

Original Article

# Pattern Perception in Quiet and at Different Signal to Noise Ratio in Children with Learning Disability

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**OBJECTIVES:** This study aimed to assess pattern perception at different signal-to-noise ratio (SNR) in children with learning disability (LD) and typically developing children. The first objective of this study was to estimate the identification scores in quiet and at different SNR (0 dB SNR and -5 dB SNR) in children with LD and to compare the result with the typically developing children. The second objective of the study was to estimate identification scores for words differing in syllable length (monosyllable, bisyllable, and trisyllable) for both the groups of children with LD and typically developing children and to compare the result for both the groups.

**MATERIALS and METHODS:** Participants included 60 children including 40 typically developing children and 20 children with LD in the age range 7-11 years. Speech perception was assessed using words varying in syllable length (monosyllables, bisyllables, and trisyllables), and was tested in quiet and at different SNR (0 dB SNR and -5 dB SNR).

**RESULTS:** Compared to typically developing children, perception was affected in children with LD. For children with LD, the perception was best in quiet condition and was least at -5 dB SNR. Trisyllables showed the best result followed by bisyllables and monosyllables.

**CONCLUSION:** Children with LD showed poor pattern perception compared to typically developing children. SNR had a significant effect on the performance of children with LD. The length of the stimuli also had an effect on the perception in children with LD.

**KEYWORDS:** Learning disability, speech perception, signal-to-noise ratio

## INTRODUCTION

Speech communication rarely occurs in favorable listening conditions and speech understanding is compromised in presence of noise. The noise level in a classroom often goes higher than the normal level, which leads to the poor perception of speech in children with speech and language impairment <sup>[1]</sup>. Researchers suggest signal-to-noise ratio (SNR) of +15 dB in the classroom for better perception of speech in children <sup>[2]</sup>.

Learning disability (LD) refers to a group of heterogeneous disorders that may affect the acquisition, organization, retention, understanding, or use of verbal/nonverbal information <sup>[3]</sup>. The major problem faced by children with LD is with academic skill, slow and inaccurate reading, copying, grammar, punctuation mark, and so on. They face difficulties in academic performances. They may write reversals of alphabets and numbers (e.g., 6 for 9 or vice versa). Cognitive factors including attention, memory, and fatigue may affect perception during listening to the speech in presence of noise.

Speech perception happens smoothly when the speech is presented in quiet, but it becomes difficult and demands cognitive processing when the signal is embedded with noise. In classroom condition, learning and recalling become difficult in the presence of background noise. Several studies suggest that learning in the classroom will be better at higher SNR compared to lower SNR <sup>[4]</sup>. Children with higher cognitive functioning show better speech perception in the presence of noise because they use contextual

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cues to understand the speech [5]. Few studies suggest that children find it more difficult than adults to communicate in the presence of noise, and it becomes better as the age increases [2, 6]. To manage such situations, children have to use binaural cues and benefit from fluctuations in the presence of background noise. In spite of unfavorable listening condition, the typically developing children perform to normal level because of the normal phonological processing and memory. But children with LD find it difficult to cope up with the adverse listening conditions because of the underlying poor organization, poor memory, difficulty with sequencing, and short attention span [7]. On an average, five students in a classroom have been noted to have LD in India. The level of difficulty faced by children with LD might vary based on the SNR. However, there is a dearth of literature documenting the speech perception in different SNR in children with LD. This study aimed to assess pattern perception at different SNR in children with LD and typically developing children. The first objective of this study was to estimate the identification scores in quiet and at different SNR (0 dB SNR and -5 dB SNR) in children with LD and to compare the result with the typically developing children. The second objective of the study was to estimate identification scores for words differing in syllable length (monosyllable, bisyllable, and trisyllable) for both the groups of children with LD and typically developing children and to compare the result for both the groups.

## MATERIALS AND METHODS

A total of 60 children, including 40 typically developing children and 20 children with LD in the age range of 7-11 years with a mean age of 8.9 years, were included in this study. All the children were screened for hearing as well as for any speech and language problem. All the children were attending schools with English as a medium of instruction. All the children had an exposure of English language for a minimum of three years. The pure-tone hearing thresholds of all the participants were less than 15 dB HL, and none of them reported having any middle ear pathology. The children were diagnosed as having LD based on the language tests, linguistic profile test [8], and early reading skills test [9] result. Written informed consent was obtained from the class teachers prior to the testing sessions. Institutional ethical committee approval was taken prior to the start of the study. Testing was done in a quiet classroom with minimum distraction.

The pattern perception was assessed using stimuli comprised of monosyllabic, bisyllabic, and trisyllabic English words [10]. This word list was developed for the children in the age range of 6-9 years, and it was ensured that the words used were in the vocabulary of the children. The pattern perception for both the groups was assessed in three different listening conditions (in quiet, 0 dB SNR, and -5 dB SNR) using three different word lists. The stimuli were mixed with speech babble (four talker babble) at different SNR. Speech babble was selected as the background noise in this study based on the result of the pilot study that showed identification scores to be better in presence of speech babble than speech noise. The stimuli at different SNR were generated by keeping the speech level constant and varying the noise level. The stimuli were presented using the Adobe Audition software (version 3.0) loaded on to the laptop and delivered through a calibrated headphone. The level of presentation was at 60 dB SPL. The presentation order of the stimuli was counterbalanced to avoid order effect. Verbal response was obtained from the participants, and the response was audio recorded for further offline analysis.

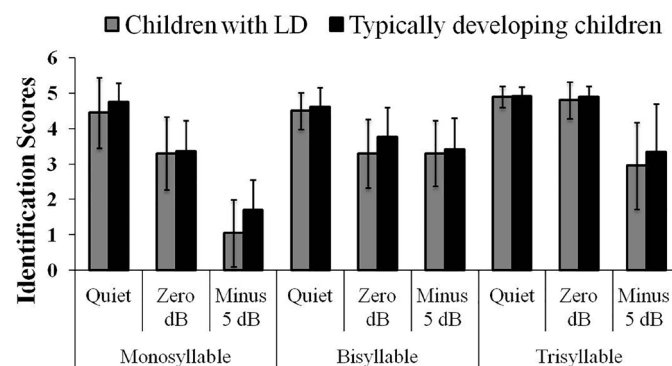
## Statistical Analysis

The percentage correct scores were calculated and used for statistical analysis using the The Statistical Package for the Social Sciences (SPSS) software version 17 (SPSS Inc., Chicago, IL, USA). The data obtained from both the groups of individuals with LD and typically developing children were checked for normality using the Shapiro-Wilks test. The result showed data were normally distributed ( $p > 0.05$ ), and thus parametric test was done.

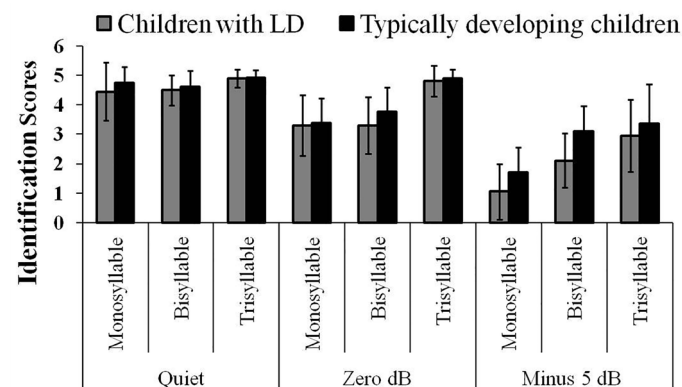
## RESULTS

To investigate the first objective of this study, which was to estimate the identification scores in quiet and at different SNR (0 dB SNR and -5 dB SNR), in individuals with LD and to compare the result with the scores of typically developing children, the data were tabulated and descriptive statistics were done. Figure 1 shows the mean and the standard deviation of the identification scores obtained in quiet and at different SNR in children with LD and typically developing children.

As it is evident from Figure 1, the identification score was best in quiet condition and showed deterioration with a decrease in SNR (0 dB SNR and -5 dB SNR) for both the groups of children with LD and typically developing children. Compared to bisyllables and trisyllables, monosyllables showed greater deterioration in performance with a decrease in SNR.



**Figure 1.** Mean and standard deviation of the identification scores obtained from children with LD and typically developing children across listening conditions (quiet, 0 dB SNR, and -5 dB SNR) for different syllables (monosyllables, bisyllables, and trisyllables). The error bar represents one standard error.



**Figure 2.** Mean and standard deviation of the identification scores obtained from children with LD and typically developing children across syllables (monosyllables, bisyllables, and trisyllables) in different listening conditions (quiet, 0 dB SNR, and -5 dB SNR). The error bar represents one standard error.

As shown in Figure 2, trisyllables were perceived maximally followed by bisyllables, and performance was least for monosyllables. A similar pattern was seen in all the listening conditions (quiet, 0 dB SNR, and -5 dB SNR). The variation in response was also more at -5 dB SNR as shown by the increased error bar.

To analyze statistically, repeated measures ANOVA was performed with the listening conditions (quiet, 0 dB SNR, and -5 dB SNR) and syllables (monosyllables, bisyllables, and trisyllables) as within-subject factor and groups (typically developing children and children with LD) as the between-subject factor. The results showed significant main effect of listening condition [ $F(2, 116) = 173.43, p < 0.05$ ] and syllables [ $F(2, 116) = 130.69, p < 0.05$ ] on the pattern perception. However, none of the two ways interactions were significant ( $p > 0.05$ ). Further, pairwise comparison with Bonferroni's correction revealed a significant difference between the all the syllable pairs ( $p < 0.05$ ) and listening conditions ( $p < 0.05$ ). Results revealed trisyllables to be perceived best followed by bisyllables and least perceived was monosyllables ( $p < 0.05$ ). The pattern perception was best in quiet condition followed by 0 dB SNR and performance deteriorated at -5 dB SNR.

Error pattern analysis was done for the data obtained from both the groups of children with LD and typically developing children. The frequency of errors was more in children with LD compared to typically developing children. Children with LD showed errors on 22 of 45 words presented to them, whereas typically developing children showed error only on 12 words presented to them. Children with LD showed more of substitution error followed by deletion. The children with LD also showed cluster reduction error and error with glides that was not seen in typically developing children. Commonly observed errors in children with LD were substitution, where the posterior sounds are substituted by frontal sounds, for example, /pakey/ for /hockey/, /pool/ for /cool/, /palender/ for /calender/, /bow/ for /cow/. Next, errors showed anterior sounds substituted by posterior sounds, for example, /cage/ for /page/, /clay/ for /play/, /gost/ for /post/. Next seen error was cluster reduction: /codile/ for /crocodile/, /kool/ for /school/ then glide errors /wife/ for /roof/, /liver/ for /river/, /wine/ for /rain/, then seen error was nasalization where oral sounds are substituted for nasal sounds, /buttom/ for /butter/, /system/ for /sister/. Voiced sounds substituted for voiceless sound was the next commonly seen error, for example, /ball/ for /wall/, /boost/ for /post/. Other frequently seen errors were final consonant deletion: /man/ for /mango/, /ban/ for /bank/, /butter/ for /butterfly/; and initial consonant deletion /groo/ for /kangaroo/, /nature/ for /furniture/, /mato/ for /tomato/. Addition error was also seen, for example, /mountains/ for /mountain/. Same pattern of errors was seen in typically developing children but with less frequency of errors.

## DISCUSSION

The result of this study showed better pattern perception in typically developing children compared to children with LD. The perception was observed to be poorer for all the different syllables (monosyllables, bisyllables, and trisyllables) compared to typically developing children. The poor perception of syllables in children with LD compared to typically developing children could be because of the poor phonological representation of speech. The deficit is found to be even more in presence of adverse listening conditions<sup>[2, 6]</sup>. In quiet situation, monosyllable, bisyllables, and trisyllables showed similar performance for both the groups of children with LD and typically developing children. In ad-

verse listening condition, that is, at 0 dB SNR and -5 dB SNR, trisyllables were perceived better compared to monosyllables and bisyllables; and the reason could be because of the advantage of durational cues (trisyllable being longer in duration, followed by bisyllable and monosyllable). The better perception of longer duration stimuli as compared to short duration stimuli could be because of the more lexical activation for the longer stimuli compared to a shorter one<sup>[11]</sup>.

Comparing across listening conditions, it was found that the children with LD showed poor performance for words at 0 dB SNR and -5 dB SNR, which suggests a greater masking effect of noise on the speech stimuli. Other researchers reported similar findings, where children with LD had poor speech in noise performance for words and sentences than the typically developing children, and the performance deteriorated with decreasing SNR<sup>[2, 6]</sup>. It is recommended that the minimum of +15 dB SNR is maintained in the environment of children with LD to make them understand speech same like typically developing children<sup>[2]</sup>. It has been shown that the poor SNR in the classroom affects the reading and the spelling ability of the children with LD more than the typically developing children.

## CONCLUSION

This study showed poor pattern perception in children with LD compared to typically developing children. The perception was better for longer duration stimuli compared to shorter duration stimuli, and the durational advantage was maximum at lower SNR. The level of noise also had an effect on the overall performance of the children, showing better performance at a lower noise level. The result of this study will help the clinician in selecting the optimal listening condition for the rehabilitation of children with LD. The result also suggests clinicians to use longer duration stimuli while rehabilitating the child with LD. This study suggests the need for modification in the classroom to decrease the overall noise level.

**Ethics Committee Approval:** Ethics committee approval was received for this study from Ethics Committee of JSS Institute of Speech and Hearing, Mysuru, Karnataka, India.

**Informed Consent:** Written informed consent was obtained from the patients who participated in this study.

**Peer-review:** Externally peer-reviewed.

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**Conflict of Interest:** The authors have no conflict of interest to declare.

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