Binaural Fusion Test in English for Children

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Abstract

While evaluating individuals with (central) auditory processing disorders it is essential that different processes be assessed. One such process that requires to be evaluated is binaural interaction. Hence the present study was carried out with the intention of developing a binaural fusion test for children speaking English in India. The developed test comprised of four lists of CVC words with each list having 25 phonemically balanced words. These word lists were filtered using a low band pass of 500 Hz to 700 Hz and a high band pass of 1800 Hz to 2000 Hz. The developed test material was administered on 50 normal hearing children in the age range of 7 years to 12 years. The results indicated that as the age increased, performance on the binaural fusion test also increased. However, there was no significant difference between the gender and the lists.

Introduction

When a child has a (Central) Auditory Processing Disorder (C) APD, impairment in the ability to attend, discriminate, remember, recognize or comprehend auditory information occurs. These processing difficulties become more pronounced in challenging listening situations such as noisy backgrounds or poor acoustic environments, great distances from the speaker, speakers with fast speaking rates or speakers with foreign accents (Musiek & Lamb, 1994).

Following routine audiological tests (C) APD is assessed through the use of special tests designed to evaluate the various auditory functions of the brain (Chermak & Musiek, 1997). One such special behavioural test is a binaural interaction tests. There are a variety of tests that are used to evaluate binaural interaction. The commonality of the tests is that the two ears (auditory systems) must interact (Chermak & Musiek, 1997). Binaural interaction tests include Masking Level Difference (Schoeny & Talbott, 1994), Interaural Timing Tasks (Levine et al., 1993), Rapidly Alternating Speech Perception (Willeford, 1977) and Binaural Fusion Test (BFT) (Matzker, 1959). Tests of binaural interaction generally assess the ability of the central auditory nervous system to process disparate, but complementary, information presented to the two ears. Unlike dichotic listening task the stimuli utilized in binaural interaction tasks typically are presented either 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 (Bellis, 1996). Most of these tests have been used clinically.

In India an interaction test that is commonly used is the masking level difference (MLD). Although the MLD test has been shown to have a good sensitive to detect brain stem dysfunction

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(Bellis, 1996) other experts have shown the binaural fusion test to be more sensitive in identifying binaural interaction in children with processing problems (Singer, Hurley & Preece, 1998). Thus, there is a need to develop a binaural fusion test (BFT).

Welsh et. al. (1980) noted that the average intelligibility scores of binaural fusion increased systematically as a function of age in normal children. This reflects the maturation of the central auditory processing mechanism. There is a need to see if similar findings would be obtained in children from other geographical backgrounds. Thus, the present study was carried out with the aim to developing a BFT in English for children in India, obtaining data across different age groups. The study also aimed to investigate if there was any difference in the results between gender and the different lists that were developed.

Method

The entire study was conducted in two stages. In the first stage material was developed. Following this the developed test was administered on a group of normal children in the second stage.

Subjects

For developing the test twenty children in the age range of 7 to 7 years 11 months were taken to ensure that the test material was familiar to children in that age range. Fifty normal children in the age range of 7 years to 11 years 11 months were taken for collecting normative data. These children were grouped into five different age groups each group consisting of 10 children (5 males and 5 females). The age groups were 7 years to 7;11 years, 8 years to 8;11 years, 9 years to 9;11 years, 10 years to 10;11 years and, 11 years to 11;11 years.

Participant selection criteria

In order to be selected for the study the participants had to have a hearing sensitivity within normal limits i.e., air conduction thresholds less than or equal to 15 dB HL in the frequency range of 250 to 8000 Hz in both the ears and the air bone gap less than 10 dB HL. In addition they had 'A' type tympanograms and reflexes present in both the ears and no past history of otological or neurological problems. Their IQ was found to be normal. The educational performance of the children was good/average as per the teachers' report. It was ensured that the children had been studying in schools with English as medium of instruction for at least two years. To screen out any central auditory processing disorder the children had to pass the 'Screening Checklist for Auditory Processing' (SCAP) developed by Yathiraj and Mascarenhas (2003). It was ascertained that none of the children had any illness on the day of testing.

Instrumentation

A Pentium 4 computer with Creative Wave Studio and Sound Edit Pro (Version 2.1.126) software was used to record and to develop the material. A calibrated two channel diagnostic audiometer was employed for selecting the participants and for running the BFT. The presence of middle ear pathology was ruled out using an immittance audiometer. The developed material was played on a CD player (CD_R 700MB).

Test Environment

The testing was done in a sound treated double room. The ambient noise levels were within permissible limits as recommended by ANSI (1989).

Procedure

Stage I: Development of test material:

Initially 300 CVC words that are commonly used were selected from parents, teachers and age appropriate books. These words were presented to 20 children in the age range of 7 years to 7;11 years to check for their familiarity. Each participant was tested individually where they were asked to describe words or show the picture representing the words. For developing the test material 100 words were selected which were familiar to all the twenty children. Using these familiar words four lists were constructed each having 25 words. These lists were phonetically balanced using frequencies of occurrence of English speech sounds in India by Ramakrishna et al. (1962).

Recording of Material

Recording was done using a female speaker who spoke English fluently. Her fundamental frequency was within normal limits (212 Hz) which was measured using the Vaghmi software. The words were recorded in a Pentium 4 computer using the Sound Edit Pro software with a 24000 Hz sampling rate. Scaling of the words was done using the same software to ensure that the intensity of all words was brought to the same level. A five seconds inter-word interval was maintained. These words were band passed using the Sound Edit Pro (Version 2.1.126) 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. The band width for the high and low band passes were the same i.e., 200 Hz.

The four recorded lists were band-passed in the following manner:

- List one and two were filtered such that the low pass band was presented to the left ear and the high band pass to the right ear.
- List three and four were filtered so that the high band pass was presented to the left ear and the low band pass to the right ear.

A 1 KHz calibration tone was recorded prior to each list. The recorded material was burnt on a CD using a CD burner, Nero Express.

Stage II: Evaluation of normal hearing children:

Initially to check the equality of the four lists that were developed the recorded unfiltered stimuli were presented to children aged 7 to 8 year who met the participant selection criteria. All four lists were presented to 20 children at a comfortable listening level (40 dB SL). The stimuli were presented with the help of a CD player through ear phones. The children were required to repeat the words heard. The responses were scored such that a correct response was given a score of one and a wrong response a score of zero. It was found that all the words were repeated in all four lists showing that the four lists were of equal difficulty.

Following this data were obtained for the developed BFT. The test was administered on a group of fifty normal hearing children who met the participant selection criteria. Prior to the administration of the test all children underwent pure tone audiometry. Their speech recognition thresholds were obtained using the English pair-word list developed by Chandrashekar, (1972).

The recorded BFT material that was developed was played using a Philips CD (CD_R 700MB) player. The output of the player was routed to the dual channel diagnostic audiometer Orbiter 922. The 1 KHz calibration tone was used to adjust the volume unit (VU) meter deflection of the audiometer to zero. The output from the audiometer was played at 40 dB SL with reference to the participant's speech recognition threshold. The participants heard the material through head phones (TDH 39 with MX-41/AR ear cushion). All the participants listened to all four lists. The order in which they heard the lists was randomized to avoid a list order effect. The participants were instructed to repeat what they heard. Their oral responses were transcribed by the tester and later scored. A correct response was given a score of '1' and a wrong response a score of '0'.

Results and Discussion

Using the SPSS (Version 10.0) software statistical analyses were done to obtain information on the *list* effect, *gender* effect and *age* effect. Besides using descriptive statistics the list, gender and age effects were analyzed using repeated measures ANOVA, two-way ANOVA and one-way ANOVA respectively. When necessary the Duncan's Post hoc test was used.

1. List Effect

To check the perceptual equality of the four lists prior to the filtering repeated measures of ANOVA was carried out. It was observed that there was no significant difference between the lists [$F(3, 79) = 0.357$, $p > 0.05$]. This indicated that the four phonemically balanced lists were equal in terms of perceptual difficulty. Hence any one of them can be used for determining speech intelligibility and yet provide similar results.

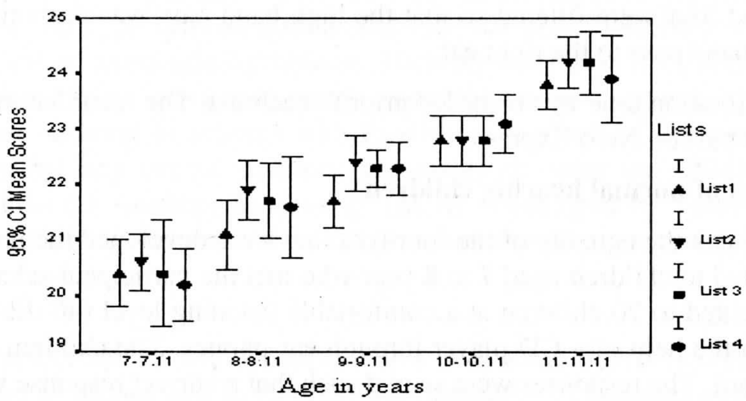

Figure 1: 95% confidence interval (CI) mean scores for different lists across the age groups

Further to check the equality of the four lists developed to evaluate binaural fusion the mean and standard deviation were obtained for the five different age groups. A repeated measure of ANOVA was done in order to find out the effect of test lists. The results indicated that there was no significant difference between the four lists [F (3, 135) = 2.255, p > 0.05]. This was observed across different age groups as well as between males and females. This indicated that distorting the word lists by filtering them and then obtaining binaural fusion scores does not alter the equality of the lists. This is evident from Figure 1 above.

Thus immaterial whether a high pass signal is presented in the left ear and low pass signal in the right ear or vice versa there is no significant difference. Smith et al. (1972), Stollman et al. (2004) and Roush and Tait (1984) also found that there was no significant difference in presentation mode i.e., high pass signal is presented in the left ear and low pass signal in the right ear or vice versa in binaural fusion test.

2. Gender Effect

The mean and standard deviation of the scores on the binaural fusion test was determined for males and females. Two-way ANOVA was done in order to find out the effect of gender on binaural fusion scores. The results indicated that there was no significant difference between males and females for all four lists [F (1, 40) = 0.136, p > 0.05]. This lack of gender difference was seen across different age groups as well as for the four lists that were developed.

Studies have shown that young girls aged 1 to 5 years are more proficient in language skills, talk at an earlier age, produce longer utterances and have larger vocabularies than do boys (Ruble & Martin, 1998, cited in Plotnik, 1999). Although there appears to be a gender difference in verbal abilities favouring girls this difference is relatively small and thus has little practical significance (Hyde, 1994, cited in Plotnik, 1999). The result of the present study also indicated that there exists no significant difference between the performance of males and females across age and across lists. Hence it can be construed that boys and girls in the age range of 7 to 12 years develop in a similar manner with respect to the way in which binaural interaction takes place.

3. Age Effect

As no significant difference was observed between males and females as well as between the lists these scores were combined. Thus for each age group there was one score which represented the average score of the male and female and the values obtained for the four lists.

Table 1: Mean, standard deviation (SD) and confidence intervals for different age groups

			95% Confidence interval for mean	
Age	Mean	SD	Lower Bound	Upper Bound
7 - 7.11	20.4000	0.9554	20.0944	20.7056
8 - 8.11	21.5750	0.9842	21.2602	21.8898
9 - 9.11	22.1750	0.6751	21.9591	22.3909
10 - 10.11	22.8750	0.6480	22.6678	23.0822
11 - 11.11	24.0250	0.8002	23.7691	24.2809

These scores across the different ages are shown in Table 1. ANOVA was carried out to check the significance of difference between means across the five age groups. The results indicated that there was a significant difference between age groups [F (4, 199) = 109.156, p < 0.001].

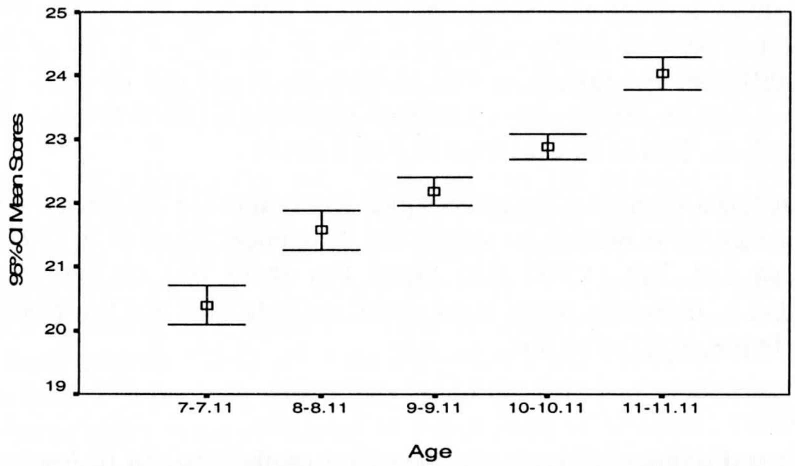

Figure 2: Mean scores for different age groups.

From Table 1 and Figure 2 it is evident that as the age increased from 7 years to 12 years auditory processing ability also increased. To further check the difference between the age groups Duncan's post hoc analysis was carried out.

Table 2: Significance of difference in mean scores between the age groups based on Duncan's Post Hoc test

Age in years	Subset of mean scores for alpha = 0.05				
	1	2	3	4	5
7 – 7;11	20.4000				
8 – 8;11		21.5750			
9 – 9;11			22.1750		
10 – 10;11				22.8750	
11 – 11;11					24.0250

The post hoc analysis (Table 2) shows that there was a significant age difference observed between all the groups. There was a steady increase in the scores with increase in age. Each age group differed significantly from the other. The youngest age group (7-7;11 years) performed the poorest and the oldest age group (11-11;11 years) performed the best. These results suggest that as the age increases from 7 years to 12 years auditory processing ability also increases.

Similar results have been reported in literature also. Stollman et al. (2004) studied the affect of age on central auditory processing using a test battery which included a binaural fusion. They found that as the age increased from 6 to 12 years auditory processing ability also increased. These results indicated that maturation does occur in auditory processing abilities up to an age of 12 to 13 years.

Neijenhuis, Snik, Priester, van Kordenoordt and van den Broek (2002) also studied the age effects and normative data on a Dutch test battery which also included binaural fusion test for auditory processing disorders in 9 to 16 year old children. Their results suggest that age effects were present where performance increased as the age increases from 9 to 16 years. This suggests that maturation of auditory processing abilities takes place even during adolescence.

Current research indicates that neuromaturation of some portions of the auditory system may not be complete until age 12 or later (Bellis, 2003).

The present study also confirms that as the age increases from 7 to 12 years, auditory processing ability grows. This outcome indicated that neuromaturation of the auditory system occurs till age 12 years or later. Further the results of the present study also suggest that when testing children using the binaural fusion test that has been developed, their scores should be checked against age appropriate norms.

Conclusion

It can be concluded from the findings of the present study that there exists no significant difference between the lists developed and that there exists no significant difference in the performance of males and females across ages and across the four lists. However, there was considerable difference in scores of the binaural fusion test across the age groups. As the age increased from 7 to 12 years the performance on binaural fusion task is also increased. Hence, while using a binaural fusion test as a clinical tool age appropriate norms should be referred to.

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Appendix

Binaural Fusion Test in English for Children

Sl.No	List I	List II	List III	List IV
1.	Cage	Nine	Van	Wire
2.	Smile	Ride	Guess	Gun
3.	Keep	Chair	Sell	Shout
4.	Name	Dress	Please	Thin
5.	Will	Join	Note	Youth
6.	Crow	Fish	Tell	Fix
7.	Bird	Voice	Nice	Close
8.	Start	Him	Road	Ring

9.	Root	Loud	Pig	Wheat
10.	Yes	Hunt	Jar	Case
11.	Cup	Pen	Neck	Key
12.	Did	Raw	Live	Rain
13.	Give	Save	Dish	Team
14.	Moon	Bath	Smooth	Fat
15.	Hole	Take	Comb	Bad
16.	Fan	Dog	Choice	Drop
17.	Real	Wife	Make	Front
18.	Teach	White	Talk	Hurt
19.	Coat	Frog	Well	Love
20.	Shell	New	Cap	Chain
21.	Gum	Rose	Done	Neat
22.	Soup	Long	Home	Duck
23.	Ten	Class	Box	Shirt
24.	Match	Hit	Bat	Star
25.	Bowl	Rest	Rat	Had