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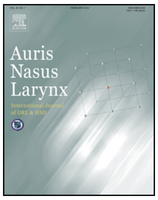

The role of the medial olivocochlear system in the complaints of understanding speech in noisy environments by individuals with normal hearing[☆]

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ABSTRACT

Objective: The aim of our study is to investigate the relationship between the complaint of speech understanding in noisy environments and the findings of contralateral suppression of transient evoked otoacoustic emissions and speech recognition in noise test methods in individuals with normal hearing.
Methods: Sixty-nine subjects between 18 and 53 years of age with normal hearing participated in the present study. The subjects were assigned to one of two groups, reported difficulty understanding speech in noise or no reported difficulty understanding speech in noise. After hearing and immitancemetric evaluation, contralateral suppression of transient evoked otoacoustic emissions and speech recognition in noise tests were administered to both groups. Suppression was calculated in half-octave frequency bands centered at 1.0, 1.5, 2.0, 3.0 and 4.0 kHz.
Results: We found out that the speech recognition in noise scores and contralateral suppression values were lower in subjects with the complaint of speech understanding in noise than those who do not have such complaints.
Conclusions: We concluded that the complaint of speech understanding in noise may be related to the medial efferent system dysfunction, so central auditory nervous system.

1. Introduction

Humans substantially depend on their sensations consisting of the impressions created by their experiences. Our sensations are critical for perception, comprehension, memory, imagination, and thinking. Any loss in the senses decreases our experiences and therefore information.

The sound produced by the cochlea, depending on the normal cochlear function, can be recorded and is called otoacoustic emissions [1]. The suppression effect identified as the decrease with the additional tone stimulation of the otoacoustic emission amplitude is a test method used in the measurement of the efferent auditory system [2,3]. Stimulation of the medial olivocochlear (MOC) efferent system is responsible for this otoacoustic emission reduction after contralateral acoustic stimulation. In the cochlea, feedback from the medial olivocochlear system controls the gain of cochlear amplification, which is responsible for the high sensitivity and frequency selectivity [4].

Understanding speech depends on the perception of correct information by a listener, whether in a discrimination, identification, recognition or comprehension model [5]. During speech comprehension, bottom-up processing of acoustic signals in the auditory system and top-down cognitive mechanisms of stimulus interpretation are influenced by each other [6]. The contribution of cognition becomes evident when a listening condition is challenged with background noise or hearing loss [7,8]. Speech recognition in noise (SRN) test, the reduction of the one-syllable speech lists with addition the noise, is one of the methods by which the function of the perception of speech in noise is measured [9,10]. White noise or speech spectrum noise is used generally and the signal noise rates change between 0 dB and +10 dB in SRN test [10,11].

Efferent system functional role in auditory perception and the relationship between the MOC reflex and listening in noise are still not clear. MOC bundle may help to speech perception in noise, thereby suggesting a possible role of cochlear efferent fiber in hearing [12,13].

In present study, we aimed to reinvestigate the theory that cortical mechanisms involved in listening to speech affect function

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with the MOC efferent system by retesting the relationship between the speech in noise performance and contralateral suppression of transient evoked otoacoustic emissions (TEOAEs) tests. We compared the findings of this two test methods in the subjects who hear well depending on whether they have complaint of understanding speech in noise or not.

2. Materials and methods

2.1. Subjects

The study was performed in the Audiology and Speech Pathology Unit of Ankara University. Overall 69 individuals (18–53 years, mean age 34.16 ± 10.37) participated in this study; 34 (49.3%) of these individuals were female and 35 (50.7%) of them were male. All subjects had normal otoscopic findings and were divided in two groups depending on whether they have complaint of understanding speech in noise (the first group) or not (the second group) (Table 1). Informed consent was obtained from the subjects after the nature of the experimental procedures was explained. This study was approved by the ethical committee of Ankara University. The tests were carried out bilaterally and inclusion criteria of the first and second groups were (1) no exposure to noise, no otological disorder, metabolic disease or ototoxic medicine usage, (2) pure tone hearing thresholds ≤ 15 dB hearing level (HL) at octave intervals from 0.5 to 8.0 kHz, (3) speech recognition scores in quiet <88% and (4) the middle ear pressures were between ±50 mm H_2O.

2.2. Identifying the complaint of speech understanding in noise

It was asked to the individuals who participated in the study whether they have the complaint of speech understanding in noise or not. We asked 7 questions to all individuals participating in the study to find out the presence of difficulty understanding speech in noise. Questions are as follows; "Have you got any speech understanding problem in noisy environments?" "Can you follow a conversation when you are talking to several persons?" "Is it difficult for you to understand what is said to you in noisy conditions (e.g. when TV is turned on)?" "Can you carry on a conversation easily in a car or bus?" etc. [14,15]. If individuals answered these questions as "yes", then we asked "How often do you misunderstand other people's conversation?". When the subjects who answered as "yes" to 3 or more of these 7 questions and the frequency was "frequently" or "usually", we thought that they may have a difficulty understanding speech in noise (the first group).

2.3. Methods

Pure tone hearing threshold measurements were performed between 0.25 kHz and 6 kHz according to ANSI (American National Standard Institute) standard (ANSI, 1996) [16]. Hearing and speech tests were carried out within the sound proof rooms using Interacoustics (Assens, Denmark) AC-40 audiometry using TDH-39 standard earphones with MX41/AR covers. Immitancemetric measurements were made by Interacoustics (Assens, Denmark) AZ-7 and TDH-39 earphones.

Table 1
The distribution of groups according to age and gender of individuals.

	n	Gender		Mean age ± standard deviation
		Male	Female	
First group (noise complaint)	25	14	11	34.24 ± 11.26
Second group (no noise complaint)	44	21	23	34.11 ± 9.97

TEOAEs measurements were made with Transient Evoked (TE) full menu with Otodynamics ILO88DP OAE V5.6y version and adult TEOAE probe. The eliciting stimuli consisted of a conventional nonlinear clicks of 80-μs duration delivered at 83 ± 3 dB peak sound pressure level (SPL) [17]. The inclusion criteria for contralateral suppression measurement was the TEOAE signal-to-noise ratio in at least three of the five highest frequency bands exceeding 3 dB [18,19]. The TEOAE measurements (260 click trains), were included for further analysis if both the whole wave reproducibility and the stimulation stability was 70% or higher [18,19]. We excluded subjects when the TEOAE reproducibility and stimulus stability was less than 70%.

Contralateral suppression of TEOAE (65 dB SPL nonlinear click) recording was first made without noise stimulation, and then it was repeated with 40 dB SL white noise from the opposite direction. Contralateral acoustic stimulation (CAS) was applied at under a level which would arrive the opposite side of the OAE recorded ear and which would create middle ear muscle reflex (MEMR) [17,18]. Before TEOAE and the suppression measurement, the contralateral MEMR thresholds for broadband noise (0.125–4 kHz) were measured for each participants [20]. The suppression was derived by subtracting the emission levels with CAS from the emissions levels without CAS at five highest frequency bands (1.0, 1.5, 2.0, 3.0 and 4.0 kHz)[18,19]. Ear Tone-3A insert earphone (Etymotic Research, Elk Grove Village, IL) was used for presenting the CAS [19].

Speech recognition in noise test was applied to the individuals with the signal to noise ratio was +10 dB [10,11]. A mono-syllable phonetically balanced word list at 40 dB SL and white noise at 30 dB SL was presented to subjects' ipsilateral test ear at the same time. The word lists were presented to subjects via an adapted CD player. Phonetically balanced word lists comprising 25 syllables were presented to ears and 4 different lists were used in order to reduce the effect of learning.

2.4. Statistical analysis

All the findings obtained were evaluated statistically with "SPSS 20.0 for Windows". "Students' *t*-test" was used for the inter-variable relations of age and "Chi-square test" was used for the inter-variable relations of gender. "Students' *t*-test" was used for comparison of SRN scores and TEOAE amplitudes according to the complaint of speech understanding in noise or not and "Paired *t*-test" was used for comparison of right and left ear. "Mann–Whitney *U* test" was used for comparison of SRN scores and TEOAE amplitudes according to the complaint of speech understanding in noise or not and "Wilcoxon test" was used for comparison of right and left ear at each frequency. The relationship between age, SRN scores and suppression levels was studied with "Spearman Rank Correlation Analysis" and the relationship between age and TEOAE levels with "Pearson Correlation Analysis. Limit of significance was set at 0.05.

2.5. Results

TEOAE amplitudes of all participants according to the frequencies were measured and presented in Table 2. It was found out that left ear TEOAE amplitudes were lower than right ear amplitudes and this difference was statistically significant for 3.0 kHz ($p < 0.05$). There was no difference in the TEOAE amplitude levels between the two groups.

When we investigated the correlation between the age and TEOAE amplitudes, we found negative correlation in the first group, TEOAE amplitudes decreased with increasing age. This correlation was significant at 3.0 kHz for right ear and 3.0 and 4.0 kHz for left ear ($p < 0.05$). We found no correlation between the age and TEOAE amplitudes in the second group.