Original Article

Speech Perception in Quiet and in Different Types of Noise in Children with Learning Disability

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Abstract

Introduction: Studies suggest that children with learning disability (LD) have poor phonological representation. Furthermore, in individuals with LD, it has been reported that in spite of having normal intelligence, they have poor speech perception in quiet and in the presence of noise. As per the literature, there was no published report which highlights pattern perception in quiet and in the presence of different types of noise in children with LD. Thus, the present study aimed to assess pattern perception in quiet and in the presence of noise in typically developing children and in children with LD. **Methods:** A total of forty children including twenty typically developing children and twenty children with LD in the age range of 5–10 years were included in the study. Word identification scores were calculated in quiet and in the presence of different types of noise at 0 dB signal-to-noise ratio. The words used as stimuli contained a different number of syllables (monosyllable, bisyllables, and trisyllables). **Results:** Children with LD had poor performance in quiet, in the presence of speech babble, and speech noise compared to typically developing children. The response was best in quiet condition followed by in presence of noise (speech babble and speech noise). Compared across noise conditions, the responses obtained in the presence of speech noise did not differ significantly compared to response obtained in the presence of speech babble. Compared across syllables, trisyllables yielded the best result followed by bisyllables and the least perceived was monosyllables. **Conclusion:** The present study highlights the poor phonological processing of speech in children with LD and also represents the effect of noise on the speech perception. This study also highlights the poor pattern perception seen in children with LD.

Keywords: Learning disability, pattern perception, speech babble, speech noise, speech perception

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Introduction

Speech perception in the presence of noise depends on many factors, including sensory and cognitive processes and the interaction between them.[1] Extracting the target sound from the competing signal depends mainly on the spectrotemporal cues.[2,3] Major spectral cues responsible for speech perception are spectral tone, inflection, location, timing, pitch, and acoustic structure of the speech.[4] In the presence of noise, the acoustic features of the speech might get disturbed resulting in a reduction of modulation in the signal or addition of spurious modulation. There are varieties of clinical conditions, where individuals find it difficult to cope up with the daily listening environment, especially in unfavorable listening conditions. Some of the individuals with poor speech perception in noise are with central auditory processing disorders, auditory neuropathy spectrum disorder, and learning disability (LD). LD is a neurodevelopmental disorder that impedes the ability to learn or use specific academic skills, such as reading, writing, or arithmetic. The individuals with LD will have the short attention span, poor memory, difficulty in discriminating between letters, numerical or sounds, poor reading and writing abilities, difficulty in sequencing, poor coordination, disorganization, difficulty in finding important points or ideas, confusion of similar words, difficulty in the following direction, and other sensory difficulties.[5] Individuals with LD also shows poor phoneme discrimination and identification abilities. Individuals with LD show difficulty in letter-sound decoding as well as written word identification in spite of having adequate intelligence,[6] and this deficit is enhanced in the presence of

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background noise.[7] The above-mentioned difficulties might result due to poor phonological representation and thus poor phonological awareness.[8,9] Children with LD are not getting benefit from stimulus regularities as evident on the response obtained from stimuli with regular repetition compared to stimuli with variable presentation.[1] Few researchers have suggested that the speech perception in the presence of noise do not correlate well with the speech perception in quiet and the pure-tone thresholds.[10] The phonological deficits hypothesis holds that children with LD have difficulty with constructing, maintaining, and retrieving phonological representation.[11] The poor phonological representation may affect speech perception, especially in the presence of noise. Furthermore, in individuals with LD, it has been reported that in spite of having normal intelligence. they have poor speech perception in quiet as well as in the presence of noise.[12] However, there is a dearth of literature stating the mechanistic relationship between central processes and speech perception in noise. In addition, there are fewer studies about speech perception in different types of noise in children with LD.[7] As per the literature, there was no published report which highlights pattern perception in quiet and in the presence of different types of noise in children with LD. Thus, the aim of the present study was to assess pattern perception in quiet and in the presence of noise in typically developing children and in children with LD.

Methods

A total of forty children, including twenty typically developing children and 20 children with LD were the participants. The children with LD were in the age range of 5.0–10.0 years (mean age 8.8 years) and age-matched typically developing children were considered. All the 40 children included in this study were screened for hearing as well as for any speech and language problem. All the forty children showed normal hearing sensitivity in both the ears with thresholds better than 15 dB HL for the frequencies from 250 Hz to 8000 Hz and had no prior otological complaints. All the children had Kannada as their mother tongue and English as the medium of instruction in school. All the children were attending primary school, had a minimum of 3 years of exposure to English, and were a fluent speaker of English. The children were diagnosed as having LD based on the language tests that are linguistic profile test (LPT)[13] and early reading skill (ERS)[14] test results. LPT was used to assess the language proficiency of the children under three main sections: phonology, syntax, and semantics. Typically, developing children showed age-appropriate performance on all the three sections of LPT. ERS was used for grade-level assessment of the children and all the children who were lacking behind by two grades were considered as having LD. Written informed consent was obtained from the class teachers prior to the testing sessions. Institutional ethical committee approval was obtained before starting the study. Testing was done in a quiet classroom with minimal visual and auditory distraction. The test room was selected away from the busy area of the school such as classroom with students, playground, canteen, and generator room.

The test stimuli included English monosyllabic, bisyllabic, and trisyllabic words.[15] This word list was developed for the children in the age range of 6–9 years. The pattern perception for both the groups was assessed in three listening conditions (in quiet, in the presence of speech noise, and speech babbles). Four talker babble with two males and two females voices were used in this study. The signal-to-noise ratio (SNR) selected for this study in the noise condition was 0 dB SNR. 0 dB SNR was selected based on the pilot study. It was observed that 0 dB SNR yielded word identification scores above chance level (scores >50%) and −5 dB SNR showed performance below the chance level (scores <50%) for the children with LD. The stimulus presentation level across different conditions was the same, and it was 60 dB sound pressure levels. Three equivalent word lists having five monosyllabic, five bisyllabic, and five trisyllabic words were considered for this study. One list per listening condition was administered to each participant. The presentation order of the stimuli was counterbalanced across number of syllables and listening conditions in order to avoid order effect. The speech stimuli were mixed with speech noise and speech babble using Adobe Audition software (Adobe Systems Inc, California, USA). The stimuli were presented through a calibrated headphone. The children were instructed to repeat the words as correctly as possible and were allowed to guess the words in case it was not clearly perceived. The response was audio recorded for offline analysis, and the correct responses (number of words repeated correctly) were scored and analyzed by SPSS software (version 17, SPSS Inc., Illinois, USA). The correct response, as well as the error pattern analysis, was done for the data obtained from all the participants.

Results

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 that the data were normally distributed ($P > 0.05$), and thus, the parametric test was done. To investigate the first objective, that was to estimate the identification scores in quiet and in presence of different types of noise (speech noise and speech babble) in individuals with LD and typically developing children, the data were tabulated, and descriptive statistics were done. The mean and standard deviation of the identification scores for the different listening conditions (quiet, speech noise, and speech babble) and syllables (monosyllables, bisyllables, and trisyllables) are shown in Figure 1. As evident from Figure 1, the identification score was best in quiet condition and scores reduced in the presence of noise (speech noise and speech babble).

To investigate the second objective of the study, that was to estimate identification scores for words differing in syllable length (monosyllable, bisyllables, and trisyllables) for both the groups of children with LD and typically developing children, the mean and the standard deviation of the data was calculated and

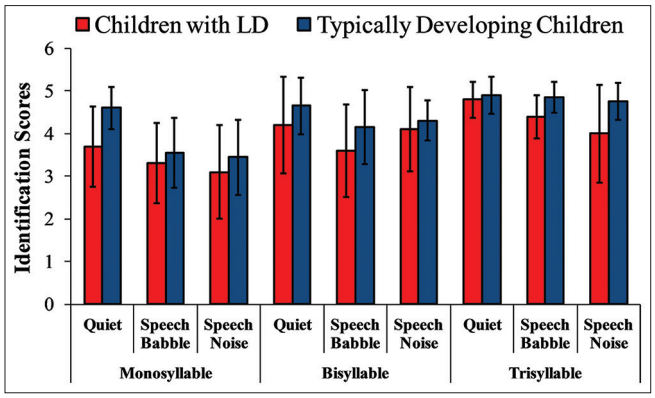

Figure 1: Identification scores obtained in three different listening conditions (in quiet, in speech babble, and speech noise) for the syllables (monosyllables, bisyllables, and trisyllables) in children with learning disability and typically developing children. The error bar represents one standard error

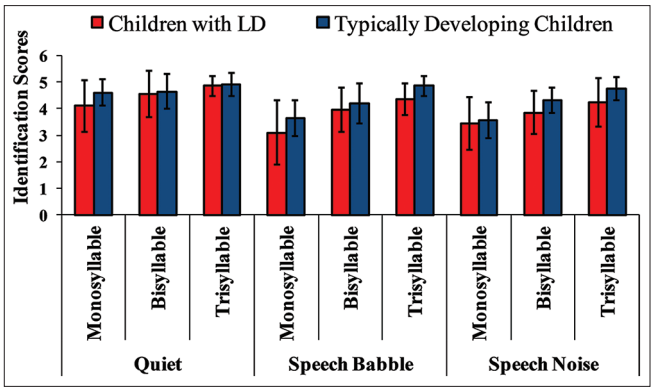

Figure 2: Identification scores obtained for the syllables (monosyllables, bisyllables, and trisyllables) in children with learning disability and typically developing children in three different listening conditions (in quiet, in speech babble, and speech noise). The error bar represents one standard error

is shown in Figure 2. As evident from Figure 2, scores were least for monosyllables followed by bisyllables and scores were best for trisyllables. The pattern was similar across all the listening conditions (in quiet, speech babble, and speech noise) for both the groups of children with LD and typically developing children.

To analyze statistically, repeated-measures ANOVA was performed with the listening conditions (quiet, speech noise, and speech babble) 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 conditions ($F[276] = 33.14$, $P < 0.01$]) and syllables ($F[276] = 51.75$, $P < 0.01$) on the pattern perception of typically developing children and children with LD. The main effect of groups was also significant ($P < 0.01$). However, none of the two way interactions were significant. Further, pair-wise comparison with Bonferroni's correction revealed a significant difference between all the syllables pairs ($P < 0.05$). Trisyllables were perceived significantly better than the bisyllables, followed by monosyllables ($P < 0.01$). Pair-wise comparison for the listening condition showed significantly better pattern perception in quiet compared to in speech babble and speech noise condition ($P < 0.01$) but did not show a significant difference between speech babble and speech noise listening conditions ($P > 0.05$).

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 23 words out of a total of 45 words presented to them, whereas typically developing children showed error only on 14 words presented to them. More commonly observed error in children with LD was fronting, were the posterior sounds are substituted by frontal sounds (e.g.,/pockey/for/hockey/,/pool/for/cool/,/propodile/for/crocodile/,/boat/for/goat/). Following fronting error was backing errors, where posterior sounds are substituted for anterior sounds (e.g.,/cot/for/pot/,/clay/for/play/,/goof/for/roof/). Next commonly seen error was nasalization where nasal sounds are substituted for oral sounds (/button/for/butter/,/now/for/cow/,/system for/sister/). Substitution of voiced for voiceless sound was the next commonly seen error (/ball/for/wall/,/bot/for/pot/,/tynasaur/for/dynasaur/). Other errors which are frequently seen are final consonant deletion (/car/for/card/), weak consonant deletion (/kangu/for/kangaroo/,/aney/for/money/), and substitution of sounds within same manner of articulation (/finger/for/singer/). Substitution within the same place and manner of articulation was less commonly seen than other errors. Typically, developing children showed errors pattern similar to that of children with LD, but with less number of errors.

Discussion

The results of the present study showed poorer performance for the children with LD across all the listening (quiet, speech noise, and speech babble) and syllables (monosyllables, bisyllables, and trisyllables) conditions compared to typically developing children. In children with LD, the performance was best in quiet condition and showed deterioration in the presence of noise. The performance of children did not vary with different types of noise. With respect to a number of syllables, trisyllables were perceived better followed by bisyllables and monosyllables. The children with LD do not show any structural abnormality in the auditory system, the difference in the performance of the children with LD and typically developing children might result from the subtle functional deficit in the auditory pathway in children with LD. This difference in performance between the children with LD and typically developing children might be the result of poor phonemic representation in the auditory pathway in children with LD.[8,9] The finding of the present study supports the previous report that children with LD have poor phonological representation and results in poor speech perception in noise.[7,16]

In the present study, the pattern of speech perception seen in children with LD was similar to that of typically developing children. The perception was best in quiet condition compared to

in noise condition for all the syllables. Although not statistically significant, the pattern perception was found to be better for syllables presented with speech babble compared to speech noise. The better pattern perception in the presence of speech babble compared to speech noise shows the better release of masking in speech babble compared to speech noise.[17] This could be because of the amplitude fluctuation seen in speech babble compared to speech noise. The other reason could also be because the children in school setup get accustomed to the speech babble (speech of the fellow classmates) in the classroom and thus perform better with speech babble in the test situation than the speech noises. Other researchers suggest that the reduction in speech performance in presence of noise is because of the reduction in the speech feature robustness or contrast between the speech and the noise.[18]

Both the groups of children with LD and typically developing children showed a better perception of trisyllables compared to monosyllables and bisyllables. The better perception of trisyllabic words compared to bisyllabic words and monosyllabic words could be because of the advantage of durational cues (trisyllabic words being longer in duration, following bisyllabic words and monosyllabic words). One of the probable reasons for the better perception of longer duration stimuli as longer words generate more lexical activation than a shorter one.[19] Error pattern analysis in the present study showed more substitution errors in children with LD compared to typically developing children, which also supports the previous findings.[20,21] The error patterns seen in the present study in children with LD are as follows: substitution more commonly seen followed by deletion and distortion. With respect to substitution errors, place of articulation showed more substitutions when compared to the manner of articulation and voicing.[18] The difference in error patterns seen in children with LD and typically developing children could be because of the difference in phonological processing between the groups. The perception of speech will also be important in the phonological deficit associated with reading failure.[22]

Summary and Conclusion

The present study highlights the poor pattern perception seen in children with LD compared to typically developing children. The children with LD showed more disturbances in speech perception in the presence of noise compared to in quiet condition. The error analysis showed the difference in error pattern among the two groups of children with LD and typically developing children which could be the result of the difference in the underlying phonological processing in both the groups. The finding of the present study will help the clinician to assess the error pattern in children with LD and will also help in rehabilitating the children with LD.

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Conflicts of interest

There are no conflicts of interest.

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