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Medial olivocochlear function in children with poor speech-in-noise performance and language disorder

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A B S T R A C T

Objectives: Contralateral masking of transient-evoked otoacoustic emissions is a phenomenon that suggests an inhibitory effect of the olivocochlear efferent auditory pathway. Many studies have been inconclusive in demonstrating a clear connection between this system and a behavioral speech-in-noise listening skill. The purpose of this study was to investigate the activation of a medial olivocochlear (MOC) efferent in children with poor speech-in-noise (PSIN) performance and children with language impairment and PSIN (SLI + PSIN).

Methods: Transient evoked otoacoustic emissions (TEOAEs) with and without contralateral white noise were tested in 52 children (between 6 and 12 years). These children were arranged in three groups: typical development (TD) (n = 25), PSIN (n = 14) and SLI + PSI (n = 13).

Results: PSIN and SLI + PSI groups presented reduced otoacoustic emission suppression in comparison with the TD group.

Conclusion: Our finding suggests differences in MOC function among children with typical development and children with poor SIN and language problems.

1. Introduction

Efferent pathways are present along the auditory system, with connections from the cortex to the most peripheral structures. However, their anatomy is still not perfectly known [1].

The most known circuit of the efferent system, according to Warr and Guinan [2], is the set of fibers originating from the olivary complex, called the olivocochlear bundle, comprising two main tracts: medial and lateral. The lateral tract arises from the lateral superior olive nucleus and its surrounding area. It is predominantly composed of unmyelinated and ipsilateral fibers, which project to the inner hair cells (IHC) of the cochlea. The medial tract is composed of myelinated fibers arising from the surrounding area of the medial superior olive. Most fibers (approximately 80%) cross to the opposite cochlea, where they connect directly to the outer hair cells (OHCs) [3] and [4].

With the discovery of otoacoustic emissions (OAEs) [5], the efferent pathway of the medial olivocochlear (MOC) system fibers has been getting special attention [6]. MOC fibers project from the superior olivary complex to innervate the OHCs of the cochlea through cholinergic synapses. Physiologically, MOC activation causes hyperpolarization of an OHC, inhibiting its electromobility and reducing the cochlear amplification gain [4]. This alteration in the amplitude of an OAE is called inhibition or suppression of the MOC system.

The function of the medial efferent system is complex, since it involves different action mechanisms mediated by the medial and lateral tracts of the olivocochlear bundle. The integrity of this system allows for a decrease in the amplitude of otoacoustic emissions, a decrease of the action potential N1 of the cochlear nerve, a localization of the sound source and an improvement in detection of a sound source in noisy environments, protection against acoustic trauma, an improvement of auditory sensitivity, control of the mechanical condition of the cochlea, selective attention, and a reduction of the masking noise effect [4,7], and [8]. Regarding this last function, it has been demonstrated that the activity of the medial olivocochlear (MOC) system may be involved in signal

Abbreviations: MOC, medial olivocochlear; SIN, speech-in-noise; TEOAE, Transient-evoked otoacoustic emissions; SIN, Speech-in-Noise; TD, Typical Development; PSIN, Poor Speech-in noise; SLI, Specific Language Impairment; ASHA, American Speech-Language-Hearing Association; MLU, Mean Length of Utterance; TELD, Test of Early Language Development; IQ, Intelligence Quotient; ANOVA, Analysis of Variance; SLP, Speech Language Pathologist.

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perception in noise.

Researchers have been assigning an important role to the MOC system in the performance of the ability of speech intelligibility in noise [4] and [9]. Studies using computational models of the cochlea and speech recognition have shown that the activation of the MOC system improves speech-in-noise recognition [10] and [11].

Therefore, the integrity of the MOC system in humans, influenced by corticofugal modulation [12], must be of great importance to the functioning of the peripheral auditory system [13] as well as for the improvement of auditory processing, especially for listening in noise [9].

Many studies have shown that the medial efferent system is related to the suppression effect of otoacoustic emissions observed when there is contralateral noise. Otoacoustic emissions (OAEs) are generally reduced by efferent activity when a contralateral stimulus is applied [14,15], and [16]. This decrease is due to the action of the MOC system through the synapses in the OHC, reducing the cochlear amplification gain and consequently inhibiting basilar membrane responses, changing the amplitude of an OAE [4].

Jerger and Musiek [17] have emphasized the clinical application of an OAE in the evaluation of an auditory processing disorder (APD). The authors have stated that an OAE can be an important tool for the differential diagnosis of APD, making it possible to verify whether there is an influence of alterations in peripheral hearing on lower levels of the auditory brainstem and to exclude possible peripheral alterations at the level of the hair cells.

Muchnik et al. [18] studied the suppression of nonlinear click-evoked otoacoustic emissions in 13 children with ages between 8 and 13 years and diagnosed with APDs and learning disabilities (study group). Compared to the control group, children in the study group showed significantly reduced suppression of transient evoked otoacoustic emissions (TEOAE). According to these authors, these results show that some children with APDs and learning disabilities have lower activity of the medial olivocochlear system, which affects speech comprehension in the presence of background noise. These authors also recommended the inclusion of TEOAE suppression in the battery of tests for APD diagnosis in children.

Sanches and Carvallo [16] studied the TEOAE suppression effect of white noises as a suppressor stimulus in children with APD. The authors showed that abnormal suppression of TEOAE was significantly more common in children with APD than in the control group. The study also defends the use of contralateral TEOAE suppression in the assessment of the efferent pathway in children with APD.

In a more recent study, Boothalingam et al. [12] investigated cochlear tuning and MOC function in children with suspected APD (sAPD) and children with typical development (TD). Subjects with sAPD had longer stimulus frequency otoacoustic emission group delays and reduced MOC function compared to children with TD. For these authors, the results obtained suggest that there are differences between these groups in cochlear and MOC functions.

Other studies, however, were unable to show a relation between the performance of speech intelligibility in noise and the magnitude of TEOAE suppression values. Harkrider and Smith [19], for instance, failed in find a correlation between phoneme recognition in noise and the magnitude of contralateral TEOAE suppression in 31 normal individuals. Similarly, Wagner et al. [20] did not find a correlation between the activity of the efferent system measured by the magnitude of contralateral suppression of DPOAE and the sentence recognition threshold in noise in 49 normal adults. Butler et al. [1] did not find differences in the DPOAE inhibition effect between normal hearing and APD groups.

Clarke et al. [15] studied the TEOAE suppression effects in 18 children with SLI (study group) and 21 normal children (control group). Their results did not show significant differences in the TEOAE suppression effect between groups. These authors also found no right/left asymmetry in the suppression effect. According to the authors, children with SLI do not have auditory processing problems at the MOC system level.

There are other findings supporting the theory that, in addition to the sensorial mechanisms, cortical mechanisms are also involved in the ability to perform SIN [21] and interfere with cochlear function through the MOC efferent system [22].

The studies mentioned above, which have investigated the efferent function of the MOC system in speech perception in noise, still present conflicting results. Therefore, the activation of an MOC efferent in speech intelligibility in noise is not very clear. Moreover, all the studies found did not include a comparison of the magnitude of otoacoustic emission suppression in noise (bottom-up mechanisms) and language alterations (top-down mechanisms) of auditory perception.

Thus, the aim of this study was to compare the magnitude of TEOAE suppression between children with poor performance on a speech-in-noise task and children with language development disorders.

Since the “top-down” mechanisms in the auditory system modulate the peripheral auditory system through the efferent pathway, we hypothesized that children with language disorders would have greater impairment in the magnitude of TEOAE suppression compared to children with poor performance of the speech-in-noise ability.

2. Materials and methods

This study was approved by the Ethics Committee under protocol number 1049/07. Children's parents or caregivers were informed about the procedures of the research and signed the free and informed consent form.

2.1. Sample

Participants were 52 children with ages between 6 and 12 years (109 ± 25.51 months). All the individuals assessed had thresholds within normal limits (≤15 dB HL) for the frequencies tested (250 Hz–8000 Hz), a speech recognition score ≥88%, normal tympanometric measures (static acoustic admittance between 0.35 and 1.75 mmho and peak pressure between +50 and −100 daPa in both ears), and absence of any neurological, cognitive or psychiatric disorders. Individuals were divided into three groups:

a. Typical development (TD): 25 children with normal development (111.12 ± 27.14 months; 12 boys and 13 girls), according to parent and classroom teacher reports, who had no prior history of language impairment, neurological disorder, or learning or behavioral problems. The inclusion criteria for these children consisted of normal performance on the speech-in-noise test.
b. Poor speech-in-noise performance (PSIN): 14 children with normal development (111.26 ± 24.61 months; 9 boys and 5 girls), (resembling inclusion criteria used in the TD group) who had poor performance on the speech-in-noise test.
c. Specific language impairment with poor speech-in-noise performance (SLI + PSIN): 13 children (104.07 ± 24.48 months; 8 boys and 5 girls) recruited from the Investigation Laboratory on Language Development and Impairment of the University of São Paulo. Inclusion criteria were based on Leonard's “diagnosis by exclusion”, which consists of significant speech or language difficulties that cannot be accounted for by factors such as hearing loss, autism, learning or physical disability, or neurologic or cognitive impairments. All SLI children had a persistent history of language impairment after more than 2 years of