Original Article

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Speech Perception in Noise among Children with Learning Disabilities

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Abstract

Background: Learning disability is thought to interfere in speech recognition in a large number of individuals. These intelligibility deficits are enhanced in the presence of background noise.The objective of the present study is to compare the Word Recognition Scores of children with Learning Disability (LD) and age matched typical children in the age range of 9 to 12 years, in quiet and in presence of noise (four-talker babble).**Material and Method:**Study group includes 30 children who have been diagnosed with LD and control group has 45 typical children. After otoscopic examination, Pure Tone Audiometry (PTA) and Impedance audiometry, Word Recognition Scores (WRS) were obtained in quiet, +15 dB, +8 dB and 0 dB Signal to Noise Ratios (SNR). Non-parametric tests like Wilcoxon Signed Ranks Test, Mann-Whitney Test, and Kruskal-Wallis Test were used to analyse statistical significance.**Results**: Children with LD have poorer WRS as compared to controls, statistically significant differences ($p<0.05$) are found at +8 dB SNR and 0 dB SNR. Both groups showed reduction of scores with decreasing SNR. **Conclusions**: Children with LD show increased speech recognition deficits in the presence of noise. Moderate amount of background noise can interfere with speech perception and can impair educational outcomes in children, with more effect on younger children. Modifications should be implemented in classrooms and during intervention process of children with LD.

Key-words:Word recognition scores, learning disability, speech perception, background noise, SNR.

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INTRODUCTION

Children with Learning Disability (LD) show uneven areas of ability, short attention span, poor memory, inability to discriminate between letters, numerals, or sounds, poor reading and/or writing ability, eye-hand coordination problems, poor coordination, difficulties with sequencing, disorganization and other sensory difficulties.[1] Studies have shown difficulty in understanding speech in a large proportion of individuals with LD. [2,3,4,5] These difficulties become more severe in the presence of background noise. [6, 7, 8, 9, 10]In the educational environment, children are often expected to multitask. In addition, the educational environment is not always optimal for listening as classrooms have noisy environments. It is generally accepted that noise has a detrimental effect upon learning and educational attainment of school children.[11] Two critical aspects involved in auditory learning are acoustics (ambient noise, reverberation, and the signal to noise ratio) and the hearing ability of the child. The acoustic environment can dramatically decrease effectiveness of teaching and learning. According to American Speech-Language-Hearing Association, ambient noise should be no louder than 30-35 dB in an empty classroom and the signal-to-noise ratios (SNR) should be no lower than +15 dB. Classroom SNRs have typically been reported to be in the range of -7 dB to -5 dB and are often close to 0 dB.[12, 13, 14] The noise levels of 120 classrooms attended by 1st to 8th graders (6-14 years old)in a part of India were recorded.[15] The reported background noise level in the schools at quiet sites is 45 dB A and at noisy sites is 61.1 dB A, which is above the upper limit of background noise for school classrooms.[16] Indian towns and cities are generally noisy due to high population density. In classrooms, there is a single teacher for 50 students. In addition to high noise levels, increased teacher-child distance further reduces the signal-to-noise ratio.[17] Speech perception studies have been used in the past to find the influence of noise on recognition of syllables, words, or sentences especially by children with problems that interfere with academic achievement in mainstream school settings.[18]India is estimated to have approximately ninety million people with varying degrees of Learning Disabilities and an average class in schools has about five students with LD.[19] Most of them are integrated in regular schools which are noisy. It would be interesting to study the effect of noise on recognition of words among children with LD so that necessary recommendations can be considered during their intervention process. Such information will be helpful in making simple modifications to listening environments (e.g. classroom acoustics) for optimizing listening performance and learning in children with learning disability. Thus, the objective of the present study was to compare the Word Recognition Scores of English speaking children with Learning Disability (LD) with age and education matched typical children in the age range of 9 to 12 years, in quiet and in presence of noise (four-talker babble).

MATERIAL AND METHODS

The study was conducted in the Audiology department of Ali Yavar Jung National Institute for the Hearing Handicapped (AYJNIHH), Mumbai and the protocol for the study was approved by its Ethics Committee. All procedures were in strict adherence to the protocol.The study group included 30 subjects (18 Males, 12 Females) with Learning Disability and the control group included 45 typical children (23 Males, 22 Females) in the age range of 9-12 years. In Study group, 10 subjects each and in Control group 15 subjects each were included in 9-10 years, 10-11 years and 11-12 years age range. All the study group subjects were certified from local municipal hospitals for presence of LDand were recruited for the study from local regular English Medium schools and multidisciplinary centres.

Inclusion and Exclusion criteria

For both the study and control group, subjects in the age range of 9-12 years with age appropriate expressive and receptive language skills as screened on Milestones for Early Communication Development,[20] having English as their first language, with bilateral normal hearing sensitivity with pure tone average of the two ears not exceeding 20 dB HL (in the octave frequencies of 250 to 8 kHz) were included. For the study group, subjects having Learning Disability were included. Subjects with a previous history of otologic disease, neurologic disease, vascular disease, metabolic problems, Attention Deficit Hyperactivity Disorder, Pervasive Developmental Disorders, Cognitive Sub-normality, Visual problems, syndromes, Neuro-motor Disorders, abnormal otoscopic findings and middle ear problems were excluded from the study. The demographic details of the participants are shown in Table 1.

Stimulus Material

The speech material consisted of four phonetically balanced word lists with each list having twenty-five words.

Recording of the speech material

A male speaker was selected for recording of stimulus lists. The test material was recorded in a professional recording studio by a sound engineer using Nuendo Version 4.0. The target items were edited using the Adobe Audition version 3.0 software.[21] Four-talker babble was created to be used as the competing signal. Two female and two male adult voices were used for constructing the babble. Each of the speakers was recorded individually at the professional studio. The separate recordings were edited to remove unnatural pauses caused by speaker hesitation. They were then equalized for overall intensity and finally mixed together to construct the four-talker babble.

Equalization of test lists

Equalization procedure was done to establish the equivalence/difficulty level of the 4 lists. The 4 lists of monosyllabic words were tested under +2dB SNR condition in ten typically developing children. These included 8 girls and 2 boys with a mean age of 10.64 and 9.7 respectively. The scores were evaluated for the 4 lists. The mean scores of list 1, list 2, list 3 and list 4 were 82.4, 82.0, 81.4 and 81.6 respectively. T-test was applied and shows that there is no significant difference among the three lists.

Testing Procedure

Informed consents were obtained from the subjects and their parents for participation in the study. Case history was taken in accordance to inclusion and exclusion criteria. Otoscopic examination, impedance audiometry (using GSI Tympstar) and audiological evaluation (using dual channel diagnostic audiometer, GSI 61) were done. The audiological assessment was carried out in a two-room sound treated audiometric test setup which confirmed to American National Standards Institute ANSI S3.1 and International Organization for standardization (ISO) standards for maximum permissible noise level. The stimulus presentation for WRS testing was done on the same audiometer. Two sound field speakers were kept at $+45^0$ and -45^0 azimuth. The distance between the participant and each of the loudspeakers was maintained at 1 meter across all test conditions. Instructions were given to the subjects. The test materialwas played from a laptop computer connected to the External A and External B inputs of the GSI-61 audiometer using a stereo cable. External output was routed to both right and left speakers simultaneously.

Stimulus presentation

The presentation level used for the stimulus material was 55 dB HL. Both, the stimuli as well as the four-talker babble were presented simultaneously through both the speakers. The word lists of 25 words each were randomly assigned to the four listening conditions i.e. quiet, +15 dB SNR, +8 dB SNR and 0 dB SNR. For the quiet condition, stimulus list was presented with no babble noise. For +15 dB SNR, stimulus list was presented at 55 dB HL and four talker babbler at 40 dB HL. For +8 dB SNR, stimulus list was presented at 55 dB HL and four talker babbler at 47 dB HL. For 0 dB SNR, stimulus list was presented at 55 dB HL and four talker babbler at 55 dB HL. Participants were asked to listen carefully and repeat the word which he/she heard in the microphone.

Scoring

A binary scoring procedure in which correct reproduction is scored as 1 and incorrect reproduction is scored as 0 was used. Percentage score for each condition was then calculated by dividing the obtained score by the total number of words (i.e., 25) and multiplying it by 100.

Statistical analysis

Test of normality was applied to test the distribution of the parameters. For this purpose, the one sample Kolmogorov-Smirnov Test was computed, which showed that the parameters did not follow the normal distribution. Therefore, Non-parametric tests like Wilcoxon Signed Ranks Test, Mann-Whitney Test, and Kruskal-Wallis Test were used to analyse statistical significance between the word recognition scores in quiet and noise in typical children and children with LD.

RESULTS

The Mean scores obtained by different age groups in typical children and children with LD as afunction of SNRs is shown in Figure 1.

Effect of listening condition on WRS

To find out whether the difference in mean WRS across the four listening conditions is statistically significant, Wilcoxon Signed Rank Test was applied and is shown in Table 2. Paired comparisons were made for the following six pairs: 0 dB SNR and Quiet, +8 dB SNR and Quiet, +15 dB SNR and Quiet, +8 dB SNR and 0 dB SNR, +15 dB SNR and 0 dB SNR and +15 dB SNR and +8 dB SNR. Statistically significant differences ($p<0.01$) were seen in all conditions.

Effect of Learning Disability

On comparing the scores obtained by different age groups of typical children and children with learning disability for a given listening condition, it was seen that typical children scored higher than children with learning disability for all three age groups in all four listening conditions. Scores obtained by 10-11 year and 11-12 year old children with learning disability in quiet are similar (Mean WRS is 98.80% ranging 92-100), but that of 9-10 year old subjects are lower i.e. 98.00% (range 92-100). Contrary to that, in typical group, 9-10 and 10-11 year old subjects scored similar results (Mean WRS is 98.93%, range 92-100 and 96-100 respectively) and 11-12 year old subjects obtained thehighest obtainable score of 100% in quiet. The results of the Wilcoxon Signed Rank Test and Mann Whitney Test for word recognition scores (WRS) as a function of listening conditions (quiet,

+15 dB SNR, +8 dB SNR, 0 dB SNR) in typical children and children with Learning Disability are presented in the Table 3. It is seen that statisticallysignificant differences (p<0.05) are seen at +8 dB SNR and 0 dB SNR.

Table 1. Demographic details of participants

	GROUP A Typical children				Group B Children with Learning Disability			
	9-10 years	**10-11 years**	**11-12 years**	**Total**	**9-10 years**	**10-11 years**	**11-12 years**	**Total**
N	15	15	15	45	10	10	10	30
Males	7	8	8	23	6	5	7	18
Females	8	7	7	22	4	5	3	12
Mean Age	9.50	10.37	11.51	10.46	9.35	10.45	11.55	10.45
Age Range	9.0-9.9	10.0-10.9	11.0-11.11	9.0-11.11	9.0-9.11	10.1-10.9	11.0-11.9	9.0-11.9
Mean PTARight Ear (dB HL)	17.84	15.27	15.88	16.33	16.17	15.27	18.04	16.64
Mean PTA Left Ear (dB HL)	18.46	15.89	16.47	17.28	15.82	15.89	17.7	16.63

Table 2. Comparison of Word Recognition Score between the listening conditions in typical children and children with learning disability

Listening conditions	**Z(Typical Children)**	**p-value***(2-tailed)*	**Z(Children with LD)**	**p-value***(2-tailed)*
0 dB SNR – Quiet	-5.873**	<0.00001	-4.806**	<0.00001
+8 dB SNR – Quiet	-5.783**	<0.00001	-4.804**	<0.00001
+15 dB SNR – Quiet	-5.248**	<0.00001	-3.922**	<0.00004
+8 dB SNR – 0 dB SNR	-5.547**	<0.00001	-4.363**	<0.00002
+15 dB SNR – 0 dB SNR	-5.764**	<0.00001	-4.747**	<0.00001
+15 dB SNR–+8 dB SNR	-5.130**	<0.00001	-4.430**	<0.00001
Note: *=Significant at 0.05 level of significance				
*****= Significant at 0.01 level of significanc***				

Table 3. Comparison of word recognition score between the test groups in different listening conditions

	Group	N	Mean Rank	Mann-Whitney U	Wilcoxon W	Z	Asymptote Significance P(2-tailed)
Quiet	Normal	45	39.81	593.500	1058.500	-1.266	.206
	LD	30	35.28				
+15 dB SNR	Normal	45	40.79	549.500	1014.500	-1.446	.148
	LD	30	33.82				
+8 dB SNR	Normal	45	42.58	469.000	934.000	-2.298*	.022
	LD	30	31.13				
0 dB SNR	Normal	45	42.13	489.000	954.000	-2.047*	.041.
	LD	30	31.80				

Note: *=Significant at 0.05 level of significance
*****= Significant at 0.01 level of significance***

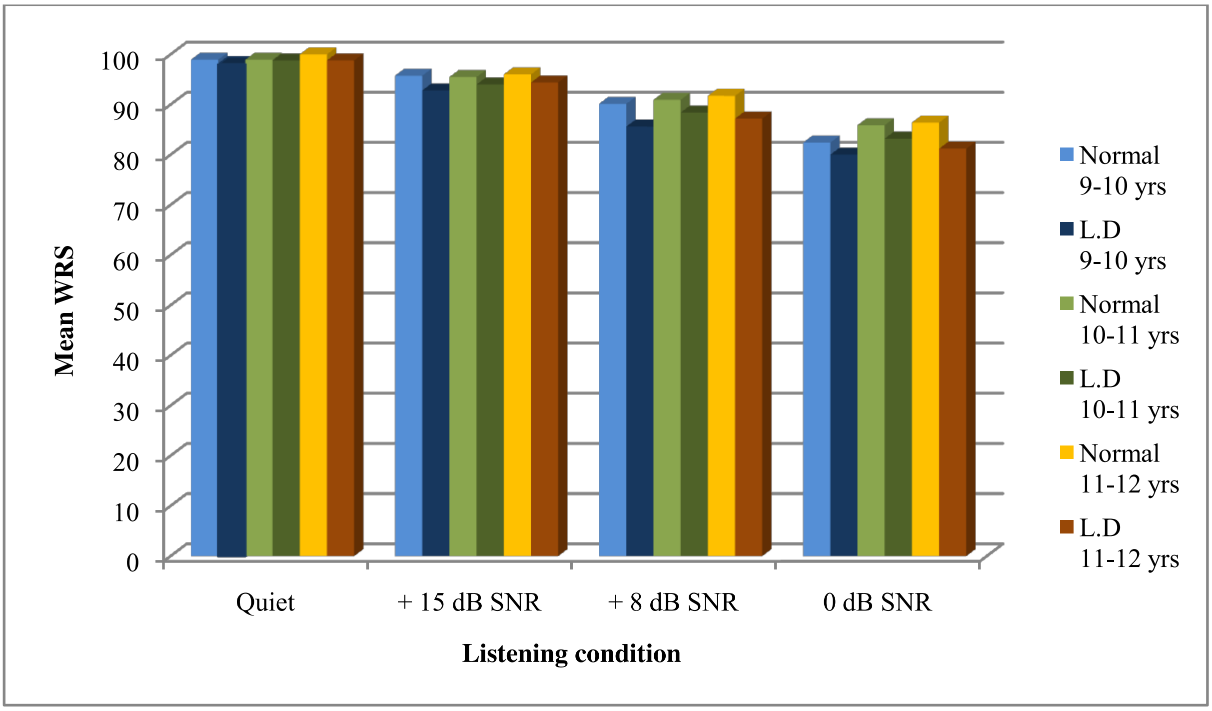

Fig. 1. Mean WRS as a function of SNR in typical children and in children with Learning Disability

Effect of age on WRS

Chi square was applied to find the differences in Word Recognition Scores between the age groups for the four listening conditions. There was no significant difference (p>0.05) in Word Recognition Scores of typical children (p=0.122 in quiet, p=0.857 at +15dB SNR, p=0.517 at +8 dB SNR and p=0.102 at 0 dB SNR) and those with LD (p=0.593 in quiet, p=0.934 at +15dB SNR, p=0.547 at +8 dB SNR and p=0.680 at 0 dB SNR) in the age range of 9 to 10, 10 to 11 and 11 to 12 years.

DISCUSSION

Speech perception ability is the highest at favourable SNRs and decreases as a function of reduction in SNR.[6,22,23,24] In the present study, results show an increase in WRS with an increase in SNR from 0 dB SNR to +15 dB SNR to quiet for both typical children and children with LD across the three age groups (Figure 1). In comparison of different listening conditions, statistical differences were seen in both typical children and children with LD (Table 2). Similar results were found while comparing children with LD to control group on sentence perception in noise[10]. A study was attempted to find recognition in presence of multi-talker babble in children with normal hearing and children with minimal degrees of sensorineural hearing loss, and similar effect of SNR was found in both groups.[25] Thus, there is an increasing difficulty in perceiving speech signals with increase in noise levels. The ability to focus on speech in the presence of competing noise is a developmental skill that evolves with maturation of the brain and mastery of language. The auditory mechanism does not mature fully until the age of 13 to 15 years[26]. Young children are particularly vulnerable to perceptual difficulties in the presence of background noise, and require better acoustical environments. There is a predictable degradation in speech understanding as background noise increases. These studies support the effect of different SNRs as found in the group of 9-12 year old children in present study. Possible explanation for poorer WRS at lower SNR is the greater masking effect for the listeners.There is an effect of noise on the attainments and cognitive performance of primary school children. The effect of acute noise exposure on children’s ability to complete series of verbal and nonverbal academic tasks was assessed[27]. Performance on verbal tasks (reading and spelling) significantly reduces in the classroom babble condition and the speech tasks are negatively affected by the babble. The results obtained in the present study also highlight the need for low background noise, because noise leads to poor learning and performance in the studied age range.In the current study, at all listening conditions, WRS of children with learning disability are poorer than that of typical children of all age groups and statistically significant at +8 dB and 0 dB SNR (Table 3). When the SNR decreases below a certain level (+15dB SNR), children with learning disabilities find it difficult to perceive speech signals. In the past, many studies have revealed significant differences in speech perception in noise between learning disability group and normal group.[10, 28, 29, 30, 31] Thus, there is a positive involvement of LD in the perception of words at low SNRs in children. It is found that minimum +15 dB SNR is required for children with LD to understand speech similar to typical children. Thus it is important to control noise levels for this special group in classrooms and speech therapy rooms.Results of the present study indicate that in typical children and children with learning disability, the WRS of 11-12 year old subjects are better than that of 10-11 year old subjects followed by 9-10 year old across all listening conditions (i.e. +15 dB SNR, +8 SNR and 0 SNR). However, this difference was not statistically significant. The statistical insignificance of the effect of age on WRS in this study may be attributed to thenarrowage range i.e. 9-12-year-old group. The impact of non-sensory perceptual factors like attention, cognition, etc. is minimal in groups made from such a narrow age range.

CONCLUSIONS

Learning disability being a problem of multiple areas has a positive involvement in recognition of monosyllabic words in presence of noise. In all listening conditions, WRS of children with LD are poorer than those of typical children. Noise has a detrimental effect on speech perception, seen in both groups of children. In real life situations, the moderate amount of background noise can interfere with speech perception and can impair educational outcomes in children, with more effect on younger children. Thus, modifications to decrease the background noise should be implemented in classrooms.

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