



Sensory deprivation due to otitis media episodes in early childhood and its effect at later age: A psychoacoustic and speech perception measure



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ABSTRACT

Background: Past research has reported that children with repeated occurrences of otitis media at an early age have a negative impact on speech perception at a later age. The present study necessitates documenting the temporal and spectral processing on speech perception in noise from normal and atypical groups.

Objectives: The present study evaluated the relation between speech perception in noise and temporal; and spectral processing abilities in children with normal and atypical groups.

Methods: The study included two experiments. In the first experiment, temporal resolution and frequency discrimination of listeners with normal group and three subgroups of atypical groups (had a history of OM) a) less than four episodes b) four to nine episodes and c) More than nine episodes during their chronological age of 6 months to 2 years) were evaluated using measures of temporal modulation transfer function and frequency discrimination test. In the second experiment, SNR 50 was evaluated on each group of study participants. All participants had normal hearing and middle ear status during the course of testing.

Results: Demonstrated that children with atypical group had significantly poorer modulation detection threshold, peak sensitivity and bandwidth; and frequency discrimination to each F0 than normal hearing listeners. Furthermore, there was a significant correlation seen between measures of temporal resolution; frequency discrimination and speech perception in noise. It infers atypical groups have significant impairment in extracting envelope as well as fine structure cues from the signal.

Conclusion: The results supported the idea that episodes of OM before 2 years of age can produce periods of sensory deprivation that alters the temporal and spectral skills which in turn has negative consequences on speech perception in noise.

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1. Introduction

Otitis media is a common disease characterized by the accumulation of fluid in the middle ear space. It occurs secondary to infection at the upper respiratory tract with poor Eustachian tube function. It is also associated with minimal to moderate degree of hearing loss with fluctuating nature. The associated hearing loss can be corrected by medication and surgical corrections. Though the hearing loss lessen and come back to normal audibility range

after medical treatment, there is a evidence that children with otitis media (OM) at earlier ages have subtle difficulty in speech perception in adverse listening conditions [1,2]. In children with frequent attacks of otitis media, auditory input may fluctuate constantly. This temporary reduction in auditory input has negative consequences on speech processing at the later ages [3,4]. The age of onset, number of episodes and duration of otitis media have a direct relation to central auditory processing [5]. Incidence of OM is found to be higher in the first 3 years of life [6]. In Indian scenario there is no such evidences as that of western population, WHO [7] reported that 83% of the hearing impaired population in India are suffering from OM.

Past researches have demonstrated that early OM in children

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influences speech perception abilities. Schilder, Snik, Straatman and van den Broek [8] studied effect of otitis media with effusion at preschool age on speech perception skills. A significant effect of Otitis Media with Effusion (OME) was found on the speech-in-noise test. It is believed that when the spectral cues and temporal cues were altered by noise, children who had a history of OM find it difficult to extract inherent cues to follow the message. Mody, Schwartz, Gravel and Ruben [9] investigated speech perception abilities on children with and without history of OM. Stimuli of varying degrees of phonetic contrast were administered on these groups at the age of nine years. The children who had OM positive, performed poorly in phonetically similar stimulus than OM free group. In addition Petinou, Schwartz, Gravel, and Raphael [10] documented that children who had history of OM have performed poorly on morpho-phonological skills. This suggests that occurrence of OM at the earlier age had a negative impact on phonological awareness and speech and language comprehension at the later life [1,11,12]. The literature review clearly infers that children with OM occurred repeatedly at early stage has negative impact on subtle speech and language processing skills at later milestones though the children are provided with appropriate medical care. Now the research question is do children with history of recurrent OM exhibits impairment on sentence perception at later age due to subtle speech perception problem at early age?

In the present study 7–9 years old children who had episodes of otitis media attacks (less than 4 episodes, 4 to 9 episodes and more than 9 episodes) before the age of 4 years were compared with children without episode of otitis media were enrolled. We focused to investigate the temporal processing by temporal modulation transfer function. Peak sensitivity and bandwidth were derived from modulation threshold at different frequencies. These provide information on temporal resolution skills in children who had a history of recurrences of OM at early childhood days. In addition, complex tone was derived by adding 2 to 5 harmonics of corresponding fundamental frequency of having same amplitudes and phase. These complex tones were used for discrimination test such that it directly assesses the frequency discrimination ability. Further, speech perception in noise requires one's ability of temporal and spectral processing skills as noise obliterates temporal cues and distorts the spectral cues.

The secondary effect of OM extends difficult to comprehend complex message which leading to label them as slow learners. Thus, the purpose of the study is to document consequences of repeated occurrences of otitis media on speech perception in noise sheds light on which processing skill might have been strongly utilized than other to follow speech can be addressed. The alternative hypothesis was formulated as children who had a history of otitis media found to have difficulty experience to follow speech perception in noise due to imprecise temporal and spectral processing.

2. Method

A standard group research design was utilized to study the effect of recurrent OM at an early stage and its consequences at a later stage with the age matched typical normal children on spectral and temporal processing and sentence perception in noise.

2.1. Participant's selection criteria

A total of 40 participants were involved in the study. They were classified into four groups. Atypical group comprised of thirty children within the age range of 7–10 years, who all had otitis media (OM) in their chronological age between 6 month and 2 years. The selected children were further sub-grouped into three,

based on the episodes of OM a) less than four episodes b) four to nine episodes and c) more than nine episodes. Normal group comprised of ten children. None of the children had history of OM. Normal group children were matched for age and socio economic status with that of the atypical group. All the participants had normal hearing sensitivity. Pure tone audiometry thresholds at octave frequencies (250 Hz–8 kHz) were within normal limits in all the participants. The middle ear status was normal such that all children had 'A' type tympanogram for conventional 226 Hz probe tone frequency. All the children belonged to lower socioeconomic status, which was confirmed by administering the screening test to assess the socioeconomic status developed by Venkateshan [13]. All the children were native speakers of Kannada and are attending normal school. Further from each child's parent the written consent was taken after explaining the purpose and procedure of entire study.

2.2. Test environment

Testing was carried out in a sound treated double room, with the ambient noise levels within permissible limits as recommended.

2.3. Procedure

Two experiments were carried out. In experiment-1 temporal and spectral processing were performed. Experiment-2 was conducted to estimate the noise level at which a score of 50% obtained on sentence recognition.

2.3.1. Experiment-1

2.3.1.1. Temporal processing - temporal modulation transfer function

2.3.1.1.1. Generation of amplitude modulated white noise. Temporal modulation transfer function was used to assess the temporal resolution ability in children who had with and without OM. The TMTF stimuli developed by Narne [14] who adapted procedure of Lorenzi, Dumint and Füllgrabe [15] were utilized. The stimuli comprised of unmodulated noise and modulated sinusoid. These two stimuli were generated using a sampling frequency of 44.1 kHz with 16 bit resolution. Each stimulus was having 500 ms duration with a raised cosine ramp of 20 msec. The modulated signal was generated by multiplying the unmodulated noise by a dc shift of modulating sin wave. The modulation depth of each modulated signal (fm) in Hz (4, 8, 16, 32, 64, 120 and 256) was varied by changing its amplitude between 0 and -30 dB. Where 0 dB means 100% modulation and -30 dB means no modulation. The depth of modulation threshold in dB was obtained for each modulation frequency using below equation

$$\text{Modulation depth (dB)} = 20 \log_{10}(m)$$

Where, m = threshold of lowest modulation depth that the children can detect.

2.3.1.1.2. Procedure. The modulated threshold at each modulated frequency was determined based on three alternative forced choice (AFC) method with a 2 down and 1 up adaptive method (estimate 70.7% correct point on psychometric function). In this method, a set comprised of three stimuli having one modulated signal and other two unmodulated white noise were sequentially presented. The participant was instructed to identify the modulated signal that is different from other two. The modulated signal depth was reduced after two correct responses and increased the depth of modulated signal after incorrect response. Initially modulated step size of 4 dB was used and then reduced to 2 dB after two reversals. The mean of last eight reversals in a block of 14 was taken as a threshold. The presentation of TMTF stimuli were

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