category of social communication behavior. These behaviors reflect the reciprocal nature of conversation and the joint co-operation required from the participants. This is a perceptual rating scale formed on the basis of standardized Damico’s Clinical Discourse Analysis scale (1985) and Grice’s (1975) Cooperative Principles for conversation, for differentiating discourse abilities between the groups of individuals with TBI and healthy talkers. A detailed description of all the parameters of discourse is shown in Appendix A.

Aim

The study aimed to assess, compare and differentiate the discourse abilities among the individuals with TBI and the healthy talkers.

Method

Participants: A total of 20 right handed individuals with TBI (Closed Head Injury) following road traffic accidents (male – 16, female – 6) in the age range of 20 to 40 were taken as TBI group. Although Kannada as mother tongue was the criteria, knowledge of other languages (English, Hindi, Tamil and Telugu) were noted. None of the patients included in the study had Aphasia as confirmed by Western Aphasia Battery test (Kertesz, 1982). They all belonged to a middle/high socioeconomic status confirmed from NIMH Socioeconomic Status Scale (NIMH, 1997). Participants were also selected according to the severity of the trauma. Participants who were identified as having moderate to severe injury on the basis of Glasgow Coma Scale (Jennette & Teasdale, 1981) were selected for the study. Participants with any other type of trauma like open head injury and mild insult were not selected for the study. All participants presented a history of post-traumatic amnesia and there was a gap of at least 1-5 months post accident.

The group of healthy talkers comprised of 20 normal individuals matched for age, sex and education with no history of traumatic brain injury or any other brain insult. They were also screened for any speech, language, cognitive-linguistic and hearing impairment using Western Aphasia Battery (Kertesz, 1982), Mini Mental Status Examination (MMSE) (Folstein, Folstein & McHugh, 1975) and routine pure tone audiometry. The detailed demographic data is tabulated in Table 1.

Procedure: The target task was free conversation between the participants and the investigator. A total of two sessions of conversation, each varying from 10 to 20 minutes, was carried out on various topics. The first session was aimed to improve interaction between the investigator and the participants to build rapport. During the second session the participants showed less inhibition in their conversation, since they became quite accustomed to the investigator. The succeeding single session was recorded. Only ten to fifteen minutes speech sample of this session was selected for the final analysis. The conversation was recorded using a Wave Surfer 1.5.7, computer software program. The participants were aware that their speech was being recorded. All the recordings were carried out in a quiet room with no distraction in between the recordings. Before recording, the participants were instructed to talk in a way similar to two friends talking to each other. They were also informed that they were free to ask any questions to the examiner during the conversation. Conversation sample was centered on particular topics like family and other few general topics like job, hobbies, hospital etc in order to keep the topic of conversation constant across all the participants.

From the recorded audio sample, transcription was done using broad International Phonetic Alphabet, (2007). Conversations between investigator (I) and participants (S) were transcribed. During transcription, initiation time, pause time, filled
Table 1: TBI group case by case description

<table>
<thead>
<tr>
<th>Pt No</th>
<th>Sex</th>
<th>Age at injury</th>
<th>DAA (months)</th>
<th>Type of trauma</th>
<th>Severity</th>
<th>D H</th>
<th>GC S</th>
<th>PT A</th>
<th>LK</th>
<th>Lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>50</td>
<td>5</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>6/15</td>
<td>+ve</td>
<td>K, E, H</td>
<td>RTA with concussive head injury with fracture of left frontal bone with underlying fracture haematoma (small extra dural haematoma). Left frontal haemorrhagic contusion</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>40</td>
<td>3</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>8/15</td>
<td>+ve</td>
<td>K, E</td>
<td>RTA with concussive head injury with deep lacerated wound on left side of occipital scalp</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>20</td>
<td>3</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>8/15</td>
<td>+ve</td>
<td>K, H, E</td>
<td>RTA with severe concussive head injury</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>28</td>
<td>5</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>6/15</td>
<td>+ve</td>
<td>K, H, E</td>
<td>RTA with severe concussive head injury. Fracture of right temporal bone and right zygoma with multiple intra cerebral contusion in left frontal and temporal region with gross cerebral edema</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>40</td>
<td>3</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>5/15</td>
<td>+ve</td>
<td>K, E</td>
<td>RTA with moderate head injury with left frontoparietal subdural haematoma with faciomaxillary injury</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>38</td>
<td>4</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>8/15</td>
<td>+ve</td>
<td>K, E</td>
<td>RTA with severe head injury</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>40</td>
<td>5</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>8/15</td>
<td>+ve</td>
<td>K, E, H, To</td>
<td>RTA with concussive head injury</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>40</td>
<td>5</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>7/15</td>
<td>+ve</td>
<td>K, E</td>
<td>RTA with head injury with left emporomastoid bone fracture with left parietal bone fracture with underlying pneumozecephalum</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>45</td>
<td>5</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>7/15</td>
<td>+ve</td>
<td>K, E</td>
<td>RTA with severe head injury with large temporal contusion</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>34</td>
<td>4</td>
<td>RTA</td>
<td>Severe</td>
<td>L</td>
<td>6/15</td>
<td>+ve</td>
<td>K, E, H</td>
<td>RTA with head injury with fracture post column left acetabulum with deep laceration of left frontal region</td>
</tr>
</tbody>
</table>
pauses, unfilled pauses, false start etc. were carefully noted, for each episode. The time taken by the participants to respond to any question was noted from the same software.
The discourse was analyzed using “Discourse Analysis Scale” developed by Hema and Shyamala (2008) for the conversation and picture description task in Kannada. The scale consists of conversational parameters under two headings, the propositional aspect and the non-propositional aspect of conversational discourse (Hartley, 1995). Each parameter of this discourse scale is explained in detail in Appendix-A.

**Scoring:** Each parameter was rated and recorded on a specific criterion as shown in Appendix A. A five point perceptual rating scale (Appendix-A) was used to score two of the parameters, coherence and gaze inefficiency. A four point perceptual rating scale (Appendix-A) was used to score delay before responding. The other parameters were scored using a three point rating scale. The investigator repeated the process of transcription of discourse sample i.e., the conversation sample of two TBI and two healthy talkers were transcribed again after 10 days for verification of transcription, scoring, and reporting of the features. The findings were found to be correlating in the two instances.

**Results**

A comparison was made at the level of propositional and non-propositional aspects of discourse in communication tasks among the two groups using Mann-Whitney U test. Experimental group consisted of 10 TBI participants with LHD, 10 TBI participants with RHD and 20 healthy talkers as control group. As can be seen in Table 2, the healthy talkers showed very good performance in the discourse task when compared to TBI group.

It can be observed from Table 2 that the mean value for all the parameters in normal healthy talkers are higher compared to the TBI participants, except for information adequacy, inappropriate speech style and inappropriate intonation contour where it was found comparable.

Individual scores were calculated and Mann Whitney test applied for the sub-parameter of the discourse analysis procedure. The results are tabulated in Table 3. Among the TBI participants and healthy talkers, there was significant difference in their performance at both propositional and non-propositional aspects for conversation task. Except for information content and message inaccuracy, all the other parameters in discourse analysis showed significant difference at 0.05 level between the TBI and healthy talkers group for conversation task.

**Discussion**

An attempt is made in the present study to describe the features impaired in the discourse mode of conversation in TBI individuals comparing them with that of the healthy talkers. A comparison was made at the level of propositional and non-propositional aspects of discourse in communication tasks. The healthy talkers showed very good percentage of performance when compared to TBI group. The significant difference in performance of TBI participants as compared to healthy talkers are discussed in detail under various sections.

The findings of this study have several implications pertaining to the characterization of conversational discourse performance following TBI and the use of discourse analysis procedure.

**Propositional aspects of discourse**

**Failure to structure discourse**

Between the TBI participants with LHD/RHD and healthy talkers, there was a significant difference for few parameters under discourse analysis. There are studies which support the results of the present study where the TBI groups lack forethought and organizational planning in their discourse structure. Study by Martin and McDonald (2003), describes a frontal lobe executive function account of pragmatic deficits resulting from traumatic brain injury. Pragmatic and discourse deficits resulting from RHD often mirror executive function deficits. Impulsivity, disorderization, poor planning, and poor judgment associated with executive function deficits are reflected in tangential, disorganized discourse, including responses that are not well thought out and may not be appropriate for a given situation according to Tompkins (1995). In summary, the TBI participants with LHD/RHD exhibit this particular feature of disorganized discourse and poor planning of discourse compared to normal control group.

**Communication intent**

Healthy talkers tended to greet others by themselves, but TBI participants did not make an effort to greet others by themselves. TBI groups were able to greet in response to other’s greeting. When compared to healthy talkers, these individuals were however, poor at initiating a conversation.
Table 2: Showing the mean, standard deviation of discourse analysis of conversation task for the TBI versus normal group

(* FSD-Failure to Structure Discourse, CI- Communication Intent, TM- Topic Management, IA- Information Adequacy, IC- Information Content, MI- Message Inaccuracy, COH- Coherence, NSV- use of Non-Specific Vocabulary, LNF- Linguistic Non-Fluency, ISS- Inappropriate Intonational Contour, GI- Gaze Insufficiency, TT- Turn Taking, CR- Conversation Repair, RB- Revision Behavior, NPT- Non-Propositional Total, PNPT- Propositional and Non-Propositional Total)

<table>
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<th>Parameters *</th>
<th>GROUP</th>
<th>TBI</th>
<th>Normals</th>
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<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>FSD</td>
<td>85.00</td>
<td>18.84</td>
<td>100.00</td>
</tr>
<tr>
<td>CI</td>
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<td>14.92</td>
<td>100.00</td>
</tr>
<tr>
<td>TM</td>
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<td>13.49</td>
<td>100.00</td>
</tr>
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<td>IA</td>
<td>100.00</td>
<td>.00</td>
<td>100.00</td>
</tr>
<tr>
<td>IC</td>
<td>97.50</td>
<td>11.18</td>
<td>100.00</td>
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<tr>
<td>MI</td>
<td>92.50</td>
<td>18.31</td>
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</tr>
<tr>
<td>COH</td>
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<td>11.56</td>
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</tr>
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<td>.00</td>
<td>100.00</td>
</tr>
<tr>
<td>IIC</td>
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<td>.00</td>
<td>100.00</td>
</tr>
<tr>
<td>GI</td>
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<td>20.51</td>
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<tr>
<td>PNPT</td>
<td>72.10</td>
<td>7.88</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Table 3: Results of Mann-Whitney test for the parameters of discourse analysis for conversation task

(Note: * indicate not significant difference)

†FSD-Failure to Structure Discourse, CI- Communication Intent, TM- Topic Management, IC- Information Content, MI- Message Inaccuracy, COH- Coherence, NSV- use of Non-Specific Vocabulary, LNF- Linguistic Non-Fluency, GI- Gaze Insufficiency, DR- Delayed Response, PT- Propositional Total, TT- Turn Taking, CR- Conversation Repair, RB- Revision Behavior, NPT- Non-Propositional Total, PNPT- Propositional and Non-Propositional Total)

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<th>/Z/</th>
<th>'P' value</th>
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<tr>
<td>CI</td>
<td>5.793</td>
<td>0.000</td>
</tr>
<tr>
<td>TM</td>
<td>5.346</td>
<td>0.000</td>
</tr>
<tr>
<td>IC</td>
<td>1.000</td>
<td>0.317*</td>
</tr>
<tr>
<td>MI</td>
<td>1.778</td>
<td>0.075*</td>
</tr>
<tr>
<td>COH</td>
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<td>GI</td>
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<td>0.001</td>
</tr>
<tr>
<td>DR</td>
<td>5.510</td>
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<tr>
<td>PT</td>
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<td>5.822</td>
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<td>RB</td>
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<td>PNPT</td>
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</table>
**Topic management**

Lesser and Milroy (1993) define topic as “what is talked about through some series of turns at talk”. Topic coherence can be defined as something that is constructed across turns by the collaboration of participant. It was noted that some of the TBI participants exhibited irrelevant introduction of topics which is an abnormal behavior. This result is in support with the study by Mentis and Prutting (1991) and Coelho, Liles and Duffy (1994) who found that TBI individuals produced unrelated topic changes.

There was a significant difference between TBI and healthy talkers for the parameter called rapid topic shift. It is reported in literature that some TBI participants change topics rapidly within few seconds. There was a mean difference between TBI participants and healthy talkers for this feature. This finding is in support of the study by Ehrlich and Barry (1989) where they report of rapid topic shift in TBI participants. The reason for this could be the deficit at executive functional level of the participants.

For non-coherent topic change there was significant difference between TBI participants and healthy talkers. Mentis and Prutting (1991) and Coelho, Liles and Duffy (1994) observed that TBI participants produced non-coherent topic changes compared to healthy talkers. Results of this study thus support, to some extent, that TBI participants, in general, exhibit this particular abnormal behavior in a conversation. This finds support with an Indian study done by Tanuja (2004) who found that TBI participants showed irrelevant and non-coherent topic changes when compared to normal speakers.

Perseveration in speech is reported in TBI participants. Here, an attempt was made to see if perseverance in terms of topic maintenance was observed even when the conversation partner changed the topic. TBI group showed some amount of perseverance behaviors. Most of the times, perseverance for topic was seen for a shorter time, which faded after two to three turns and very few times it persisted for a longer time. That is, TBI participants kept talking about the same topic for a long time.

Healthy talkers are seen to expand all the turns, unlike TBI participants who expand very few turns, according to study done by Tanuja (2004). This finding is in support of the earlier study done by Coelho, Liles and Duffy (1994) where they found that individuals with TBI contribute less elaboration to the topics, more often leaving it to the communication partner to develop and extend the topic.

Usually, healthy talkers give adequate elaboration to topics. They do not give more or less information. According to Hartley and Jensen (1991), some individuals with brain injury provide too many details and speak longer than required, while other individuals provide only short utterances and then give drastically reduced information. In the present study, the presence of this particular behavior was assessed and scored using three point perceptual rating scale (Appendix- A). There was a significant difference between the TBI participants and the healthy talkers.

Study done by Coelho, Liles and Duffy (1994) found that TBI participants provided shorter, less elaborations of a topic, more often leaving it to the communication partner to introduce and develop the topic. The results of the present study partially support this observation as minimal elaboration of topic was observed in the TBI groups. This could be because of individual’s linguistic and cognitive abilities. However, significant difference was found between the TBI participants and the healthy talkers.

In summary, it was seen that all the parameters under topic management showed significant difference between the TBI participants and the healthy talkers.

**Other propositional aspects of discourse**

*Information adequacy*

It was noted whether the information adequacy was at word level, sentence level or multiple sentence level. It was said to be adequate when it satisfied the question asked by the conversation partner. There was no significant difference when it satisfied the question asked by the conversation partner. There was no significant difference between the TBI participants and the healthy talkers. These results are in contrast with the few studies, where the authors have revealed some pragmatic inappropriateness relative to difficulty in initiating and/or sustaining conversation with decreased response adequacy in individuals with TBI (Mentis & Prutting, 1991; Parsons, Lambier, Snow, Couch & Mooney, 1989; Snow, Douglas & Ponsford, 1997). Another supporting study by Hartley and Jensen (1991) reports that participants with closed head injury produce only one half or two-thirds the amount of accurate content produced by normal participants and have drastically reduced information. This was quoted with reference to the narrative discourse but
the same findings are not seen in the present study on conversational discourse, where both the groups performed equally well.

**Information content and message inaccuracy**

There was no significant difference between the TBI participants and healthy talkers for information content and message inaccuracy. Thus it is suggested that none of the participants showed any redundancy, incoherence and ambiguity in their speech. But studies have shown reduced informational content in TBI participants (Chapman et al., 1992; Ehrlich, 1988; Mentis & Prutting, 1991). In this study however, the difference was not seen.

**Coherence**

The present study reveals the same results as that of studies by Hough and Barrow (2003), Glosser (1993), Myers (1999a), Van Dijk and Kintsch (1983), where TBI participants demonstrate greater difficulty with global than local coherence showing more performance variability among participants in global as compared to local coherence.

**Use of non-specific vocabulary**

The speaker uses deictic terms such as “this”, “that”, “then”, “there”, pronouns, proper nouns and possessives when no antecedent or referent is available in the verbal or nonverbal context. Consequently, the listener has no way of knowing what is being referred to. Individuals displaying this difficulty also tend to overuse generic terms such as “thing” and “stuff” when more specific information is required. There are a few reports which say that individuals with TBI exhibit this behavior. Here TBI participants showed the presence of this particular behavior to a greater extent with a rating as ‘partially present’ when compared to healthy talkers. Statistical results showed significant difference at 0.05 level between the TBI participants and healthy talkers.

**Linguistic nonfluency**

Linguistic nonfluency can be defined as the speaker’s production disrupted by the presence of repetitions, unusual pauses, and hesitation phenomena. TBI groups have exhibited this particular behavior to a greater extent than healthy talkers, while there was a significant difference between the TBI participants and healthy talkers. In the present study among the many propositional aspects of discourse, linguistic nonfluency was present more in the TBI participants than among healthy talkers.

**Inappropriate Speech Style**

Inappropriate Speech Style means that the speaker does not change the structural, lexical, or prosodic form of his utterances according to the needs of the audience or the context. This may involve the occurrence of dialectal structural forms, code switching, style-shifting, language transfer, or interlanguage phenomena or idiosyncratic language codes. The TBI participants and healthy talkers did not show any difference in their mean and standard deviation as is shown in Table 1. Thus, between the two groups there was no significant difference.

**Inappropriate Intonational contour**

Both the groups did not show the presence of inappropriate intonational contour in terms of abnormal rising, falling and flat intonation contour with respect to a particular context. There was no difference in the mean and standard deviation, thus there was no significant difference between the two groups. But the study says the joint construction of discourse and the role of the conversational partner’s tone in the communicative exchange are additional factors to be considered in the analysis of discourse of adults with CHI (Togher, Hand & Code, 1997). These investigators studied information-seeking exchanges with five adults with CHI and with their non-brain injured matched controls. Their results suggest that not only did the participants with CHI differ from the controls in the way they “provided, requested, and negotiated information exchange”, but the communication partners interacted differently with the CHI population as well. For example, they found evidence of less information being given to the TBI population. Such features were not found in the present study.

**Gaze insufficiency**

The percentage score for gaze insufficiency was considered and the result of non-parametric test showed significant difference at 0.05 level between the TBI participants and healthy talkers.

**Delay before responding**

Time taken by the TBI participants in responding to any questions asked by investigator was noted using a four point rating scale (Appendix- A). The participants in TBI group with LHD and RHD showed a delay of 4-6secs respectively in responding to any question. There was a significant difference between the TBI participants and healthy talkers.
Non-Propositional aspects of discourse

Turn taking

Between the TBI participants with LHD/RHD and healthy talkers, there was significant difference for all the parameters under non propositional aspects of discourse. Normal participants are seen to initiate many turns in a conversation. In contrast, TBI participants are reported to take less initiation of turns. They initiate very few turns in conversation. This result is in support with the findings of Milton, Prutting and Binder (1984). TBI group were very reluctant to initiate the turns. Only few participants were able to initiate the turns.

Wave Surfer 1.5.7, computer software was used to note down the time (in terms of seconds) taken to start a turn. From the individual scores it was noticed that all the TBI participants showed the presence of this particular feature. Participants took little time to start the turn. However, there was significant difference between the TBI participants and healthy talkers.

According to Schegloff (1987), normal individuals are reported to take contingent turns in conversation. Results suggest that there was a significant difference between the two groups. This is supported by literature where, according to Milton, Prutting and Binder (1984), three out of five adults in their study presented problem in taking contingent turns. The non-contingent turns can be attributed to lack of perception of flow of conversation. It seemed like they could not perceive the meaning of the preceding turn because of lack of concentration, subsequent to which they concentrated on one particular word and started speaking in relation to that word in a non-coherent way.

Many studies have implicated the right hemisphere in the production and comprehension of prosody, specifically emotional prosody (Baum & Dwivedi, 2003; Pell, 2006; Ross, 1981; Walker, Daigle, & Buzzard, 2002). In general, prosodic cues are necessary in conversation to take over the turn from the other partner. A normal speaker is able to understand the prosodic cues in a sentence to take over the turn. However, the TBI groups failed to take prosodic cues from the conversation partner in order to take over the turn. Results from Table 1 show that there was significant difference between the TBI group with LHD/RHD and healthy talkers. This observation supports the proposition by Milton (1984) and Hartley (1995) who reported that TBI participants had problem in understanding prosodic cues to take over the turn. It is seen that individuals with very severe TBI shift their mode of communication to nonverbal because of the impairment in verbal mode. In the present study, the TBI participants exhibited this particular behavior and there was significant difference between the TBI and healthy talkers.

In normal conversation, it is expected that only when one communication partner stops, the other partner initiate the turn. Results showed that there was significant difference between the TBI participants and healthy talkers. But all participants in the TBI groups showed the presence of a behavior called ‘persistent to listener’s or speaker’s mode’ in their conversation. These participants started speaking abruptly without letting the other person finish his turn and used to stay either in listener’s mode or speaker’s mode. This result is in support of a study by Mc Tear (1985), where the TBI population persists longer in either speaking or listening mode. This conversation behavior can be attributed to their lack of the ability to appropriately monitor and shift attention in TBI individuals.

Conversation repair

Conversation repair is a necessary strategy present in the conversation to convey a message in an effective manner. Results suggested significant difference between TBI participants and healthy talkers. But the individual scores in TBI group indicated that except for four participants all the other participants used too much of self repair through repetition in their conversation. This result is in support with the study by Tanuja (2004), who found that in TBI group, participants showed more of self repair strategy. The possible reasons for use of too much self repetition could be due to variability in terms of participants’ features. Many participants showed disfluencies, because of which there were many self corrections observed. The TBI participants used too much of revisions through clarification in their conversation when compared to healthy talkers. This result contradicts the one found by Marsh and Knight (1991) where the TBI individuals do not ask for clarification even if they do not understand the conversation. The reason for observation of more revisions in the speech of experimental group in the present study can be explained on the basis of their
inability to add on further information in speech in terms of giving clarification. Few participants made an effort to use clarifications given by the investigator and tried using the same as revisions.

Too much of other initiated repair behavior was seen when participants failed to convey the message and the partner asked for more clarification. The reason for use of too much of other initiated repair strategy is because of lack of perception of their own speech due to which they do not try to self-initiate the repair. Other reasons could be increased redundancy, incoherence, dysfluency, reduced information, fast rate of speech and unintelligibility in their speech leading to inability of the conversation partner to understand the message conveyed by the participants. This was observed more in TBI participants than healthy talkers.

**Revision behavior**

Revision behavior was observed and assessed based on the presence or absence of false starts and self-interruptions (Appendix-A). The results show significant difference between the TBI participants and healthy talkers. From the individual scores it was seen that in the TBI group, all the participants showed the presence of revision behavior except four participants.

**Inter-rater reliability**

To check for inter-rater reliability, ten percent of the data from the TBI participants and healthy talkers was considered. The alpha co-efficient was found to be 98% indicating good inter-rater reliability.

**Conclusion**

Everyday use of language underlies a complex system of cognitive and linguistic process. Language can be viewed and analyzed on many levels, one of which is “language in use” or discourse. Compared to production of sounds, words, or sentences in isolation, discourse production as an integrative and context-driven construct is thought to be representative of the complex communication needed for daily life activities. Therefore, cognitive and linguistic analysis at the level of discourse should be more sensitive to characterizing the types of communication deficits that various clinical populations may exhibit in the context of daily living.

An effort was made to combine all parameters taken from many discourse analysis tests and use as a “Discourse Analysis Scale” (Appendix-A). This will help the clinicians to tap the totality of discourse impairment in conversation. Thus, discourse analysis procedure was used to assess the discourse ability in individuals with TBI and healthy talkers. All the parameters of discourse were significantly different between the TBI participants and healthy talkers except information content and message inaccuracy of propositional aspects of discourse.

It is concluded that TBI participants have impairment in discourse when compared to healthy talkers because of injury effects. In summary, there was significant difference between the TBI participants and healthy talkers on a few parameters. In general, the healthy talkers performed better compared to TBI group in all the aspects of discourse. Both the groups showed a better performance on propositional aspects of discourse compared to non-propositional aspects of discourse. The clinical implications are many and they would further help in assessment, formulation of prognosis and development of appropriate treatment strategies for such population. The study could be extended to include not only a larger sample but also different post morbid durations as well as comparison of unstructured verses semistructured conversational tasks of discourse in the traumatically brain injured.

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**Acknowledgement**

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Appendix- A
Discourse Analysis Scale
By Hema and Shyamala, 2008

Points to be considered while using Discourse Analysis Scale:
The parameters of propositional and non-propositional aspects of conversation were quantified with few
general instructions to the evaluator as:
1. Scoring procedure involves the use of rating scale.
2. Should read the keys provided in each sub headings which explains the exact meaning of the parameters
to be scored.
3. Each appropriate behavior (normal) is given a higher score and the inappropriate behavior (abnormal)
is scored as lowest value.
4. Finally if needed, one can find discourse quotient, using the total score on propositional and non-
propositional aspects of communication which should be divided by total scores of all the features of
propositional and non-propositional aspects of communication. This may be multiplied with hundred to
get the score in percentage.

Propositional aspects of communication.
1) Failure to Structure Discourse (DS) [Score: 0-Frequently present, 1-Seldom present, 2-Absent]
   Key: The discourse is confusing even if it's organized with respect to overall plan, theme or topic and
   how individual utterances are conceptually linked to maintain unity.
   a) Lacks for thoughts \(\rightarrow\) (    )
   b) Lacks organizational planning \(\rightarrow\) (    )
2) Communication intent (CI) [Score: 0-Absent, 1-Seldom present, 2-Frequently present, except for (e)]
   Key: Presence or absence
   a) Greets others:
      -By themselves \(\rightarrow\) (    )
      -In response to other’s greeting \(\rightarrow\) (    )
   b) Introduces self \(\rightarrow\) (    )
   c) Starts a conversation \(\rightarrow\) (    )
   d) Asks for information \(\rightarrow\) (    )
   e) Asks for assistance in understanding conversation \(\rightarrow\) (    )
   [Score: 0-Frequently present, 1-Seldom present, 2-Absent]
   f) Criticizes the conversation by agreeing or disagreeing to a part in the conversation \(\rightarrow\) (    )
   g) Fabricates/imagines events \(\rightarrow\) (    )
   h) Understands advancers and blockers in the conversation \(\rightarrow\) (    )
3) Topic management (TM) [Score: 0-Frequently present, 1-Seldom present, 2-Absent, except for (e)]
   Key: Presence or absence
   a) Irrelevantly introducing topics \(\rightarrow\) (    )
   b) Rapid topic shift \(\rightarrow\) (    )
   c) Non coherent topic changes/Inappropriate topic changes \(\rightarrow\) (    )
   d) Perseveration in the topics \(\rightarrow\) (    )
e) Responses which expand topics → (  )  
[Score: 0-Absent, 1-Seldom present, 2-Frequently present]

f) Minimal responses (Giving only Yes/No responses) → (  )

g) Extra elaboration of topics → (  )
h) Minimal elaboration → (  )

4) Information adequacy (IA)
   Key: Answer to any question during conversation at word level/single sentence level/multipl sentence level. Underline the level at which the patient is positioned.
   ● Word level/ Single Sentence level/ Multiple sentence level → (  )  
   [Score: 0-Absent, 1-Seldom present, 2-Frequently present]

5) Information content (IC)
   Key: Meaningful and adequate information to any of the question in terms of initiating and/or sustaining conversation or if you know what the person is talking about...even if the information doesn’t appear to be available then give higher score.
   ● Non-meaningful and inadequate information → (  )  
   [Score: 0-Frequently present, 1-Seldom present, 2-Absent]

6) Message Inaccuracy (MI)
   Key: An attempted communication involving inaccurate/misinformation.
   ● Incorrect answers to the question/confabulation within the same question frame → (  )  [Score: 0-Frequently present, 1-Seldom present, 2-Absent]

7) Coherence (COH)
   ● Global coherence → (  )  
   Key: Presence of relationship between the meaning and content of verbalization with respect to the general topic of conversation.
   [Score: 0-Absent, 1- Seldom presents 2- Frequently present, 3-Very frequently present, 4-Always present]

   ● Local coherence → (  )  
   Key: Presence of relationship between the meaning and context of verbalization with that of the immediately preceding utterance produced either by interviewer or participant. [Score: 0-Absent, 1-Seldom presents 2- Frequently present, 3-Very frequently present, 4-Always present]

8) Use of Nonspecific Vocabulary (NSV) → (  )
   Key: Overuse of generic terms such as “thing” and “stuff” when more specific information is required. [Score: 0-Frequently present, 1-Seldom present, 2-Absent]

9) Linguistic Nonfluency (LNF) → (  )
   Key: Presence of repetition, unusual pauses, hesitations [Score: 0-Frequently present, 1-Seldom present, 2-Absent]

10) Inappropriate Speech Style (ISS) → (  )
    Key: Presence of dialectal structural forms, code switching, style-shifting. [Score: 0-Frequently present, 1-Seldom present, 2-Absent]

11) Inappropriate Intonational Contour (IIC) → (  )
    Key: Presence of abnormal rising, falling, flat intonation contour with respect to a particular context. [Score: 0-Frequently present, 1-Seldom present, 2-Absent]
12) **Gaze Inefficiency (GI)** → (  )

- Consistently no appropriate eye gaze with another person (Score- 0)
- Severe restricted eye gaze (appropriate eye gaze less than 50% of time?) (Score- 1)
- Appropriate eye gaze 50% of the time (Score- 2)
- Appropriate eye gaze 75% of the time (Score- 3)
- Consistent use of appropriate eye gaze (Score- 4)

13) **Delays before responding (DR)** → (  )

Key: Time taken to respond to any questions during the conversation which should be measured in terms of seconds.

- 7-8sec (Score-0)
- 5-6sec (Score-1)
- 2-4sec (Score- 2)
- 0.5-1sec (Score- 3)

**Non propositional or Interactional aspects of communication**

This is one of the important categories of social communication behavior. These behaviors reflect the reciprocal nature of conversation and the joint cooperation required of the participant.

The following subcategories are considered:

1) **Turn taking (TT)** [Score: 0-Frequently present, 1-Seldom present, 2-Absent, except for (a)]

Key: Presence or absence

a) Initiation of turn → (  ) [Score: 0-Absent, 1-Seldom present, 2-Frequently present]

b) Taking (some amount of) time to start a turn → (  )

c) Non contingent turn → (  )

Key: Does not fulfill the semantic or informational expectation of the previous turn, but shares the same topic. This also includes “don’t know,” “yes,” and “no” responses *when used to avoid* maintaining a topic, and echolalia.

d) Unable to take prosodic cues → (  )

e) Rapid shift in the mode → (  )

f) Persistent in listeners or speakers mode → (  )

2) **Conversation repair (CR)** [Score: 0-Frequently present, 1-Seldom present, 2-Absent]

Key: Presence or absence

a) Too much of self repair through repetition → (  )

b) Too much of revisions through clarification → (  )

3) **Revision behaviors (RB)** → (  )

Key: Presence of false starts and self-interruptions.

[Score: 0-Frequently present, 1-Seldom present, 2-Absent]
EFFECTS OF TEACHING AND VOICE REST ON ACOUSTIC VOICE CHARACTERISTICS OF FEMALE PRIMARY SCHOOL TEACHERS

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Abstract

Voice problems are known to be the most common among voice professionals worldwide. Teachers form a large group of voice professionals where females are a majority in that profession and are known to have more voice problems than males. The present study investigated the short-term effects of teaching (vocal loading) on acoustic parameters like mean fundamental frequency of phonation (pF0), standard deviation of fundamental frequency of phonation (SD pF0), speaking/reading fundamental frequency (sF0), frequency and amplitude perturbation (jitter and shimmer) and harmonic-to-noise ratio (HNR). Also, the study examined the effect of vocal rest following a workday teaching performance on these parameters. Twelve female primary school teachers in the age range of 23 to 42 years participated in the study whose average professional teaching experience was 8.6 years. The teachers were instructed to phonate vowel /a/ for 8-10 seconds at their comfortable pitch and loudness and read a standard reading passage in Kannada. These recordings were made at three different time intervals - i.e., (a) Monday morning (5-10 minutes prior to starting of teaching) - condition 1, (b) Monday evening (5-10 minutes after the school hours) - condition 2, and (c) Tuesday morning (after 17-18 hours of voice rest) - condition 3. The light-weight, portable digital audio tape (DAT) recorder was used to collect the voice and speech sample. The pF0, SD pF0, perturbation measures like jitter and shimmer and HNR were extracted from phonation of vowel /a/ and sF0 was measured from the reading sample by using PRAAT software. Results revealed that the difference between the acoustic values between condition 1 and 2 were, 14 Hz (pF0), 0.4 Hz (SD pF0), 7 Hz (sF0), 0.2% (jitter), 2.36% (shimmer) and 0.12 dB (HNR). Except HNR, all other vocal parameters increased after teaching performance (condition 2) and recovered back to baseline after 17-18 hours of voice rest (condition 3). The results indicated that these acoustic parameters (except HNR) were sensitive enough to document the extent to which the voice changes occurred due to vocal loading. Also, these altered vocal parameters were transient which recovered back to baseline after adequate voice rest.

Key words: Vocal fatigue, vocal usage, voice disorders, voice changes

Persons whose occupation places them at a high demand on vocalization are often considered to be at risk for the development of voice disorders. According to many questionnaire studies, 50% to 80% of teachers experienced voice problems (Pekkarinen, Himberg & Pentti, 1992; Gotaas & Starr, 1993) and teaching constitutes one of the 10 occupations who often require medical help for voice difficulties (Fritzell, 1996). A survey study conducted by Boominathan, Rajendran, Nagarajan, Seethapathy & Gnanasekar (2008) found 49% of high- and higher secondary Indian school teachers experienced voice problems. Voice use in teaching profession is highly demanding, and the hazardous factors are teaching often at high voice output level due to the presence of background noise, poor classroom acoustics, and poor working posture, long speaking distance, poor quality of air/ventilation,
stress, non-availability or poor-quality aids, inadequate treatment of early symptoms, especially laryngeal infections. Contributing co-factors are gender, living habits, individual endurance, vocal skills/experiences etc. Majority numbers of primary school teachers are women and Smith, Kirchner, Taylor, Hoffman, and Lemke (1998) reported that the majority of all phoniatric voice patients were women.

One of the sources of variability in the voice loading studies was experimental conditions some being conducted in laboratory and others in field conditions. Duration of loading might be considered as the second variability. Studies used the shortest loading times, being 15-20 minutes (Stone & Sharf, 1973; Linville, 1995) and the longest from 45 minutes-2 hours (Neils & Yairi, 1987; Gelfer, Andrews & Schmidt, 1996). The third difference may be the loading tasks, mostly being reading task (Neils & Yairi, 1987) or naming vowels (Verstraete, Forrez, Mertens & Debruyne, 1993). On the other hand, the loading in field condition has been habitual speaking during work such as acting in a theatre play (Novak, Dlouha, Capkova & Vohradnik, 1991), or teaching at school (Gotaas & Starr, 1993).

Very few studies were reported on voice changes induced by vocal loading. Fundamental frequency, sound pressure level, perturbation measures and long-time average spectrum have been used for documenting voice changes. These studies reported contradictory results and revealed individual differences. However, the most common result is that fundamental frequency (F0) rises after loading (Gelfer, Andrews & Schmidt, 1991; Stemple, Stanly & Lee, 1995). It has been found that the fundamental frequency depend on the circumstances i.e. lower in reading samples in laboratory condition than in teaching speech in a classroom condition (Rantala, Limdhoba & Vilkm, 1998). The problem in laboratory condition is the difficulty of simulating the real-life situation. It is feasible to manipulate one or more vocal parameters under laboratory condition that cannot adequately simulate live performance. The sound pressure level and shimmer increased after loading (Vilkman, Lauri, Alku, Sala & Silho, 1999). Laukkanen, Iломaki, Leppanen and Vilkman (2006) reported that the fundamental frequency of text-reading after a vocally loading workday registered a higher value compared to baseline in a group of primary school teachers. Interestingly, studies have shown that the jitter value increased (Gelfer, Andrews & Schmidt, 1991), or decreased (Stemple, Stanley & Lee, 1995) and/or showed no essential changes (Verstraete, Forrez, Mertens & Debruyne, 1993) due to vocal loading.

A very few empirical data are available on voice problems and the changes induced by vocal loading on voice parameters in Indian school teachers. Rajasudhakar and Savithri (2009a) reported increased fundamental frequency of phonation, standard deviation of fundamental frequency of phonation and jitter after one-day workload (teaching performance) in a primary school teacher. In a field study conducted by Rajasudhakar and Savithri (2009b) in five primary school teachers, reported after 6 hours of teaching, fundamental frequency of phonation, standard deviation of fundamental frequency of phonation, jitter and speaking fundamental frequency were increased compared to the pre-teaching (baseline) condition.

To the best of the knowledge, there have been very few empirical study on the teaching performance on voice in Indian school teachers in the natural-field situations. Also, the effect of voice rest after continuous, prolonged loud teaching is however not well understood. In this context, the present study documented and measured the short-term effect of changes in voice after teaching, and investigated the effect of voice rest on vocal parameters.

Method

Participants: Twelve female primary school teachers in the age range of 23-42 years (average age: 32.2 years) volunteered to participate in the experiment. Their teaching experience ranged from 5-20 years (average teaching experience: 8.6 years). They taught Science, Mathematics, Kannada, Social science and English to third and/or fourth grade students. The average number of students in each grade was about 30 to 35. The number of classes taken by the teachers per day was around five and the duration of each class was 45 minutes. The school timing was between 10 am to 4 pm including lunch time of 40 minute in afternoon. None of the participants were involved in private coaching/extra teaching after school hours. The participants were free from hypertension, diabetes, allergies, asthma and gastro-esophageal reflux disorder and did not
report of any speech, language, hearing or voice problems at the time of the study. **Instruments used:** A portable, light-weight digital audio tape (DAT) recorder (Olympus digital voice recorder WS-100, Japan) was used. The recorder had in-built condenser microphone (ME 15) and the weight of the device was about 54 grams (including battery). The overall frequency response of the microphone was 100 Hz to 5000 Hz and size of the DAT recorder was about 94(L) x 40(W) x 15.1(T) mm. The sampling frequency was 12 kHz and the maximum power consumption of the DAT recorder was 100mWatts. PRAAT (Boersma & Weenink, 2009) software was used to extract some acoustic parameters of voice. **Recording procedures:** The recording of voice samples was done on two regular workdays (Monday and Tuesday) after a relaxed weekend. The teachers were instructed not to over use the voice on Sunday and spend the day with more voice rest and adequate sleep. Also, the same was to follow after school hours on Monday. The DAT recorder was worn around the neck of the subject. The distance between microphone and mouth was kept 10-12 cm constantly for all the participants. The subjects were instructed to phonate the vowel /a/ for 8-10 seconds at their comfortable (habitual) pitch and loudness at three different time intervals - (1) Monday morning (5-10 min prior to the starting of school i.e. condition 1, (b) Monday evening (5-10 min after the school hours i.e. condition 2, and (3) After 16-18 hours of voice rest (Tuesday morning) i.e. condition 3. Also, the subjects were instructed to read a standardized Kannada passage (‘Bengaluru namma’ - 42 words) after the phonation of vowel /a/. Figure 1 shows the subject wearing the digital audio tape recorder. **Acoustic analyses:** PRAAT software was used to extract the acoustic parameters of voice like mean fundamental frequency of phonation (pF0), standard deviation of fundamental frequency of phonation (SD pF0), fundamental frequency of speech/reading (sF0), jitter, shimmer, and harmonic to noise ratio (HNR). The measures like pF0, SD pF0, jitter and shimmer were measured from phonation of vowel /a/. The initial and final (2 seconds) portion of the vowel phonation was truncated and the middle (4-5 seconds) steady state portion was considered for acoustic analyses. The sF0 was measured from the Kannada reading passage. **Statistical analysis:** The mean and standard deviation of pF0, SD pF0, sF0, jitter, shimmer, and HNR were calculated from twelve teachers at three conditions. Repeated measures of ANOVA was administered to check the differences across conditions and Bonferroni’s multiple comparison was done to test the pair-wise differences. Results The mean fundamental frequency of phonation (pF0) of vowel /a/ in condition 1 was 194 Hz. The pF0 value rose to 208 Hz at the end of the day (condition 2). After 18 hrs of voice rest, pF0 was dropped to 193 Hz. The mean and standard deviation of acoustics measures across three conditions were tabulated in table1. Results of repeated measures of ANOVA revealed significant difference across the conditions at 0.001 levels on pF0 [F(2,22)=11.134, p<0.001]. Results of Bonferroni’s multiple comparison revealed that there was significant difference between condition 1 and 2, and between condition 2 and 3. But, no significant difference was noticed between condition 1 and 3. The standard deviation of fundamental frequency of phonation (SD pF0) was 1.61 Hz in condition 1. The SD pF0 increased to 2.01 Hz in condition 2 and dropped to 1.52 Hz in condition 3. Results of repeated measures of ANOVA revealed significant difference across conditions at 0.001
levels on SD pF0 \[F(2,22)=15.237, p<0.001\]. Results of Bonferroni's multiple comparison revealed significant differences between condition 1 and 2, and condition 2 and 3. But, no significant difference was noticed between condition 1 and 3.

The mean fundamental frequency of speaking/reading (sF0) in condition 1 was 203 Hz. The sF0 rose to 210 Hz at the end of the day (condition 2). After 18 hrs of voice rest, sF0 dropped to 202 Hz. Results of repeated measures of ANOVA revealed significant difference across the conditions at 0.001 levels on sF0 \[F(2,22)=11.412, p<0.001\]. Results of Bonferroni's multiple comparison revealed significant differences between condition 1 and 2, and between condition 2 and 3. But, no significant difference was noticed between condition 1 and 3.

Jitter, in condition 1 was 0.53% which increased to 0.73% after 5 to 6 hours of teaching (condition 2). After 17/18 hours of voice rest, jitter dropped to 0.47%. Results of repeated measures of ANOVA revealed significant differences across the conditions at 0.001 levels on jitter \[F (2,22)=9.217, p<0.001\]. Results of Bonferroni's multiple comparison revealed significant differences between condition 2 and 3 only.

In condition 1, shimmer was 10.41% and it increased to 12.77% after teaching (condition 2). In condition 3, (after voice rest) the shimmer value decreased to 10.01%. Results of repeated measures of ANOVA revealed significant differences across the conditions at 0.001 levels on shimmer \[F(2,22)=6.040, p<0.001\]. Results of Bonferroni's multiple comparison revealed significant differences between condition 2 and 3 only. Before the starting of the teaching day, the mean HNR was 14.36 dB (condition 1) and it was 14.48 dB at the end of the teaching day (condition 2). After voice rest, i.e., on the next morning, it was 13.02 dB in condition 3. Results of repeated measures of ANOVA revealed no significant difference across the conditions on HNR measure.

**Discussion**

The results showed that the frequency related measures like pF0, SD pF0 and sF0 were significantly higher in condition 2 compared to condition 1. The results indicated that the frequency related parameters were increased from condition 1 to 2 by 14 Hz for pF0, 0.33 Hz for SD pF0, and 7 Hz for sF0. Compared to any other profession, teachers often speak loudly for longer duration in presence of high level background noise and not in a conducive environment. Due to this, most of the teachers suffer from vocal fatigue at the end of the workday. The accompanying feature along with vocal fatigue would be an increase in the level of muscular and structural tension of the vocal folds as reported by Welham and Maclagan (2003), thus leading to a higher F0 value. The obtained results are in agreement with the findings of Rantala, Vilkman and Bloigu (2002) who reported that the F0 increased by 9.7 Hz between the first and last lesson and also SD pF0 after loading. Rajasudhakar and Savithri (2009a) who reported that the F0 increased about 7.24 Hz between the first class recording and last class recording in a workday.

The literature offered two explanations for the F0 rise. According to Stemple, Stanley and Lee (1995), increased F0 is a consequence of weakness of the thyroarytenoid muscle. When the muscular layer of thyroarytenoid muscle slackens, the cover and transition layers of the vocal folds stiffens. This leads to an increase in the rate of vibrations in the vocal folds and hence a rise of the F0. Vilkman, Lauri, Alku, Sala and Sihvo (1999) have suggested another explanation. The increased F0 was caused by the speaker's compensatory reactions to alterations in their voice. When compensating for the physiological changes, which could be alterations in the mucosa, the speaker increases the frequency of vocal fold vibration and the glottal adductory forces. This increased constriction influenced the F0 indirectly. It increases the sub-glottal pressure, which adds tension to the vocal folds and, consequently raised the F0.

The pF0, SD pF0, and sF0 dropped significantly from condition 2 to condition 3. After 17 to 18 hours of voice rest, the measured acoustical parameters were the same as in condition 1. The present results supported the findings of Jayaram and Kalaiselvi (2006) who reported that there was reduction in frequency measures after 12 hours of complete voice rest following vocal loading (yakshagana performance).

The perturbation measures like jitter and shimmer also increased significantly from condition 1 to condition 2 by 0.23% and 2.63%, respectively.
Gelfer, Andrews and Schmidt (1991) and Rantala, Vilkman and Bloigu (2002) reported similar findings that jitter value increased after vocal loading. Also, shimmer increased after loading (Vilkman, Lauri, Alku, Sala & Sihvo, 1999; Rantala & Vilkman, 1999). The jitter and shimmer values which increased from condition 1 to 2, reduced significantly from condition 2 to 3. This reduction would be attributed to 17-18 hours of vocal rest wherein, the vocal folds and the surrounding laryngeal regions regained blood supply. Also, the resting of vocal apparatus brought about a reduction in structural and muscular tension of vocal folds, thereby controlling the variations in the vibration of vocal folds.

Harmonic to noise ratio (HNR), is one of the noise related measure. Interestingly, it did not show any significant changes across conditions. The results of the present study is in consonance with the findings of Verstraete et al., (1993) who found no significant changes in HNR value following 60 minutes reading task in untrained voice users. But, the present findings did not support the findings of Jayaram and Kalaiselvi (2006) who reported increased HNR after Yakshagana performance (vocal loading). This needs to be studied in a larger group of teachers to make any conclusions.

Summary and conclusions

The study measured the effects of teaching performance and voice rest on acoustic voice parameters in primary school teachers. The analysis of speech and voice samples of 12 primary school teachers’ revealed that the frequency related measures like, pF0, SD pF0 and sF0 along with perturbation measures like jitter and shimmer increased after 6 hours of voice use (classroom teaching). After 17-18 hours of voice rest, following the vocal loading, the increased voice parameters dropped and it reached to pre-teaching (baseline) condition. HNR did not show any characteristic ‘trend’/changes after performance and after voice rest. It can be concluded that the acoustic voice parameters (except HNR) are sensitive enough to document the short-term effect of teaching on voice. The importance of voice rest and its concomitant effect on voice features was positive i.e., it recovered to the baseline value. So the changes induced by short vocal loading are transient and it can be brought back to normal (baseline) after adequate voice rest.

The results of the present study may augment the knowledge for speech-language pathologists in counseling the professional voice users on voice usage, voice changes consequent to vocal loading and its short- and long-term effect on voice etc, in general and particular in teachers.

Future directions: The study can be administered on large number of teachers and can include male teachers to examine gender differences. Also, the same method can be employed to study differences between trained and untrained voice users. The study can be done by manipulating the rest period at different intervals of time. Acoustic analyses of voice can be coupled with aerodynamic, or electro-myographic measures to document the changes due to vocal loading.

References


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PHONOLOGICAL AWARENESS SKILLS AND READING IN CHILDREN WHO ARE AT RISK FOR LEARNING DISABILITY: ROLE IN THE INDIAN CONTEXT?

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Abstract

Phonological awareness in young school going children has always been the emphasis on children learning to read and write English, especially in the western context. Its importance and relevance to children learning English in the Indian context has just begun. Whether phonological awareness skills are equally crucial for literacy skills in young Indian children is still been explored. Yet another challenge is to study these skills in children who are at risk for learning disability. Hence, the present study necessitates to research phonological awareness skills in typically developing children and in children who are at risk for learning disability. The aim was to study phonological awareness skills and reading in typically developing children and children who are at risk for learning disability. Two groups of subjects in the age range of 3-6 years participated in the present study. The control group consisted of sixty typically developing children (N = 60) and the clinical group consisted of twelve children (N=12) who are at risk for learning disability. All the children studied in schools with English as the medium of instruction. The results of this study indicated that in phonological awareness, the older children (5-6years) fulfilled 60% criteria on phoneme blending, phoneme identification and phoneme substitution tasks. Other skills were still in the process of development. Children who are at risk for LD did not score on any of the sub-skills of phonological awareness. Typically developing children scored better for reading words than reading non words. Children at risk for LD, performed poorer on both reading words and non words when compared to typically developing children. Overall, performance on reading task was better than phonological awareness tasks. This study has implications on early identification and remediation for children at risk for learning disability.

Key words: phonological awareness, reading, assessment, early identification, at risk for learning disability.

To develop reading skills, children must learn the code used by their culture for representing speech as a series of visual symbols. Learning to read is thus fundamentally a process of matching distinctive visual symbols to units of sound referred to as phonology. Mastery of this system allows children to access thousands of words already present in their spoken lexicons. Phonological awareness, also referred to as phonological sensitivity, comprises the ability to recognize, identify, or manipulate any phonological unit within a word, be it phoneme, rime or syllable (Goswami & Bryant, 1990). Over the decades researchers have investigated phonological awareness and its association with reading skills. A large number of studies have shown that good phonological awareness skills characterize good readers, whereas poor phonological awareness skills characterize poor readers (Adams, 1990; Brady & Shankweiler, 1991; Scarborough, 1998; Wagner & Torgesen, 1987).

Research has widely focussed to study the links between different levels of phonological awareness and literacy development which are carried out on preschool and young school-aged children. While, there may be links between awareness of syllables and progress in literacy, there are
stronger indications that awareness of phonemes and intrasyllabic units may play a greater role in the successful development of literacy (Bradley & Bryant, 1983). It also seems likely that during the early stages of literacy learning there is a reciprocal relationship between certain aspects of phonological awareness, such as the awareness of sounds, and literacy development (Cataldo & Ellis, 1988).

Most work on phonological awareness and literacy development are on monolingual English-speaking children. However, there are few studies, Durgunoglu, Nagy and Hancin-Bhatt (1993, Spanish/English: Spanish); Campbell and Sais (1995, Italian/English: English); Bruck and Genesee (1995, French/English: English); Holm and Dodd (1996), Jackson (1996) (Chinese/English: English), that have considered phonological processing and literacy in bilingual children concentrating on only one of the children’s languages in the Indian context.

Phonological awareness is proved to be a primary factor underlying early reading development in children (Ehri, Nunes, Willows, Schuster Yaghoub-Zadeh & Shanahan, 2001). Wagner, Torgesen, Rashotte, Hecht, Barker, Burgess, Danahue and Garon (1997) experimented the amount of information that a measure of phonological awareness could add to the prediction of reading, once a measure of current word reading and vocabulary was considered. The results revealed that the phonological awareness was more predictive to reading in the younger age and less efficient in prediction of reading as the child gets older. These differences have also been found among the sub-level skills of phonological awareness like word level, syllable level, onset-rime level and phoneme level skills. Goswami and Bryant (1990) studied development of phonological awareness skills in English language. The results revealed that preschoolers demonstrated good phonological awareness of syllables, onsets, and rimes in most languages. Syllable awareness was usually present by about age 3 to 4, and onset–rime awareness was usually present by about age 4 to 5 years. Phoneme awareness only develops once children are taught to read and write, irrespective of the age at which reading and writing is taught. A longitudinal study by Bradley and Bryant (1983) and Blachman (1984) observed that performances on tasks of phonological awareness skills in nursery or grade I is a powerful predictor of reading achievement.

There are a few Indian studies available to date on metalinguistic skills and reading development in Indian children. Prema (1997) studied meta-phonological skills such as rhyming, syllable and phoneme related skills in Kannada speaking children. The reports revealed the importance of metalinguistic skills for reading acquisition in Indian children. However, contradicting to this was a study reported by Sunitha (1995) and Rekha (1996) who reported that meta-phonological skills are not essential for learning to read a non-alphabetic script (Kannada), rather they reported that the knowledge of orthographic principles seem to be more significant. Samasthitha (2009) studied meta-phonological and reading skills in monolingual (Kannada) and bilingual (Kannada and English) children, in the age range of 8-9 years. Results revealed that, there is a developmental trend in the acquisition of meta-phonological skills. Rhyme and syllable awareness appears to be the earliest skills to be developed followed by phoneme awareness. Results also showed that bilingual group performed better than the monolingual group on the meta-phonological and reading tests.

According to Read, Zhang, Nie and Ding (1986) some aspects of phonological awareness are not natural result of maturation but may be a consequence of learning an alphabetic orthography. They also reported that without this instruction, individuals may gain only minimal overt knowledge or awareness of phonemic units.

Loizou and Stuart (2003) examined levels of phonological awareness in monolingual and bilingual English and Greek five-year-old children. The participants were divided in four groups: two bilingual (English-Greek, Greek-English) and two monolingual (English, Greek). A set of six phonological tasks were compared. Bilingual children were tested in both English and Greek versions of the tasks; monolingual children were tested for the phonological tasks in their mother tongue only. The results showed that the bilingual English-Greek children significantly outperformed the monolingual English children, but this pattern was not replicated in the bilingual Greek-English/monolingual Greek comparisons. This difference is discussed in terms of the bilingual
enforcement effect. Results also showed that English-Greek bilingual children performed significantly better than Greek-English bilinguals, especially on tasks requiring phoneme awareness. They concluded that learning to read in an alphabetic language promotes the level of phonological awareness.

Liberman, Shankweiler, Fischer and Carter (1974) used a tapping task to measure the development of phonological awareness at the syllable and phoneme levels in normally developing American children. Results revealed that no 4 year-olds and only 17% of 5-year-olds could manage the phoneme version of the task, whereas 70% of 6-year-olds reached a criterion of six consecutive correct responses. Cossu, Shankweiler, Liberman, Katz and Tola (1988) tested phonological awareness in Italian children and the results showed that the majority of preschoolers (ages 4 and 5 years) could not manage the phoneme task (20% reached criterion), whereas older children already at school (7- and 8-year-olds) were very proficient (97% reached criterion). Criterion at the syllable level was reached by 67% of the 4-year-olds, 80% of the 5-year-olds, and 100% of the school-age sample.

Reading acquisition should be more rapid in orthographies in which letter–sound relationships are highly consistent. Indeed, a number of monolingual studies carried out in relatively consistent writing systems have reported high accuracy scores for recoding words and nonwords toward the end of Grade 1. For example, Greek children read on average 90% of real words correctly compared with 89% for nonwords (Porpodas, Pantelis & Hantziou, 1990). Italian children read on average 94% of real words correctly compared with 82% for nonwords (Cossu, Gugliotta & Marshall, 1995). French children read about 87% of words and 80% of nonwords correctly (Sprenger-Charolles et al., 1998). Even in a Semitic language, such as Hebrew, decoding accuracy was found to be around 80% at the end of Grade 1 (Share & Levin, 1999). Note that Hebrew children learn to read pointed Hebrew, which has almost perfect grapheme-to-phoneme correspondences. These quite high accuracy scores for phonological decoding stand in sharp contrast to the performance of English children a year later, at the end of Grade 2 (Share & Levin, 1999). English has very inconsistent grapheme-phoneme relations, and in a representative study, children learning to read English scored no more than 70% correct in word reading and 45% correct in nonword reading (Frith, Wimmer & Landerl, 1998).

Blaiklock (2004) conducted a longitudinal study examining the relationship between phonological awareness and reading for a group of children during their first two years at school. Children showed rhyme awareness before they began to read but were unable to perform a phoneme deletion task until after they had developed word-reading skills. Prakash (1993) investigated the development of reading proficiency in relation to meta-linguistic awareness and reported that the acquisition of literacy in children reading a non-alphabetic script follows two successive stages, firstly the syllable decoding and secondly the syllable decoding + comprehension stages. He accounted these stages to a probable interaction between the nature of orthography and instructional process rather than meta-phonological skills per se.

Need for the study

In western context extensive research are conducted to study the development of phonological awareness and reading skills. To study the development of phonological awareness and reading skills extensive researches are carried out in the western context. It is not possible to directly generalize such studies to the Indian context because children in India are generally exposed to varied culture and language. Though there is dearth of studies in the Indian context, these studies are conducted for the older group of children. Therefore, it is essential to develop a screening tool, which assesses phonological awareness and reading skills especially in the younger age group. This in turn would aid in the early identification of children who are at risk for learning disability. Hence, there is need to study the developmental pattern of phonological awareness and reading skills in younger group of children through a tool, which will further help in the identification of children who may be at risk for learning disability.

Aims of the study

The aim of the study was to examine the relationship between phonological awareness and
reading in children.

Following were the objectives considered for the study:

- To study the relationship between phonological awareness and reading skills in typically developing children (TDC).
- To examine the difference in pattern of development amongst children who are at risk for developing learning disability (ARLD).

This study was carried out as part of an ongoing research project funded by AIISH research fund titled “Development of Early Literacy Screening Tool”.

Method

Subjects: Two groups of children participated in the study. All children studied in schools with English as the medium of instruction. The control group consisted of sixty typically developing children (N=60) in the age range of 3-6 years who were selected randomly from schools in different localities of Mysore city. They were sub divided into three groups with an inter age interval of one year (3-4 years, 4-5 years and 5-6 years). Each sub group comprised of 20 subjects including 10 boys and 10 girls. So a total of 60 subjects were considered in the first group. The clinical group consisted of twelve children (N=12) in the age range of 3-6 years with poor academic skills as reported by the teachers.

The subjects were selected based on the following criteria:

- Native speakers of Kannada, being reared in an urban ambient environment of Kannada.
- Belonging to middle socio economic status.
- Exposed to English language in their school set up.
- Attended schools which followed similar teaching methods.
- Those who passed the WHO Ten-Question Disability Screening checklist (cited in Singhi, Kumar, Prabhjot & Kumar, 2007) which screens for any speech, language and hearing deficits.

Test material: Initially test items for the tasks of phonological awareness and reading were developed by reviewing journals, books, internet and age appropriate academic books. The compiled material was rated by five Speech Language Pathologists. They were expected to rate the test items on a five point rating scale for the 14 parameters listed. E.g.: Simplicity of the test material, familiarity of the test stimuli etc. Using this material, a pilot study was conducted on a group of 20 children in the age range of 3-6 years. After analysing the piloted data, the test items which were most relevant was chosen to form the test materials for the final administration of the test.

Procedure: Participants were withdrawn from the class and worked with the examiner in a quiet room in the school. Phonological awareness tasks and reading tasks were administered to all children. Phonological awareness section consisted of 6 subsections: phoneme counting, phoneme blending, phoneme identification, phoneme substitution, phoneme deletion and phoneme oddity. Each subsection consisted of two practice items and one test item.

Reading task consisted of reading three words and three non words. Words were selected from their curriculum books which were appropriate to their age and the non words were formed based on the premise that they followed the phonotactic rules of the English language. (See Appendix-I for the test material)

Scoring and analysis: For both the tasks a gross score of ‘1’ and ‘0’ was given for correct and incorrect responses respectively. Scoring was immediately noted by the examiner on a scoring sheet. The scores were coded and then subjected to statistical analysis. From the scores obtained, mean, standard deviation were calculated for each age group. Passing criteria of 60% was set for all the skills considering that minimum of 60% of the subjects had to perform each of the tasks correctly.

Results

The objectives considered for the study were:

- To study the relationship between phonological awareness and reading skills in typically developing children (TDC).
- To examine the difference in pattern of development amongst children who are at risk for developing learning disability (ARLD).

The results presented in the following sections are those of the main cohort of 60 children, who were identified as developing literacy (in English) without difficulties and 12 children who were identified as at risk for learning disability. Since the focus of this paper is the development of task, we give here only descriptive statistics, by which we mean the
aggregate means and standard deviations of the children’s scores. For ease of comparison across the age ranges and between the two groups the task results are given as proportions and displayed in a series of graphs.

Table 1 shows the overall mean and SD for phonological awareness skills and reading skills across three groups of typically developing children (3-4 years, 4-5 years and 5-6 years). From the Table 1 and Figure 1 and 2 it is evident that, in both the groups of children a developmental trend was observed for phonological awareness and reading skills across the age range. There was a drastic improvement observed from 4-5 years to 5-6 years for both the skills. Children at risk for LD scored lesser than the typically developing children in both the skills. Another salient feature observed was that, reading scores were better than phonological awareness skills in both typically developing and children who are at risk for LD.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Typically developing Children</th>
<th>Children At Risk for LD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3-4 Years</td>
<td>4-5 Years</td>
</tr>
<tr>
<td>Phonological Awareness</td>
<td>Mean</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0</td>
</tr>
<tr>
<td>Reading Skills</td>
<td>Mean</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1: Mean and SD for Phonological awareness and reading skills of TDC and ARLD across age.  
(Maximum score= 6.00 each for Phonological awareness and reading skills)

Figure 1: Mean scores of Phonological awareness and reading skills of TDC and ARLD across age.

Figure 2: Mean percentile scores of Phonological awareness and reading skills of TDC and ARLD across age.
Further descriptive statistics was conducted separately for all the sub-skills of phonological awareness and reading.

**Performance of children on Phonological Awareness Skills**

In the present study, phonological awareness tasks included were phoneme counting (PC), phoneme blending (PB), phoneme identification (PI), phoneme substitution (PS), phoneme deletion (PD) and phoneme oddity (PO).

The results of the present study on phonological awareness skills revealed that, overall a developmental trend was seen across most of the sub-skills (see Table 2 & Figure 3). In sub-skills of phonological awareness, the older children (5-6 years) in typically developing group fulfilled 60% criteria on phoneme blending, phoneme identification and phoneme substitution tasks. Other sub-skills like phoneme counting (50%), phoneme deletion (35%) and phoneme oddity (20%) were still in the process of development. Even the older children (5-6 years) who are at risk for LD did not score in any of the sub-skills of phonological awareness.

**Performance of children on reading words and non words**

Reading task included reading a list of three words (RW) and three non-words (RNW) in English by two groups of children (TDC and ARLD) in the age range of 3-6 years. The performance of children in reading words and non words is explained below.

From Table 3 and Figure 4, it is evident that, performance of reading skills is improving from younger children to older children. Typically developing children scored better for reading words (91.6%) than reading non words (53.3%). A similar comparison could not be observed in children at risk for LD, as reading non words emerged only in the older group (5-6 years) and the performance was equal to that of reading words. However, in both reading words and non words children at risk for LD could not meet the criteria of 60%. Also, to note that children of 3-4 years in both groups (TDC & ARLD) did not score in reading section.

![Figure 3: Mean percentile scores for sub-skills of Phonological awareness in TDC and ARLD across age.](image-url)
Discussion

The present study aimed to examine the difference in pattern of development in typically developing children and children at risk for learning disability. The study also aimed to investigate the relationship between phonological awareness and reading skills in the two groups.

Analysis of results for phonological awareness skills revealed a developmental trend in typically developing children from younger to older children. The older typically developing children (5-6 years) fulfilled 60% criteria on phoneme blending, phoneme identification and phoneme substitution tasks (see Table 2). Other sub-skills like phoneme counting, phoneme deletion and phoneme oddity were still in the process of development. This supports study by Cossu, Shankweiler, Liberman, Katz and Tola (1988) on phonological awareness in Italian children. Their results also revealed that majority of preschoolers (ages 4 and 5 years) could not manage the phoneme tasks (20% reached criterion), whereas older children already at school (7- and 8-year-olds) were very proficient (97% reached criterion). On the other hand in the present study even older children at risk for LD could not perform on any of the sub-skills of phonological awareness. This may be because children at risk for LD have not attained mastery of at least a few phonological awareness skills which are achieved by the typically developing children.

Table 2: Mean percentile scores for sub-tasks of Reading skills in TDC and ARLD across age.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Typically developing Children</th>
<th>At Risk for LD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3-4 Years</td>
<td>4-5 Years</td>
</tr>
<tr>
<td>RW</td>
<td>0</td>
<td>43.3</td>
</tr>
<tr>
<td>RNW</td>
<td>0</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Table 3: Mean percentile scores for sub-tasks of Reading skills in TDC and ARLD across age.

Analysis of results on reading skills revealed that, typically developing children in the age range of 4-6 years scored better than children who are at risk for LD (see Table 3). In typically developing children, reading words was better than reading non-words. It is an accepted phenomenon that reading words in English involves the direct route and non-words involves the indirect route. Indirect which is more dependent on the phoneme-grapheme or grapheme-phoneme correspondence generally takes longer time to be decoded especially in an irregular language like English. Hence, children take longer time to read non-words than words. This difference may be significantly seen in the younger children as children would not have mastered all the skills required to decode a non-word through the indirect route. This finding supports Frith, Wimmer and Landerl (1998) in English language. Their results revealed that since English has very inconsistent grapheme–phoneme relations, children learning to read English scored better for word reading (70%) than nonword reading (45%). Children in the younger group of 3-4 years in both groups (TDC & ARLD) did not score in reading section. This can be attributed to the fact that, the children in this age range were exposed only to reading alphabets and not reading words and non words and these children were still in the process of combining letter or phoneme strings to form words for reading.

The study also revealed that performance on tasks...
reading skills were better than phonological awareness skills. This is indicative of the fact that phonological awareness is probably an underlying skill to development of reading skills in children. This finding supports Read, Zhang, Nie and Ding (1986), phonological awareness does not appear to be a natural result of maturation but seems to be a consequence of learning an alphabetic orthography. They also reported that without this instruction, individuals may gain only minimal overt knowledge or awareness of phonemic units. Loizou and Stuart (2003) concluded that learning to read in an alphabetic language promotes the level of phonological awareness. According to Goswami and Bryant (1990) phoneme awareness only develops once children are taught to read and write, irrespective of the age at which reading and writing is taught.

Conclusions

Overall the results of this study indicated a developmental progression in both phonological awareness and reading skills. The performance of children improved from younger age to older age group. However, a slope was observed for typically developing children in the age range of 4-5 years to 5-6 years (see Figure 1 & Figure 2) and these children showed significant improvement in both phonological awareness and reading skills. This progression was not evidently noted in children who are at risk for LD. Overall, performance on reading task was better than phonological awareness tasks.

Implications

This study has implications on early identification and remediation for children at risk for learning disability. The study would have an impact in the Indian context, since the availability of the appropriate test material in assessing phonological awareness skills and reading are sparse.

Limitations of the study

This study included a small sample of 20 typically developing children in each age range. Administration of it on a large sample would help in standardization of the tool. Only 12 children who are risk for learning disability were considered in the study. Including larger number of subjects in this group would provide a better insight into the results.

References


relations between phonological processing abilities and word level reading as children develop from beginning to skilled readers: A 5-year longitudinal study. Developmental Psychology, 33 (3), 468-479.

Acknowledgements

The authors wish to thank Dr. Vijayalakshmi Basavaraj, Director, AIISH, for permitting to present part of project as paper for publication and all the support provided to conduct this study. The authors also wish to thank all the subjects who participated in this study and teachers for their co-operation.
Appendix-I

Phonological Awareness Skills

Maximum score: 06

a. Phoneme counting

*Instructions:* I am going to say a word and I want you to say how many sounds you hear in that word.
Example: When I say cat, I hear three sounds, /k/, /a/, /t/. When I say go, I hear two sounds, /g/, /o/. Now you try.

- Van

b. Phoneme Blending

*Instructions:* I am going to say some words, spreading out the sounds. Guess the word I am saying.
Example: If I say ‘f-at’, you say ‘fat’. If I say ‘m-ug’, you say ‘mug’.

- m-at

c. Phoneme Identification

*Instructions:* I want you to listen to just one sound in a word. Tell me the sound you hear at the beginning of each word I say.
Example: If I say ‘car’, the first sound in the car is /k/. In Nest, the first sound is /n/.

- Time-/t/

d. Phoneme Deletion

*Instructions:* Now I will say a word, you will have to take off the first sound and make a whole new word.
Example: If I say ‘cat’, you say ‘at’. If I say ‘eat’, you say ‘at’.

- Meat
  
  /m/
  
  eat

e. Phoneme Substitution:

*Instructions:* Now let us play another game. I will give you a word. Listen to it carefully and change one phoneme to another as indicated by me and tell the whole new word.
Example: If I Say the word ‘goat’ by changing the /g/ to /b/ it becomes ‘boat’.

- Hat-mat (change /h/ to /m/)

f. Phoneme Oddity

*Instructions:* Now I will tell four words, you have to listen to it carefully and pick the odd one out
Example: bat, cat, mat, elephant

- Sun, gun, rat ,fun

Reading skills

Maximum score: 06

Task: Ask the subject to read the words.

Note: Check for G-P-C skills for scoring.

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Words</th>
<th>Non-Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ant</td>
<td>Gog</td>
</tr>
<tr>
<td>2</td>
<td>Cap</td>
<td>Dar</td>
</tr>
<tr>
<td>3</td>
<td>Bag</td>
<td>Nat</td>
</tr>
</tbody>
</table>
TIMED TEST OF SWALLOWING IN SIX MONTH POST STROKE INDIVIDUALS

* Radish Kumar. B., **Rishita, U., & ***Jayashree S. Bhat

Abstract

The swallowing problems after acute stroke are often temporary but sometimes leads to various complications such as aspiration pneumonia, dehydration and death. Though these individuals recover from swallowing disorder as assessed subjectively and objectively, it is not known if they have recovered completely. Hence the present study was attempted at identifying any swallowing problems in six month post stroke individuals, using timed test of swallowing. The study followed the Prospective case control design. All the participants in both the clinical and the control group were asked to drink 150 ml of water from a plastic beaker ‘as quickly as possible’. The number of swallows performed by the participants was counted by observing the movement of the thyroid notch. A stopwatch was started when the water first touched the lower lip, and stopped when the larynx came to rest, ensuring the last swallow. Timed test of swallow includes quantitative elements i.e., the volume swallowed, the number of swallows used and the time taken, which yields three quantitative indices, which are average volume per swallow (ml), average time per swallow (s) and swallowing capacity (volume swallowed in ml/s) in both the group of participants. The results revealed a significant difference between the means for both the group of participants, at p <0.05 for all the three indices of timed test of swallowing, suggesting that the clinical group exhibited lower volume per swallow, increased time per swallow and a lower swallowing capacity in each swallow than control group. The obtained results were discussed with respect to the stroke and its effect on swallowing. Hence, the timed test of swallow can be used as a clinical tool for identifying swallowing problems in post stroke individuals.

Key words: Post stroke individuals, timed test, swallowing capacity

The swallowing problems after acute stroke are often temporary but sometimes lead to various complications such as aspiration pneumonia, dehydration and death (Gordon, Hewer & Wade, 1987; Holas, Depippo & Reding, 1994; Johnson, McKenzie & Seivers, 1993; Warnecke et al., 2008; Smith Hammond et al., 2009). Though these individuals do not complain of swallowing disorder six months post stroke, it is not known if the recovery is complete as assessed subjectively and objectively. Previous studies of individuals with dysphagia, used quantitative measurements like amplitude of EMG muscle activity during swallow, time duration for which the activity is present, swallowing apnea duration, etc. in the assessment of individuals with swallowing disorders (Vaima, Eviatar & Segal, 2004).

Simple timed test of swallowing was proposed in addition to the routine assessment of individuals with neurological impairment along with reliability and validity (Nathadwarawala, Nicklin & Wiles, 1992; Hughes & Wiles, 1996). Timed test of swallow includes quantitative elements i.e., the volume swallowed, the number of swallows used and the time taken, which yields three quantitative indices, which are average volume per swallow (ml), average time per swallow (s) and swallowing capacity (volume swallowed in ml/s). These indices might be useful in screening those at risk for dysphagia or its complications (Koji et al., 1999). We consider that these measures are the indicators of complete

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recovery as it assesses the finer aspects of swallowing behavior i.e., volume per swallow, time per swallow and the swallowing capacity. We considered that the individuals obtaining age appropriate scores are believed to have recovered completely from their abnormal swallowing behavior and the individuals failing from this test are considered to have persisting swallowing problems which warrants further instrumental evaluation to evaluate the swallowing physiology in them.

Hinds and Wiles (1998) have reported abnormal findings of timed test of swallowing in acute stroke individuals and concluded that a timed water swallowing test can be a useful test of swallowing and may be used to screen patients for referral to a speech language therapist after a acute stroke. Swallowing speed was significantly slower in individuals who reported swallowing problem or those who had abnormal symptoms or signs compared to those who did not, providing further evidence for the validity of timed test of swallowing (Nathadwarawala, McGroary & Wiles, 1994). This study also provided evidence of a significant incidence of disordered swallowing in individuals who had not reported any swallowing problems but, who had symptoms potentially relevant to swallowing (Nathadwarawala, McGroary & Wiles, 1994). Hence this particular measure was chosen in the present study to identify swallowing problems if any in six months post stroke individuals. Six months after the stroke, though these individuals do not complain of swallowing disorder, it is not known if they have recovered completely as assessed subjectively and objectively. Hence the present study was an attempt in this direction with the aim of identifying swallowing problems if any in six month post stroke individuals using timed test of swallowing.

Method

Patients: Participants were divided into two groups. Group 1 comprised of forty male individuals with a history of dysphagia in their acute period of stroke six months ago. All these participants were in the age range of 40 to 60 years. Group 2 consisted of forty male healthy age matched volunteers.

The study protocol followed the case control design.

Assessments

All the participants in both the groups were subjected to clinical assessment of swallowing.

Clinical Assessment of Swallowing: All the participants were submitted to a detailed clinical assessment of swallowing by a speech pathologist, which included patient identification, questioning about different aspects of swallowing, and structural and functional clinical assessment. For the functional assessment, two 5-ml boluses of liquid (water) and 5 ml of thick consistency, obtained by the dilution of commercially available rice flakes were offered through a graduated syringe. The following parameters were assessed: presence of swallowing complaints on specific questioning; posture during the assessment; cervical auscultation before, during, and after bolus swallowing; vocal quality before and after swallowing; labial closure; use of compensatory maneuvers when swallowing; bolus stasis after swallowing; pneumonia, choking; cough; weight loss and dyspnea. The presence of abnormal findings in any of the assessed parameters, independent of the presence of complaints after specific questioning, classified the participants as having abnormal swallowing function during clinical assessment. All the participants in both the groups were classified as having normal swallowing function as they successfully completed the clinical assessment of swallowing.

All the participants were well oriented and were able to follow the instructions given during the study. All the participants in the group 1 had history of dysphagia with aspiration, as their primary symptom during their acute period of stroke for around ten day following which they returned to oral feeding as ascertained from the medical records. All these participants were on nonoral feeding for around ten days during their acute stroke period and they did not undergo any swallowing therapy due to the orientation and auditory comprehension problem. Presently all these participants were on oral feeding consuming all types of food. The exclusionary criteria considered for both the groups were those who exhibited difficulty in swallowing 10ml of water, those with a past medical history of major surgery on or above the neck, thyroid disease, and individuals who had consumed alcohol in the previous 9 hours. All patients and control volunteers were fully informed about the objectives and methods of the study and gave written informed consent before participation. This study was approved by the local Human
Research Ethics Committee.

**Timed test of swallowing:** The participants were seated comfortably on a chair in an upright position. The timed test of swallowing was then administered on those who followed the norms of the study. These participants were asked to drink a 150 ml of water from a plastic beaker ‘as quickly as possible’. The number of swallows performed by the participants was counted by observing the movement of the thyroid notch. All the participants were able to hold the beaker of water to their mouth and drink. A stopwatch was started when the water first touched the lower lip, and stopped when the larynx came to rest, subsequent to the last swallow. Participants were instructed not to spill the water through the mouth while performing the test. This was repeated when the spillage through the mouth was observed. Hence the number of swallows performed by the participants and the time taken to complete the 150 ml of water was noted by the two independent judges.

Using these information, following timed test parameters were calculated by both the judges.

1. **Volume per swallow** is defined as the volume of the water consumed during single swallow i.e., 150 ml/average no of swallows performed by the participants.
2. **Time per swallow** is defined as the time taken to consume a single bolus of water i.e., average time taken to complete the 150 ml of water / average no of swallows performed by the participants.
3. **Swallowing capacity** is defined as volume of the water consumed per second i.e., 150 ml/average time taken to consume the 150 ml of water.

Inter judge reliability was calculated in fifteen of the participants to ensure that the measurement made by the judges were same. Independent t-test was used to compare the significant difference between the means of both the groups.

### Results

The present study investigated swallowing problems if any in six month post stroke individuals using timed test of swallowing. The results of independent t-test revealed that there is a significant difference between the means of both the groups, at p<0.05 for all the three indices of timed test of swallowing which is shown in the table 1. Inter judge reliability was found to be 96% and hence the measurement made by both the judges were considered as reliable.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control group</th>
<th>Clinical group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average volume per swallow (ml)</td>
<td>25.01 ± 25</td>
<td>16.85 ± 2.25</td>
</tr>
<tr>
<td>Average time per swallow (s)</td>
<td>1.027 ± 0.173</td>
<td>1.328 ± 0.171</td>
</tr>
<tr>
<td>Swallowing capacity (ml/s)</td>
<td>25.32 ± 7</td>
<td>8.159 ± 2.547</td>
</tr>
</tbody>
</table>

Table 1: Mean and SD of the timed test indices in six months post stroke individuals.

From the table, it is clear that the clinical group exhibited lower swallowing capacity and volume per swallow and increased time per swallow as compared to the control group. Also 11 participants from the clinical group (28%) obtained age appropriate scores and the remaining participants (72%) obtained reduced bolus volume per swallow, increased time per swallow and lowered swallowing capacity suggesting persisting subtle swallowing abnormality though they do not complain of swallowing problem. This indicates that few of the post stroke individuals did have subtle swallowing abnormality which needs to be evaluated using other instrumental evaluation. This further suggests the need for screening of swallowing behavior in the post stroke individuals using the timed test of swallowing.

### Discussion

Most of the previous studies with dysphagia and stroke have aimed at detecting aspiration through bedside examination and video fluoroscopy. Previous bedside assessments of swallowing function have included oral sensory and motor examinations, 3oz water swallow test and simply observing the patient during eating. But, these findings are unlikely to provide information on the subtle swallowing problems, if any, in six months post stroke individuals especially because these individuals do not complain of swallowing disorder. Also, it is not known if they have recovered completely from the initial swallowing problems with no overt complaints. Hence, timed test of swallowing was assessed to identify the dysphagia risk in these individuals. The results revealed a
A reduction in swallowing capacity can be due to a reduction in average bolus volume, or a prolongation of average time per swallow, or a combination of both. Temporary cessation of breath will lead to prolongation of the average time per swallow and a reduced swallowing capacity; volume per swallow is less affected by respiratory function and in this regard is a better measure of swallowing function alone (Hughes & Wiles, 1996). Changes in average time per swallow and average bolus volume per swallow contribute to the significant reduction in swallowing capacity seen in stroke individuals with a swallowing problem; ‘taking smaller sips’ and spending longer on each swallow are obvious ways of reducing the risk of overt decompensation occurring (Hughes & Wiles, 1996). Hence, the reduction in the swallowing capacity due to the reduction in volume per swallow or increased time per swallow in the clinical group may be expected as a compensatory mechanism for an abnormal swallowing behavior mechanism (Hughes & Wiles, 1996). But it is interesting to note that these individuals did not attend any swallowing rehabilitation during their acute periods of stroke. However, they learnt the compensatory mechanism without the guidance from the speech language therapist which is evident in the present study. This may pose the individual at risk for developing swallowing problems at the later course of the life span. Therefore, this measurement of swallowing is a likely indicator of abnormal swallowing behaviour.

There are specific patient signs that correlate with presence of dysphagia and aspiration, such as, cough or inability to produce a cough; voice quality change; dysarthria to name a few. These clinical signs are predictors of dysphagia from a screening examination. But these were not evident in six month post stroke individuals at the start of the study but the “timed test of swallowing” revealed increased time per swallow and lowered swallowing capacity in these individuals. This suggests that the recovery is not complete in the clinical group. The failure of the individuals from this test further recommends the use of other instrumental evaluation to delineate the physiological underpinnings of increased time per swallow and lowered swallowing capacity which would guide the clinician to initiate the rehabilitation process in these individuals.

Though sex is the major determinants of swallowing function (Alves, Cassiani, Santos & Dantas, 2007), it was not controlled in the present study. Also the events such as double swallow could not be accounted for using this procedure which adds further limitations to the present study.

**Conclusion**

The present study assessed the swallowing in six months post stroke individuals using timed test of swallowing and the results revealed that there is a significant difference between the means for the clinical and control group at p <0.05 for all the three indices of timed test of swallowing suggesting lower volume per swallow, increased time per swallow and a lower swallowing capacity in each swallow of six month post stroke individuals than control groups. Hence the timed test of swallow can be used as a tool for identifying swallowing problems in post stroke individuals who do not complain about swallowing.

**References**


Koji, T., Risa, U., Yoshizumi, Y., Yukari, Y., Atsushi,


VOICE CHARACTERISTICS AND RECOVERY PATTERNS IN INDIAN ADULT MALES AFTER VOCAL LOADING

*Prakash Boominathan, **Anitha R., ***Shenbagavalli M. & ****Dinesh G.

Abstract

The study aimed to measure the effects of vocal loading on voice characteristics in Indian adult males, to document complaints associated with vocal fatigue and to monitor recovery patterns of voice after the vocal loading task. Twenty adult males between the ages of 18 and 30 years participated in this study. The subjects were instructed to read a book at 75-80 dB SPL up to an hour or until they reported themselves as fatigued. Pre and post experiment voice assessments were carried out using GRBAS scale and MDVP analysis. The duration of prolonged reading and signs of vocal fatigue were documented. Voice recovery was tracked at 5, 10, 15, 20 minutes and 24 hours following the immediate post experiment. Paired t test and repeated measure of analysis of variance (ANOVA) were used for statistical analysis. Overall quality of voice change (Grade) was more pronounced after vocal loading. Significant reduction (around 6 seconds) in maximum phonation time and a significant increase in S/Z ratio were found. MDVP analysis revealed significant decrease in lowest fundamental frequency and increase in phonatory fundamental frequency range, short and long term frequency and amplitude measurements, noise and voice irregularity related measures after vocal loading. Initial signs of fatigue such as throat pain, throat tightness and running out of breath were noticed as early as 15 minutes and subjects were able to sustain the task for not more than 30 minutes. Short and long term frequency and amplitude measures and noise to harmonics ratio revealed a significant recovery pattern. Complaints of vocal fatigue, voice symptoms, and vocal recovery after vocal loading can be tracked and monitored using perceptual and acoustic measures. These findings can be applied to understand vocal endurance, susceptibility to vocal fatigue and physiological changes due to vocal loading.

Key words: vocal loading task, GRBAS, MDVP, vocal endurance and susceptibility

Terms ‘vocal abuse’ and ‘vocal misuse’ occur frequently in discussion of voice disorders related to vocal hyperfunction. Phonation under these conditions results in tissue changes in larynx which alters the mass, elasticity and tension of the vocal folds. The tissue changes and mechanical alterations of the vocal folds together result in abnormal production of voice and vocal fatigue.

Many individuals report symptoms of vocal fatigue after extended voice use. Vocal fatigue is a frequent complaint among individuals who depend on their voice for their profession and those who have disordered voice. The mechanical basis of vocal fatigue is not well known. Titze, 1983 (as cited in Callaghan, 2000) postulated that vocal fatigue is linked to inefficient use of mechanism and dehydration. Vocal fatigue may result from both the fatiguing of the respiratory and laryngeal muscles and from bio-mechanical challenges in non muscular tissues that cause the vocal folds to vibrate less efficiently. Symptoms of vocal fatigue include complaints of increased effort to talk, not able to talk continuously and a tired, weak voice (Smith, Kirchner, Taylor, Hoffman & Lemke, 1998). One common scenario of excessive voice use is a condition in classrooms which involves teaching for long hours, which is usually referred to as vocal loading. Kelchner, Toner and Lee (2006) defined vocal loading...
as “Prolonged loud voice use and has four distinct phases: warm up (adapting to the voicing task), performance (continuance of the voicing task), vocal fatigue (perceived increase of physical effort associated with voicing; physical challenges to the larynx), and rest or recovery.” Prolonged loud reading is one of the vocal loading task that is most often used to mimic excessive usage of voice (Stemple, Stanley & Lee, 1995; Kelchner, Lee & Stemple, 2003; Kelchner et al., 2006). These prolonged loud reading protocols vary with reference to procedural variations, loudness levels and total time spent on reading. Most reported outcome data involving vocal loading task include comparisons of pre and post perceptual, acoustic, stroboscopic and aerodynamic measures (Stemple, et al., 1995; Kelchner et al., 2003; Kelchner et al., 2006).

Voice use can also be documented by using voice accumulators (Ohlsson, Brink & Lofqvist, 1989) and portable DAT recorders (Sodersten, Granqvist, Hammarberg & Szabo, 2002; Rajasudhakar & Savithri, 2009). Other methods include vocal loading measurements in experimental conditions (Stemple et al., 1995; Kelchner et al., 2003; Kelchner et al., 2006) and work environments or real life situations (Rajasudhakar & Savithri, 2009). The experimental methods used a procedure which was similar to classroom and other vocal loading conditions (singing, acting) thereby measuring the effects of it on voice production. Several methods have been developed over the years to document the amount of voice use in professional voice users especially teachers during work and other experimental conditions. Krishna and Nataraja (1995) developed criteria for susceptibility to vocal fatigue in 5 teachers and 5 non-teachers based on MDVP parameters before and after an hour of loud reading. Teachers as a group showed significant changes in the acoustic parameters like average fundamental frequency ($F_0$), average pitch period ($t_0$), standard deviation of $F_0$ (STD), highest fundamental frequency ($F_0hi$) and lowest fundamental frequency ($F_0lo$) after reading. However, this study was limited to describing acoustic changes after vocal loading without mentioning recovery patterns across time and effects of observing vocal hygiene and conservative voice use post vocal loading task. Other studies have examined various factors related to vocal loading such as environment (Sodersten et al., 2002), health (Roy, Merrill, Thibeault, Parsa, Gray & Smith, 2004) and stress related (Smith et al., 1998).

There are numerous social and educational situations an adult may engage in using loud voice. These events can often result in voice change and complaints of vocal strain and fatigue. People who use their voice excessively are at risk for voice disorders. Boominathan, Rajendran, Nagarajan, Muthukumaran and Jayashree (2008) studied regarding vocal abuse and vocal hygiene practices among different levels of professional voice users (teachers, singers, vendors & politicians) in India. The results indicated alarming levels of vocally abusive behaviors and poor vocal hygiene practices among the groups studied.

These increased occurrences of vocally abusive behaviors in professional voice users could possibly be applied to general population as well. Vocally abusive behaviors lead to vocal hyperfunction and is generally believed that vocal hyperfunction is an underlying component in majority of voice disorders (Boone, 1983, as cited in Hillman, Holmberg, Perkell, Walsh & Vaughan, 1989).

Apart from information regarding vocal abuse and hygiene practices, understanding the vocal health status of normal adults becomes important. Data on vocal health may facilitate prevention and management of voice problems in adults. Further, understanding of the effects of vocal loading, fatigue and endurance may be the first step to define vocal health physiologically. In this connection, the present study aims to add information on the effects of controlled prolonged loud voice use and resulting complaint of vocal fatigue or voice change and recovery pattern of voice in the healthy adult Indian males.

**Method**

**Subjects**

Twenty normal adult Indian males between the ages of 18 and 30 years participated in this study. The subjects were recruited based on the exclusion and inclusion criteria given below.

**Exclusion criteria:**

1. History of smoking, laryngeal pathology, intubation, neurologic disorder, respiratory disorder, systemic illness, and surgery/accident/
trauma,
2. Sustained (prolonged use) medications for any medical condition,

**Inclusion criteria:**
1. Perceptually normal voice in terms of pitch, loudness and quality,
2. Loudness dynamic range of 40 - 80 dBSPL.

**Procedure**

**I. Pre-experiment phase**

**Directions to subjects prior to participation in the experiment:** Every subject was asked to refrain from excessive voice use (yelling, prolonged singing / talking, whispering and throat clearing), to avoid caffeine, and was instructed to drink adequate water (6-8 glasses) for 24 hours preceding their appointment to participate in the experiment.

**Pre experimental recording for obtaining baseline measures:** To obtain baseline measures, the subjects were asked to phonate /a/, /i/, /u/ and sustain /s/, /z/ as long as possible and speak (1 minute) at their comfortable pitch and loudness before performing the experimental task. The subjects were seated in a comfortable upright posture and the recording was done with a microphone (SM 48) distance of 10 cm from the mouth, at an off angle position of 45°. The signal was recorded using KAY Computer Speech Lab model 4300 (Kay Elemetrics Corp., NJ, USA), at 44,100 Hz sampling rate.

**Pre experiment analysis for baseline measures:**

*a) Perceptual analysis:* Phonation and conversation samples were judged for the perceptual correlates of voice by a qualified Speech Language Pathologist for parameters of pitch, loudness and quality. The judge performed the perceptual evaluation in one session with two pauses, and there was no limit as to how many times the judge was allowed to listen to each of the voice samples. For intra-judge reliability the samples were reanalyzed entirely with a minimum gap of 1 day. Maximum Phonation Time (MPT) and S/Z ratio were also analyzed and noted. The GRBAS scale (Hirano, 1981) was used for the perceptual analysis of voice in conversation tasks.

*b) Acoustic analysis (PrT):* The recorded phonation sample was analyzed using Multi Dimensional Voice Profile (model 5105, Kay Elemetrics Corp., NJ, USA). The first portion of the phonated sample /a/ (0.25 s) was cut off, and measurements were performed during the subsequent 3.0 seconds, thus minimizing variability caused by sampling errors. The remaining portions of the sample were discarded, which ensured that the initial and final parts of voicing did not influence the final result. The recorded phonation samples were analyzed for frequency related (F$_0$), amplitude related (I$_0$), voice break, noise related, sub-harmonic component, voice irregularity and voice tremor related measures.

**II. Experimental phase**

**Prolonged loud reading task:** A calibrated (acoustic calibrator 4231) Sound Level Meter (SLM) (Bruel & Kjaer sound analyzer 2260) with a pre-polarized free field ½ inch condenser microphone (Model 4189) was mounted on a stand and kept at a distance of 18 inch from the subject’s mouth. Using the SLM as a guide for intensity, the subjects were instructed to read a book or reading material of their interest at 75-80 dB SPL in standing posture up to an hour or until they reported themselves as fatigued.

The experimenter cued the subject to maintain comfortable pitch and loud intensity level as needed, and monitored I$_0$ for every 30 seconds for the entire duration of prolonged loud reading task. The experimenter monitored and noted the time of initial sign of vocal fatigue from the beginning of the reading. The number of times the experimenter asked the subject to increase his loudness after the initial sign of vocal fatigue was also recorded. The frequency of reminder was taken as a subjective indicator of vocal fatigue.

In case, a subject was unable to read at that intensity level for 1 hour, the reading was terminated and the duration of prolonged reading was noted. In addition, the experimenter observed for any physical or vocal signs of discomfort (e.g. coughing, throat clearing, & voice quality change). These signs were meticulously noted by the experimenter.

**III. Post experiment phase**

**Directions to subjects after the participation in the experiment:** Subjects were asked to remain
silent between the termination of the prolonged loud reading task and the immediate post-test assessment. The subjects were asked to follow strict vocal hygiene guidelines: 1) no extreme voice use (yelling, prolonged singing, talking, whispering & throat clearing), 2) avoid caffeine, 3) avoid smoking, 4) coughing, 5) throat clearing, and 6) drink adequate amounts of water for 24 hours after the experimental task. The subjects were refrained from throat clearing until the post evaluation procedures were completed.

**Post experiment recording and analysis:**
Following the prolonged loud reading task, the phonation and conversation samples were recorded again as mentioned in baseline measurements and MDVP parameters were analyzed. MPT and S/Z ratio were also analyzed. The data obtained immediately after vocal loading task served as immediate post-test measurements, which was named as P\textsubscript{oT\textsubscript{o}}.

Voice recovery was tracked at 5, 10, 15 and 20 minutes and 24 hours following the immediate post task, which were named as P\textsubscript{oT\textsubscript{5}}, P\textsubscript{oT\textsubscript{10}}, P\textsubscript{oT\textsubscript{15}}, P\textsubscript{oT\textsubscript{20}}, and P\textsubscript{oT\textsubscript{24hr}}, respectively.

Paired t test was used to measure the pre and post test voice measures. A repeated measure of analysis of variance (ANOVA) was performed on P\textsubscript{oT\textsubscript{5}}, P\textsubscript{oT\textsubscript{10}}, P\textsubscript{oT\textsubscript{15}}, P\textsubscript{oT\textsubscript{20}}, and P\textsubscript{oT\textsubscript{24hr}} to measure the recovery of vocal function.

**Results & Discussions**

I. Pre and immediate post-experiment comparisons

**Perceptual analysis of phonation and conversation:** The pre-experiment (PrT) analysis for phonation and conversation sample was judged to be normal with respect to pitch, loudness and quality. Immediate post vocal loading task (P\textsubscript{oT\textsubscript{o}}) analysis of phonation samples revealed pitch deviancies (low pitched phonation), loudness deviancies (soft phonation) and quality deviancies (hoarse & breathy voice) in phonation. The results are tabulated in Table 1. This change was observed in 100% of the subjects on the immediate post vocal loading task. Acoustic analysis (discussed later) ascertains the perceptual findings. These changes are attributed as effects of vocal loading. However, contrary to these findings, Kelchner et al. (2003) assessed quality in phonation after the vocal loading task and reported no significant difference in the voice quality.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Severity</th>
<th>PrT</th>
<th>P\textsubscript{oT\textsubscript{o}}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>Normal</td>
<td>100%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Roughness</td>
<td>Normal</td>
<td>100%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>0%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Breathiness</td>
<td>Normal</td>
<td>100%</td>
<td>87.5%</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>0%</td>
<td>12.5%</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Asthenia</td>
<td>Normal</td>
<td>100%</td>
<td>92.5%</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>0%</td>
<td>7.5%</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Strain</td>
<td>Normal</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 1: Perceptual evaluation of conversation samples using GRBAS scale obtained from Pre (PrT) and immediate post experiment (P\textsubscript{oT\textsubscript{o}}) recordings.

The pre-experiment analysis for conversation samples was judged to be normal with respect to grade, roughness, breathiness, asthenia and strain. The post experiment revealed 0 % strain. This may be due to the difficulty in identifying strain. Both grade and roughness showed 50 % mild deviancies. Breathiness (12.5 %) and asthenia (7.5 %) were less commonly observed in the conversation samples.

To check intra-judge reliability for phonation and conversation samples, Spearman coefficient of correlation was done. Statistically significant correlation was obtained between the repeated ratings made by the judge at two different times (phonation: +0.37; conversation: +0.25). Hence the perceptual evaluation by the judge was considered reliable.

a) **MPT and S/Z ratio:** The maximum phonation time (MPT) for /a/, /i/, /u/ and S/Z ratio was measured pre and post experiment (PrT & P\textsubscript{oT\textsubscript{o}}) to obtain status of laryngeal function and coordination with breathing mechanism after the vocal loading task. The results are given below in Table 2.
Table 2: Mean, standard deviation and p-values for maximum phonation time and S/Z ratio.

Table 2 revealed a significant reduction in MPT after the vocal loading task. The reduction in MPT ranged from 4 – 8 seconds. On contrary, Kelchner et al. (2006) found no significant difference in MPT in pre-pubescent males after the vocal loading task. The S/Z ratio also revealed a significant increase in post-test. Higher S/Z ratio indicates poor laryngeal control rather than poor expiratory forces. Eckel and Boone, 1981 (as cited in Prater & Swift, 1984) found that 95% of their patients with laryngeal pathologies had S/Z ratios that were greater than 1.40. For better identification of laryngeal pathologies, it has been recommended that S/Z ratio greater than or equal to 1.20 to be used as the cutoff value. The significant differences in MPT and S/Z ratio could be taken as an effect of vocal loading on the coordination of respiratory and the laryngeal mechanism.

a) Acoustic analysis: Mean, standard deviation and p-values for the acoustic measures are tabulated based on the different parameters specified in MDVP. A series of two tailed paired t-tests for correlated samples was run for each of the acoustic measures to determine statistical difference between the pre (PrT) and post experiment (PpoT) data.

i) Frequency related parameters: Mean, standard deviation and p-values for the frequency related parameters are tabulated in Table 3.

Table 3 indicated no significant differences for most of the frequency related measures, except for phonatory fundamental frequency range (PFR) and lowest fundamental frequency (F\textsubscript{Lo}). The PFR showed an increase in values and F\textsubscript{Lo} revealed a decrease in the values. The slight decrease in F\textsubscript{Lo}, F\textsubscript{Vo} and increase in PFR was in strong agreement with the perceptual findings reported in this study. Similarly, Neils and

Table 3: Mean, standard deviation and p-values for frequency related measures.

Yairi, 1987 (as cited in Rantala & Vilkman, 1999) reported no significant changes in F\textsubscript{o} in vocally untrained women following 45 minutes of reading in background noise (50 – 70 dB A).

However, Krishna and Nataraja (1995) found significant differences in average fundamental frequency (F\textsubscript{Vo}), average pitch period (t\textsubscript{o}), standard deviation of F\textsubscript{Vo} (STD), highest fundamental frequency (F\textsubscript{Hi}) and lowest fundamental frequency (F\textsubscript{Lo}) after a 30 minutes reading task. In a similar study, Stemple et al. (1995), Geller and Andrews, 1991 (as cited in Stemple et al., 1995) and Vilkman, Lauri, Alku, Sala and Sihvo (1999) documented increase in habitual F\textsubscript{o} following prolonged voice use. This discrepancy may be due to variations in duration of vocal loading tasks and gender differences across the studies.

ii) Short and long term frequency measurements: Table 4 showed mean and standard deviation of frequency perturbation measures. Measures such as jitter in % (Jitt), relative average perturbation (RAP), pitch period perturbation quotient (PPQ), smoothed pitch perturbation quotient (sPPQ) and absolute jitter (Jita) showed significant difference and vFo did not show any significant difference in pre and immediate post experiment. All these parameters measure the short and long term variations of the pitch period within the analyzed sample. The increase in the short and long term frequency measurements may be due to irregular vibration of the vocal folds. This altered mode of vibration could have lead to an increase in frequency perturbation measures. These changes are attributed as effects of vocal loading.
Table 4: Mean, standard deviation and \( p \) - values for short and long term frequency related measures.

The finding in the present study also stands in support of the results from Gelfer et al., 1991 (as cited in Stemple et al., 1995) that found a significant change between pre- and post test Jitter ratio for the vowel /i/ in trained singers after vocal loading task. In contrast to this findings, Verstaete, Forrez, Mertens and Debruyne, 1993 (as cited in Welham & Maclagan, 2004) found no significant changes in jitter values in untrained voice users.

iii) Short and long term amplitude measurements: The amplitude perturbation measures in Table 5 indicated a significant increase in all the measures such as shimmer (\( Sh \) dB), shimmer percent (shim), amplitude perturbation quotient (APQ), smoothed amplitude perturbation quotient (sAPQ), and peak amplitude variation (vAm).

All these parameters measure the period-to-period variability of peak to peak amplitude within analyzed sample. The higher values in amplitude measures can be explained as the inability of the subjects to maintain a constant intensity in phonation after the vocal loading task. However, Verstaete et al., 1993 (as cited in Welham & Maclagan, 2004) found no significant differences in shimmer values in untrained voice users.

Table 5: Mean, standard deviation and \( p \) - values for short and long term amplitude related measures.

iv) Noise related parameters: The mean, standard deviation and significance of noise related measures such as soft phonation index (SPI), voice turbulence index (VTI) and noise to harmonics ratio (NHR) is showed in Table 6. The results showed a significant increase in NHR and SPI. Higher NHR values indicated that there is considerable increase in noise component in voice after vocal loading task and this may be due to increase in glottal gap during phonation. The other noise related VTI did not show a significant difference. On the contrary to these findings, Krishna and Nataraja (1995) found no significant difference in noise related measures.

v) Voice break related parameters: Table 7 showed no significant variations in the pre- and post experiment values for voice break related measures such as degree voice breaks (DVB) and number of voice breaks (NVB). Therefore, indicating no effect of vocal loading task on voice break related measures. Krishna and Nataraja (1995) also found
no significant differences in voice break measures.

Table 7: Mean, standard deviation and $p$-values for voice break related measures.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PrT Mean (SD)</th>
<th>$P_{0Ta}$ Mean (SD)</th>
<th>$p$</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVB (%)</td>
<td>0.00 (0.00)</td>
<td>0.18 (0.59)</td>
<td>0.186</td>
<td>-</td>
</tr>
<tr>
<td>NVB</td>
<td>0.00 (0.00)</td>
<td>0.10 (0.30)</td>
<td>0.163</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 7: Mean, standard deviation and $P$-values for voice break related measures.

vi) **Sub-harmonic component measures**: The results in Table 8 show no significant variations in the pre- and post test values such as degree of sub harmonic segments (DHS) and number of sub harmonic segments (NSH). Therefore, indicating vocal loading task is not affecting sub-harmonic components in the current study. Krishna and Nataraja (1995) also found no significant differences in sub-harmonic component measures.

Table 8: Mean, standard deviation and $p$-values for sub-harmonic component related measures.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PrT Mean (SD)</th>
<th>$P_{0Ta}$ Mean (SD)</th>
<th>$p$</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSH (%)</td>
<td>0.03 (0.09)</td>
<td>0.35 (0.93)</td>
<td>0.132</td>
<td>-</td>
</tr>
<tr>
<td>NSH</td>
<td>0.10 (0.30)</td>
<td>1.1 (2.8)</td>
<td>0.116</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 8: Mean, standard deviation and $p$-values for sub-harmonic component related measures.

vii) **Voice irregularity related measurements**: The results in Table 9 showed significant variations in the pre- and post test values for voice irregularity parameters such as degree of unvoiced segments (DUV) and number of unvoiced segments (NUV). This irregularity in voicing was due to the effect of vocal loading on vocal mechanism. However, Krishna and Nataraja (1995) found no significant differences in voice irregularity measures.

Table 9: Mean, standard deviation and $p$-values for voice irregularity related measures.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PrT Mean (SD)</th>
<th>$P_{0Ta}$ Mean (SD)</th>
<th>$p$</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUV (%)</td>
<td>0.08 (0.03)</td>
<td>1.2 (5.8)</td>
<td>0.06</td>
<td>+</td>
</tr>
<tr>
<td>NUV</td>
<td>0.25 (0.83)</td>
<td>2.9 (6.8)</td>
<td>0.05</td>
<td>+</td>
</tr>
</tbody>
</table>

Table 9: Mean, standard deviation and $p$-values for voice irregularity related measures.

viii) **Voice tremor related measurements**: The mean, standard deviation and significance of voice tremor related measures such as Fo- tremor frequency (Fftr), amplitude tremor frequency (Fatr), frequency tremor intensity index (FTRI) and amplitude tremor intensity index (ATRI). Table 10 showed significant increase for FTRI and Fftr measures. This may be explained due to the tremor component in the voices of the subjects after the vocal loading task. There were no significant differences noticed for the other voice tremor related measures.

Table 10: Mean, standard deviation and $p$-values for voice tremor related measures.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PrT Mean (SD)</th>
<th>$P_{0Ta}$ Mean (SD)</th>
<th>$p$</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fftr</td>
<td>1.8 (1.9)</td>
<td>4.1 (3.3)</td>
<td>0.024</td>
<td>+</td>
</tr>
<tr>
<td>Fatr</td>
<td>1.6 (1.8)</td>
<td>2.1 (2.1)</td>
<td>0.446</td>
<td>-</td>
</tr>
<tr>
<td>FTRI</td>
<td>0.1 (0.1)</td>
<td>0.4 (0.3)</td>
<td>0.005</td>
<td>+</td>
</tr>
<tr>
<td>ATRI</td>
<td>1.3 (1.4)</td>
<td>2.6 (2.9)</td>
<td>0.107</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 10: Mean, standard deviation and $p$-values for voice tremor related measures.

ix) **Prolonged reading task** - duration as an indicator of vocal fatigue: The overall mean and standard deviation for duration of total loud reading time and notice of initial fatigue are described in Table 11.

Table 11: Minimum, Maximum, Mean and standard deviation for duration of prolonged reading and symptoms of initial fatigue.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total reading time</td>
<td>30</td>
<td>45</td>
<td>35 (4.34)</td>
</tr>
<tr>
<td>(minutes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial fatigue</td>
<td>10</td>
<td>23</td>
<td>15 (3.36)</td>
</tr>
<tr>
<td>noticed (minutes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of reminder (number)</td>
<td>13</td>
<td>21</td>
<td>16 (2.28)</td>
</tr>
</tbody>
</table>

In the current study, the length of time an individual could maintain loud reading task was subjectively interpreted as a partial indicator of vocal fatigue or endurance. Krishna and Nataraja (1995) suggested 30 minutes of reading was sufficient to induce fatigue. In the present study duration of reading ranged from 30 - 45 minutes. The mean duration of prolonged reading for subjects was 35
minutes with a standard deviation of 4.34. It was found that prolonged loud reading for 35 minutes itself was sufficient to induce vocal fatigue which was indicated by changes in the acoustic measures.

None of these subjects were able to complete the prolonged loud reading task for an hour. The time of initial fatigue revealed that all of the subjects reported fatigue before 25 minutes of the loud reading task. The mean duration of initial fatigue reported by the subjects was 15 minutes with a standard deviation of 3.36.

Majority of the subjects reported throat pain as a primary complaint along with throat tightness and running out of breath during prolonged loud reading task. These complaints correlate with some of the primary symptoms of vocal fatigue listed by Kostyk and Roche, 1998 (as cited in Welham & Maclagan, 2003).

II. Immediate post comparisons with PoT5, PoT10, PoT15, PoT20, and PoT24hr Voice recovery pattern: The MDVP parameters were recorded before, immediately after and at each additional 5 minutes increment till 20 minutes and 24 hours following the experimental task. The subjects were asked to follow strict vocal hygiene guidelines for 24 hours after the experimental task. Repeated measures of ANOVA was used in which time was modeled as a within subject effect. Test results demonstrated a significant difference in the group for immediate post-test and post-tests till 20 minutes for some of the voice measures. Graphical representation of the recovery patterns of different voice measures are given below.

Frequency related measurements:

The frequency related measurements such as Fo, Flo, Fhi, STD and PFR did not show a significant recovery pattern through comparisons from the pretest to the post-tests till 20 minutes. However, Kelchner et al. (2006) documented significant recovery pattern for Fo in prepubescent males. This variation may be due to the duration and intensity of reading employed in the study (Figure 1).
Figure 1: Voice recovery pattern of Fo, Fl, Fhi, STD Fo, and PFR.

**Short and long term frequency measurements:** The parameters such as Jitt, RAP, PPQ, sPPQ and jita showed significant difference from the immediate post-test to the post-test done at 20 minutes. Whereas, vFo did not reveal a significant recovery pattern. There was a significant increase in the values of the measures observed after the experimental task. And there was a subsequent recovery pattern noticed which was indicated by the returning of the values to near pre-test level within 20 minutes from the vocal loading task. The measures reached the pre-test levels at post-test done at 24 hours. This indicated that the voice parameters recovered completely after the acute physiologic change due to the vocal loading task 24 hours later (Figure 2).
Figure 2: Voice recovery pattern of Jitt, RAP, PPQ, sPPQ, vFo, and Jita.
Figure 3: Voice recovery pattern of Sh dB, Shim, APQ, sAPQ, and Noise related measures:

In the noise related measures, NHR showed a significant difference from the immediate post-test to the post-test done at 20 minutes. Whereas other parameters such as SPI and VTI did not reveal a significant difference in the recovery patterns. There was significant increase in the values and there was a subsequent recovery pattern noticed which was indicated by the returning of the values to near pre-test level within 20 minutes. The values reached the pre-test levels at 24 hours post-test (Figure 4).

Figure 4: Voice recovery pattern of SPI, VTI, and NHR

Conclusions

The results revealed several interesting facts:

1. Effects of vocal loading:
   a) Changes in pitch, loudness and quality were noted after the vocal loading task. Overall voice quality change was more pronounced. Vocal loading lead to a more rough voice quality. Strain was difficult to measure.
   b) The maximum phonation time showed a significant reduction (around 6 seconds) after the vocal loading task for all the three vowels (/a/, /i/, /u/) measured. The S/Z ratio also revealed a significant increase after the vocal loading task.
   c) The acoustic analysis measured using MDVP revealed significant difference for some of the parameters. The parameters such as fundamental frequency, PFR, short and long term frequency measurements, short and long term amplitude measurements, noise and voice irregularity related measures showed significant difference after the vocal loading task.

2. Fatigability time: None of the subjects could sustain (75 - 80 dB SPL) loud reading task for an hour. Initial signs of fatigue were seen as early as 15 minutes. So it was concluded that normal healthy adult males could possibly sustain voice at such loudness levels not more than 30 minutes. It would be interesting to note if this sustained time would vary in women, children and with altered intensity levels.

3. Associated vocal fatigue symptoms: Majority of the subjects reported throat pain as a primary complaint along with throat tightness and running out of breath while talking.

4. Voice recovery pattern: Various acoustic parameters such as short and long term frequency measures, short and long term amplitude measures and NHR in noise related measures revealed a significant recovery pattern. This recovery was characterized by the returning of values to pre-test levels 24 hours after the vocal loading task.

The information obtained in this study ascertains that prolonged voice use can result in vocal symptoms. Complaints of vocal fatigue, voice
symptoms, and voice recovery can be tracked and monitored using perceptual and acoustic measures. These findings can be applied to understand vocal endurance, susceptibility to vocal fatigue and physiological changes due to vocal loading.

References


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Auditory Brainstem Responses to Forward and Reversed Speech in Normal Hearing Individuals

*Sujeet Kumar Sinha, **Vijayalakshmi Basavaraj

Abstract

Differences in the coding of forward and reversed speech has indicated that the human auditory system is sensitive to different types of speech sounds. Infants as well as adults are reported to respond differently to forward and reversed speech. Functional magnetic resonance imaging (FMRI) have revealed that listening to forward speech activates large regions of the temporal lobe, whereas reverse speech evokes significantly diminished and non-localised brain responses. The objective of the present study was to assess the differences, if any, in the brainstem responses to forward and reversed speech stimuli. 50 normal hearing adults participated for the study. A synthesized 40msec short stimulus /da/ syllable was used as the stimulus for both forward and reversed conditions. The syllable was reversed with the help of Adobe Audition software. Auditory brainstem responses were recorded for the forward and reversed /da/ stimulus. Results revealed that the amplitude of wave V was larger for reversed speech as compared to the forward speech. On the other hand, the amplitude of the frequency following responses, fundamental frequency and the formant frequency were smaller in the reversed speech condition as compared to the forward speech condition. The findings of the present study suggest that differential processing of forward and reversed speech occurs at the brainstem level as well even for a short duration stimulus. The better response to forward speech could be due to the universal temporal and phonological properties of human speech which is familiar to the brainstem and hence is processed efficiently. These findings suggest that Speech evoked ABR may throw light to understand the encoding of complex acoustic stimulus at the brainstem level.

Key words: Brainstem, Speech Evoked ABR, Forward Speech, Reversed Speech.
top-down mechanisms (Banai & Kraus, 2008).

Given the information that the brainstem does contribute to processing of speech, it will be interesting to study the nature of processing of the different aspects of speech by the subcortical structures.

Reversed speech is considered as a good stimulus to investigate in this area since reversed speech has the unique characteristics to maintain the physical characteristics of speech such as the distribution of frequency of sounds, their global amplitude and, to some extent, their temporal and rhythmic characteristics. The main difference between forward speech and reversed speech lies in the coarticulations which are totally distorted in the reversed signal. If speech stimuli are played backwards it sounds like unfamiliar and often bizarre sounding language eventhough phoneme duration and the fundamental voicing frequency are preserved (Binder et al. 2000; Dehane, Dehane & Hertz-Pannier, 2002). This is because reverse stimulation violates phonological properties universally observed in human speech (Binder et al., 2000; Dehane et al., 2002).

There are reports which suggest differences in the coding and processing of forward and reverse speech stimulus. Adults as well as infants are sensitive to these stimulus differences. It has been reported that 4 days old neonates and 2 months old infants can discriminate native and foreign languages but not when those sounds are played backwards (Mehler, Jusczyk, Lambertz, Halsted, Bertoncini & Amiel-Tison, 1988). Functional magnetic resonance imaging (fMRI) have indicated that the left angular gyrus, right dorsolateral prefrontal cortex and the left mesial parietal lobe (precuneus) get significantly more activated by forward speech than by backward speech. (Mehler et al., 1988). FMRI studies have also shown that listening to forward speech activates large regions of the temporal lobe, but backward speech evokes significantly diminished and nonlocalised brain responses (Binder et al. 2000). The direct contrasts Words-Pseudowords and Words-Reversed have no areas of significant activation difference in either direction in neither hemisphere, nor a direct contrast between Pseudowords and Reversed conditions (Binder et al., 2000).

The segmental and suprasegmental features of speech may condition and modify brainstem neurons to process familiar sounds more selectively and preferentially. It is also possible that the type of signal processing may affect the subsequent cortical development and language lateralization. Galbraith et al. (2004), where they have obtained the brainstem responses to forward and reversed speech (using an 880 msec 4 syllable phrase. Both horizontal and vertical electrode montages were used to record the responses on a small sample of 11 subjects. There is a need to ascertain the findings of Galbraith et al. (2004) on a larger sample. Also, there is a need to explore the auditory brainstem processing using different types and duration of speech stimuli, with and without background noise and with different methods of presentation. The information documented by such studies especially using a larger sample than that used by Galbraith et al (2004) would throw light on the similarities and differences between the subcortical and cortical processing of speech, the interaction between the two levels and implication of these interactions or the lack of it. Since, Galbraith et al (2004) did only FFT analysis of the brainstem responses, it will be interesting to measure the amplitude of each peak to substantiate the differences between the forward and reversed speech. Therefore there is a need to study the amplitude of each peak and FFT analysis on a larger sample. Thus, the objective of the present study was to assess the possible differences in brainstem responses to forward and reversed speech stimuli.

**Method**

**Research design:** "A Within Subject" research design was used where in the responses of each subject to forward and reversed speech stimuli were compared.

**Hypothesis:** The null hypothesis that there is no difference between the ABR responses for forward and reversed speech stimuli were compared.

**Participants:** Fifty young adult students (30 males and 20 females) in the age range 17 to 23 years, with a mean age of 19 years consented to participate in the study. All the subjects had normal hearing thresholds as defined by puretone thresholds of <20 dBHL from 250 Hz to 8000 Hz with normal middle ear functions as revealed by A type of tympanograms and presence
of acoustic reflexes present at 500 Hz, 1000 Hz, 2000 Hz & 4000 Hz for both ipsi and contralateral stimulation.

**Test Stimulus:**

Synthesized /da/ syllable of 40 msec length was used as the test stimulus, synthesized with a Klatt synthesizer (Klatt, 1980). The stimulus was prepared to include an onset burst frication at F3, F4, and F5 during the first 10 msec and a fundamental frequency range of 105-121 Hz, followed by 30-msec F1 and F2 transitions ceasing immediately before the steady-state portion of the vowel. Although the stimulus does not contain a steady-state portion, it is psychophysically perceived as a consonant-vowel speech syllable. Such a stimulus was first developed at Northwestern University by King et al (2002) and the same has been used for research at Northwestern University.

Figure-1 shows the /da/ stimulus of 40 msec whereas the figure 2 shows the reversed waveform of the same stimulus. Stimulus in the figure-2 is the mirror image of the stimulus in figure-1. Adobe audition version-2 software was used to reverse the stimulus.

![Figure 1: Waveform of the forward /da/ stimulus.](image1)

![Figure 2: Waveform of the temporally reversed /da/ stimulus.](image2)

**Instrumentation:**

- A calibrated (ANSI S3.6-1996), two channel clinical audiometer Madsen OB922 with TDH-39 headphones housed in Mx-41/AR ear cushions were used for Pure tone audiometry. Radioear B-71 bone vibrator was used for measuring bone conduction thresholds.
- A calibrated middle ear analyzer, (GSI Tymppstar) using 226 Hz probe tone was used for tympanometry and reflexometry.
- Intelligent Hearing (Smart EP windows USB version 3.91) evoked potential system with insert ear ER-3A receiver was used for recording auditory brainstem responses.

**Procedure**

All the subjects underwent puretone audiometry and
tymanometry to ensure that they had normal hearing sensitivity and normal middle ear functions. The speech evoked auditory brainstem responses were recorded for all the subjects for both the forward and the reversed /da/ stimulus in the EP system of Intelligent Hearing systems version 3.91. The details of the protocol for recording the speech evoked ABR are given in table-1

**Analysis:**

Speech evoked ABR consists of six peaks. These peaks are labeled as (V, C, D, E, F, & O. (Russo et al., 2004; Russo et al., 2005, Johnson et al., 2005). The amplitude of waves V, D, E and F were measured for the forward as well as reversed conditions. Wave C and wave O were not taken into consideration for analysis as they were not present in all the subjects. Two audiologists who have the knowledge of the Speech evoked ABR analyzed the waveforms independently. The inter audiologist reliability was ensured by doing a correlational analysis for all the peaks. All the peaks showed a high positive correlation for the peaks marked by the two audiologists.

**Measurement of Fundamental frequency (F0) and First Formant frequency (F1):**

FFR consists of energy at fundamental frequency of the stimulus and its harmonics. The period between response peaks D, E, and F in the recorded waveform corresponds to the wavelength of the F0 of the utterance (Johnson et al., 2005). Moreover, Fourier analysis of this portion of the response confirms a spectral peak at the frequency of F0. Additionally, the spacing of the small, higher-frequency fluctuations between waves D, E, and F correspond in frequency to the F1 of the stimulus (Russo et al., 2004; Russo et al., 2005, Johnson et al., 2005). Fast Fourier analysis was performed on the recorded waveform. Activity occurring in the frequency range corresponding to the fundamental frequency (F0) of the speech stimulus (103-121Hz) and activity corresponding to the first formant frequency (F1) of the stimulus (220 Hz-729 Hz) were measured. 2 ms on-2 ms off Hanning ramp was applied to the waveform. Zero-padding was employed to increase the number of frequency points where spectral estimates were obtained. A subject's response was required to be above the noise floor in order to include in the analysis. This calculation was performed by comparing the spectral magnitude of pre stimulus period to that of the response and if the quotient of the magnitude of the F0 or F1 frequency component was greater than or equals to one the response was considered to be present. The analysis of F0 and F1 was done with the MATLAB software.

**Results**

A long term average speech spectrum of both the forward and reversed speech was performed to see whether the spectrums of the two sounds are different. On analysis it was found that the spectrum of the forward and reversed stimuli remained the same. Figure 3 shows the long term average spectrum of the forward and reversed speech stimuli. Since there was a perfect overlap of the two spectra it was difficult to differentiate one from the other. Hence, the SPL of the reverse speech (shown in continuous line) was deliberately reduced to differentiate it from the forward speech spectrum (shown in dotted line).

Wave V was identified for the forward and the reversed speech similar to the way it is identified for click stimulus. Since wave V is the result of an onset response, this is similar to both the click and the speech evoked ABR. Johnson et al., (2005) have reported and illustrated that the visual analysis of / da/ stimulus waveform and its corresponding brainstem response has several similarities. They

<table>
<thead>
<tr>
<th>Stimulus parameter</th>
<th>Stimulus</th>
<th>Forward /da/ and reversed /da/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>40 msec</td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td>80 dB nHL</td>
<td></td>
</tr>
<tr>
<td>Polarity</td>
<td>Alternating</td>
<td></td>
</tr>
<tr>
<td>Repetition rate</td>
<td>9.1/sec</td>
<td></td>
</tr>
<tr>
<td>Total no. of stimulus</td>
<td>2000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acquisition parameter</th>
<th>Analysis time</th>
<th>60 msec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Filter setting</td>
<td>30 to 3000 Hz</td>
</tr>
<tr>
<td>Electrode Montage</td>
<td>Noninverting(+ve): Vertex, Inverting(-ve): Test ear mastoid, Ground: Non test ear mastoid</td>
<td></td>
</tr>
<tr>
<td>Transducer</td>
<td>Insert receiver-ER-3A</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Recording parameters for the speech evoked auditory brainstem responses for the forward /da/ and the reversed /da/ stimulus
have recommended to shift the stimulus waveform by approximately 7 msec to account for neural conduction time to identify the speech ABR peaks which correlate with the peaks in the stimulus, namely peak D, E and F. In the present study the speech ABR peaks corresponding to the peaks D, E and F in the stimulus were identified using the same procedure for both the forward and reversed speech keeping the burst of the stimulus as reference. The burst for the forward stimulus appears in the beginning of the stimulus and for the reversed speech it appears in the last of the stimulus and hence, the peaks D, E, and F occurs in the reversed order for the reversed speech and thus it can be seen from figure 4b that wave F follows wave V against wave D.

Figure 3. Long term average speech spectrum of forward and reversed speech

Figure 4a. Sample of Speech evoked ABR for the forward Speech and its correlation with the stimulus peaks

Figure 4b. Sample of Speech evoked ABR for the reversed Speech and its correlation with the stimulus peaks
Descriptive statistics:

SPSS software version 15 was used for statistical analysis. Mean and standard deviations for the amplitude alone of waves V, D, E and wave F were determined for all the subjects for the forward and reverse speech. Latency parameter was not subject to analysis as this is determined by the stimulus parameters. The mean and Standard deviation (SD) of amplitude of the different waves for the forward & reversed speech are presented in table 2.

From the table 2 it can be noticed from that the mean amplitude for wave V is larger for the reversed speech as compared to that for the forward speech condition. The amplitude of others peak (waves D, E & F) are larger for forward speech condition as compared to that for the reversed speech condition. This can be seen in figure 5 as well.

<table>
<thead>
<tr>
<th>Wave</th>
<th>Forward Speech Amplitude (µv)</th>
<th>Reversed Speech Amplitude (µv)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Wave V</td>
<td>0.18</td>
<td>0.10</td>
</tr>
<tr>
<td>Wave D</td>
<td>0.33</td>
<td>0.25</td>
</tr>
<tr>
<td>Wave E</td>
<td>0.35</td>
<td>0.16</td>
</tr>
<tr>
<td>Wave F</td>
<td>0.28</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Table 2: Mean and standard deviations (SD) for amplitude (µv) of different peaks for the forward & reversed speech.

To know the significance of difference between the amplitude of different peaks the dependent 't' test was done. The results of dependent 't' test revealed a significant difference between the amplitude of wave V [t (49) = 6.54, p...
wave D \[t (49) = 6.27, p < 0.01\], wave E \[t (49) = 5.03, p<0.01\] & wave F \[t (49) = 4.80, p<0.01\]. Also an analysis of fundamental frequency and first formant frequency was done. This was done using "Matlab Software". A sample figure of how the fundamental frequency and the first formant frequency were measured is given in the figure 6 above.

**F0 and F1 analysis:**

Analysis of Fundamental frequency and first formant frequency revealed that the mean amplitude of fundamental frequency for forward speech was 15.72µv and of the reversed speech was 9.23 µv. The amplitude of first formant frequency for forward speech was 12.86 µv and that of reversed speech was 7.83 µv. A dependent’s test was applied to compare the amplitude of fundamental frequency and the first formant frequency of forward speech and reversed speech. This revealed a significant difference for the F0 \[t (49) = 2.34, p<0.05\] and for the F1 \[t (49) =2.22, p<0.05\].

Thus the null hypothesis that there is no significant difference between the brainstem responses to forward and reversed speech conditions was rejected. To summarize the results, amplitude of all the peaks for forward speech except for "wave V" was more as compared to that of the reversed speech. Also, the amplitude of fundamental frequency and first formant frequency was more for forward speech as compared to the reversed speech.

**Discussion**

Auditory brainstem is the site of extensive synaptic complexity and acoustic signal processing in the auditory pathway (Eggermont, 2001). The regularities in the acoustic biotope, consisting of individual vocalizations and background sounds that are part of the natural habitat are likely to be manifested in the response properties of auditory neurons (Aertsen, Smolders, & Johannesma, 1979; Nelken, Rotman, & Yosef, 1999; Smolders, Aertsen, Johannesma, 1979).

In the present study the frequency following responses to forward and reversed speech were recorded in a vertical montage. The vertical frequency following responses measure responses originating in the rostral brainstem (Galbraith, 1994; Gardi, Merzenich & Mckean, 1997). The principal finding of the present study is that there is a significant difference between the forward and the reversed speech coding even for a short duration stimulus of 40 msec at the brainstem level. The amplitude of the frequency following responses to reversed speech stimulus were reduced as compared to that for the forward speech. Further, the results also indicate that the amplitude of fundamental frequency and the first formant frequency were also reduced in the individuals for the reversed speech condition. The reduced amplitude of FFR, fundamental frequency and the first formant frequency suggests that the brainstem processes the forward speech differently than the reversed speech. Galbraith et al (2004) have also reported a reduced FFT response to reversed speech compared to the forward speech. The present study supports their findings and further illustrates that the differential processing is seen even for a short duration CV stimulus like /da/. However, responses obtained for short duration stimuli using horizontal montage needs to be explored as present study used only vertical montage.

It is possible that the reduced amplitude of the frequency following responses (i.e. the amplitude of the wave D, E and F) may simply be due to the coarticulation effect in forward and reversed speech. The coarticulations are reported to be totally distorted in the reversed signal (Binder et al., 2000; Dehane, et al., 2002). One may argue that the reduced responses in the brainstem may be due to the distortion of the coarticulations in the reversed speech rather to the differences in the processing at brainstem level. However in the present study, the FFT analysis of the FFR shows reduced amplitude of F0 and F1. It is difficult to explain the reduced responses of F0 to the coarticulation effect because in the reversed speech some of the parameters such as distribution of frequency of sounds, their global amplitude, phoneme duration and the fundamental voicing frequency are preserved (Binder et al.2000; Dehane, et al. 2002), as shown in figure 3 also. Therefore, the findings in the present study may not be due to the distortion of the coarticulation effect alone. It appears to be because of the differential processing of forward and reversed speech at the brainstem level. Thus, the results of the present study suggest that the brainstem structures processing is also different for familiar and non familiar stimuli similar to the cortical processing.
It appears that the synaptic processing at the level of rostral brainstem is more effective for speech stimuli characterized by highly familiar prosodic and phonemic structures as illustrated by better ABR responses for the forward speech condition. This could be due to the conditioned exposure to native speech patterns that may modify the microanatomy and processing capabilities of the auditory system (Querleu & Renard, 1981). Indeed there are studies which suggest that there is plasticity even at the level of brainstem (Russo et al, 2005). The notion that neural activity in the rostral brainstem is sensitive to language experience, (i.e., language-dependent) is also reported (Krishnan et al. 2005). At this point, a question arises as to whether these observed FFR effects are stable for all types of stimuli. Further studies with a longer duration stimuli, a tonal stimulus, words and sentences will strengthen the present area of research.

Conclusion

The present study highlights the differential processing of forward and the reversed speech at the brainstem level similar to that at the cortex. Differences in the processing at the cortical level for forward and reversed speech has been reported (Binder et al., 2000). Findings of the present study suggest that the differential processing occurs at the brainstem level as well. The differences in the processing of forward (familiar) and reversed (non familiar) speech could be due to the previous exposure to the forward speech making the universal temporal and phonological properties of speech familiar to the auditory system. Findings of the present study also suggest that speech evoked ABR provides information to understand the encoding of complex acoustic stimulus at the brainstem level. Further research on normal and abnormal speech evoked ABR may throw light on some of the factors contributing to the poor speech perception in the clinical population. Although speech perception involves various cognitive processes that go beyond a single neural code and the brainstem encoding of speech sounds alone may not account for the speech perception, it is possible that abnormal neural response patterns at the brainstem may be one of the many factors which contributes to the poor speech perception.

References


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- Head of the Department of Audiology for permitting to conduct the study.
- Dr. Nina Kraus and Dr. Erika Skoe of Northwestern University for permitting us to use the /da/ stimulus for the study.
- All the students who participated in the study
EFFECT OF SENSORINEURAL HEARING LOSS ON SPEECH EVOKED
AIDED AUDITORY LATE LATENCY RESPONSE

*Kumari Apeksha, **Ms. N. Devi

Abstract
The aim of present study was to compare the auditory late latency response (ALLR) waveform obtained for naturally produced speech tokens, such as /ba/, /da/, and /ga/ in unaided and aided conditions. It also aimed to evaluate the usefulness of ALLR in selection of amplification device using naturally produced speech tokens. Two groups of participants were taken, including 10 individuals with normal hearing and hearing impairment (9 ears) in the age range of 20 to 50 yrs. Speech evoked ALLR was done both in unaided and aided conditions. Aided ALLR was done with two pre-selected digital hearing aids with first fit. The results revealed that there was significant difference between unaided and aided responses ($x^2 = 197.04$, df = 26, $p < 0.001$). However, only /ba/ and /ga/ for P1 and /ba/ for N1 showed significant difference at 0.05 significance level. The latency was shorter and amplitude was higher for the group with normal hearing than hearing impaired group. There was difference in terms of latency for the speech sounds taken for the study. /ga/ stimulus was found to have shorter latency and /da/ had longer latency out of three stimuli. Similar pattern was also observed for absolute amplitude. Finding from the present study also revealed that there was significant difference between performances of individuals with sloping sensorineural hearing loss with different hearing aids in aided ALLR. Aided ALLR can help in selection of hearing aids as it mimics the hearing aid processing. It can be suggested to use aided ALLR to select hearing aids as it is objective test and can assessed in shorter duration.

Key words: Auditory Late Latency Response, Hearing loss, Hearing aids, Speech stimuli

Cortical potentials reflect the functional integrity of the auditory pathway involved in the processing of complex speech stimuli. It can be used to understand the neurophysiologic basis of speech perception, which would give information of the speech processing abilities of the individuals. It is one of the ideal objective tools for aided hearing instrument evaluation because it is reliably present in young infants and adults, it correlates well with perception, it can be evoked by a range of speech stimuli, and it seems to be sensitive to differences between speech stimuli (Tremblay, Friesen, Martin & Wright, 2003).

The long latency auditory evoked potentials are characterized by components comprising time domain of 50 to 500 msec (McPherson & Starr, 1993) and are labelled according to their latency and polarity at the vertex (Picton, Woods, & Proulx, 1978). The major component of Auditory Late Latency Response (ALLR) are characterized by an initial positive peak between 60-80 msec (P60/P1), having an amplitude of about 7 µv and a width of about 15 msec. The second peak occurs between 90-100 msec (N100/N1) and is a negative peak with amplitude of 10 µv and width of 40-50 msec. The third peak is a positive occurring at about 100-160 msec (P160/P2) and has amplitude of 6 µv and a width of 40-50 msec. The forth peak occur at 180-200 msec (N200/N2) is a negative peak and has amplitude of 6 µv and width of 70 msec. The major applicability of cortical auditory evoked potentials comes from the fact that it can be recorded from premature and full term newborns, and from older children. Contrary to

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maturation effect seen in early childhood, there is an increase in latency and decrease in amplitude with the advancing age (Cranford & Martin, 1991).

Yetkin, Ronald, Christensen and Purdy (2004) suggested the physiological reasons for difference in the ALLR responses for the low and the high frequency stimuli. They reported that the cortical area responding to low frequency auditory stimuli are located more superficially than the deep layer of the cortical regions for high frequency. Hence low frequency stimuli produce smaller latency of ALLR than high frequency speech sounds.

Some of the reports indicate that ALLR may be used to assess the capacity of the auditory cortex to detect changes within the speech stimuli (Martin & Boothroyd, 1999). An investigation by Hinduja, Kusari and Vanaja (2005) revealed that ALLR of individuals with a hearing aid showed larger amplitude and shorter latency when the aided thresholds were within speech spectrum than compared to the hearing aid in which aided thresholds were outside the speech spectrum. These pre-attentive cortical potentials have also been used to reflect on the auditory training induced changes.

Tremblay, Billings, Friesen and Souza (2006) recorded ALLR for amplified speech sounds /Si/ and /?i/ in 7 adults with mild to severe sensorineural hearing loss and in 7 normal hearing individuals. The results revealed that the speech evoked ALLR can be used reliably both in aided and unaided conditions. Similar results are reported by Korczak, Kurtzberg and Stapells (2005) in individuals with severe to profound hearing loss.

Most of the subjects with hearing loss showed increase amplitude, decreased latencies and improved waveform morphology in the aided conditions. Furthermore, most subjects with hearing loss tested by Korczak, Kurtzberg and Stapells (2005) showed longer peak latencies and reduced amplitudes than the normal hearing group. The amount of response change is quiet variable across individuals as reported by Tremblay et al. (2006).

ALLR was recorded in both aided and unaided condition using /i/, /m/ and /s/ in 10 hearing impaired children in the age range of 5-7 years (Shruthi, 2007). The response obtained from the three stimuli resulted in distinct responses indicating that the stimuli are coded differently in the auditory system. Stimuli /i/ resulted in better morphology, shorter latency, and higher amplitude than /m/ and /s/ stimuli, indicating that vowels are better coded than the consonants.

ALLR was recorded using three speech stimuli, /ba/, /da/ and /ga/ from cochlear hearing loss subjects (Sumitha, 2008). It was observed that the P1-N1-P2 latency was shorter for /ga/ stimuli, and longer for /da/ stimuli. Amplitude did not show significant difference across the three sounds in both normal hearing individuals as well as individual with hearing loss.

Need for the study

It is important for any listener to listen to all the speech sounds, which encompasses the speech spectrum. It is not sufficient to study only the processing of single frequency stimuli. Hence, there is a need to study the ALLR, which is evoked by speech stimuli which largely encompasses the speech spectrum. Hence, the three different speech stimuli /ba/ which has spectral energy concentration in low frequency, /ga/ syllable dominated by mid frequency spectral energy and /da/ syllable dominated by high frequency spectral energy will be taken up for the study.

Aim of the study

The aim of present study was to compare the ALLR waveform obtained for naturally produced speech tokens, such as /ba/, /da/, and /ga/ in unaided and aided condition with that of normal hearing individual. And also to evaluate the usefulness of ALLR for naturally produced speech tokens, such as /ba/, /da/, and /ga/, in validation of appropriate hearing aid.

Method

Participants:

Two groups of participants were included in the study. Group I included 10 individuals with normal hearing in the age range of 20 to 50 years and Group II included 9 ears with hearing impairment in the age range of 20 to 50 years having moderate to moderately-severe sloping sensorineural hearing loss.

Participant selection Criteria:

Group I included individuals having hearing sensitivity less than 15 dB HL at octave frequencies between 250 Hz to 8000 Hz for air conduction and from 250 Hz to 4000 Hz for bone conduction. They
had normal middle ear functioning as indicated by immittance evaluation. Auditory brainstem response (ABR) and transient evoked otoacoustic emission (TEOAE) were done to rule out auditory dysynchrony. Participants having speech identification scores greater than 90% and having no history of any otologic, neurologic problems were included for this study.

Group II included individuals having pure tone thresholds greater than 41 dB HL and less than 70 dB HL with air bone gap of less than 10 dB. They had normal middle ear functioning as revealed by immittance evaluation. ABR and TEOAE were done to rule out auditory dys-synchrony. Participants having speech identification scores proportionate to their pure tone average and having no history of any otologic and neurologic problems were considered for this study.

**Instrumentation:**

To carry out the pure tone audiometry and speech audiometry, a calibrated two channels Orbiter-922 diagnostic audiometer with TDH-39 headphone with MX-14/AR ear cushion, Radio ear B-71 bone vibrator, and loudspeaker were used. A calibrated immittance meter, GSI-Tympstar was used to assess middle ear functioning. ILO (version, VI) OAE Analyser was used to check for the hair cell functioning. Bio-logic system (version, 7.0) with matched loudspeaker was used to record and analyse the speech evoked auditory late latency responses (ALLR) and ABR. NOAH HI-PRO software (version, 3.12) was used to program the hearing aids.

**Materials:**

Stimuli for recording ALLR were /ba/, /da/, and /ga/. Those syllables were spoken by an adult speaker having clear articulation, into a unidirectional microphone connected to the computer. The recording was done using Adobe Audition software (version 2) with a sampling rate 48000Hz and 16 bit resolution. The stimuli duration was kept less than 250 msec across all the speech sounds. The wave file was loaded for ALLR recording.

**Test Environment:**

All the measurement was carried out in an acoustically treated double room situation. The ambient noise level was within the permissible level according to ANSI (1991). For presentation of stimuli for recording ALLR, the speaker was calibrated with the help of sound level meter. The presentation level of the speaker was adjusted such that the output of the speaker at 1 m distance was 65 dB SPL as measured in sound level meter. The same output level was maintained throughout the study.

**Test Procedure for Group I:**

Pure tone thresholds were obtained in the sound field for octave frequencies between 250Hz to 8000Hz for air conduction using modified Hughson-Westlake procedure (Carhart & Jerger, 1959). The tympanometry and acoustic reflex were carried to rule out any middle ear pathology. ALLR recording was done for the participants who meet the selection criteria.

ALLR recording: Participants were made to sit comfortably in order to ensure a relaxed posture and minimum rejection rate. Speaker was placed at a distance of one meter and at a 0° azimuth to the test ear. Silver chloride electrodes were placed after cleaning the electrode sites with skin preparing gel. Conduction paste was used to improve the conductivity of the signal. The electrodes were secured in place using plasters, conventional electrode montage with non-inverting electrode on Fz, inverting electrode on the mastoid of the test ear and common electrode on the mastoid of the non-test ear. The electrode impedance value was kept less than 5 kΩ and the inter electrode difference was less than 3 kΩ.

**Test procedure for Group II:**

Similar to the procedure used in group I, pure tone thresholds, Tympanometry and acoustic reflexes were done for participants of group II. Two digital hearing aids having similar features (2 channels, 3 programmable memories, suitable till moderately severe degree of hearing loss) were selected and programmed based on the audiological findings and first fit option was selected. Aided ALLR was used to rate the hearing aids regarding their suitability.

ALLR Recording:

ALLR was recorded separately for the three stimuli /ba/, /da/, /ga/ without the hearing aid as well as with the preselected hearing aids. The procedure selected for the ALLR was same as that used for group I.
Analysis

The waveform was analysed by two audiologists who were unaware of the test conditions identified the P1-N1-P2 peaks. Latency and amplitude of the identified peaks were noted.

ALLR test protocol:

<table>
<thead>
<tr>
<th>Stimuli</th>
<th>ba, da, and ga.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulus Level</td>
<td>65 dB SPL</td>
</tr>
<tr>
<td>Transducer</td>
<td>Loudspeaker at 0° azimuth</td>
</tr>
<tr>
<td>Rate</td>
<td>1.1 sec</td>
</tr>
<tr>
<td>Polarity</td>
<td>Alternating</td>
</tr>
<tr>
<td>Filters</td>
<td>1-30 Hz</td>
</tr>
<tr>
<td>Notch Filters</td>
<td>On</td>
</tr>
<tr>
<td>Number of channels</td>
<td>Single channel</td>
</tr>
<tr>
<td>Recording time window</td>
<td>500 msec</td>
</tr>
<tr>
<td>Amplification</td>
<td>50,000</td>
</tr>
<tr>
<td>Sweeps</td>
<td>200</td>
</tr>
<tr>
<td>Number of Repetition</td>
<td>2</td>
</tr>
</tbody>
</table>

Results

The aim of the present study was to investigate the effects of spectrally different speech syllables on the auditory long latency responses in individuals with normal hearing and sloping sensorineural hearing loss. The latencies and amplitudes of P1, N1, and P2 peaks were measured. The Mean and standard deviation (SD) were calculated for 2 groups for 3 syllables for latencies and amplitudes of P1, N1 and P2.

From table 1 and graph 1, it can be inferred that the unaided mean and SD latencies of clinical group was higher than the control group for /ba/, /da/ and /ga/. Further, it was seen that latencies for aided was shorter than unaided clinical group for P1, N1, and P2.

Similarly from table 2 and graph 2, it can be inferred that the unaided mean and SD amplitudes of clinical group was lesser than the control group for /ba/, /da/ and /ga/. Further, it was seen that amplitudes for aided was higher than unaided clinical group for P1, N1, and P2.

Further, Friedman test was carried out to find out the difference between unaided and aided condition. Results revealed that overall there was significant difference between unaided and aided responses ($x^2 = 197.04$, df = 26, $p < 0.001$). However, when it was done separately, only /ba/ and /ga/ for P1 and /ba/ for N1 showed significant difference at 0.05 level of significance.

Wilcoxon signed rank test was done to compare the hearing aid 1 and hearing aid 2 findings. Results revealed that there were differences in performance with two different hearing aids for /ba/ stimuli for P1, N1 and P2. Further, for /da/ stimuli only P2 showed significant difference between two hearing aids performance. However, for /ga/ there was no significant difference noticed at all the peaks (Table 3).
Graph 1: Mean for P1, N1, and P2 latencies elicited by /ba/, /da/, and /ga/ syllables in control and clinical group (unaided and aided).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Syllables</th>
<th>Control group</th>
<th>Clinical group (Unaided)</th>
<th>Clinical group (HA1)</th>
<th>Clinical group (HA2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>P1</td>
<td>/ba/</td>
<td>1.10</td>
<td>0.71</td>
<td>0.39</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>/da/</td>
<td>1.29</td>
<td>0.66</td>
<td>0.28</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>/ga/</td>
<td>0.96</td>
<td>0.38</td>
<td>0.61</td>
<td>0.53</td>
</tr>
<tr>
<td>N1</td>
<td>/ba/</td>
<td>3.40</td>
<td>1.08</td>
<td>1.77</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>/da/</td>
<td>3.60</td>
<td>1.57</td>
<td>1.15</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>/ga/</td>
<td>3.73</td>
<td>1.23</td>
<td>1.82</td>
<td>1.27</td>
</tr>
<tr>
<td>P2</td>
<td>/ba/</td>
<td>3.38</td>
<td>1.44</td>
<td>1.28</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>/da/</td>
<td>3.44</td>
<td>1.38</td>
<td>0.29</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>/ga/</td>
<td>2.34</td>
<td>0.80</td>
<td>0.49</td>
<td>1.31</td>
</tr>
</tbody>
</table>

Table 2: Mean and SD for P1, N1, and P2 amplitudes elicited by /ba/, /da/, and /ga/ syllables in control and clinical group (unaided and aided).

Graph 2: Mean for P1, N1, and P2 amplitudes elicited by /ba/, /da/, and /ga/ syllables in control and clinical group (unaided and aided).

<table>
<thead>
<tr>
<th>Peaks</th>
<th>Group (HA1 &amp; HA2)</th>
<th>Z-value</th>
<th>Significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>/ba/ - /ba/</td>
<td>-2.07</td>
<td>0.03*</td>
</tr>
<tr>
<td></td>
<td>/da/ - /da/</td>
<td>-0.53</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>/ga/ - /ga/</td>
<td>0.23</td>
<td>0.81</td>
</tr>
<tr>
<td>N1</td>
<td>/ba/ - /ba/</td>
<td>-2.19</td>
<td>0.02*</td>
</tr>
<tr>
<td></td>
<td>/da/ - /da/</td>
<td>-1.26</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>/ga/ - /ga/</td>
<td>-0.89</td>
<td>0.37</td>
</tr>
<tr>
<td>P2</td>
<td>/ba/ - /ba/</td>
<td>-2.31</td>
<td>0.02*</td>
</tr>
<tr>
<td></td>
<td>/da/ - /da/</td>
<td>-2.31</td>
<td>0.02*</td>
</tr>
<tr>
<td></td>
<td>/ga/ - /ga/</td>
<td>-0.17</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Table 3: Wilcoxon signed rank test for comparison of hearing aid 1 and 2 (*p < 0.05).
Discussion

The speech stimulus in the present study was selected in such a way that it covered the low frequency, mid frequency and high frequency region. The stimuli varied only in the spectral content. All the stimuli selected for the study was voiced CV syllable, the vowel /a/ was kept constant. Sound /ba/, which has a spectral energy concentration majorly in low frequency, was selected as low frequency stimuli; /ga/ was selected as mid frequency stimuli and /da/ as high frequency stimuli.

It has been noticed in present study that the latency of /da/ stimuli was longer than /ba/ and /ga/ for both clinical group as well as control group. The speech stimuli /ga/ elicited a shorter latency for both control and clinical group (Table 1 & graph 1). Further, absolute amplitude of all the stimuli also showed similar patterns (Table 2 & graph 2). Study by Sumitha (2008) also revealed a similar finding in subjects with normal hearing and cochlear hearing loss.

Agung, Purdy, McMahon and Newall (2006) used the speech stimuli /a/, /u/, /i/, /s/, /sh/, /m/ and /é/ which covered a broad range of frequencies across the speech spectrum. They found that latencies of speech stimuli with high frequency content had significantly prolonged latencies than the other stimuli. In individuals with normal hearing as well as in individual with hearing loss, low frequency speech stimuli represents better responses than mid or high frequency speech stimuli. The present findings are in agreement with the finding of other studies (Agung et al., 2006; Shruthi, 2007; Sumitha, 2008).

The physiological reasons for difference in ALLR responses for low and high frequency stimuli was investigated using fMRI studies by Yetkin, Ronald, Chriestensen and Purdy, (2004). These investigators reported that the cortical areas that respond to the low frequency auditory information are located more superficially (i.e. closer to the surface of the scalp) than the deep layer of the cortical regions for high frequency. Hence, the low frequency stimuli may activate more superficial cortical areas and produce smaller latency of ALLR component than the high frequency speech sounds, when surface scalp electrodes are used.

Finding from the present study also revealed that there was significant difference between performances of individuals with sloping sensorineural hearing loss with different hearing aids in aided ALLR. However, the difference was not noticed for all the individuals in clinical group. It may be because of individual variation. Tremblay et al. (2006) also noticed that even though most of the subjects with hearing loss showed increased amplitude, decreased latency and improved waveform morphology in the aided conditions the amount of responses change was quite variable across individuals. This variability may be related to the fact that the hearing aid alters the acoustics of a signal, which in turn affect the evoked response pattern. It was also noticed that /ga/ stimuli was not showing any changes between two hearing aids performance. Similar finding was also observed by Shruthi (2007).

Conclusion

It can be concluded that the aided ALLR recorded by spectrally different speech sounds were different in individuals with normal hearing and sloping sensorineural hearing loss. This suggests that neurophysiological processes are different for different speech sounds. Longer latency for /da/ suggests that latency of the processing at the cortical center was also different depending on the frequency composition of the signal. Further, it also concludes that aided ALLR can help in selection of hearing aids as it mimics the hearing aid processing. But, it was difficult to say whether it can be sensitive with different configuration of hearing loss. However, one must noticed that there was difference in performance in sloping hearing loss individuals. It can be suggested to use aided ALLR to select hearing aids as it is objective test and can be assessed in shorter duration.

Implication of the study

- It will help us to decide objectively the most appropriate hearing aid for a client.
- To assess the speech perception ability of the cortical structures objectively.
- It helps in selecting hearing aids for difficult to test clients.

References


**Acknowledgement**

The authors would like to thank Dr. Vijayalakshmi Basavaraj, Director, All India Institute of Speech and Hearing, Manasagangothri, Mysore for granting permission to conduct the present study. The authors also extend thanks to Dr. P. Manjula, professor and HOD, department of Audiology for permitting to use instruments required for the study. The authors thank all the participants and anonymous reviewers.
EXAMINATION OF AUDITORY EFFECTS OF NOISE EXPOSURE DURING MAGNETIC RESONANCE IMAGING

* Snithin Sasheendran, ** Mritunjay Kumar, *** Krishna Y., & **** B. Rajashekhar

Abstract

The purpose of this study was to determine if there is any noise induced Threshold Shift resulting from the noise exposure for the various Magnetic Resonance Imaging examinations. A total of 17 adult patients (34 ears) were scheduled for MRI studies anticipated to require atleast 20 mins of imaging time were included in this study. Screening OAE test was done & baseline pure tone air & bone conduction thresholds were determined employing a step size of 2dB for each ear. The MRI instrument under the present study is a General Electrical Sigma Contour 0.5 Tesla device. The post MR imaging audiometric threshold estimation was done as soon as possible after the completion of MRI study. Statistical analysis using the paired ‘t’ test shows that there was a significant increase (p < 0.001) in the air conduction thresholds at 4 kHz and at 8kHz (p < 0.001) after. This shows that there is a noise induced Threshold Shift in the normal hearing subjects after the MRI which suggests that the noise exposure during the MRI has damaging effects on the auditory system. The parents study shows that the noise exposure during an MRI scan has an effect on the human auditory system and has been found to cause significant noise induced threshold shift at 4 kHz and 8 kHz. Noise and its auditory and non-auditory effects are proven in the literature. Since the present study revealed significant noise induced Threshold Shift, there is a need for effective Ear Protective Devices usage during MRI procedures to reduce long-term auditory effects.

Key words: MRI, noise induced threshold shift, pure tone audiometry

The introduction of Magnetic Resonance Imaging (MRI) has resulted in a tremendous advance in the technology of medical diagnosis. However with all positive advances there are normally some negative aspects. One of the potentially adverse aspects of MRI is that the equipment is extremely noisy. Many patients complain of noise, which is so loud that some children are frightened by it; some tinnitus sufferers claim that it makes their tinnitus more, such loud sounds are not only an annoyance to the patients undergoing MRI, but they have the potential of adversely affecting the patients hearing. It is a well-known fact that loud sounds can induce a hearing loss. The hearing loss can be permanent if the sound is sufficiently intense and the exposure sufficiently long. Less intense sounds or shorter periods of exposure will result in a reversible hearing loss. Since the first Magnetic Resonance Imaging (MRI) concept was devised, gradient coils and gradient pulsing has been the basic imaging book for decades. This basic gradient pulsing in conjunction with the magnetic field in MRI produces what is called acoustic noise.

Ever since the appearance of clinical MRI scanners, it has been one of the most disturbing obstacles for MRI patients scanning, especially for psychiatric patients and small children (Quirk, Letendre, Ciottone, & Lingley, 1989; Brummett, Talbot, & Charuhas, 1988; Hurwitz, 1989).

There have been some attempts to reduce the noise by using the antiphase noise cancellation technique (Goldman, Grossman, & Friedlander,
1989) and the Lorentz force cancellation technique (Mansfield, Chapman, Botwell, Glover, Coxon, & Harvey, 1995). Most of these techniques have not been very successful and significant sound noise still remains. A simpler and perhaps more ideally used technique is the use of ear plugs but this method seems to protect only against sound transmitted by the auditory canal to the ear and does not protect against the sound transmission through bone conduction mode. In fact, patients still experience loud sound noise even after wearing ear plugs since ear plugs suppress only the high-frequency sound noise within audible frequency band (Mansfield et al., 1995).

Although studies have been reported on noise during MRI procedures and its' effects, it is felt that a more quantitative physical analysis of sound noise produced by recently variable MRI systems would be an important asset for future research on this important problem, especially in connection with the newly developing functional MRI and other cognitive science research.

Review

Acoustic noise levels during Echo Planar Imaging (EPI) have been reported to increase significantly pure tone hearing thresholds in the optimal frequency hearing range between 0.1 to 8 kHz. These effects vary across the frequency range. The threshold changes according to the characteristics of the sequence-generated acoustic noise. Notably, if may be possible to take into account the MR system-induced auditory activation by using a control series of scans in task paradigms. Experimental results have been reported for mapping auditory activation induced by MR system-related acoustic noise.

The ear is highly sensitive wide-band receiver. The human ear does not tend to judge sound powers in absolute terms but assesses how much greater one power is than another. Combined with the very wide range of powers involved, the logarithmic decibel scale, dB, is used when dealing with sound power.

Since the ear is not equally sensitive to all frequencies, data may be weighted using the dB (A) measurement scale, which biases the meter to respond similarly to the human ear. The quality or efficiency of hearing is defined by the audible threshold, that is, the SPL at which one can just begin to detect a sound.

Noise is defined in terms of frequency spectrum (in Hz), intensity (in dB), and duration (in minutes). Noise may be steady state, intermittent, impulsive, or explosive. Transient hearing loss may occur following loud noise, resulting in a Temporary Threshold Shift (TTS) (shift in audible threshold). Brummett, Talbot, & Charuhas, (1988) have reported temporary shifts in hearing thresholds in 43% patients scanned without ear protection and also in those with improperly fitted protection. Recovery from the effects of noise should be exponential and occur quickly. However, if the noise insult is severe, full recovery can take up to several weeks. If the noise is sufficiently injurious, this may result in a Permanent Threshold Shift (PTS) (i.e., permanent hearing loss) at specific frequencies.

MRI-related acoustic noise:

The gradient magnetic field is the primary source of acoustic noise associated with MR procedures (Goldman, Grossman, & Friedlander, 1989; Hurwitz, Lane, Bell & Brant-Zawadzki, 1989). This noise occurs during the rapid alternations of currents within the gradient coils. These currents, in the presence of a strong static magnetic field of MR system, produce significant (Lorentz) forces that act upon the gradient coils. Acoustic noise, manifested as loud tapping, knocking, or chirping sounds, is produced when the forces cause motion or vibration of the gradient coils as they impact against their mountings which, in turn, also flex and vibrate.

Alteration of the gradient output (rise time or amplitude) caused by modifying the MR imaging parameters will cause the level of gradient-induced acoustic noise to vary. This noise is enhanced by decreases in section thickness, field of view, repetition time, and echo time. The physical features of the MR system, especially whether or not it has special sound insulation, and the material and construction of coils and support structures also affect the transmission of the acoustic noise and its subsequent perception by the patient and MR system operator.

Gradient magnetic field-induced noise levels have been measured during a variety of pulse sequences for clinical MR systems with static magnetic field strengths ranging from 0.35 to 1.5 T
(12-21) and one 2.0 T research system. Hurwitz et al., (1989) reported that the sound levels varied from 82 to 93 dB on the A-weighted scaled and from 84 to 103 dB on the linear scale.

Table 1 shows the relationship between the noise duration and recommended permissible sound levels for occupational exposures. The U.S. Food and Drug Administration indicates that the acoustic noise levels associated with the operation of MR systems must be below the level of concern established by pertinent federal regulatory or other recognized standards-setting organizations. If the acoustic noise is not below the level of concern, the manufacturer of the MR system must recommend steps to reduce or alleviate the noise perceived by the patient. No recommendations exist for non-occupational or medical exposures.

<table>
<thead>
<tr>
<th>Noise duration / day (hours)</th>
<th>Sound level (dB A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>92</td>
</tr>
<tr>
<td>4</td>
<td>95</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
</tr>
<tr>
<td>1.5</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>102</td>
</tr>
<tr>
<td>0.5</td>
<td>105</td>
</tr>
<tr>
<td>0.25</td>
<td>115</td>
</tr>
</tbody>
</table>

Table 1: Permissible Exposure Levels to Acoustic Noise

In general, the acoustic noise levels recorded by various researchers in the MR environment have been below the maximum limit permissible by the Occupational Safety and Health Administration (OSHA) of the United States. This is particularly the case when one considers that the duration of exposure is one of the most important physical factors that determine the effect of noise on hearing. These recommended limits for acoustic noise produced during MR procedures are based on recommendations for occupational exposures that are inherently chronic exposures with respect to the time duration. Of note is that comparable recommendations do not exist for non-occupational exposure to relatively short-term noise produced by medical devices.

Need for the study

The sensitivity of the ear is frequency dependent. Peak hearing sensitivity occurs in the region of 4 kHz; and is also the region where the potential maximum hearing loss will occur which change spreading into neighbouring frequencies. Recovering from the effects of noise exposure during an MRI should be exponential and quick (Brummet et al., 1988). However if the noise insult is severe, full recovery can take up to several weeks.

Gradient magnetic field –induced noise leads have been measured during a variety of pulse sequences for clinical MR systems with static magnetic field strengths ranging from 0.35 Tesla to 1.5 Tesla. Hurwitz et al. (1989) reported that the sound levels varied from 82 to 93 dB (A) and from 84 to 103 dB on a linear scale.

Aim of the study

The purpose of this study was to determine if there is any noise induced Threshold Shift resulting from the noise exposure for the various MR imaging examinations.

Method

1. Instruments used:
   - MAICO MA 53 audiometer with Telephonics TDH 49
   - P headphones & Radio ear B-71 bone vibrator
   - MAICO ERO SCAN OAE Test system
   - General Electric Sigma Contour 0.5 Tesla MRI device

2. Participants:
   A total of 17 adult patients (34 ears) who were scheduled for MRI studies anticipated to require at least 20 mins of imaging time were included in this study. Informed consent was obtained from all patients after the nature of the procedure was fully explained.

3. Procedure:
   - All the subjects with positive history of ear pathology, medical history for otological damage, noise exposure or the use of any ototoxic drugs were excluded from this study.
   - An otoscopic examination was performed on each patient to check the status of the external auditory meatus & the tympanic membrane.
   - Then, a screening OAE test was done using
EROSCAN, Etymotic Research, MAICO OAE Screening instrument to check the status of the outer hair cells of the cochlea.

- All the evaluations were carried out in a quiet room with ambient noise within permissible limits as per ANSI (1977) using biological calibration.

- Then the baseline pure tone air & bone conduction thresholds were determined employing a step size of 2dB for each ear using the MAICO MA-53 audiometer with TDH 49P headphones & Radio ear B-71 bone vibrator. The bone conduction thresholds were also found out to rule out any middle ear condition noticed through the Air Bone Gap (ABG). The test frequencies were 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz & 8 kHz. All the subjects had normal hearing air conduction thresholds (20 dBHL or below across frequencies 250 Hz to 8 kHz).

- The MRI instrument under the present study is a General Electric Sigma Contour 0.5 Tesla device. The average of noise exposure ranged from 30 mins to 1 hour 30 mins depending on the type of scan (determines the number and type of sequences for it) & patient’s status; the time taken for the MRI of pelvis is found to be approximately 80 mins for 8 sequences, for knee is 40 to 60 mins for 6 sequences, for spine is 30 to 45 mins for 5 sequences, for shoulder is 60 to 90 mins & for brain is 30 to 45 mins for 5 sequences.

Out of the 17 subjects 5 had pelvis scan, 2 had knee scan, 6 had spine scan, 3 had shoulder scan & 1 had brain scan.

- The post MR imaging audiometric threshold estimation was done as soon as possible after the completion of MRI study. The average time taken to initiate the test after the termination of the MRI was approximately 5-10 mins.

- Mean, Standard Deviation (S.D.) of the pre, post and between different MRI procedures were calculated. Further to estimate if the mean difference is significant, paired ‘t’ test was used using SPSS version 5.

**Results and Discussion**

The literature reveals that various studies have found that the noise levels during the MRI procedure causes Temporary Threshold Shift. Noise levels in the scanning room were done using Brüel & Kjaer Sound Level Meter revealed that average Leq levels were 129 dBSPL for 20 mins. The hearing thresholds obtained pre and post MRI procedure are presented and discussed below.

The mean and Standard Deviation (S.D.) for baseline AC thresholds of the 34 ears are as shown in Table 2.
The Mean and S.D. of difference in thresholds between the pre and post MRI thresholds are tabulated above for the different scan procedures (Table 3).

The Mean and S.D. of difference in thresholds between the pre and post MRI thresholds are tabulated above for the different scan procedures (Table 4).

The mean values between the pre and post MRI thresholds shows a difference at 4 kHz and 8 kHz, and to check if there is a statistical significant difference, paired ‘t’ test was performed and it was observed there was a significant increase (P < 0.001) in the air conduction thresholds at 4 kHz and at 8 kHz (P < 0.001) after MRI. The frequencies from 250 Hz to 2 kHz did not show any statistically significant difference after exposure to acoustic noise of MRI. This that there is a noise induced Threshold Shift in the normal hearing subjects after the MRI which suggests that the noise exposure during the MRI has damaging effects on the auditory system shows.

These findings can be correlated to the finding of Brummett et al., (1998) where in a total of 14 adult patients were subjected to MRI study of 0.35- Tesla equipment, wherein significant threshold shifts of 15 dB or above were found in frequencies 560 Hz, 4 KHz, 6 KHz and 8 KHz in 43% of patients. Ear plugs, when properly used can abate noise by 10-30dB, which is usually an adequate amount of sound attenuation for the MR environment. The use of disposable ear plugs has been shown to provide a sufficient decrease in acoustic noise that in turn would be capable of presenting the potential temporary hearing loss associated with MR procedures (Bandettini, Wong, Hinks, Tikofsky, & Hyde, 1992). Passive noise control techniques of using Ear Protective Devices (EPD) provide poor attenuation of noise transmitted to the patient through bone conduction.

**Conclusion**

The presents study shows that the noise exposure during an MRI scan has an effect on the human auditory system and has been found to cause significant noise induced threshold shift at 4 kHz and 8 kHz. Noise and its auditory and non-auditory effects are proven in the literature. Since the present study revealed significant noise induced Threshold Shift, there is a need for effective Ear Protective Devices usage during MRI procedures to reduce long-term auditory effects.

**References**


HEARING LOSS IN ELDERLY: AN INDIAN PERSPECTIVE

*Nachiketa Rout, ** Bijoyaa Mohapatra, *** Sushmit Mishra

Abstract

The article aims to analyze audiological findings of 151 geriatric individuals with hearing loss who complained of a progressive reduction in hearing since 10 years. The degree of hearing loss corresponded to moderately severe sensory-neural hearing loss (52%). Cardiovascular diseases including high blood pressure (42%) and diabetes (17%) were the most frequently associated condition while 34% reported no known etiologies of hearing loss. Most common symptoms included difficulties in understanding conversational speech (54%) followed by tinnitus (49%), vertigo (25%) and intolerance to loud sounds (15%). The prevalent audiogram contour corresponded to a steep sloping pattern (45%). Males mostly (52%) had steep sloping high frequency hearing loss as compared to females (60%) who predominantly had a flat audiogram or gradually sloping audiogram (10%). There was a poor follow-up of 14%, most of who came with a complaint of poor benefit from the hearing aid especially in noisy situations.

The causes of hearing loss observed in these individuals are among the well known causes that are responsible for old age hearing loss. Even the audiograms obtained correspond to those of Schuknecht’s audiograms. It is found that there is quite much an acceptance to hearing loss in the Indian population and intervention is sought until and unless it is found to reach a degree where it interferes with one’s day to day communication.

Key words: Audiogram, speech recognition thresholds, cochlea.

Despite major advances in the ability to prolong life, there have been fewer concomitant advances designed to reduce the illnesses and disabilities attendant upon increased age. Ranking highest among age-related disabilities are those involving communication (Jacobs-Condit, 1984). Hearing loss (HL) which essentially affects oral communication is the third most common chronic condition reported by geriatric population (Lethbridge-Cejku, Schiller & Bernadel, 2002). The geriatric population is defined as population aged 60 years and above (Elango, 1998). HL that is significant enough to interfere with social function affects 25% of persons aged 65 to 74 years and 50% of those age 75 years and older (Marcincuk & Roland, 2002). In spite of the high prevalence and only about 20% of the elderly individuals in America with significant hearing impairment obtain hearing aids; as many as 30% of the hearing aid owners are dissatisfied (Kochkin & Marke Trak, 2003) and 16% of them never used the aids after obtaining them (Kochkin & Marke Trak 2000). Hearing loss in this population needs to be addressed because of its isolating effects and the increasing geriatric age group. Population projections indicate that individuals over 65 years of age will increase to approximately 22% by the year 2050; by this time 59% of the individuals over 65 years of age will have hearing impairments (Fein, 1983). The geriatric population in India which was 6.3% in 1991 has increased to 7.5% (Census, 2001), 3.4% of this population has both speech and hearing disabilities (National Sample Survey Organization,-2003).

Studies pertaining to HL in the elderly population of India are very few and hardly conclusive. Articles concerning health problem of the geriatric often ignore HL, probably because of its invisibility, non
acute nature and unawareness amongst both the participants and researchers. The social and medical dynamics of India is rapidly changing. The social problems have been caused by the break-up of the joint family system, housing shortages in urban areas and the increasing participation of women in the workforce. The health care of the pediatric and the especially the geriatric group which were taken care by the family is of concern. Further it’s observed that age old traditional of medical systems of India like Ayurveda is losing its effect and the western mode of medication, Allopath is being preferred. Common life styles to maintain hearing prescribed by Ayurveda like putting mustard oil in the ears daily to maintain healthy hearing is strictly being prohibited by the new age doctors. Thus health issues concerned with hearing which was taken care by the traditional wisdom of the family and the traditional healers are slowly becoming the concern of the state. In this regard there is a need to understand the hearing loss and its effects which would facilitate data to address the issues and allocate resources towards them. The present study is an effort in the same direction.

This article aims to answer questions pertaining to HL in the elderly. The issues addressed include, type and degree of HL in this group, the most common symptoms, the pattern of HL, the probable etiological factors which might have precipitated the HL and the amplification device which suited most of them.

Pathophysiology A few eminent researchers including Gacek & Schuknecht (1969) have identified four sites of aging in the cochlea and divided presbycusis into four types based upon these sites. They are Sensory (cochlear) Presbycusis, Neural Presbycusis, Strial Presbycusis, and Inner ear Conductive (Mechanical, cochlear- conductive) Presbycusis (Figure 1). The histological changes are correlated with symptoms and auditory test results.

Sensory presbycusis: Type 1. Sensory presbycusis refers to the epithelial atrophy with the loss of sensory hair cells and supporting cells in the organ of Corti. This process originates in the basal turn of the cochlea and slowly progresses towards the apex. These changes are correlated with the precipitous drop in the high frequency thresholds, which begins from the middle age. The speech discrimination often is persevered. The process is slow progressive over the time.

Neural presbycusis: Type 2. It refers to atrophy of nerve cells in the cochlea and central neural pathways. Gacek & Schuknecht (1969) estimates that 2100 neurons are lost every decade (of 35,000 in total). This loss begins early in the life and may be genetically predetermined. Effects are not noticeable until old age, because pure tone average is not affected until 90% of the neurons are gone. Atrophy occurs throughout the cochlea. Therefore no precipitous drop in high frequency threshold on audiogram is observed. A disproportionately severe decrease in speech discrimination in clinical testing correlate to neural presbycusis and may be observed because HL is noted as fewer neurons are required to maintain speech threshold than speech discrimination.

Metabolic (strial presbycusis): Type 3. It results from the atrophy of the Stria Vascularis. The Stria Vascularis normally maintains the chemical and bioelectric balance and the metabolic health of the cochlea. Atrophy of the Stria Vascularis results in HL represented by flat hearing curve because the entire cochlea is affected. Speech discrimination is preserved. This process tends to occur in people aged 30 – 60 years. It progresses slowly and may be familial.

Mechanical (cochlear conductive): Type 4. This type of presbycusis results from thickening and secondary stiffening of the basilar membrane of the cochlea. This thickening is more severe in the basal turn of the cochlea where the basilar membrane is narrow. This correlates with a gradually sloping high frequency sensorineural HL that is slow progressive in nature. Speech discrimination correlates with pure tone average.

Presbycusis, referred to as hearing loss due to aging may be the most common cause of diminished hearing in the older population, but it should not be diagnosed until other potential causes of hearing loss have been ruled out (Marcincuk & Roland, 2002). Conditions that may contribute to presbycusis include atherosclerosis, chronic noise exposure, chemical exposure, diet and metabolism, and genetics (Velazuez-Villasensor et al, 2000).
Method

Participant details

The participants of the study included 151 clients, 101 males and 50 females in the age range of 60-83 years (mean 70 ± SD: 7.2 years). All approached Ali Yavar Jung National Institute for the Hearing Handicapped (AYJNIHH, ERC), an aural rehabilitation centre in eastern India with a complained of progressive reduction in hearing sensitivity and could not attribute any cause to it. Individuals having any type of external and middle ear diseases were not included in the study. They availed aural rehabilitation as hearing loss had become severe enough to be noticed by family and interfered a lot with day today activities. Some did not know where to go (33.11%) or (11.25%) did not have facilities to come to AYJNIHH, ERC. A few (7.28%) of the participants reported no specific reason for the delay. Twelve (7.94%) of the participants consulted otolaryngeologists for the HL. The physician attributed HL to aging and recommended hearing aid to seven while others were prescribed neuro-vitamins.

The participants belonged to poor socio-economic strata with a monthly income below Rupees 6,500/-. The Government of India categorizes this income group as considerably poor, and provides them with free of cost hearing aids. All the participants resided in and around Kolkata, one of the metro cities of India. The symptoms of HL were noticed by the participants 10 years prior to coming to the clinic. When inquired about the reason for the delay, they frequently (48.36%) attributed it to the procrastination.

Procedure

The participants came to AYJNIHH with a complaint of hearing loss. After a detailed case history the clients were referred for an ENT and audiological evaluation. A detailed audiological evaluation protocol included pure tone audiometry along with immittance measures. Most comfortable level (MCL) and Uncomfortable level (UCL) were done for participants who complained of intolerance to loud sounds. The hearing trial followed where ever a
hearing aid was opted and recommended. Audiological evaluations and hearing aid trial was done in acoustically treated rooms with a noise level below 27dBA. The hearing aid prescription followed a counselling session in a one to one setup. The MAICO MA52 audiometer and the GSI 38 Auto-lymp immittance meter were used for the evaluations.

The clinical data, symptoms and auditory test results and were correlated and classified under four types of presbycusis as mentioned by Gacek & Schuknecht (1964). Statistical Package for Social Sciences (SPSS) for Windows (version 10) was used for descriptive statistical analysis.

Results

During otological evaluation 28% of the participants (28 males and 15 females) had impacted wax in their ear canal which was cleared by syringing the ears before commencement of the audiological evaluations. On immittance audiometry, 92.05% of the participants had ‘A’ type tympanogram indicative of an apparently mobile and intact middle ear. Seal could not be obtained in three of them and six had ‘As’ type indicative of a relatively stiff middle ear mechanism. Only three participants had ‘B’ type tympanogram which is usually suggestive of a minimally mobile middle ear and may be indicative of pathology, though visual otological evaluation did not suggest the presence of any abnormality in them.

All the participants were diagnosed to be having bilateral sensory neural hearing loss mostly (52%) of moderately severe degree. The audiogram patterns of the participants were classified into four types (Type 1-4). Nine audiogram contours did not fit into any category. Majority, 45% of the audiograms corresponded to Type 1 followed by Type 3 (24.5%) and Type 4 (13.2%) had type 2 audiograms. Males mostly (52%) had Type 1 audiogram corresponding to a steep sloping high frequency hearing loss as compared to females (60%) who predominantly had a flat audiogram.

Many (47%) participants did not have any medical records with them. The associated conditions as reported and noted from medical records include, unknown etiology in 34% of the participants, high blood pressure was as frequent as in 42%. History of exposure to noise was reported both males (25%) and females (26%) and 17% of the participants had diabetes. These factors were in present isolation as well as in combination (figure 2). The symptoms which were more frequently reported by the participants included difficulty in understanding speech (54%) followed by tinnitus (49%), vertigo (25%) and intolerance to loud sounds (15%) etc. As reported in 13.2% of the cases, tinnitus was the primary symptoms with HL and in 36% of the cases tinnitus was associated with other symptoms (figure 3).

Most Comfortable Level (MCL) and Uncomfortable Level (UCL) were obtained using Bengali sentences for 15% clients who reported of intolerance to loud sounds. Out of the fifteen eight participants had a narrow dynamic range of 10 dB HL and less. Hearing aid trial for the eight candidates was done at different tone control positions in noisy (70 dB Broad band Noise) and in a relatively quiet room in clinic. All the eight did not complaint of intolerance to conversational speech at ‘H’ settings of the tone control in a quiet room. All of them preferred using the hearing aid.

A moderate class hearing aid was preferred and fitted to most (79%) of the participants. After a counseling session the participants were asked to pay a follow up visit in 3 months for re-evaluation of their hearing and the hearing aids. Only 14% participants paid a follow up visit in 1-3 months. Most of them came with a complaint of malfunction in the hearing aid or distorted output from the aid. On examination of the hearing aid by the electronic technician, 5 of them were found to be having minor problems like damaged cords or defective switches, 16 of them reported to have minimal benefit from the aid especially in noisy situation like market place or where they were in conversation with more than 2-3 persons at a time.

Discussion

With age the entire physiology of the body changes and so does the auditory system. The outer ear loses its elasticity and strength with increased activity of cerumenous glands rising the likelihood of cerumen impaction (Weinstein, 2002), as in 28% of the participants in the present study. Cerumen can accumulate significantly without any accompanying hearing loss, an occlusion of 95% and more results in significant conductive hearing loss (Roland, Marple & Meyerhoff, 1997). Middle ear was found to be considerably healthy and mobile in majority of the
participants never the less eight percent of the participants had an abnormal tympanogram of ‘As’ type or ‘B’ type. With age arthritic changes occur in the middle ear and the tympanic membrane becomes stiff (Roland et al., 1997). Degeneration and stiffening of the middle ear muscles and ossicular ligaments may be reflected as an ‘As’ type tympanogram although structural changes in middle ear mechanism due to aging have minimal effect on impedance test of hearing loss and greater hearing loss severity (Agrawal, Platz & Niparko, 2008). The implication is that income and education influence access to healthcare and adequate nutrition, as well as increased exposure to adverse environmental and social conditions, which in turn impact hearing.

In the present study majority of the participants noticed hearing loss at the age of 60 years; approximately 10 years prior to coming to the clinic.

![Figure 2: Distribution of associated conditions/probable etiologies.](image)

![Figure 3: Distribution of symptoms](image)

(Weinstein, 2002)

The participants in the study belonged to the lower socio economic strata and had a lower educational level. Prior studies have related low income and educational levels to a higher prevalence During case history when it was asked “What do you mean by noticeable HL?” 83% replied, when they could not effortlessly participate in regular conversation. It seemed others mumbled and friends and family members started complaining about he/
she not being able to understand verbal commands especially when spoken from behind and name called from the other room. Most of the participants with mild to moderate degree of hearing loss presented complaint of tinnitus or vertigo rather than hearing loss. Some (3%) with mild degree of hearing loss in one ear and moderate to moderately severe degree of hearing loss in the other reported of hearing loss only in the poorer ear and perceived the better ear to be normal. The Articulation Index theory predicts the intensity of average conversational speech to be 60 dB sound pressure level (SPL) (American National Standards Institute, 1969). The low frequency vowels and diphthongs, which have an intensity of 65-70 dB SPL (Fletcher, 1953) contributes importantly to performance on sentence material. Vital audiometric frequency region for correctly identifying sentence material is around 750 Hz and a person with high frequency hearing loss will typically experience little problems with sentence identification tasks (Hall & Mueiler, 1997). The performance of individual in social communication and linguistic skills improve with age and hence older adults tend to fill in the missing linguistic input better (Pichora-Fuller and Singh, 2006). Thus till the hearing loss progresses up to 60-65 decibels (moderately severe degree) the person does not considerably appreciate the hearing loss which is in progress since a few years. Further elderly people usually do not experience problems understanding speech in ideal listening conditions that include quiet environments and familiar talkers, as long as the speech level permits audibility of high frequency information (Dubno, Dirks & Morgan, 1984). A few, 9% of the participants had history of ear discharge in childhood but no middle ear disease was detected by the otologist. Eastern India especially the coastal belt is a hot and humid, many people living in villages still take bath in ponds. This makes them prone to middle ear infections especially during childhood.

In addition to age related degeneration, excessive exposure to occupational or recreational noise, genetic factors, eighth nerve tumor, trauma, metabolic diseases, vascular diseases, infection, ingestion of ototoxic agents (aminoglycosides, ethaerynic acid salicylates) and cardiovascular diseases (CVD) contribute to hearing loss (Weinstein, 2002). CVD has been identified as a risk factor for hearing loss in older adults (Brant et al., 1996; Susmano & Rosenbush, 1988). CVD-related potential risk factors include heart disease, hypertension, diabetes mellitus, smoking history and white blood cell count. Majority of the participants (69%) in the study had either diabetes or high blood pressure along with HL. Conversely, many researchers have not found an association between hearing loss and CVD risk factors or combinations of risk factors (Bunch, 1931, Karamitsos et al., 1996). In a recent study (Pratt & Geriatric Research Education and Clinical Center, 2009) contrary to expectations; CVD histories did not appear to influence hearing thresholds in this group of elders, suggesting that characteristics intrinsic or strongly tied to the groups in this study disposed them or made them resistant to hearing loss.

The fact that persons with diabetes have hearing impairment is a relatively recent discovery especially after diabetes induced animal studies of micro vascular changes in the inner ear including in circulation flow, narrowing capillaries and loss of outer hair cells that amplify sound energy entering the cochlea, an overall atrophy of the ganglion cells are also seen in persons with diabetes (Salvinelli et al, 2004). There is no recent research that has directly evaluated the association between CVD and cochlear function in older adults (Torre III., Cruickshanks, Barbara, Ronald & David, 2005). To date, researchers have used animal models to investigate the restriction of cochlear blood flow and its effect on DPOAEs (Distortion product otoacoustic emission) (Mom, Telischi, Martin & Lonsbury-Martin, 1999). Once the blood flow was restored, DPOAE levels returned to pre compromise levels.

In this study hearing loss in 34.34% of the participants could not be attributed to any known etiology. Brant et al, (1996) found a relationship between a large sample of older adults who were free of noise induced HL and other etiologies causing hearing related disorders. There are many physiological factors which trigger hearing loss. Conclusions of a study by Frisina (2002) signify the reduced levels of aldosterone, with age contributed to the hearing loss. Aldosterone is a hormone which is important for regulation of sodium and potassium ions in the inner ear and has protective functions. Auditory efferent feedback system starts declining in middle age in both humans and mice.
The effect of noise on hearing occurs primarily in the high frequencies above 1000 Hz. The effect of noise and hearing are difficult to separate from presbycusis since noise also causes hair cell damage and has a similar audiometric configuration (Stach, 1990). For whatsoever reason, beyond a certain age no differentiation can be made between the two. As a result, the problem of hazardous noise exposure becomes less and less important and maintenance of reasonable hygiene of the ear becomes more and more routine (Davis & Silverman, 1970).

The extent to which an individual recognizes this disability may influence his or her motivation to seek assistance through amplification or aural rehabilitation. Age related differences are observed on measures of perceived hearing disability. In a study with adults and elderly Americans with mild to moderate HL, elderly adults (65-76 years) report less social and emotional impact of hearing impairment in their daily life (Gordon-Salant, Labtz, Fitzgibbons, 1994). In a large scale study of 2150 adults in Japan, there were significant age differences in self perceived hearing problems. Elderly subjects (60-79 years) reported less hearing disability than middle aged subjects (40-59 years) (Uchida, Nakashima, Ando, Niino & Shimokata, 2003). These analogous studies conducted in United States and Japan has similar findings and underscores the universality of the phenomenon. In the present study during the case history interview process when the patients were inquired about their problem, some of them replied there was no problem per se; it’s just that they had reduced hearing sensitivity which is usually associated with old age. Seven participants remarked (in Hindi) “ye to prakritik den hae” which means it’s “by the grace of nature”. This reflects a laid-back attitude of the elderly towards their HL and an accepted deterioration of sensory function in old age. A few of the elderly in the study reported hearing loss to be advantageous especially in some situations which they want to avoid.

The symptoms which was most frequently reported was difficulty in understanding speech (54.30%), Van Rooij, Plomp and Orlebeke, 1989 report the proportion of persons with problems in perceiving speech doubles per decade, from 16% at age 60 to 32% at age 70, to 64% at age 80. However, there are large individual differences in understanding speech in individuals over 60 years of age (Weinstein, 2002). Investigators have attempted to isolate several factors that contribute to this variability. Several hypotheses have been posited to explain the mechanism underlying speech understanding problems experienced by the older adults including the peripheral hypothesis, the central auditory hypothesis, and the cognitive hypothesis (Humes, 1996).

Vertigo and tinnitus were frequently reported symptoms. The sense of balance is largely regulated by the inner ear structures called the vestibular system. American Speech-Language-Hearing Association (1999) reports that the elderly between ages 65 and 75 who do not present any major health problem or acute balance disorder, at least 25–35% complained a significant fall annually. As many as 25% of the participants reported of vertigo and were prescribed medications for the same. Most of them recover by symptomatic treatment (Igarashi, 1984).

The principal treatment of age related HL at present is with suitable amplification (Gordon-Slant, 1994). Despite the documented benefit of amplification for elderly hearing impaired individuals (Stark and Hickson, 2004), market trend as reported by some private practitioners in West Bengal show that only 20-25% of the population who come for hearing evaluation purchase hearing aids. Factors reported by elderly people who do not adhere to recommendations to purchase a hearing aid are cost and relatively low value placed on effective communication (Garstecki & Erler, 1999). Some who do not wear aids report the main reasons for not wearing hearing aid to be poor benefit, particularly in noise, restaurants and large group (Kochkin, 2000). The hearing aids provided by the government of India are conventional body level aids. Conventional hearing aids have relatively few options (e.g., gain, output, frequency response) and few controls (e.g., on/off, volume, tone) that could be adjusted by the user according to his or her situation-specific listening preferences.

In this study although all had opted for hearing aids, most of them did not follow up for re-evaluation in spite of the recommendations. Follow up is expected after a period of 3-4 months as the mostly stops functioning due to damage of cords. The drop out of patients may be attributed to various factors...
like lack of use of hearing aids, lack of facilities to follow up at AYJNIHH due to distance as well as the cost of travel or on health grounds.

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Mom, T., Telischi, F. F., Martin, G. K., & Lonsbury-


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INTELLIGENCE, CREATIVE THINKING ABILITIES AND ACADEMIC ACHIEVEMENT OF CHILDREN WITH HEARING IMPAIRMENT - A CORRELATION STUDY

*Vijetha, P. & **Jangaiah, C.

Abstract

The present study investigated the relationship between intelligence and creative thinking abilities, intelligence and academic achievement and also academic achievement and creative thinking abilities of 11 to 13 years old children with hearing impairment studying in Residential special schools in Mysore. For testing Intelligence, Standard Progressive Matrices by J. C. Raven and for testing creative thinking abilities, Non- Verbal test of Creative Thinking Abilities by Baqer Mehdi tools were used for the study. These tools were administered on 50 (24 boys and 26 girls) 11 to 13 years old children with hearing impairment. Participants were instructed and the data was scored as per the manual. For testing the Academic achievement both the present and past class exam marks were collected from school records. The results indicated that there exists no significant relationship between intelligence and creative thinking abilities, academic achievement and creative thinking abilities. But there exists significant relationship between intelligence and academic achievement. The study also revealed that children scoring Intelligence Grade V indicating “intellectually impaired” outperformed in creative thinking abilities compared to those children scoring Grade III indicating “intellectually average” and Grade IV indicating “below average in intellectual capacity”. The results of the current study can be used to plan special programs based on the abilities and talents of children with hearing impairment rather than intelligence and school exam marks in order to foster their creative thinking abilities and thereby prepare them for appropriate and productive vocations.

Key words: Special programs, abilities, productive vocations

Education is the fundamental right of every child. Children with disability have a right to education that promotes them to their fullest potential. In India, there are billion persons and Census of India (2001) revealed that over 21 million people in India are suffering from one or the other kind of disability which is equivalent to 2.1% of the population. Among them (7.5%) and (5.8%) of population has some kind of speech or hearing disability respectively.

Early identification and early intervention of children with hearing impairment has its own benefits and rewards. But at the same time in the society there are children with hearing impairment, who are late identified, who come from poor-social economic backgrounds, those who are born in rural areas or less advantaged and they are quite sizeable in society. So, it is imperative to develop services to cater to these children with hearing impairment in order to actualize their potential.

At present there are approximately 700 special schools for children with hearing impairment in India. Most of these schools tend to focus their educational objectives and goals on remediation related to different aspects of their disability rather than focusing on identifying and fostering special abilities and talents hidden in children with hearing impairment. Due to which they are often gone unrecognized and undeveloped. Consequently these lacunae lead to many ill effects. And one of the major ill effects is their underemployment and unemployment. Large numbers of deaf people seem to be employed in jobs that are far beneath their ability (Schein & Delk, 1974). Therefore it is very important to recognize and develop special abilities and talents. Shanker (1968)
points out that the study of exceptional types of children with a view to finding ways and means of their proper location, care, rehabilitation, education and guidance is essential both from the individual and the social points of view. In order to support these thoughts strong evidence based research is required. Buch (1991) also suggested that there is a need to devise programs and methods, which would promote creativity and divergent thinking.

In addition to the above, a review of related literature emphasized that very few studies worked on creative thinking abilities of children with hearing impairment especially compared to typically developing children. Further hardly any study found to have correlated Intelligence and Academic Achievement to Creative thinking abilities of children with hearing impairment. This is the major research gap. Thus, keeping this in view the present study is taken up to find out whether any significant relationship exists between Intelligence, Creative Thinking Abilities and Academic Achievement of children with hearing impairment.

In this context, the present study on “Intelligence, Creative Thinking Abilities and Academic Achievement of children with hearing impairment - A correlation study” is mainly aimed at studying the relationship between the three variables - Intelligence, Creative thinking Abilities and Academic Achievement of Children with Hearing Impairment.

Objectives of the Study
1. To study the relationship between Intelligence and Creative thinking abilities of children with hearing impairment.
2. To study the relationship between Intelligence and Academic Achievement of children with hearing impairment.
3. To study the relationship between Creative thinking abilities and Academic Achievement of children with hearing impairment.
4. To study the Gender differences for Intelligence.
5. To study the Gender differences for Academic Achievement.
6. To study the Gender differences for Creative thinking abilities.

Operational Definitions
A number of terms and concepts have been used in the study. To convey the specific meaning an attempt has been made to explain in what sense these terms and concepts have been used in the present study.

Children with Hearing Impairment
Children with hearing impairment are those who have problems in hearing the various sounds. In the present study, children with hearing impairment refers to those who have hearing loss of 60dB or above in the better ear in the conversational range of frequencies.

Creative Thinking Abilities
Creative thinking abilities refer to the ability of an individual to think creatively. In the present study, it refers to the ability of an individual in the three non-verbal sub-tests namely Picture construction, Picture completion, and Triangles and Ellipses. The creative thinking abilities are measured by using Baqer Mehdi’s Non-verbal test of creativity.

Academic Achievement
It refers to the marks obtained by children with hearing impairment in Annual Examination of present class and previous class in the school.

Intelligence
In the present study, it refers to the score and grade obtained using Standard Progressive Matrices by J.C. Raven.

Method
Sample: The sample consisted of fifty children with hearing impairment. They were studying in Residential special schools for children with hearing impairment in Mysore. The participants included 24 boys and 26 girls in the age range of 11 to 13 years. The method of teaching in these special schools is Total communication. The sample for the study is selected by means of convenience sampling which included the following criteria: (i) Severe to Profound hearing loss, (ii) Age range between 11 to 13 years and (iii) No additional impairment.

Tools used for the Study: For testing Intelligence, Raven, J. C. Court, J.H. & Raven, J. (1998) “Manual for Raven’s Progressive Matrices Vocabulary Scale”, Standard Progressive Matrices was used. It is made up of five sets of diagrammatic puzzles. Each puzzle has a part, which the person taking the test has to find among the options. The standard test consist of 60 problems divided into five sets (A, B, C, D and E), each made up of 12 problems. These five sets provide five opportunities to grasp.
the method of thought required to solve the problems and five progressive assessment of a person’s capacity for intellectual activity. After completing the test the raw scores were computed and converted into the scaled scores, which are then totaled, and the grade of intellectual capacity was obtained from the Manual.

For testing Creative thinking abilities, Mehdi, B. (1989) Manual for Non-verbal Tests of Creative Thinking was used. It is intended to measure the individual’s ability to deal with figural content in a creative manner. Three types of activities are used for this purpose, viz., picture construction, picture completion, and triangles and ellipses. Scoring is done for elaboration and originality dimensions. Elaboration is represented by a person’s ability to add more ideas to the minimum and primary response to the stimulus figure. The minimum and the primary response to the stimulus figure is that the response, which gives essential meaning to the picture. It is important to see the primary and minimum response is meaningful and relevant to the stimulus. Originality is represented by uncommonness of a given response.

Procedure: Standard Progressive Matrices was administered on each child with hearing impairment individually at school in a quiet classroom. Every attempt was made to ensure a good testing environment. The child was instructed carefully to closely observe the pictures and to note the responses in the score sheet. Each child required approximately 35 to 40 minutes for completing the test. The investigator computed the raw scores and converted them into scaled scores as per the manual. The degree of intelligence against this scaled score was established from the manual. Non-verbal test of Creative thinking abilities was administered in a group of approximately ten children with hearing impairment. It was administered in a good classroom environment away from unnecessary noise and distractions. Children were instructed to think and carefully draw the pictures with the given figure. Any clarifications required by the children were given individually. Each child required approximately 40 to 45 minutes to complete the test. After completing the test, raw scores were computed as per the guidelines given in the manual in terms of two dimensions elaboration and originality. For testing the Academic achievement, previous and present class exam marks of children were obtained personally from the school records with the permission of the School Principal.

Results and discussion

Statistical Techniques Employed: Descriptive statistics are given for Intelligence, creative thinking abilities and Academic achievement. Independent t-test was done to study the gender differences. Spearman’s correlation coefficient was used to see the correlation between the parameters under study.

The above Table 1 shows the mean and standard deviation of intelligence, creative thinking abilities and academic achievement in males and females. And by observing the scores in the present study, it can be inferred that in Creative thinking abilities, Academic achievement and in Intelligence, females scored higher than males but it is not statistically significant. The following Table 2 shows results of independent t-test. Independent t-test was administered to study the differences between males and females in intelligence, creative thinking abilities and academic achievement. It revealed no significant differences between males and females.

This is supported by Pandey & Pandey (1984) reporting that there were no consistent gender differences in respect of various factors of creativity.

The following Table 3 shows the mean and standard deviation of Academic Achievement and creative thinking abilities in relation to Intelligence. Figure 1 shows the relationship between Intelligence, Creative thinking abilities and Academic Achievement.

The results of the present study revealed interesting findings and discussions. First, it reveals that the calculated correlation coefficient between intelligence and elaboration dimension of creative thinking ability is $r = -0.123$ and intelligence and originality dimension of creative thinking ability is $r = -0.161$. These values are not significant at 0.05 level. Hence there is no significant relationship between Intelligence and Creative thinking abilities (elaboration and originality).

This finding is in consonance with the study done by Kaltsoounis (1970) where he compared the creative thinking abilities of deaf students and hearing students by using Torrance Tests of Creative Thinking – Figural. He founded that deaf subjects surpassed
hearing age-mates on measures of non-verbal fluency and originality, whereas hearing subjects were superior in Non-verbal flexibility. Kitano & Kirby (1986) state “an individual can be extremely bright but uncreative or highly creative but not necessarily intellectually gifted”.

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</tr>
<tr>
<td></td>
<td>Female</td>
<td>26</td>
<td>75.19</td>
<td>28.59</td>
</tr>
</tbody>
</table>

Table 1: The mean and standard deviation of Intelligence, Creative thinking abilities and Academic Achievement in males and females.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>t(48)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligence</td>
<td>0.197</td>
<td>&gt;0.05</td>
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<tr>
<td>Creative thinking abilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elaboration</td>
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<tr>
<td>Originality</td>
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<td>&gt;0.05</td>
</tr>
<tr>
<td>Academic achievement</td>
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<td></td>
</tr>
<tr>
<td>Previous class exam marks</td>
<td>0.622</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Present class exam marks</td>
<td>0.189</td>
<td>&gt;0.05</td>
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</table>

Table 2: The results of t-test for Intelligence, Creative thinking abilities and Academic Achievement in males and females.

<table>
<thead>
<tr>
<th>Intelligence Grade</th>
<th>Parameters</th>
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<th>Std. Deviation</th>
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<tr>
<td>III</td>
<td>% of previous class exam marks</td>
<td>41</td>
<td>75.41</td>
<td>12.66</td>
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<tr>
<td></td>
<td>% of present class exam marks</td>
<td>41</td>
<td>73.42</td>
<td>15.08</td>
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<tr>
<td></td>
<td>elaboration</td>
<td>41</td>
<td>66.93</td>
<td>19.22</td>
</tr>
<tr>
<td></td>
<td>originality</td>
<td>41</td>
<td>58.95</td>
<td>20.32</td>
</tr>
<tr>
<td>IV</td>
<td>% of previous class exam marks</td>
<td>7</td>
<td>54.90</td>
<td>8.16</td>
</tr>
<tr>
<td></td>
<td>% of present class exam marks</td>
<td>7</td>
<td>66.49</td>
<td>14.15</td>
</tr>
<tr>
<td></td>
<td>elaboration</td>
<td>7</td>
<td>61.26</td>
<td>20.52</td>
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<tr>
<td></td>
<td>originality</td>
<td>7</td>
<td>55.27</td>
<td>16.64</td>
</tr>
<tr>
<td>V</td>
<td>% of previous class exam marks</td>
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<td>40.60</td>
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</tr>
<tr>
<td></td>
<td>% of present class exam marks</td>
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<td>49.60</td>
<td>17.57</td>
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<td></td>
<td>elaboration</td>
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<td>77.88</td>
<td>17.68</td>
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<tr>
<td></td>
<td>originality</td>
<td>2</td>
<td>72.30</td>
<td>6.53</td>
</tr>
<tr>
<td>Total</td>
<td>% of previous class exam marks</td>
<td>50</td>
<td>71.15</td>
<td>15.19</td>
</tr>
<tr>
<td></td>
<td>% of present class exam marks</td>
<td>50</td>
<td>71.50</td>
<td>15.58</td>
</tr>
<tr>
<td></td>
<td>elaboration</td>
<td>50</td>
<td>66.58</td>
<td>19.21</td>
</tr>
<tr>
<td></td>
<td>originality</td>
<td>50</td>
<td>58.97</td>
<td>19.52</td>
</tr>
</tbody>
</table>

Table 3: The mean and standard deviation of Academic Achievement and creative thinking abilities in relation to Intelligence.
Second, the calculated correlation coefficient between intelligence and previous class exam marks is $r = 0.711$ and intelligence and present class exam marks is $r = 0.413$. These values are significant at 0.001 level. Hence there is significant relationship between Intelligence and Academic achievement (previous class exam marks and present class exam marks). This finding is supported by Alam (2001) stating that there is a positive and significant correlation between academic achievement and intelligence. This finding is also supported by Meadow (1980), McCall (1977) revealing that intelligence tests predict academic achievement.

Third, the calculated correlation coefficient between elaboration dimension of creativity and previous class exam marks is $r = -0.028$ and elaboration dimension of creativity and present class exam marks is $r = -0.043$. These values are not significant at 0.05 level. It means that there is no significant relationship between elaboration dimension of creativity and previous and present class exam marks. It also revealed that the calculated correlation coefficient between originality dimension of creativity and previous class exam marks is $r = -0.159$ and originality dimension of creativity and present class exam marks is $r = -0.062$. These values are also not significant at 0.05 level. It means that there is no significant relationship between originality dimension and previous and present class exam marks. Hence there is no significant relationship between Creative thinking abilities (elaboration and originality) and Academic achievement (previous class exam marks and present class exam marks) and it is supported by Marschark (2003) stating deaf children frequently have different experiences; different language backgrounds and different cognitive skills and do not mean that deaf students are in any way deficient.

Another major finding depicted in Figure 2 above revealed that children scoring Intelligence Grade V indicating “intellectually impaired” outperformed in creative thinking abilities compared to children scoring Grade III “intellectually average” and Grade IV “below average in intellectual capacity” respectively. In this study, Creative thinking of children with hearing impairment became apparent even though their academic performance and Intelligence scores are found below average. But this has to be supported by more concrete evidence based research. As reported by Whitmore & Maker (1985) deaf children have been less likely than their hearing peers to be screened, identified and served by special programs to assess and develop their creativity.

Therefore it is important to take up some special programs based on the abilities of children with hearing impairment to nurture their hidden talents rather than concentrating on what they are lacking. The fact that they are “differently able” must be accepted positively. As rightly pointed out by Johnson, Karnes & Carr (1977), failure to identify and serve deaf children with creative thinking abilities is an indictment against the society and a problem that should not be tolerated.

As there are no gender differences in Intelligence, Creative thinking abilities and Academic achievement, all the boys and girls can be trained for special programs for fostering creative thinking abilities.
Figure 2: Graph showing children scoring intelligence Grade V outperformed in creative thinking abilities compared to children scoring Grade III and Grade IV.

Limitations
There were few limitations that should be considered due to paucity of time, limited availability of resources and several other aspects that could not be covered in this present study due to practical constraints.

1. The study was limited only to fifty children with hearing impairment and they were selected on the basis of convenience sampling.
2. The study was confined to selected three Residential special schools in Mysore for children with hearing impairment.
3. For Academic achievement, no test was administered but previous and present class exam marks of children were obtained from the school records.

Summary
The present study summarized that there exists no significant relationship among Intelligence and creative thinking abilities, Academic achievement and creative thinking abilities of children with hearing impairment. It also highlighted the need for planning of special programs to foster creative thinking abilities of children with hearing impairment based on abilities and talents rather than Intelligence and school exam marks. Future research can be carried out such as a comparative study in creative thinking abilities of children with hearing impairment and children with hearing. A study to find out the relative effectiveness of Bagher Mehdi’s verbal and Non-verbal tests of creativity may be taken up with reference to children with hearing impairment studying in regular schools.

More specifically, a special curriculum for children with hearing impairment may be designed to foster their creative thinking abilities and thereby prepare them for appropriate and productive vocations. Thus, the present study contributed significant educational implications on its findings.

References
Marschark, M. (2003). Interactions of Language and


Acknowledgement

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2. Dr. C. Jangaiah, Associate Professor, English and Foreign Languages University, Hyderabad.
INTONATION IN THE WH AND Y-N QUESTIONS OF MOTHERS OF HEARING IMPAIRED: INFLUENCE OF TYPE OF PARTNER IN COMMUNICATION

*Amulya, P. Rao, **Sushma Manjunath, ***R. Manjula & ****Priyashri Sridhar

Abstract

'intonation' a prosodic feature of speech is characterized by the variation of fundamental frequency over time. The study attempted to analyze the variations in the use of intonation patterns of WH and Y-N questions in mothers following two approaches; Woodford Oral technique and non-specific technique, when they speak (a) to their children with hearing impairment and compare the same with their use of the same questions when it is addressed to (b) normal adults and (c) normal children. 30 mothers of children with hearing impairment served as participants and they were divided into 2 groups – one group followed Woodford Oral Technique and the other group followed non-specific technique. The participants were instructed to ask as many questions as possible to 3 different communication partners on a selected picture stimuli. A total of 14 WH and 5 Y-N questions spoken with a similar syntactic structure were analyzed for the intonation features that were expressed by majority of the mothers of the two groups. The intonation contours for each question across WH and Y-N questions, three conditions and two groups of mothers were extracted and plotted. Temporal measures included duration of the intonation contours and frequency measures included the analysis of onset and terminal F0 of the intonation contour, F0 range in the intonation contour, terminal contour of the intonation curve and declination gradient in the intonation contour. The results revealed a significant difference in the pattern of intonation contours especially in the frequency related parameters across the two groups of participants, across the conditions. Also, significant difference in the intonation contours were observed across the conditions for mothers following Non-Specific Technique suggesting that more natural intonation curves were used by mothers in Non-Specific Technique than the Woodford Oral Technique.

Key words: Hearing impaired, Intonation contours, Woodford Oral technique, Non specific technique

Supra-segmental features or ‘Prosody’ are considered as one of the most important but highly evasive properties of spoken language (Price, Ostendorf, Shattuck-Hufmagel and Fong, 1991). According to Lehiste (1970) and Crystal (1986), prosody represents the linguistic use of vocal aspects of speech, such as variations in fundamental frequency (perceived as pitch), intensity (perceived as loudness) and duration (perceived as length) without consideration of the segmental aspects (speech sounds or phonemes). ‘intonation’ is a prosodic feature of speech characterized by the variation of fundamental frequency over time (Collier, 1991), and it has many communicative roles: conveys attitudes (Crystal, 1986); old or new information, social status; grammatical functions; and information about discourse and speakers attitude (Brazil, Coulthard & Johns, 1980).

There are limited studies addressing the intonation features in Indian languages. Manjula (1979) and Nataraj (1981) found that in Kannada language, sentences are expressed with a final fall except for those with emotions like fear and anger, wherein a final-rise is noticed. Manjula (1997) studied the features of intonation and stress in question words (WH) and Yes – No (Y-N) interrogatives in standard dialect of Kannada and found that there is a general rise in the fundamental frequency (F0) for
Y-N and fall in F0 for WH questions, and there are different patterns of declination and inclination in F0 observed for Y-N and WH questions.

Early communication in typically developing infants is extremely melodic in nature. Infants express using various intonation patterns which reflect their physiological and emotional needs (Lewis, 1951; Lennenberg, 1967). Amongst the suprasegmental features, the role of intonation in the acquisition of language has received relatively less attention. Crystal (1973) suggested that infants respond to supra-segmentals at an early age, possibly at the expense of other linguistic features. Infants master voice patterns that vary in pitch well before words are learned and this in turn facilitates acquisition of both speech perception and production skills (Smith and Goodenough, 1971).

Prosodic variations, including boundary phenomena, are especially prominent in the speech of adults directed to children or otherwise popularly known as “motherese” (Fernald & Simon, 1984; Albin & Echols, 1996). Child-directed speech or infant-directed talk, also referred to as baby talk or caretaker speech (and informally as “motherese”, “parentese”, or “mommy talk”), is a nonstandard form of speech used by adults while talking to toddlers and infants. It is usually delivered with a “cooing” pattern of intonation which is different from that of normal adult speech: high in pitch, with many glissando variations that are more pronounced than those of normal speech. Motherese is also characterized by the use of short and simple words. Swanson, Leonard & Gandour (1992) examined the vowel duration in mothers' speech with their typically developing children as compared to adult directed speech. They reported that the content words in the speech of mothers were often highlighted due to the lengthening of vowels in the content words rather than on function words. Ratner (1996) compared the child directed and adult directed speech of mothers in preverbal, holophrastic and combinatorial expressions and reported that vowels of content words were longer in phrase-final position in child directed speech when compared to adult directed speech.

Most of the specialists including the speech language pathologists recognize that mothers of hearing impaired children speak with their hearing impaired children in a very different prosodic form when compared to the mothers of typically developing children. The differences stand out in terms of exaggerated suprasegmental patterns in their speech which they probably do to facilitate increased auditory input to the child or slow down the rate of speech or improvise speech reading skills of the child and many other reasons. At times, a shift in the suprasegmental patterns of the mothers of hearing impaired children are seen with respect to the situation that they are placed in (For example, formal and informal contexts), persons that they are speaking to (For example, elders in the family, addressing a normal child etc), situation/context of the speech (For example, teaching the child versus holding small talk with the child etc). Overall, a noticeable change in the prosody of speech is observed in mothers of hearing impaired children when compared to mothers of children diagnosed as presenting other types of communication disorders such as mental retardation or cerebral palsy or learning disability etc. Although this impression is gained by most of the listeners who communicate with mothers of hearing impaired children, there is very little documented evidence available in the form of studies to understand this issue.

The role of intonation in the acquisition of language has received relatively less attention. The same is true for children with hearing impairment. A review of existing literature reveals a dearth of research regarding the nature of motherese in general and intonation patterns in specific, in mothers of children with hearing impairment. There are scanty reports that address this issue in western context and hardly any in the Indian context. One of the studies conducted in the western context by Szagun (1997) suggests that there is exaggerated intonation pattern used by mothers of hearing impaired.

Use of appropriate intonation patterns has a great impact on child’s development of communication skills. Mothers of children with hearing impairment use different techniques to communicate with their children and to teach them how to communicate. This is often different from the natural or typical manner of speaking. For example, few mothers of hearing impaired children who follow ‘Woodford oral technique’ (used extensively as a teaching method at Balavidyalaya, Chennai, India,
which is a school for hearing impaired children that promotes aural verbal approach) give the impression of use of exaggerated prosody, especially in terms of intonation use. It is of scientific interest to verify how different the intonation pattern of this group of mothers is, and if it is different, what is the extent to which it is affected and are there any observable differences in the use of intonation patterns of these mothers as used with different groups of communication partners. Another point of interest that is well acknowledged is that the prosodic characteristics in general and intonation contours in particular, of different speakers is also influenced by the type of utterance. For example, a question would show an intonation contour that varies from that of a statement. Similarly, within questions, the category of questions [WH versus Yes-No (Y-N)] would also play an important role in deciding the intonation contour. Another influential parameter would be the communication pattern. Considering that the mothers of children with hearing impairment follow different methods of communication, it becomes extremely necessary to find answers to questions such as “Do mothers use the same intonation with children and adults who have hearing within normal limits?” Fetching answers to such questions will not only help us understand the extent to which their speech is same or different across different contexts, but also serves as benchmarks that help us evaluate the extent to which a method is influential.

Although one can find a decent review of literature on segmental features in children with hearing impairment, the same cannot be said of supra segmental features. Despite the widespread occurrence of prosodic problems in some communicatively impaired individuals, relatively few studies have examined the nature of prosodic impairment and how best to remediate prosodic problems (Shriberg & Kwisatkowski, 1985; Shriberg et al., 1986). An understanding of the mothers’ prosody will enable us to understand the prosodic deficits seen in children with hearing impairment, because, mothers serve as models of communicative behaviour right from infancy through childhood to adulthood; their model of speech goes a long way in determining the type of deficits seen in communication of children. Knowing the deficits along with the cause will equip us to tackle them more effectively and establish appropriate patterns of communication.

This study is proposed to understand the differences in WH and Y-N questions of selected mothers of hearing impaired children, as spoken to their hearing impaired child, a normal child without hearing impairment and an adult, in a simulated experimental design. Comparison of stylistic use of intonation in these contexts by mothers of hearing impaired children will throw light on the flexibility of the intonation mechanism that a mother of hearing impaired uses across the said context. If the differences are evident, it will provide scope to introspect the reasons behind such shifts in intonation styles adopted by mothers of hearing impaired children.

**Aims of the study**

The study aims to compare the intonation patterns (in terms of F0 range, initial and terminal F0 range and terminal intonation contours) for selected ‘WH’ and ‘Yes-No (Y-N)’ questions in Kannada language of mothers of children with hearing impairment as used with the following groups (three conditions):

- Hearing impaired children
- Normal adult
- Normal children

**Method**

**Participants:** For the experimental study, thirty Kannada speaking mothers of children with hearing impairment were included. All the mothers were in the age range of twenty five - forty years. The duration for which they were training their children ranged from one month to four years. The group included those mothers who were following the ‘Woodford oral technique’ (fifteen number) exclusively and those who did not follow any specific method of teaching (fifteen number).

**Material:** The stimulus material used to elicit utterances from the mothers in the three conditions of the experiment consisted of a non-emotional picture of kitchen items (enclosed as Appendix 1). This stimulus was selected on the basis of a pilot study that was carried out by the investigators prior to the experiment.

**Pilot study:** A pilot study was conducted in the first
phase of the experiment to ensure that the stimuli material used in the study could generate questions with similar syntactic structure across the speakers. Ten adult participants (mothers of typically developing children) in the age range of twenty five – forty years, who were not part of the actual experiment, were randomly assigned to two groups of five each to administer two tasks.

The task of one group of mothers was to rate for the familiarity and ambiguity of the pictures on a three point rating scale. Three pictures which provided scope for use of non emotional utterances were considered as stimuli for the pilot study. The three pictures depicted a city, a study room and items used in the kitchen. On the rating scale, a score of ‘2’ indicated that the items/actions are familiar and non-ambiguous, ‘1’ indicated that the items/actions are less familiar and somewhat ambiguous and ‘0’ indicated that the items/actions are unfamiliar and ambiguous. If the ratings were ‘0’ or ‘1’ they were asked to explain the actual reason for the rating. Based on the pilot study, the picture of kitchen items which elicited a 5/5 response was selected for the experiment.

The task of another group of mothers was to look into the possibilities of eliciting question sentences of WH and Y-N with similar syntactic structure using the pictures. This was required since the intention of the study was to compare the intonation contours of groups of mothers keeping the syntactic structure similar. Each mother was instructed to construct as many WH and Y-N questions as possible for each picture. The picture depicting kitchen items elicited the greatest number of similar questions. Thus, the picture depicting the kitchen items was considered as the final stimulus for the study.

Procedure: For the experiment, the speech samples of thirty mothers of hearing impaired children (fifteen mothers who followed Woodford oral technique and fifteen who followed non specific teaching methods) were collected individually in a sound treated room. The mothers were instructed to ask as many WH and Y-N questions under each of the three conditions. The three conditions included asking questions about the stimuli picture to:

(1) Their child with hearing impairment
(2) A normal child
(3) A normal adult.

The stimuli picture was placed in between the mother and the participant in such a way that the card was visible to both of them at a time. Looking at the picture, the mothers asked as many questions as possible to the participant. The mothers and their communicating partners were kept blind to the purpose of the study. They were not even sensitized as to the type of questions to be asked. The stimuli of kitchen picture was so constructed that it provided opportunities for the mother in framing WH and Y-N questions in a natural manner, more than any other type of questions. In order to maintain a true representation of the simulated condition of the experiment, the speech of communication partner was also recorded on a portable tape recorder, although the speech of the partner was not analyzed or included in the study design. When the mother asked the questions, she was instructed to do so as naturally as possible. The speech samples were recorded using a professional digital tape recorder with external microphone and the data was directly stored on a computer using line feed procedure. The speech recordings of mothers across the three conditions were randomized to counterbalance and to control order effect if any. The syntactic structure of WH question forms ‘where’ & ‘what’ were not the same across the mothers & hence these were not included in the final analysis.

Analysis: From the recorded samples, questions which were framed using similar syntactic structure across the thirty mothers & across all the three conditions in both WH and Y-N question categories were selected. This process yielded a total of nineteen questions (fourteen WH and five Y-N questions) (see Appendix 2). These questions were transferred through line feed to Praat software (Boersma & Weenink, 2001) to analyze the intonation contours of WH and Y-N questions, using ‘F0 analysis’ module in the Speech analysis section of the software. The speech signal was digitized at a sampling rate of 16000 Hz. The basic unit of analysis included the WH or Y-N question, within which the temporal and F0 measurements were carried out. For the purpose of pitch analysis, F0 range was set between 100 to 350 Hz and the window frame length of analysis was 25 ms. The pitch contours were
extracted using pitch extracting algorithm of PRAAT software. The F0 contours of WH and Y-N questions analyzed were stored as separate files. In order to obtain accurate duration measurements and facilitate discernible boundaries of syllables and intonation units, the utterances were displayed on a wide-band spectrogram. The spectrographic display was obtained between 0-80% Nyquist frequency and was analyzed in Blackman window weighting. The pre-emphasis level was set at 0.80. The acoustic measurements were carried out by the investigators of the study. To check for reliability of measurements of temporal and F0 parameters, approximately 10% of the speech sample was measured independently by another investigator, and these were found to be reliable as the contour to contour agreement was greater than 90 %.

The acoustic measurements of duration and F0 were obtained for the following parameters:

Temporal measures:
- Duration of the intonation contour for question as a whole

Fundamental frequency (F0) measures:
- Onset and terminal F0 of the intonation contour
- F0 range in the intonation contour
- Terminal contour of the intonation curve, with respect to rise, fall, level and the combinations of these.
- Declination gradient in the intonation contour.

Graphic representation of intonation contours: To facilitate comparison of the WH and Y-N intonation contours of the mothers, the intonation contours of each question as expressed by mothers were superimposed on each other for graphic representation and further analysis. This was carried out by copying the contours extracted through PRAAT analysis on to Microsoft PowerPoint office and placing them on the temporal and F0 scale using Microsoft paint office. The contour of each mother’s utterance was represented in specific colour as codes to facilitate identification of the mother and for further analysis and comparison. The contours for each question asked by mothers across three conditions were thus depicted graphically.

Results & discussion

The selected features of intonation contours were analyzed for WH and Y-N questions of mothers for the three conditions separately. The results are presented in two sections for Y-N and WH questions respectively.

The phonetic transcription to represent questions is based on Schiffman (1979) for Kannada language (Appendix 3). Graph 1 and 2 presented in Appendix 4 shows an example of the superimposed intonation contours for one out of five Y-N questions and one out of fourteen WH questions.

Table 1a shows the duration of the intonation contours for the yes-no questions. The duration of the Y-N questions along with mean and SD for the two groups of mothers namely, the group that followed Woodford Oral technique (Group 2) for the three conditions – adults (C1), typically developing child (C2) and their hearing impaired child (C3) was lesser compared to the group that followed non-specific technique. In general, the mean duration was higher in mothers who followed non-specific technique than that of mothers who followed Woodford Oral Technique. This was probably because of lesser number of syntactically similar questions in mothers following Woodford Oral Technique compared to mothers who used non specific technique. The mean non specific technique was higher for C1, C2 conditions and C3 was greater in Woodford Oral Technique group. Thus, the two groups of mothers revealed differences in the duration of whole sentence across conditions. However, the differences must be examined in the light of absence of syntactically similar questions in quite a few cases in Group 2 which may have resulted in lesser values. Although the data is limited to five, it can probably be inferred that there was a difference in terms of duration of intonation contours between the Woodford Oral Technique and non specific technique group.

The duration of the WH questions along with mean and SD for the two groups of mothers namely, the group that followed Woodford Oral Technique (Group 2) for the three conditions – adult with hearing sensitivity within normal limits (C1), typically developing child (C2) and their hearing impaired child (C3) are shown in Table 1b. In general, the mean duration was almost similar in mothers who followed
1. Duration of the intonation contour for Y-N and WH questions in three conditions

<table>
<thead>
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<th>Questions</th>
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<th>Mothers: Woodford technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Q1</td>
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</tr>
<tr>
<td>Q2</td>
<td>1.5</td>
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<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Q4</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Q5</td>
<td>1.4</td>
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<tr>
<td>Total</td>
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<tr>
<td>Mean</td>
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<td>1.7</td>
</tr>
<tr>
<td>S.D.</td>
<td>0.24</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Table 1a: Duration of the intonation contour for Yes - No questions in sec (C1 = Adult, C2 = N Child and C3 = HI child, '-' indicates that syntactically similar questions were not available for comparison)

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Mothers: Non-specific approach</th>
<th>Mothers: Woodford technique</th>
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<td>C1</td>
<td>C2</td>
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<td>Q2</td>
<td>1.6</td>
<td>1.6</td>
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<td>1.5</td>
</tr>
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<td>Q5</td>
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<tr>
<td>Q14</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>16.3</td>
<td>21.5</td>
</tr>
<tr>
<td>Mean</td>
<td>1.35</td>
<td>1.53</td>
</tr>
<tr>
<td>S.D.</td>
<td>0.25</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Table 1b: Duration of the intonation contours in sec for the WH questions (C1 = Adult, C2 = N Child and C3 = HI child, '-' indicates that syntactically similar questions were not available for comparison)

non-specific technique and mothers who followed Woodford Oral Technique, with very minor differences across the conditions in both the groups. Thus the two groups of mothers revealed no differences in the duration of the whole sentence across conditions. This is reflected in the changes seen in the intonation contour. One can see that there are almost similar modulations in the intonation contour in both the conditions.

Table 2a shows the difference in range of onset and terminal F0 in Hz for yes-no questions for both groups of mothers. Table 2b shows the difference in range of onset and terminal F0 in Hz for WH-questions for both groups of mothers. The difference was calculated as the value of the final /end point of the contour minus the initial / onset of the contour. A positive value indicates an upward inclination in the contour and a negative value indicates a downward declination in the contour. In Y-N and WH questions, mothers who followed Woodford Oral Technique showed lesser standard deviations in all three conditions as compared to those mothers who followed a non-specific technique, who showed greater variability in onset and terminal F0 range. In WH questions, the greatest variability in terms of the range was found for C2 condition in both groups. The least variability was found for the C3 condition in both groups.

The groups showed similar inter-condition changes within their respective groups. The results point to the possible explanation that the type of communication partner did not have a significant effect on the onset and terminal F0 in mothers who follow Woodford Oral Technique. It seems like the mothers who follow Woodford Oral Technique tend to generalize the method across communication
partners and tend to show more of flat pitch than mothers who follow the non-specific method. Table 3a shows the F0 range of Y-N intonation contours of both the groups of mothers for yes-no questions along with the total, mean and standard deviation. Table 3b shows the F0 range of WH intonation contours of both the groups of mothers for WH questions along with the total, mean and standard deviation. For both the question types, mothers who followed the non specific technique exhibited wider range of F0 with a higher mean F0.

They demonstrated significant intra-group variability and hence a higher standard deviation was noticed. Also, across conditions, they demonstrated

2. Difference between onset and terminal F0 of the Y-N and WH intonation contours

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Mothers: Non-specific approach</th>
<th>Mothers: Woodford technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Q1</td>
<td>110</td>
<td>140</td>
</tr>
<tr>
<td>Q2</td>
<td>-50</td>
<td>210</td>
</tr>
<tr>
<td>Q3</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>Q4</td>
<td>-20</td>
<td>-30</td>
</tr>
<tr>
<td>Q5</td>
<td>-50</td>
<td>-50</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>320</td>
</tr>
<tr>
<td>Mean</td>
<td>12</td>
<td>64</td>
</tr>
<tr>
<td>S.D.</td>
<td>98</td>
<td>146</td>
</tr>
</tbody>
</table>

Table 2a: Difference between onset and terminal F0 (in Hertz) of the intonation contour (C1 = Adult, C2 = N Child and C3 = HI child, '-' indicates that syntactically similar questions were not available for comparison)

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Mothers: Non-specific approach</th>
<th>Mothers: Woodford technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Q1</td>
<td>-10</td>
<td>-</td>
</tr>
<tr>
<td>Q2</td>
<td>-10</td>
<td>160</td>
</tr>
<tr>
<td>Q3</td>
<td>-20</td>
<td>-40</td>
</tr>
<tr>
<td>Q4</td>
<td>-10</td>
<td>10</td>
</tr>
<tr>
<td>Q5</td>
<td>-20</td>
<td>-10</td>
</tr>
<tr>
<td>Q6</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>Q7</td>
<td>-30</td>
<td>-50</td>
</tr>
<tr>
<td>Q8</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Q9</td>
<td>-110</td>
<td>90</td>
</tr>
<tr>
<td>Q10</td>
<td>-100</td>
<td>100</td>
</tr>
<tr>
<td>Q11</td>
<td>0</td>
<td>-100</td>
</tr>
<tr>
<td>Q12</td>
<td>-10</td>
<td>-80</td>
</tr>
<tr>
<td>Q13</td>
<td>100</td>
<td>-30</td>
</tr>
<tr>
<td>Q14</td>
<td>10</td>
<td>-20</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>-60</td>
</tr>
<tr>
<td>Mean</td>
<td>2.72</td>
<td>-4.28</td>
</tr>
<tr>
<td>S.D.</td>
<td>97.27</td>
<td>155.71</td>
</tr>
</tbody>
</table>

Table 2b: Onset and terminal F0 in Hertz of the intonation contour for WH questions (C1 = Adult, C2 = N Child and C3 = HI child, '-' indicates that syntactically similar questions were not available for comparison)

3. F0 range in the Y-N and WH intonation contours

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Mothers: Non-specific approach</th>
<th>Mothers: Woodford technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Q1</td>
<td>110</td>
<td>160</td>
</tr>
<tr>
<td>Q2</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>Q3</td>
<td>120</td>
<td>70</td>
</tr>
<tr>
<td>Q4</td>
<td>70</td>
<td>40</td>
</tr>
<tr>
<td>Q5</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>410</td>
<td>440</td>
</tr>
<tr>
<td>Mean</td>
<td>82</td>
<td>88</td>
</tr>
<tr>
<td>S.D.</td>
<td>38</td>
<td>72</td>
</tr>
</tbody>
</table>

Table 3a: F0 range in Hertz in the intonation contour for yes-no questions (C1 = Adult, C2 = N Child and C3 = HI child, '-' indicates that syntactically similar questions were not available for comparison)
variability in their F0. Highest values of F0 were obtained for C2 followed by C1 and C3. This implies that F0 variations were highest with typically developing children and adults as against children with hearing impairment. On the other hand, the total F0 range of mothers who followed Woodford Oral Technique was significantly lesser than the F0 range of mothers who followed the non specific technique and also showed lesser intra-group variability. All the F0 values obtained under each condition were the same.

This shows that mothers who follow Woodford Oral Technique use lesser variations in F0 and show little intra-group variability as compared to the other group. The F0 range was higher for C1 than C2 indicating that the mothers who follow Woodford Oral Technique use a higher range of F0 with adults than typically developing children. However, no syntactically similar questions were obtained for C3 and hence the condition was not analyzed.

The terminal contours of the Y-N and WH intonation contour were examined and were categorized as rise, fall, level and combinations of these. The result of the general pattern that emerged for Y-N questions is shown in table 4a and that of WH questions is shown in table 4b. The number of syntactically similar questions elicited for mothers who follow the Woodford Oral Technique was lesser and hence the pattern of the terminal contour of mothers who followed Woodford Oral technique was found to be mixed consisting of both rise and fall. In both the question types, the pattern of terminal contours of mothers who followed non specific technique was mainly of falling types with not much inter-condition variability within the group. Thus, more consistency in terms of the terminal contour pattern was found in mothers who followed the non-specific approach. The pattern of the terminal contour of

### 4. Terminal contour of the Y-N and WH intonation curve, with respect to rise, fall, level and the combinations of these.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Mothers: Non-specific approach</th>
<th>Mothers: Woodford technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Q1</td>
<td>Fall</td>
<td>Fall</td>
</tr>
<tr>
<td>Q2</td>
<td>Fall</td>
<td>Fall</td>
</tr>
<tr>
<td>Q3</td>
<td>Rise</td>
<td>fall</td>
</tr>
<tr>
<td>Q4</td>
<td>Fall</td>
<td>fall</td>
</tr>
<tr>
<td>Q5</td>
<td>Fall</td>
<td>fall</td>
</tr>
</tbody>
</table>

**Table 4a:** Terminal contour of the Y-N intonation curve, with respect to rise, fall, level and the combinations of these for yes-no questions (C1 = Adult, C2 = N Child and C3 = HI child, '-' indicates that syntactically similar questions were not available for comparison)
mothers who followed Woodford Oral technique was found to be mixed consisting of both rise and fall with majority of them showing rise pattern.

The intonation contours were analyzed in terms of inclination or declination pattern. The declination and inclination gradients are tabulated in table 5a and 5b and compared across the two groups of mothers for yes – no and WH questions respectively. For both the question types, in mothers who follow the non specific technique method, significant inter and intra-group variability was found across the three conditions with C1 and C2 showing declination for few questions and inclination for few. However, there was not much variability in C3 with most of the mothers showing a declination pattern. In mothers who follow the Woodford Oral Technique, no fixed pattern was noticed.

In Y-N questions, the number of syntactically similar questions elicited was very less for C2 and C3. Hence a declination gradient could not be calculated. The two groups of mothers demonstrated significant difference in the declination gradient. In WH questions, not much of inter-condition variability emerged and a careful analysis reveals similar patterns across the three communication partners for each question. This indicates that the mothers who follow the Woodford Oral Technique tend to generalize the intonation pattern across different communication partners.

The present study is the first of its kind to be carried out in the Indian context. Despite the widespread occurrence of prosodic problems in some communicatively impaired individuals, relatively few studies have examined the nature of prosodic impairment and how best to remediate prosodic problems (Shriberg & Kwiatkowski, 1985; Shriberg et al., 1986). One of the studies in the western context conducted by Szagun (1997) suggests that there is exaggerated intonation pattern in mothers of hearing impaired. However, the exact nature of prosody in mothers of children with hearing impairment and how it is influenced by the method followed is not highlighted.

This study highlights the difference in WH and

### Table 4b: Terminal contour of the intonation curve, with respect to rise, fall, level and the combinations of these for WH- questions (C1 = Adult, C2 = N Child and C3 = HI child, ‘-’ indicates that syntactically similar questions were not available for comparison)

|---------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|

Table 5a: Declination/ Inclination gradient in the intonation contour for yes-no questions. (C1 = Adult, C2 = N Child and C3 = HI child)
Table 5b: Declination gradient in the intonation contour for WH questions. (C1 = Adult, C2 = N Child and C3 = HI child, "-" indicates that syntactically similar questions were not available for comparison)

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Mothers: Non-specific approach</th>
<th>Mothers: Woodford technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Q1</td>
<td>-</td>
<td>inclination</td>
</tr>
<tr>
<td>Q2</td>
<td>declination</td>
<td>inclination</td>
</tr>
<tr>
<td>Q3</td>
<td>declination</td>
<td>inclination</td>
</tr>
<tr>
<td>Q4</td>
<td>declination</td>
<td>inclination</td>
</tr>
<tr>
<td>Q5</td>
<td>-</td>
<td>declination</td>
</tr>
<tr>
<td>Q6</td>
<td>inclination</td>
<td>inclination</td>
</tr>
<tr>
<td>Q7</td>
<td>declination</td>
<td>declination</td>
</tr>
<tr>
<td>Q8</td>
<td>inclination</td>
<td>inclination</td>
</tr>
<tr>
<td>Q9</td>
<td>-</td>
<td>inclination</td>
</tr>
<tr>
<td>Q10</td>
<td>declination</td>
<td>inclination</td>
</tr>
<tr>
<td>Q11</td>
<td>No change</td>
<td>declination</td>
</tr>
<tr>
<td>Q12</td>
<td>declination</td>
<td>declination</td>
</tr>
<tr>
<td>Q13</td>
<td>inclination</td>
<td>declination</td>
</tr>
<tr>
<td>Q14</td>
<td>declination</td>
<td>declination</td>
</tr>
</tbody>
</table>

Y-N intonation contours across two groups of mothers following two different techniques across different communication partners namely typical adult, typically developing child and child with hearing impairment. The results indicate that there is not much of inter-condition variability in mothers who follow the Woodford Oral Technique as compared to mothers who follow the non specific technique. This suggests that mothers who follow Woodford Oral Technique exhibited similar exaggerated intonation and stereotypic patterns irrespective of the age and diagnosis of the communication partner. On the other hand, mothers who follow the non specific technique showed more variability across the conditions suggesting a more natural way of communication and that which is similar to the typical communication patterns.

The differences in the intonation contours for WH and Y-N questions within the groups across participants are not very different. This suggests that a similar pattern is maintained for the type of questions by subjects using one method. There are however, significant differences across the two groups (Woodford Oral Technique and non specific technique) especially in terms of the F0 range, terminal contours, declination gradient and range of F0 onset and termination values. The durational measures are however, not significantly different across the two groups suggesting that temporal parameters are not greatly affected by the method adopted whereas frequency measures, which are core features of intonation are highly dependent on the method followed for both the Y-N and WH questions.

**Conclusion**

The present study was conducted to compare the intonation contours of Y-N and WH questions across the two groups who follow the Woodford oral technique and the Non specific technique. Comparisons were also made across three conditions (with communication partners including typically developing children, normal adults and children with hearing impairment) in which the mothers uttered the Y-N and WH questions in simulated experimental conditions. The results reveal a significant difference in the pattern of intonation contours especially in the frequency related parameters across the two groups of participants, across the conditions. Also, significant difference in the intonation contours were observed across the conditions for mothers following non specific technique suggesting that more natural intonation curves were used by mothers in non specific technique than the Woodford Oral Technique.

**Implications**

The study compared the intonation patterns of WH and Y-N questions of two groups of mothers who used two different teaching methods to teach and stimulate their children with hearing impairment. Results suggest that the mothers of the Woodford Oral Technique go on to generalize the same with
other communication partners irrespective of their age and hearing status. This gives rise to unnatural use of intonation by such mothers. It also implies that they are less flexible and rather rigid in the stylistic use of intonation in different communication contexts.

On the other hand, mothers who follow the non specific technique who do not actually abide by any specific technique of teaching intonation seem to be more flexible in terms of their intonation use especially so as reflected in the use of WH and Y-N questions. Extrapolating this finding to the modeling of language by adult to child, one can attribute the prosodic deficits seen in the children to the method adopted by the mother. That is, the parameters of ‘motherese’ is reflected not only in terms of segmental variations but also in terms of intonation variations and this may in turn have an effect on the production of intonation in children’s speech.

References
Appendix 1 – Picture stimuli
Appendix 2
Questions of participants with common syntactic patterns which were analyzed for intonation contours
[Notations used from Schiffman (1979)]

<table>
<thead>
<tr>
<th>WH Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. bindige yaake beeku?</td>
</tr>
<tr>
<td>2. gyaas sTov yaake beeku?</td>
</tr>
<tr>
<td>3. bakeT yaake beeku?</td>
</tr>
<tr>
<td>4. baaNaLe yaake beeku?</td>
</tr>
<tr>
<td>5. mora yaake beeku?</td>
</tr>
<tr>
<td>6. paip yaake beeku?</td>
</tr>
<tr>
<td>7. sink yaake beeku?</td>
</tr>
<tr>
<td>8. chaaku yaake beeku?</td>
</tr>
<tr>
<td>9. , porke yaake beeku?</td>
</tr>
<tr>
<td>10. Tuut braS yaake beeku?</td>
</tr>
<tr>
<td>11. iiLigemaNe yaake beeku?</td>
</tr>
<tr>
<td>12. miksi yaake beeku?</td>
</tr>
<tr>
<td>13. haalinkaanu yaake beeku?</td>
</tr>
<tr>
<td>14. friDj yaake beeku?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Y-N Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. aDige maaDabahuda?</td>
</tr>
<tr>
<td>2. anna maaDabahuda?</td>
</tr>
<tr>
<td>3. hallu ujjabahuda?</td>
</tr>
<tr>
<td>4. kasa guDisabahuda?</td>
</tr>
<tr>
<td>5. snaana maaDabahuda?</td>
</tr>
</tbody>
</table>

Appendix 3
Transcription of sounds in Kannada language using Schiffman’s (1979) transcription procedure

Vowel Sounds

<table>
<thead>
<tr>
<th></th>
<th>Frontal</th>
<th>Central</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Short</td>
<td>i</td>
<td>u</td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>ii</td>
<td>uu</td>
<td></td>
</tr>
<tr>
<td>Mid Short</td>
<td>e</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>ee*(ae)</td>
<td>oo</td>
<td></td>
</tr>
</tbody>
</table>

Diphthongs
“ai” and “au”

Consonant Sounds

<table>
<thead>
<tr>
<th></th>
<th>Unaspirated</th>
<th>Aspirated</th>
<th>Unaspirated</th>
<th>Aspirated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velar</td>
<td>k</td>
<td>kh</td>
<td>g</td>
<td>gh</td>
</tr>
<tr>
<td>Palatal</td>
<td>c</td>
<td>ch</td>
<td>j</td>
<td>jh</td>
</tr>
<tr>
<td>Retroflex</td>
<td>T</td>
<td>Th</td>
<td>D</td>
<td>Dh</td>
</tr>
<tr>
<td>Dental</td>
<td>t</td>
<td>th</td>
<td>d</td>
<td>dh</td>
</tr>
<tr>
<td>Lateral</td>
<td>p</td>
<td>ph</td>
<td>b</td>
<td>bh</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>V</th>
<th>UV</th>
<th>V</th>
<th>UV</th>
<th>V</th>
<th>UV</th>
<th>V</th>
<th>UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glides</td>
<td>Pharyngeal</td>
<td>hi</td>
<td>Retroflex</td>
<td>L</td>
<td>Apicopalatal</td>
<td>sh</td>
<td>Alveolar</td>
<td>i</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

V = voiced and UV = unvoiced or voiceless
Appendix 4:
Graph 1: A sample of superimposed Yes – No (Y-N) intonation contours of mothers in the two groups (G1= Mothers using non specific approach and G2 = Mothers using Woodford’s technique)

Graph 2: Intonation contour of a WH question of mothers in the two groups (G1= Mothers using non specific approach and G2 = Mothers using Woodford’s technique) across 2 groups and 3 conditions
PILOT STUDY ON PROCESS EVALUATION OF DHLS PROGRAM
CONDUCTED THROUGH REAL VIS-À-VIS VIRTUAL MODES: 2007-08

*Vijayalakshmi Basavaraj, ** Venkatesan S., *** Vasanthalakshmi M.S., &
**** Purusotham P.

Abstract

Distance Learning (DL) is a system and process for providing instruction from a distance. This is distinguished from real or traditional instruction, in which all students are on campus face-to-face with the instructor. There are several misconceptions and misapprehensions regarding DL-especially regarding its newer formats by use of two way live and interactive teleconference modes, use of virtual classrooms and/or such other technology enabled services for teaching and education. The DHLS (Diploma in Hearing, Language and Speech) program initiated at AIISH, Mysore (2007-08) through terrestrial linked two way video-conference mode in 11 centers across the country offers a splendid occasion and opportunity to undertake a comparative process evaluation through real vis-à-vis virtual modes of instruction. By combining the use of a cross sectional multi-group comparison design along with a component of survey and tool development embedded within it, the present study seeks to evaluate interpersonal perceptions between teacher-pupil, their views on the technology enabled methods of instruction as well as their impact in terms of comparative performance and results in the end annual examination of the students by using appropriate and standardized questionnaires, rating scales and self reporting schedules. Results indicate highly satisfactory mutual ratings both by teacher/supervisors as well as students across real and virtual centers. In terms of the findings on evaluation of the video-conferencing, teachers experience greater problems or glitches related to the use of this technology than the recipient students. Finally, there appears to be no differences in the eventual outcome of results in final examinations between the two modes of distance learning in the field of communication disorders. The implications of the study along with future potential and possibilities for research along these lines are presented and discussed.

Key words: Open Distance Learning – Process Evaluation – Virtual Learning – DHLS Program

Distance Learning (DL) is a system and process for providing instruction from a distance (Bates, 1995). It occurs when a teacher and student are physically separated by real time or space. It reduces, sometimes eliminates, the constraint of space, time and individual differences. There are numerous formats for this instruction. They include courses on audio/video tape; two-way live interactive question answer formats on hotlines, telephones and television, print as well as on World Wide Web. Further, there can be teleconference courses, audio/video conference, correspondence courses, computer based online or web based courses (real time or delayed) respectively. Contrast this with web based learning or online education where in interactions occur between faculty and students via emails, virtual class rooms, electronic forums, chat rooms, bulletin boards, instant messaging, internet, world wide web, and other forms of computer based communication. A fine line exists between online programs and distance learning courses since it is difficult to call all distance-learning courses as online courses. The technology in both the mode may be different in some cases (Holmberg, 1989).

In practice, each of these formats often include multitude of subsidiary formats (such as, fax, mail or...
telephone) to support teacher-student exchanges of information. Across these formats, DL is a powerful and versatile tool for assisting student learning. It holds unprecedented opportunities for expanding the academic community. It includes distance teaching. The three components of DL are: teacher’s role in the process—distance learning, and the student’s role in the process and the desired outcome-distance education (Verduin & Clark, 1991; Lane, 1992, Willis, 1993).

DL is distinguished from (a) real or traditional instruction, in which all students are on campus face-to-face with the instructor, (b) teach-yourself programs, in which students engage exclusively in independent private study, and (c) other uses of technology in education, such as independent computer-assisted instruction (Keegan, 1986). DL refers to the whole process or system of education (Lane, 1992; Willis, 1993). It refers to the teacher’s role in the process of providing instruction at a distance (Lane, 1992; Willis, 1993; Schlosser and Anderson, 1994).

DL models are based on entirely different footing than the brands of traditional education. It is learner centered. The students have to actively discover, create meanings and construct knowledge. They have to be proactive during the learning process. They develop their own thinking. They manage their own learning at their own pace. The teacher is mere facilitator who provides instructional supports. Contrast all this with the traditional system which is teacher centered. The teacher presents knowledge. The student is receptive and reactive during the teaching process. They run according to the pace of the teaching or teacher. The teacher dominates the entire proceedings during the teaching or learning process (Venkatesan, 2007).

DL is an upcoming, untapped and unrecognized agenda in contemporary educational practice. Programs under this mode range from high end options leading to award of doctoral degrees, masters, bachelors and/or graduate, post graduate diplomas or the more modest low end certificate/bridge courses across various disciplines and subjects. It is currently plagued with several startup problems, misconceptions and misapprehensions and misconceptions. A few important mistaken beliefs are given below (Clarke, 1993; Imel, 1998; Inman and Kerwin, 1999):

- It is not real teaching
- It represents weaker learning
- Effective instruction can/must be live and face-to-face
- Student-faculty interaction is minimized in DL
- Certain subject matter can be taught only in live traditional classrooms.
- Some DL formats eliminate the need for faculty.
- Academic dishonesty among DL students is frequent and uncontrollable.
- DL courses will decrease on-campus enrollments (Barron, 1987; Carl, 1991; Dillon & Walsh, 1992; Moore, 1995). These misgiving are more a result of functional fixedness in the attitudes of its perpetuators and protagonists. When it comes to the issue of analyzing or understanding issues and problems related to DL, there is need for attitudinal shift in educational planners, policy makers and program implementers. There is mistaken notion on “change the individual, rather than the system” orientation in many people (Evans, 1982). This “system-centered” tendency obviously is directly opposed to “student-centered” approach, a characteristic feature of these programs (Phelps, 1991).

The DHLS Program

The DHLS (Diploma in Hearing, Language and Speech) program is aimed at training lower level functionaries in the field of speech and hearing. After the completion of this 10-month course, they are eligible to work as speech and hearing assistants. Their job functions generally include activities like carrying routine screening, assessment and therapeutic management of clients with communication disorders. The location of their work can include Child Guidance Centers, District General Hospitals, Primary Health Centers, Special Schools for Deaf, Inclusion Schools and/or under the ongoing National Program on Prevention and Control of Deafness. They are designated as “Speech and Hearing Assistants”. The completion of this course also allows these candidates to gain lateral entry into the graduate level BASLP program.

The entry requirements for this Diploma Program are 10+2 level courses with majors in science
subjects in the age above 17 years. The medium of instruction is English/Hindi or other regional languages. The prescribed course content covering six subjects extends over 400 hours. As recommended by Rehabilitiation Council of India (RCI), it contains 40% of total number of working hours on theory and 60% of the time on practical and clinical work. There are prescribed rules and regulations on the designation and teaching experience of the staff, minimum space requirements and equipments or materials required to start or run this program.

For example, it is mandated that the mode of teaching must be in the form of classroom lectures/demonstrations, virtual classes through distance mode supplemented by handouts, manuals, brochures, checklists, proforma, audio-visual tools with supervised clinical practice. There are minimum requirements to be guaranteed by every centre with regard to appointment of at least two lecturers in audiology/speech language pathology with graduate/post graduate level educational qualifications apart from visiting staff as one each clinical/rehabilitation psychologist and, special education teacher. There are minimum requirements of space with specified dimensions for at least one class room, audiometric room, staff/office room, group therapy room, ear mould lab/cum hearing aid workshop, library and two individual therapy rooms respectively. The minimum requirement of equipment / materials include an audiometer, hearing aids of all makes and models, speech trainer, hearing aid repair kit, group hearing aids, sound recorders with CDs and cassettes, therapeutic toys, auditory trainers, models of the ear and larynx, etc. A summary table on prescribed vis-à-vis availability matching of staff, materials, equipments, infrastructure and human resources across sample centers during the period of this study (2007-08) as verified by on site/field inspection by one of the investigators is given under table one.

The DHLS Program is currently being run at 30 centers across the country including the host center (AIISH, Mysore) in the year 2007-08.

With the commencement of DHLS Program through virtual mode at AIISH, Mysore; it becomes pertinent to initiate a simultaneous process evaluation of its efficacy and equivalence with the traditional modes of instruction. Such an evaluation is likely to throw light on the relative merits and demerits of both these modes of instruction as also they may offer useful suggestions for any needed improvisation in the ongoing program. It was the aim of this study to undertake a process evaluation of DHLS program conducted through real vis-à-vis virtual modes of instruction at various centers across the country.

**Method**

The present study combines the use of a cross sectional multi-group comparison design along with a component of survey & tool development embedded within it.

**Sample:**

FOUR centers across various zones in the country that run the DHLS Program under the recognition of RCI along with the FOUR study centers under the virtual mode from AIISH, Mysore, were chosen as the target institutions for this multi-centered study. The host center (AIISH, Mysore) may be viewed as a unique entity blending both the features of real and virtual centers since the students are located in front of the teacher as also they can interact and are affected by the under-camera factors that influence participants from the other virtual centers.

**Tools & Materials:**

Evaluation is recognized as a dynamic scheme for assessing the strengths and weaknesses of programs, policies, personnel, products and organizations to improve their effectiveness (American Evaluation Association, 2002). Process evaluation describes and assesses program materials and activities. Outcome evaluation studies the immediate or direct effects of the program on participants. Impact evaluations look beyond the immediate results of policies, instruction or services to identify long term as well unintended program effects. Regardless of the kind of evaluation, all of them use qualitative as well as quantitative data collected in a systematic manner. In the context of
the aims and objectives of this study, it covered three inter-related but distinct components:

(a) Teacher-Pupil Evaluation,
(b) Technology Evaluation, and
(c) Outcome Evaluation

All these components were covered through development of appropriate measurement tools and materials. The following measuring instruments were developed as part of this endeavor:

(a) **Institution & Infrastructure Profile**

This format contained questions to elicit information on or about the participating institution. Some of the included questions related to title of the institution, whether government or private, date of

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Variable</th>
<th>PRESCRIBED PER CENTER</th>
<th>AVAILABILITY IN CENTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>STAFF</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical Staff</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Speech Therapist/Audiologist</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Psychologist-Part Time</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Special Education Teacher-Part Time</td>
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<td>1</td>
</tr>
<tr>
<td></td>
<td>Internship Students</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Host Center Faculty</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>MATERIALS/EQUIPMENTS</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Audiometer &amp; Impedance Audiometer</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Specimen Hearing Aids</td>
<td>4 each</td>
<td>4 each</td>
</tr>
<tr>
<td></td>
<td>Speech Trainer/Auditory Trainer</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Hearing Aid Repair Kit</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Group Hearing Aids</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sound Recorders with CD/Cassettes</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Therapeutic Toys</td>
<td>1 set</td>
<td>1 set</td>
</tr>
<tr>
<td></td>
<td>Models of Ear/Larynx &amp; Ear Mould Materials</td>
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<td>1 set</td>
</tr>
<tr>
<td></td>
<td>Videoconference System</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>OAE Hand Screen</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Spiro Meter</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Otoscope</td>
<td>-</td>
<td>-</td>
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<tr>
<td></td>
<td>Immitance Meter</td>
<td>-</td>
<td>-</td>
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<td></td>
<td>Computer</td>
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<td>-</td>
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<td></td>
<td>Router Modem</td>
<td>-</td>
<td>-</td>
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<td>C</td>
<td>INFRASTRUCTURE</td>
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<tr>
<td></td>
<td>Class Room</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Audiology Room</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Staff/office Room</td>
<td>1</td>
<td>1</td>
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<td></td>
<td>Group Therapy Room</td>
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<td>1</td>
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<tr>
<td></td>
<td>Ear Mould Lab/Hearing Aid Workshop</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Library</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Individual Therapy Rooms</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>TEACHING PRACTICES</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lectures/Supervisor</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>OHP/PP Presentations</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Group Discussions</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Case Demonstrations</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Virtual Class Rooms</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Hand Outs</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Self Learning Materials</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Checklists/Scales</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Supervised Clinical Practice</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Study Manuals</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 1: Prescribed vis-à-vis Availability Matching for Staff, Materials, Equipments, Infrastructure & Human Resource across Centers (2007-08)
establishment, objectives and activities, funding, manpower development courses being run, staff strength and patterns in terms of administrative, technical, professional and part-time, date of commencement of DHLS course, student strength, earlier history of pass-outs, space available, infrastructure, costs, etc.

(b) Teacher-Pupil Evaluation Profiles

This format had questions related to individual teacher-student characteristics in the context of traditional classroom and DL teaching procedures. Depending on the background of the given sample, individual teachers and students were administered this Likert type rating scales for responses on individual items. Part A of this questionnaire related to characteristics of the individual teachers (to be blind rated by sub-sample of students), such as, extent or depth of their knowledge, competency in expressive language, approachability through the medium of their instruction (either real or virtual), clarifications or explanations to be able to seek or receive, maintenance of class controls, supervisions possible or otherwise, etc. Part B of this questionnaire comprised of items related to pupil features (to be blind rated by a sub-sample of teachers/supervisors), such as, their classroom participation, ability to ask or answer questions, complete assignments, supervision by distant/remote or near, communicability, responsiveness of pupils, spontaneity, classroom milieu, feeling of familiarity-unfamiliarity, approachability, visibility, convenience for monitoring, etc. In in-house 2-week test retest reliability exercise revealed a correlation coefficient of 0.87 and another inter-rater reliability coefficient between two investigators as 0.91 respectively. Face validity for the instrument was established by circulation between the authors and was found to be high.

(c) Technology Evaluation

The sample of teachers-pupils exposed to virtual format of instruction alone was subjected to this evaluation by means of a rating scale and covering on the technological aspects of the program. Queries covered details on the ease or difficulties in operating the electronic gadgets, need or availability of technical assistance at hand, trouble shooting, etc. A 2-week test retest reliability exercise revealed a correlation coefficient of 0.71 and concurrent validity between two groups of respondent sub-sample was found to be 0.79.

(d) Outcome Evaluation

This evaluation was carried out in terms of the comparative final examination results of the students across all the centers after completion of their training program. Outcome or summative evaluation in terms of job placements of the successful candidates at the end of this program across all training centers, although initially planned could not be taken before the end of this pilot study. Likewise, cost benefit evaluation in terms of monetizing input-output benefits from this program is another ongoing exercise which will be reported as part of another related study.

Procedure:

Data collection involved visiting or securing filled in questionnaires of respective respondents from four virtual centers (Mumbai, Manipur, Puducherry1 and Delhi) as well as five regular centers (Pune, Bhopal, Puducherry2, Kolkata and Mysore) across the country. This was carried out after ascertaining that the students as well as teachers have familiarized with each other at least over a period of three months from the startup date of their DHLS program.

Results & Discussion

The results of the study are presented under the following discrete but related headings:

(a) Pupil Evaluation of Teachers / Supervisors
(b) Teacher/Supervisor Evaluation of Pupils
(c) Pupil Evaluation of Technology
(d) Teacher/Supervisor Evaluation of Technology
(e) Outcome Evaluation of Results in Final Examinations

(a) Pupil Evaluation of Teachers/ Supervisors

The results on pupil evaluation of teachers/supervisors (Table 2) shows mean total score of 85.49 (SD: 13.6) for staff from virtual centers as compared to a slightly higher score of 94.33 (SD: 7.94) given by students for teachers/supervisors of actual/regular centers. The differences were compared using Mann-Whitney U Test revealed no statistically significant differences for the teachers/
supervisors across both categories of training centers (p: >0.05).

An analysis of individual ratings by students from different centers shows that the highest scores are given by students from Delhi virtual center (Mean: 99.02; SD: 3.06) followed by Pune (regular center) (Mean: 98.97; SD: 0.91), Bhopal (regular center) (93.40; SD: 5.97) and so on. The lowest score ratings are given by students at Manipur virtual center (Mean: 78.64; SD: 6.74) for their teachers and supervisors.

The specific items on which teachers/supervisors were rated ‘highly satisfactory’ by pupils included their ‘extent or depth of knowledge in the subject’, ‘competency in expressive language’, ‘updates or recent information on the subject’, ‘clarifications/explanations for doubts or queries’, ‘lecture presentations’ and ‘use of audio visual aids’, ‘summarizing or paraphrasing’, ‘dressing and general present ability’, ‘interest and involvement in class’, etc. The items on which was rated as ‘not satisfactory’ were related to ‘approachability or accessibility as a person’, ‘maintenance of class discipline/controls’, ‘intelligibility of teacher’s voice’, etc.

(b) Teacher/Supervisor Evaluation of Pupils:
Conversely, the results of teacher/supervisor evaluation of students (Table 3) shows mean total score of 73.56 (SD 11.85) for pupils from virtual centers as compared to a slightly higher score of 76.00 (SD: 14.92) given by teachers/supervisors of actual/regular centers with no statistically significant differences (p: >0.05).

<table>
<thead>
<tr>
<th>Type of Center</th>
<th>Location</th>
<th>N</th>
<th>Pupil Responses towards Teachers</th>
<th>Mean Score*</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NS</td>
<td>NI</td>
<td>S</td>
</tr>
<tr>
<td>Virtual</td>
<td>Mumbai</td>
<td>18</td>
<td>0</td>
<td>3.6</td>
<td>47.6</td>
</tr>
<tr>
<td></td>
<td>Manipur</td>
<td>108</td>
<td>0</td>
<td>11.2</td>
<td>63.0</td>
</tr>
<tr>
<td></td>
<td>Puducherry</td>
<td>103</td>
<td>5.4</td>
<td>14.6</td>
<td>35.0</td>
</tr>
<tr>
<td></td>
<td>Delhi</td>
<td>96</td>
<td>0</td>
<td>0.2</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Pune</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>41.0</td>
</tr>
<tr>
<td></td>
<td>Bhopal</td>
<td>42</td>
<td>0.1</td>
<td>2.8</td>
<td>20.6</td>
</tr>
<tr>
<td>Real</td>
<td>Pondicherry</td>
<td>50</td>
<td>0.3</td>
<td>4.9</td>
<td>60.3</td>
</tr>
<tr>
<td></td>
<td>Kolkatta</td>
<td>17</td>
<td>0</td>
<td>15.8</td>
<td>84.2</td>
</tr>
<tr>
<td></td>
<td>Mysore-Host</td>
<td>144</td>
<td>0.1</td>
<td>1.1</td>
<td>22.5</td>
</tr>
</tbody>
</table>

(Mann Whitney U Test: Z: 0.98; p: >0.05; NS); KEY: NS: Not Satisfactory, NI: Needs Improvement, S: Satisfactory, HS: Highly Satisfactory; * Calculated by the total of all 25 ratings out of 100 and converted to percentage)

Table 2: Pupil’s Evaluation of Teacher/Supervisors
example, if ‘openness’ an ‘free from inhibition’ and ‘communicability’ was rated ‘not satisfactory’ for students from one center, it was ‘poor notes taking behavior’ and ‘asking or answering questions’ which was rated on the same lines at another center. The students at the host center (AIISH) attended classes in the video conference room. They were a part of the whole group of students in the other virtual centers. The overall results on student evaluation of the video-conferencing technology (Table 4) across all four centers (N: 66; Mean: 80.20; SD: 13.49) as compared to similar evaluation from the participating students at the host center (N: 16; Mean: 91.15; SD: 9.73) alone shows a favorable overall mean score against similar ratings from virtual centers at Delhi (N: 16; Mean: 88.85; SD: 10.46), followed by Mumbai (N: 3; Mean: 76.11; SD: 3.47), Puducherry (N: 13; Mean: 73.72; SD: 11.39) and least ratings by students from Manipur (N: 18; Mean: 68.15; SD: 7.11) respectively.

This implies that Manipur located farthest in the north-east reported greatest dissatisfaction and glitches with video conferencing technology compared to all the other centers across the country. A Kruskal Wallis H test run through these findings showed significant differences between the evaluation by students from different virtual centers on or about the technology (p: <0.001). Further, to study pair wise differences, Mann Whitney U Test was administered between each pair. As a result, significant differences were observed between AIISH hosting center and all other virtual centers except Delhi (p:<0.05). This implies that pupil rating of their experience with video conferencing technology is high and similar for Delhi and the AIISH hosting center, while the mean scores of other virtual centers at Mumbai, Manipur and Puducherry are relatively lower and cluster together (p: <0.001). It must be reiterated that the host center (AIISH-Mysore) (N: 16; Mean: 91.15; SD: 9.73) with the highest score must be viewed as an odd one out because its

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>N</th>
<th>Teachers Responses towards Pupils</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
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<td></td>
<td></td>
<td></td>
<td>NS</td>
<td>NI</td>
<td>S</td>
</tr>
<tr>
<td>Virtual</td>
<td>Mumbai</td>
<td>6</td>
<td>0</td>
<td>19.2</td>
<td>60.8</td>
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<tr>
<td></td>
<td>Manipur</td>
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<td>61.7</td>
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<tr>
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<td>Puducherry</td>
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</tr>
<tr>
<td></td>
<td>Delhi</td>
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<td>0</td>
<td>30.8</td>
<td>64.2</td>
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<tr>
<td></td>
<td>Pune</td>
<td>6</td>
<td>0</td>
<td>3.2</td>
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<td>5</td>
<td>20.0</td>
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<td>5</td>
<td>6</td>
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<td>48.0</td>
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<td></td>
<td>Mysore-Host</td>
<td>9</td>
<td>1.7</td>
<td>13.9</td>
<td>73.9</td>
</tr>
</tbody>
</table>

(Mann Whitney U Test: Z: 0.576; p: >0.05; NS); KEY: NS: Not Satisfactory, NI: Needs Improvement, S: Satisfactory, HS: Highly Satisfactory; *Calculated by the total of all 15 ratings out of 60 and converted to percentage)

Table 3: Teacher/Supervisor Evaluation of Pupils

(a) Pupil Evaluation of Technology

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>N</th>
<th>Response of Pupils towards Technology</th>
<th>Mean Score</th>
<th>Standard Deviation</th>
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<td></td>
<td></td>
<td></td>
<td>NS</td>
<td>NI</td>
<td>S</td>
</tr>
<tr>
<td>Virtual</td>
<td>Mumbai</td>
<td>3</td>
<td>0</td>
<td>4.4</td>
<td>86.7</td>
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<tr>
<td></td>
<td>Manipur</td>
<td>18</td>
<td>1.5</td>
<td>34.8</td>
<td>53.3</td>
</tr>
<tr>
<td></td>
<td>Puducherry</td>
<td>13</td>
<td>6.7</td>
<td>25.1</td>
<td>34.9</td>
</tr>
<tr>
<td></td>
<td>Delhi</td>
<td>16</td>
<td>2.5</td>
<td>5.8</td>
<td>25.4</td>
</tr>
<tr>
<td>Actual</td>
<td>Mysore-Host</td>
<td>16</td>
<td>1.3</td>
<td>2.9</td>
<td>25.8</td>
</tr>
</tbody>
</table>

(Kruskal Wallis H Test: X²: (4): 36.192; p: <0.001; VHS); KEY: NS: Not Satisfactory, NI: Needs Improvement, S: Satisfactory, HS: Highly Satisfactory; *Calculated by the total of all 15 ratings out of 60 and converted to percentage)

Table 4: Student Evaluation of Technology
students share the characteristics of, both, real as well as virtual centers.

The specific kind of problems reported by students as ‘needs improvement’ are related to ‘operation of video conference equipments’, ‘electricity and availability of power’, ‘frequency of mechanical breakdown’, ‘intelligibility of teachers voice’, ‘clarity of teachers image or power point presentations’, ‘access to recorded versions’, ‘overall audio/video quality’, ‘visibility of writing on electronic board’, ‘spontaneity and naturalness of classroom situation’, etc.

(d) Teacher/Supervisor Evaluation of Technology

The overall results on teacher/supervisor evaluation of the video-conferencing technology (Table 5) across all five centers (N: 35; Mean: 73.76; SD: 10.43) is lower than student evaluation of the same (N: 66; Mean: 80.20; SD: 13.49). This implies that, on an average, teachers experience greater problems or glitches related to the use of this technology than the recipient students. The specific kind of problems reported by teachers/supervisors are related to ‘operation of video conference equipments’, ‘electricity and availability of power’, ‘frequency of mechanical breakdown’, ‘intelligibility of students voice’, ‘clarity of their images’, ‘comfort level of video conference’, ‘spontaneity and naturalness of classroom situation’, etc.

A Kruskal Wallis H test run through these findings on technology evaluation by the same teacher/supervisors for different virtual centers reveals statistically significant differences (p: <0.001). Further, pair wise differences were studied on Mann Whitney U Test to once again find significant differences between hosting center and all other virtual centers except Delhi (p:<0.05). This implies that teacher ratings of their experience with video conferencing technology is high and similar for Delhi and hosting center, while the mean scores of other virtual centers at Mumbai, Manipur and Puducherry are relatively lower and cluster together (p: <0.001).

(e) Outcome Evaluation of Results in Final Examinations

Outcome evaluation was carried out in this study only in terms of the comparative final examination results of the students across all the centers following the completion of the training program through virtual mode as against those students for the DHLS program on actual/regular mode (Table 6). An analysis of the findings reveal that while the number of students who took the final DHLS examinations (2007-08) were close to identical for actual/regular centers (N:51) and virtual centers (N:54), there are greater number of ‘distinctions’ (N:3; 6%) as well as ‘failures’ (N:20; 37%) from the latter centers as compared to the former. There are more students passing in first and/or second division from actual/regular centers than their counterparts from virtual centers respectively. On the whole, however, there appears to be no differences in the eventual outcome of results in final examinations between the two modes of distance learning in the field of communication disorders (X^2:2.235; df:3.84; p:>0.05; NS with Yates correction)

Summary & Implications

In sum, it may be inferred from the results of this investigation that, on an average, pupil evaluation of their teachers/supervisors is on the higher side for both actual/regular centers as well as virtual centers...
respectively. This is reciprocated by similar high ratings by teachers/supervisors for their students from both the types of centers although there appears to be slightly lesser scores given by teachers/supervisors for their students than vice versa. In terms of the findings on evaluation of the videoconferencing, teachers experience greater problems or glitches related to the use of this technology than the recipient students. Finally, there appears to be no differences in the eventual outcome of results in final examinations between the two modes of distance learning in the field of communication disorders. It is possible to consider outcome or summative evaluation in terms of job placements apart from only being based on successful performance in final examinations as done in the present study. Likewise, cost benefit evaluation in terms of monetizing input-output benefits is another possible exercise that can be taken as part of another related study. These findings suggest a need to continue a closer and continual monitoring of the scope, functionality, problems, issues and challenges between the traditional and virtual modes of instruction for the DHLS program. It holds promise for expanding this modes of instruction even for higher end programs in the field of communication disorders.

References

### Table 6: Outcome Evaluation of Results in Final Examinations (2007-08)

<table>
<thead>
<tr>
<th>Centre</th>
<th>Appeared</th>
<th>Distinction</th>
<th>First Class</th>
<th>Second Class</th>
<th>Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mumbai</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Manipur</td>
<td>19</td>
<td>-</td>
<td>9</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Puducherry</td>
<td>13</td>
<td>3</td>
<td>9</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Delhi</td>
<td>19</td>
<td>-</td>
<td>4</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Total (Approx. %)</td>
<td>54 (100)</td>
<td>3 (6)</td>
<td>22 (40)</td>
<td>9 (17)</td>
<td>20 (37)</td>
</tr>
<tr>
<td>Real</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pondicherry</td>
<td>5</td>
<td>-</td>
<td>3</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Kolkata</td>
<td>15</td>
<td>-</td>
<td>9</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Mysore-Host</td>
<td>17</td>
<td>-</td>
<td>14</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Total (Approx. %)</td>
<td>51 (100)</td>
<td>-</td>
<td>32 (63)</td>
<td>16 (31)</td>
<td>3 (6)</td>
</tr>
</tbody>
</table>

(X²: 2.235; df: 3.84; p: >0.05; NS with Yates correction)
communication. *American Journal of Distance Education, 5*(3), 7-19.


