BINAURAL FUSION TEST IN KANNADA FOR CHILDREN

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Abstract

The study aimed at developing a Binaural fusion test in Kannada language and establishing the normative data for the test across the 5 age groups of 7-7.11 years, 8-8.11 years, 9-9.11 years, 10-10.11 years and 11- 11.11 years. The test material was developed using a corpora of 360 CVCV words which were taken from age appropriate Kannada textbooks and 50 words which were familiar to all the children. They were then randomly grouped into 2 phonetically balanced lists, containing 25 words each. List I was picturizable and list II was non picturizable. The lists were then filtered using a low pass band of 500 to 700 Hz and a high band pass of 1800 to 2000 Hz with the help of Goldwave digital audio editor software and presented at 40 dBSL (with reference to pure tone average) to one hundred children who participated in the study and normative data was collected. The data obtained was analysed for the presence of age and gender effect. The results showed that there was an improvement in the scores for both List I and List II with an increase in age. The scores for males and females were comparable for both List I and List II, which reflected that there was no gender effect.

Introduction

"The study of central auditory processing disorders has been the cause celebre of countless researchers and practitioners across disciplines for several decades" (Ferre, 2002). Central auditory processes are the auditory system mechanisms and processes responsible for the following behavioural phenomena: sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition including, temporal resolution, temporal masking, temporal integration, and temporal ordering; auditory performance with competing acoustic signals; and auditory performance with degraded acoustic signals (ASHA, 1996).

A central auditory processing disorder is defined as "An observed deficiency in one or more of the above listed behaviours. For some, CAPD is presumed to result from the dysfunction of processes and mechanisms dedicated to audition; for others, CAPD may stem from some more general dysfunction, such as an attention deficit or neural timing deficit that affects performance across modalities. It is also possible for CAPD to reflect co-existing dysfunctions of both sorts" (ASHA, 1996).

Comprehensive evaluation of individuals with (C)APD is a challenging task. As (C)APD represents a heterogeneous group of auditory deficits, it is important that a test battery approach be used so that different underlying processes, as well as different levels of functioning within the central auditory nervous system can be assessed. There are numerous tests of central auditory processing that have been developed over the years. However, not all of these tests are equal in their ability to identify auditory processing disorders. Therefore, a battery of tests needs to be developed for assessing the different auditory processes.

Historically, tests of central auditory function have been categorized in a variety of ways. Bellis (1996) categorized central tests as: dichotic speech tests, temporal ordering tasks, monaural low redundancy speech tests, and binaural interaction tests. Tests of binaural interaction generally assess the ability of central auditory nervous system to process disparate, but complementary, information presented to the two ears. Unlike dichotic listening tasks, the stimuli utilized in binaural interaction tasks typically are presented in a non simultaneous, sequential condition, or the information presented to each ear is composed of a portion of the entire message, necessitating integration of the information in order for the listener to perceive the whole message. The tests of binaural interaction include- rapidly alternating speech perception test (RASP), masking level difference test, interaural just noticeable differences and binaural fusion test.

Binaural fusion tasks involve the presentation of different portions of a speech stimulus to each ear, necessitating fusion of the information in order for the listener to perceive the entire word. Matzker (1959) was the first to develop binaural fusion test in which bi-syllabic PB words were filtered through a low pass band in one ear and a high pass band in the other ear. Matzker theorised that the two signals were integrated within the brainstem, most likely at the level of the cochlear nuclei and medial geniculate bodies resulting in better intelligibility scores than those obtained by independent presentation of filtered signals. Matzker (1959) and Lynn and Gilroy (1972) presented data indicating that adult patients with confirmed brainstem or temporal lobe pathology tended to perform poorly than normal adults on a measure of binaural fusion.

Binaural fusion test has been found to be sensitive tool to identify auditory processing problems in children. It has been used to study subtle auditory processing disorder in children. Martin and Clark (1977), using the word intelligibility by picture identification found that 50% of their learning disabled children could be found using the binaural fusion task.

Need of the study

As it has been reported that binaural fusion test is sensitive in identifying APD in children suspected to have processing problems (Roush & Tait, 1984; Singer, et al. 1998; Welsh & Healy, 1980), the need to develop such a test arises.

1. In the Indian scenario, Shivaprasad (2006) developed a binaural fusion test in English for children in the age range of 7 – 12 years using high band pass and low band pass CVC words. This is the only test developed in Indian population. Owing to the various languages being spoken in different parts of the country and the performance variations dependent on the language (Saleh et al., 2003), there's a need to develop such a test in Indian languages.
2. Maturational effects are seen on the performance on a majority of the central tests (Bellis, 1996). However, adult values are reached by 11-12 years of age. Hence, there is a need to obtain age specific norms on these tests.

Due to the apparent lack of such tests for assessing auditory processing disorder in children, in the Indian context, there is a need to develop it in various Indian languages and obtain age appropriate norms.

Aim of the study

1. To develop a binaural fusion test in Kannada.
2. To obtain normative values using the developed test for different age groups of children.
3. To ascertain if there are any differences in the performance as a result of gender or age.

Method

The study was conducted with an aim of developing a binaural fusion test for children in Kannada language. This was done in two stages. Stage one involved development of the test material and in the stage two, normative data were collected for the same.

Subject selection criteria

For both the stages, the subjects had to meet the following criteria to be considered for the study

1. Hearing sensitivity within normal limits. The air conduction thresholds should be less than or equal to 15 dBHL at all frequencies from 250 – 8 KHz for both the ears.
2. ‘A’ type tympanograms with normal acoustic reflex thresholds for both the ears.
3. Mother tongue as Kannada as well as the language spoken at home should be Kannada.
4. No history or presence of otological problems like ear pain or ear discharge.
5. Academic performance should be good or average as per the teacher’s report.
6. Should not have auditory processing disorder as indicated by the screening checklist for auditory processing (SCAP) (Yathiraj & Mascarenhas,2003)

Stage 1

This involved development of the test material, checking the test items for their familiarity and recording of the material.

Development and familiarity checking of test material

A Corpora of 360 CVCV Kannada words that are commonly used were selected from Kannada dictionary, English to Kannada translation book and a story book entitled - Sri Krishnadevaraya and Appaji’s stories. These 360 words were selected by 5 native Kannada speakers with the criteria that they are familiar and whether they are picturizable or not.

Evaluation of familiarity of test items

20 children in the age range of 7+ to 8 years, who met the subject selection criteria, participated in this evaluation. These children, participating in the familiarity check of the test items, were instructed to classify the words on a three point scale as – “Highly familiar’, “Familiar’, or ‘Not familiar’.

The words that were considered ‘highly familiar’ or ‘familiar’ by 90% of the subjects were utilized for the final construction of the test.

50 words which were rated as ‘highly familiar’ and ‘familiar’ by all the twenty children were finalised for developing the test material. These words were grouped into 2 lists consisting of 25 words. List I consisted of picturizable words and list II consisted of non picturizable words. It was ensured that both the lists were phonetically balanced as per the frequency of occurrence of Kannada speech sounds (Ramakrishna et al. 1962).

For List I, four pictures were presented for every target word and the children had to point to the target picture. Out of the four pictures, one was that of the target, one picture was that of a similar sounding word (Homophone), one of another word from the same lexical category and the last was a picture selected at random. The order of occurrence of the target word’s picture was varied randomly throughout the list.

Recording of the test material

Recording was done using an adult female speaker whose mother tongue was Kannada. To ensure that the two lists are of equal difficulty, the recorded stimuli before filtering was presented to the twenty children in the age range of 7+ to 8 years who participated in the familiarity check of the test items. Once it was found out that the lists were of equal difficulty, the filtering of the lists was carried out.

The test items were recorded using Adobe Audition version 3.0 software and band passed using Goldwave digital audio editor software. A low pass band of 500 to 700 Hz and a high band pass of 1800 to 2000 Hz were used to filter the words.

A 1 KHz calibration tone was recorded preceding each list and a six seconds inter stimulus interval was maintained.

Stage 2

This involved administration of the test to obtain normative data**.**

Subjects

One hundred normal hearing children who met the subject selection criteria and who were in the age range of 7+ to 12 years were taken for the collection of normative data. These children were grouped into 5 age groups-

Group I – 7+ to 8 years
Group II- 8+ to 9 years
Group III- 9+ to 10 years
Group IV- 10+ to 11 years
Group V -11+ to 12 years

Each group consisted of 20 children; out of which 10 were boys and 10 were girls.

Instrumentation

The following instruments were used-

- A Pentium 4 computer with Adobe Audition version 3.0 software was used to record the speech stimuli and Goldwave editing software for filtering the stimuli.
- A calibrated dual channel diagnostic audiometer (Orbiter 922) with TDH-39 headphones housed in MX-4/AR cushion was used for running the test material. The calibration standards were as recommended by ANSI(S3.6 1996).
- Calibrated GSI- tympstar middle ear analyzer was used to rule out the presence of any middle ear pathology.
- A CD (CD_R 700MB) player was used for playing the recorded test material.

Test environment

Testing was done in a sound treated double room. The ambient noise levels were within permissible limits as recommended by ANSI (S3.1 1991.

Procedure

1. Pure tone audiometry was done for all the children. Air conduction thresholds were checked for frequencies between 250 Hz– 8 KHz. Bone conduction thresholds were checked for frequencies between 250 Hz – 4KHz.
2. Tympanometry was carried out on all the children using 226 Hz probe tone and acoustic reflexes thresholds were recorded at frequencies of 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz.
3. SCAP was administered for all the children.

The binaural fusion list was administered at 40 dBSL with reference to pure tone average and the children were asked to point to the target word's picture for list I and repeat the words for list II. Each correct response was given a score of one and a wrong response a score of zero.

Reliability check

10 percent of the children were subjected to retesting after a time gap of at least 2 days. Test- retest reliability was checked using this data.

Statistical analysis

Appropriate statistical analyses were carried out to analyse the age effect and gender effect.

Results and Discussion

The data obtained was analysed using Statistical Package for the Social Sciences (SPSS) version15 software.

The following statistical tools were used for analyzing the data-

- Descriptive statistics to calculate the mean and standard deviation for the scores obtained on list I and list II across all age groups.
- Mixed ANOVA (repeated measure ANOVA) to find out if there is any statistical significant difference across age, gender and list.

- Duncan's Post- Hoc test to find out the pair wise comparison of all age groups.
- Independent t-test for comparison of scores across gender in each age group.
- Paired t-test for comparison of lists within each age group.

I. Comparison of Lists, Age & Gender

The mean and standard deviations for all the five age groups across gender are given in table 1. The results are given for the two lists which were developed for establishing the normative data for the five age groups.

Table 1: Mean and Standard deviation (S.D) of Binaural fusion test scores for List I & II for males and females across all age groups.

Age (years)	Gender	List I Max. score:25		List II Max. score:25	
		Mean	SD	Mean	SD
7+ to 8	Male	17.70	1.76	18.40	1.07
	Female	18.40	1.42	18.30	1.49
8+ to 9	Male	19.20	1.03	20.10	1.59
	Female	20.20	1.54	19.90	1.44
9+ to 10	Male	20.90	0.73	20.30	0.82
	Female	20.80	1.22	20.50	1.43
10+ to 11	Male	21.40	0.51	21.80	0.42
	Female	21.60	0.51	21.40	0.96
11+ to 12	Male	22.30	0.67	21.80	0.63
	Female	22.70	1.05	22.10	0.56

Table 1 shows the mean scores for list I and II. It may be noted that the mean scores increase from the younger age group to the higher age groups. It may also be noted that for list I there is a slight difference in mean scores obtained for the two genders. The scores are more for the females compared to the males for 7+ to 8years and 8+ to 9 years age groups. However, for rest of the age groups and for list II the mean scores of males and females are comparable. Figure1 shows the graphical depiction of the mean scores of both the genders for List I which increase with age.

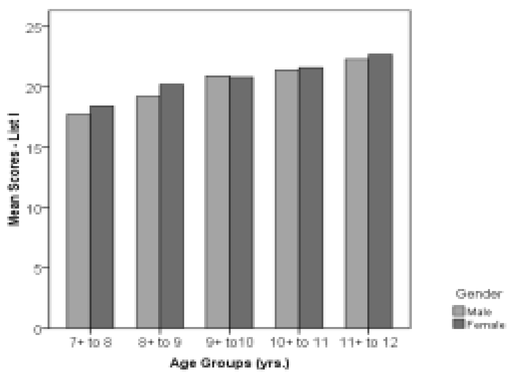

Figure 1: Comparison of mean scores for List I across the gender for each age group.

Even for list II it can be seen from Figure 2 that the mean scores increase as the age increases. However there is an overlap of mean scores for the two genders.

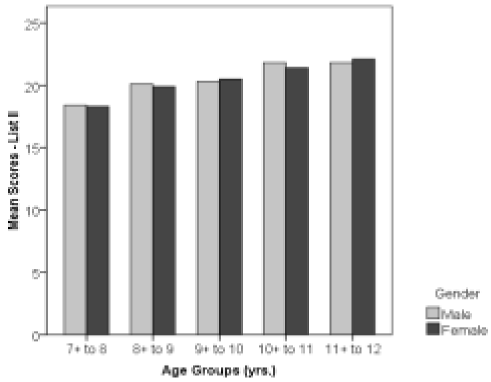

Figure 2: Comparison of mean scores for List II across the gender for each age group**.**

Figure 3 shows the comparison of the mean scores obtained on the two lists for each age group (both the genders put together). From Figure 3, one can see that there is an improvement in scores as the age increases. It is also clear from Figure 3 that the scores for the two lists are comparable for all the age groups.

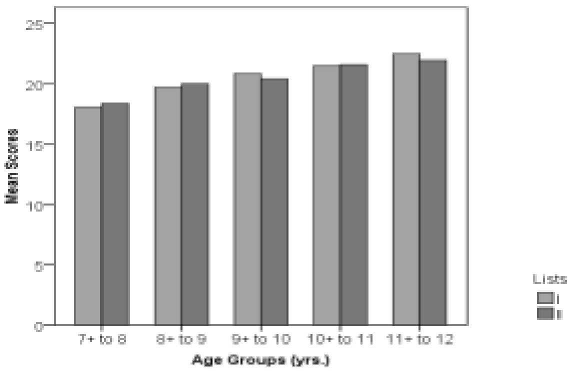

Figure 3: Comparison of mean scores across age group for the two lists.

Mixed analysis of Variance (ANOVA) was done to see if there is any statistical difference between the lists, between the age groups and between the genders. The results of Mixed ANOVA are as given in Table 2.

Table 2: The results of Mixed ANOVA comparing the lists, age groups and genders

Measure	F value	Significance
List	F(1, 90) = 0.28, p>0.05	No significant difference
Age	F(4, 90) = 53.196, p<0.001	**Significant difference**
Gender	F(1,90)= 1.085, p> 0.05	No significant difference
Age and Gender	F (4, 90) = 0.251, p>0.05	No significant interaction
Age and List	F (4,90)= 2.429, p>0.05	No significant interaction
Age, Gender and List	F(4, 90) =1.245, p>0.05	No significant interaction

Duncan's Post Hoc test was done to see which of the age groups were significantly different from each other. Results of Duncan's Post Hoc test revealed that all age groups were significantly different from one another at 5% level of significance.

The results of the present study are concurrent with the findings of Plakke, et al. (1981) who reported of a systematic improvement in binaural fusion scores with increasing age in normal hearing children of 4, 6 and 8 years of age. Also, Neijenhuis et al. (2002) found an age effect within their group of 9-12 year old children as well as when children and adolescents were compared to adults on a variety of APD tests including Binaural fusion test. Binaural interaction has been found to reach adult values by ages 6-8 (Whitelaw and Yuskow, 2006). However, the results of the present study show that the increase in scores with increase in age is seen up to 12 years and hence gives an indication of maturation of auditory processing taking place even during adolescence.

Similarly Stollman et al. (2004) also reported of an effect of age in 6-12 year old children on a battery of APD tests including Binaural Fusion test. In the Indian context, Shivaprasad (2006) reported similar findings on binaural fusion task indicating an age effect up to 12 years. The results of the present study also showed age and maturational effects till 12 years, indicating maturation of auditory processing, at least, up to an age of 12- 13 years which is in good agreement on development of auditory processing abilities and electrophysiological studies of the maturation of the cortical auditory function (Cunningham et al., 2000; Johnstone et al., 1996; Ponton et al., 1996; Sharma et al. 1997).

The present findings thus suggest the importance of having age appropriate norms while assessing children using the developed binaural fusion test.

II. Comparison of Gender in each Age group

Independent t- test was done to see if there was any significant difference between list I and list II scores for both the genders across ages. Results of the Independent t-test (table 3) revealed that there was no significant difference between gender scores for all the age groups.

Table 3: The results of Independent t-test comparing the Gender effect in each age group.

Age Group (years)	't' value	Significance
7+ to 8	List 1- t(18)= 0.974, p>0.05 List2 -t(18)= 0.172, p>0.05	No significant difference
8+ to 9	List 1- t(18)=1.698, p>0.05 List2 - t(18)= 0.293, p>0.05	No significant difference
9+ to 10	List 1 - t(18)= 0.221, p>0.05 List2 - t(18)= 0.383, p>0.05	No significant difference
10+ to 11	List 1 - t(18)= 0.866, p>0.05 List2 - t(18)= 1.2, p>0.05	No significant difference
11+ to 12	List 1- t(18)= 1.007, p>0.05 List2 - t(18)=1.116,p>0.05	No significant difference

The present findings support the results of Stollman et al. (2004) who also did not find any significant difference between the scores of males and females on a variety of APD tests including binaural fusion test. Shivaprasad (2006) also did not report any significant difference in the performance of males and females in the age range of 7-11.11 years on a measure of binaural fusion test.

Earlier studies have shown that young girls in the age range of 1-5 years are more proficient in language skills, learn to talk at an early age, produce longer utterances and have longer vocabularies than that of boys (Ruble and Martin, 1998, cited in Plotnik 1999). However, even though there appears to be a gender difference in verbal abilities favouring females, this difference is relatively small (Hyde, 1994, cited in Plotnik 1999).

III. Comparison of Lists within each Age group

Paired t-test was done to see if there was any significance difference between list I and list II scores across ages. The results of the Paired t-test showed that there was no significant difference between lists for age groups 7+ to 8 years- [$t(19) = 0.900$, $p>0.05$], 8+ to 9 years –[$t(19) = 0.860$, $p>0.05$], 10+ to 11 years- [$t(19) = 0.490$, $p>0.05$]. However, there was a significant difference between the lists for age groups 9+ to 10 years- [$t (19) = 2.131$, $p<0.05$] and 11+ to 12 years- [$t (19) = 2.604$, $p<0.05$]

The significant difference between the lists for age groups 9+ to 10 years and 11+ to 12 years could be attributed to any chance factor.

IV. Test–Retest reliability

To find out the Test- Retest reliability, Reliability coefficient á was calculated for both the lists. Reliability coefficient was 0.86 for list I and 0.85 for list II.

Conclusions

The present study aimed at developing a Binaural fusion test in Kannada language and establishing the normative data for the test across the 5 age groups of 7-7.11 years, 8-8.11 years, 9-9.11 years, 10-10.11 years and 11- 11.11 years.

The test material was developed using a corpora of 360 CVCV words which were taken from age appropriate Kannada textbooks and 50 words which were familiar to all the children. They were then randomly grouped into 2 phonetically balanced lists, containing 25 words each. List I was picturizable and list II was non picturizable.

The lists were then filtered using a low pass band of 500 to 700 Hz and a high band pass of 1800 to 2000 Hz with the help of Goldwave digital audio editor software and presented at 40 dBSL (with reference to pure tone average) to one hundred children who participated in the study and normative data was collected.

The data obtained was analysed for the presence of age and gender effect. The results showed that there was an improvement in the scores for both List I and List II with an increase in age. These findings are supported by earlier investigations by Plakke, et al. (1981); Neijenhuis et al. (2002); Stollman et al. (2004) and Shivaprasad (2006) who also found an age effect in the scores on Binaural fusion test in children. This increase in age has been attributed to the neuromaturation that takes place in central auditory nervous system till the age of 11-12 years.

The scores for males and females were comparable for both List I and List II, which reflected that there was no gender effect. This was supported by the findings of Stollman et al. (2004) and Shivaprasad (2006) who also reported the absence of any gender effect in the scores on Binaural fusion test for children aged 6- 12 years.

Thus, the Binaural fusion test in Kannada developed in the study can be used to assess children from 7-12 years of age for the presence of any auditory processing disorder. It can be used clinically as an assessment tool for auditory processing disorder in Kannada speaking children.

Limitations

Only two lists for Binaural fusion test were developed in the present study. Additional lists would have helped in finding out if there was any apparent ear effect on the scores.

Future implications

The Binaural fusion test developed in the study can be administered on children with known auditory processing disorder to find out the sensitivity and specificity of the developed test. Also, further research can be done to develop the test in other Indian languages for assessment of auditory processing disorder.

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