

## Does the Efferent Auditory System Have a Role in Children with Specific Learning Disabilities?

### Original Investigation

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### Abstract

**Objective:** This study aimed to compare the baseline transient otoacoustic emission (t-OAE) amplitudes and medial olivo-cochlear (MOC) efferent activity in children with specific learning disability (SLD) and children with normal development.

**Methods:** The study was conducted in two groups. The patient group included 30 children aged 6 to 10 years and diagnosed with SLD, and the control group included 30 children in the same age range without SLD. The patient group included eight males and 22 females, and the control group included 14 females and 16 males. t-OAE and contralateral suppression test were performed in both groups.

**Results:** In the first t-OAE measurements, a statistically significant difference was observed between the patient and the control group at frequencies of 1400, 2000, 2800, and 4000 Hz, but no such difference was

observed at 1000 Hz frequency. In the control group, significantly better emission amplitudes were observed. No differences were found at any frequency between the patient and the control groups after suppression. When the subjects in the two groups were compared among themselves, there was a statistically significant difference between the before and after suppression scores in the patient group except at 4000 Hz. Likewise, an important difference was also observed in all frequencies in the control group.

**Conclusion:** This study shows that suppression effects of t-OAE on children diagnosed with SLD and children with no SDL are not significantly different.

**Keywords:** Otoacoustic emissions, specific learning disability, outer hair cell, medial olivo-cochlear response

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### Introduction

Specific learning disability (SLD) is a heterogeneous disorder that emerges with delay or deterioration in acquiring writing, speaking, reading, comprehension, or arithmetical skills (1). Children with SLD have normal IQ performance, and have no obvious causal factors, such as hearing loss or any neurological findings. Some behavioral studies show that speech perception problems may contribute to language problems in some children with SLD (2).

Otoacoustic emissions (OAE) are the sounds produced by the outer hair cells (OHCs) of the cochlea. OAE is measured with a microphone placed in the external ear canal (3). Reduced emissions in response to the presentation of noise from the contralateral ear indicates the existence of the medial

olivo-cochlear (MOC) reflex (4, 5). This reduction, resulting from the action of the MOC system through the synapses in the OHC, decreases the cochlear amplification gain, inhibits basilar membrane responses, and changes the amplitude of an OAE (5). The MOC efferents can be influenced by cortical activity, and play an important role in auditory plasticity (6). The MOC reflex activity enables our auditory system to adapt noises by reducing its response to a constant noise presence and to adapt our dynamic hearing range to the current environment. The contralateral MOC system efferents have direct effects on the function of the OHCs. In adults without hearing impairment, contralateral noise increases the ability to understand speech in noise. The defective MOC reflexes are considered to impair language acquisition by

disturbing the separation of speech sounds from noises during critical periods of language acquisition, without considerable alterations in hearing thresholds (7).

A study conducted in 2003 showed that the auditory processing skills of children with SLD deteriorate in the background noise (8). Comprehension performance in noise was correlated with recipient and expressive language scores, which supported the relationship between language development and discriminating speech voices from noise. Thus, MOC deficits may provide a reasonable explanation for the language defect in these children. In 2017, Rocha-Muniz et al. (5) investigated the activation of an MOC efferent in children with poor speech-in-noise (PSIN) performance and children with language impairment (LI) and poor speech-in-noise PSIN (LI+PSIN). They found reduced OAE suppression compared to the typical development group. In a study conducted in 1999, a significantly lower OAE suppression was observed in 14 children with SLD than that observed in a normal hearing group (9). Yoshimura et al. (10) reported that acoustic auditory cortex plays an important role in language acquisition. The connections between the auditory cortex and the inner ear are provided by the medial olivo-cochlear system (MOCS) efferents.

This study aims to compare the MOC efferent activity and basal transient OAE between children with SLD and children with normal development.

## Methods

In May and June 2016, 30 experimental subjects aged 6-10 years who were diagnosed with SLD ( $8.26 \pm 1.04$ ) and 30 subjects in the same age group with no SLD ( $7.66 \pm 0.92$ ) as control group were included in the study. The experimental group consisted of eight males and 22 females, while the control group consisted of 14 females and 16 males. There was no significant difference in age and gender between the two groups ( $p=0.112$  and  $0.286$ , respectively). Ethics committee approval was obtained from Başkent University School of Medicine (No: KA16/161). Consent forms were obtained from the parents. Inclusion criteria included the following: (1) normal otoscopy; (2) pure tone audiometry (PTA) thresholds 20 dB HL bilaterally; (3) normal tympanometry; (4) existence of t-OAE in both ears; (5) normal contralateral acoustic reflex; and (6) no systemic disease. Diagnosis of SLD was made with the Gessel Development Figures Test and the Bender Gestalt Visual Motor Sensitivity Test.

**Table 1.** The first transient-evoked otoacoustic emission measurements

Frequency	Patient Group Mean±SD	Control Group Mean±SD	p
1000	3.00±6.87	6.02±5.96	0.011
1400	4.43±7.52	9.28±6.04	<0.001
2000	2.35±6.84	7.64±6.77	<0.001
2800	2.89±7.04	7.97±7.65	<0.001
4000	2.98±7.57	8.09±6.89	<0.001

## Procedure

Transient OAE (t-OAE) tests (Titan; Interacoustics, Assens, Denmark) were performed in a quiet room. The parameters were non-linear click stimuli; intensity  $80 \pm 3$  dB sound pressure level (SPL); frequency bands 1, 1.4, 2, 2.8, 4 kHz; reproducibility over 65%; and stimulus stability over 70% in the tested frequency; transient impulses averaged 260 times and 20-ms window. The signal/noise ratio was considered significant at 3 dB SPL or >3 dB SPL. To investigate t-OAE suppression, a white noise was presented contralateral to the tested ear at 70 dB SPL. The test was applied in two steps. t-OAEs were recorded without and with contralateral noise. Suppression amounts were derived by subtracting the emission levels with contralateral noise from the emission levels without contralateral noise at all the frequency bands (11). t-OAE and suppression tests were applied by two audiologists who were unaware about the group types.

## Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences version 23.0 (IBM Corp.; Armonk, NY, USA). Intra-group comparisons were made using the paired t-test, and intergroup comparisons using the Student t-test. Variables were examined at 95% confidence level, and p value <0.05 was considered as statistically significant.

## Results

In the first t-OAE measurements, a statistically significant difference was observed between the patient and the control group at frequencies of 1400, 2000, 2800, and 4000 Hz, but no such difference was observed at 1000 Hz frequency. In the control group, significantly better emission amplitudes were observed (Table 1). No significant differences were found in the patient and control groups after the suppression at any frequency levels (Table 2). When the subjects in the two groups were compared among themselves, there was a statistically significant difference between the before and after suppression scores in the patient group except at 4000 Hz. Likewise, an important difference was observed in the control group (Table 3).

## Discussion

Specific learning disability is often associated with auditory processing disorders, but the relationship between them is not clear (12). Contralateral suppression may provide an objective and non-invasive clinical approach to study the MOCS and the descending auditory efferent pathways in the brainstem (13).

**Table 2.** Suppression values of patient and control groups

Frequency	Patient Group Mean±SD	Control Group Mean±SD	p
1000	1.56±3.9	1.62±4.43	0.936
1400	0.85±2.92	1.38±2.44	0.281
2000	1.25±1.86	0.75±1.33	0.095
2800	0.85±2.17	0.60±1.33	0.449
4000	0.13±2.89	0.62±1.54	0.25

**Table 3.** Otoacoustic emissions before and after contralateral suppression in patient and control groups

Patient Group			
Frequency	Before CLS TEOAE	After CLS TEOAE	p
1000	3.00±6.87	1.43±6.43	0.003
1400	4.43±7.52	3.58±6.53	0.028
2000	2.35±6.84	1.09±6.85	<0.001
2800	2.89±7.04	2.03±7.00	0.003
4000	2.98±7.57	2.85±6.89	0.723
Control Group			
Frequency	Before CLS TEOAE	After CLS TEOAE	p
1000	6.02±5.96	4.40±6.17	0.006
1400	9.28±6.04	7.89±6.32	<0.001
2000	7.64±6.77	6.88±6.77	<0.001
2800	7.97±7.65	7.37±7.48	0.001
4000	8.09±6.89	7.47±6.72	0.003

CLS: Contralateral suppression; TEOAE: Transient-evoked otoacoustic emissions

This study aimed to evaluate the efferent auditory system by contralateral suppression test of children with SLD. The main finding of this study is that there is no significant difference in the t-OAE results of children with SLD compared to that in normal children after contralateral suppression.

It is suggested that the medial efferent system improves the frequency decoding capacity and the discrimination of vowels especially in noisy environments (13, 14). Many studies in the literature show decreased activity of the MOC system in children with auditory processing disorders (14, 15). However, there are contradictory studies on MOC reflex in children with SLD.

The first finding in this study was that the t-OAE amplitudes in the control group were significantly higher than those in the patient group. Mishra (14) found higher amplitude t-OAEs in children with auditory processing disorders compared with control subjects. Veuillet et al. (9) found lower emission levels in children with SLD compared to those in the control group. Garinis et al. (16) conducted a study on 18 adolescents with and 18 control adults without a learning disability. They observed lower amplitude t-OAEs in the learning disability group compared to those in the control group. Though lower amplitudes of the learning disability group may indicate weaker OHC or cochlear function, the pure tone threshold below 20 dB is used for acceptance in both the control and the learning disability groups to exclude the peripheral effects on t-OAE. In this study, PTA at 20 dB and below was defined as a criterion for inclusion in the study. Low amplitude t-OAE responses in the learning disability group compared to those in the control group may be due to the differences in the amount of MOC bundle control applied to OHCs. That the t-OAE test depends mainly on the proper functioning of the OHC brings to mind whether this is caused by a peripheral auditory impairment in individuals with SLD. With this study, it may be speculated that the peripheral auditory system of the children with SLD functions less than that of the healthy children.

In this study, there also was a statistically significant difference in the control group before and after the contralateral suppression; while a significant difference was also observed in the patient group before and after the suppression except at 4000 Hz frequency. However, there was no significant difference between patient and control group after suppression. This result is similar to that of Butler et al. (17). Despite the age and the gender similarities of the two groups, the reasons for the absence of differences in post-inhibition emission amplitudes between the two groups are not yet known. However, wider studies to be conducted on children with SLD and normal children in the future may enable us to identify these reasons by evaluating different measurements of contralateral inhibition using t-OAEs or distortion product emissions (DPOAEs). The result we found is complicated by potential confounding variables related to the MOC inhibition measurements. Some studies, such as ours, use the non-linear click method, while some other studies use the linear click method that assesses both the linear and non-linear part of the MOC inhibitory response (11, 18). Mishra and Lutman (18) reported that the non-linear click method did not represent the overall amplitude of the MOC inhibitor response but removed artifacts in click-evoked OAEs. Some studies used either click-evoked or distortion product (DP) OAEs with contralateral acoustic stimulation to measure the MOC reflex. Measurement of contralateral inhibition extends the use of OAEs beyond the assessment of the function of OHCs alone. When more research is available, the clinical benefits of these measures will improve as we increase our understanding of inter-subject variability. We can better identify the normal efferent system function using OAEs.

The limitations of this study are that the study group is specific, the contralateral inhibition was assessed with non-linear click t-OAE, and the sample size is small.

### Conclusion

This study aimed to compare the MOC efferent activity between children with SLD and children with normal development. The main finding of this study is that there is no significant difference in the t-OAE results in children with SLD compared to that in normal children after contralateral suppression. Auditory efferent system studies with larger SLD populations may help to understand the underlying mechanisms of LD, and to that end, detailed evaluation must be performed in these children.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the Ethics Committee of Başkent University School of Medicine (No: KA16/161).

**Informed Consent:** Written informed consent was obtained from the parents of the patient.

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

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

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