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Paradoxical and labile medial olivocochlear functioning as a potential marker of auditory processing disorder in a child with learning disabilities

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ABSTRACT

Introduction

The medial olivocochlear system (MOCS) is composed of fibres projecting directly onto outer hair cells and plays a role in improving the signal-to-noise ratio. The MOCS can be evaluated by measuring suppression of the otoacoustic emissions evoked by contralateral acoustic stimulation. Dyslexic children present an increased probability of auditory processing disorder (APD). These children may present paradoxical MOCS dysfunction.

Case report

We report the case of a dyslexic child with APD, who was severely disabled in a noisy environment. Audiometric tests were normal, and the central auditory assessment showed labile MOCS functioning that was not only ineffective, but also potentially deleterious, possibly accounting for this child's hearing impairment in a noisy environment.

Discussion

This case illustrates the importance of audiological assessment and objective investigation of MOCS function in children with a learning disability, especially with hearing difficulties in the presence of noise, in whom auditory training can be beneficial.

Key Words: Medial olivocochlear efferent system, Auditory processing disorder, Learning disability.

INTRODUCTION

The medial olivocochlear system (MOCS) is composed of fibres arising in the medial superior olivary complex, and projecting directly onto outer hair cells (1). Active contraction of the outer hair cells induces sound vibrations, called otoacoustic emissions (OAEs), that can be recorded in the external auditory canal (2). An objective and noninvasive method of functional investigation of these fibres is based on determination of the amplitude of transient evoked OAEs (TEOAEs) in the presence and absence of contralateral acoustic stimulation (CAS) (2, 3). Classically, TEOAEs amplitude decreases by several dB in the presence of CAS, with marked inter-individual variability (4), but with good intra-individual reproducibility in adults (5). One of the presumed roles of the MOCS would be to improve speech intelligibility in the presence of noise (6).

Children with language acquisition disorders, particularly affecting written language (dyslexia), present an increased probability of auditory processing disorder (APD) (7). These children with impaired processing of auditory information, particularly in competitive listening conditions, can also present poor, but paradoxical MOCS functioning (3).

We report the case of an adolescent girl with severe oral and written language disorder, who presented atypical and labile MOCS functioning.

MATERIAL AND METHODS

A 13-year-old, right-handed, monolingual girl, with no notable history was referred by her speech therapist for assessment of a learning disability. Oral language acquisition was laborious despite intensive speech therapy. She presented learning difficulties at school and reported difficulties understanding and remembering oral information. Neuropsychological assessment confirmed a severe oral and written language disorder.

Otoscopic and otoneurological examination was normal. Audiometric thresholds (pure-tone and speech) and tympanometry were normal. The stapedial reflex was preserved. The central hearing assessment (8) showed scores below 2 standard deviations (SD) on dichotic and Masking Level Difference tests, with normal scores (59/60) on the Lafon 60 test in silence, but very low scores in the presence of noise (11/60, signal-to-noise ratio (SNR) = 0). Auditory brainstem responses (ABR) and MRI of the internal auditory canals excluded any retrocochlear disease or auditory neuropathy.

TEOAEs were recorded with the ILO292 Echoport system (Otodynamics, v3.94B) in a soundproofed cabin. Eight-second clicks were administered at a rate of 50/s. The rejection threshold was 47.3 dB SPL, filtered between 500 and 6,000 Hz. For these sessions, TEOAEs were recorded in response to a nonlinear stimulus (2 series of 300 clicks at 81 dB (± 3) SPL). The recording window was set at 2.6-20.5 ms. Synchronous evoked spontaneous OAEs (SEOAEs) were then recorded according to the process described by Prievé et al. (9). Finally, the MOCS was investigated (T1): 2 series of 300 clicks (57 dB SPL) were presented to the ear tested with and without CAS (speech noise, 30 dB SL) in the contralateral ear using an audiometer (Interacoustic AC40) and headphones (TDH39), repeated three times. The ears were tested in random order and TEOAEs were analysed (window: 3.2-20.5 ms). The effect related to CAS was determined by subtracting the amplitude of TEOAEs with and without

CAS and calculating the mean of the 3 differences. A positive value indicated a suppressor effect, and a negative value indicated activation. Following failure of this system in the right ear at T1, the test was repeated at 4 months (T2).

RESULTS

TEOAEs and SEOAEs (**Figure 1**) were bilaterally present and stable. **Figure 2** shows the changes of TEOAEs between conditions with and without CAS in each ear at T1 and T2. At T1, a very strong contralateral suppression effect (CSE) was observed in the left ear (LE) (30 to 22.6 dB SPL amplitude reduction) and a slightly inverse effect was observed in the right ear (RE) (21 to 22.2 dB SPL). At T2, the CSE was no longer observed in the left ear and even an increased amplitude was observed (25.3 to 28 dB SPL), while a weak CSE was observed in the right ear (22.4 to 21.8 dB SPL). **Figure 3** represents the arithmetic mean amplitude of TEOAEs with and without CAS for each ear at T1 and T2, and the mean CSE. The MOCS appeared to be relatively ineffective on the right, but a completely inverted pattern between T1 (suppression) and T2 (activation) was observed on the left. **Table 1** presents the normal values obtained in a group of 20 children with no learning disability (personal communication). All values in our patient differed by more than 2 SD, excepted for the RE at T2.

DISCUSSION

This girl presented atypical MOCS functioning: constantly ineffective in the RE and highly atypical in the LE, with abnormal suppression as well as paradoxical activation.

In the absence of any retrocochlear disease, the more or less marked reduction of the amplitude of TEOAEs induced by CAS is highly reproducible in adults (5), but also in

dyslexic children (10). The case reported here is remarkable in that the CAS presented to the LE successively induced excessive reduction followed by an abnormal increase of the amplitude of TEOAEs (> 2 SD). Garinis et al. (2008) reported increased amplitudes in adults with learning disabilities, but only when CAS was presented to the LE (11).

Our patient presented multiple bilateral high-amplitude SEOAEs that remained stable over time, which is highly unlikely to be the factor responsible for the paradoxical CSE, as previous studies have demonstrated the absence of impact of these responses on the suppression effect (12).

Although the features observed in this case may suggest impaired function of MOCS fibres projecting onto the RE, particularly at T1, the intense suppression observed in the LE at T1 suggests the presence of intact efferent fibres. However, as the MOCS fibres have been shown to be under cortical control (13), the abnormal and fluctuating effects of the CAS presented to the LE could possibly reflect the fluctuating influences derived from the auditory cortex.

This girl complained of comprehension difficulties and behavioural tests demonstrated abnormally low performances for her age on all tests under competitive listening conditions. It has been shown that speech perception in the presence of noise is dependent on top-down influences mediated via the MOCS (6). Under these conditions that mobilize selective attention, MOCS activation would allow noise reduction (14). The difficulties experienced by this patient could be due to the inefficacy, lability and even deleterious effect of the MOCS.

This report of a rare case of extremely labile MOCS in a child with learning disability suggests that these anomalies might account for the divergent results for MOCS function observed in children with suspected APD (3), possibly indicating the need to repeat these measurements in the presence of atypical CSE.

This case illustrates the importance of audiological assessment and objective investigation of MOCS function in children with a learning disability, especially with hearing difficulties in the presence of noise, in whom auditory training can be beneficial

Conflicts of interest: The authors have no conflicts of interest to declare.

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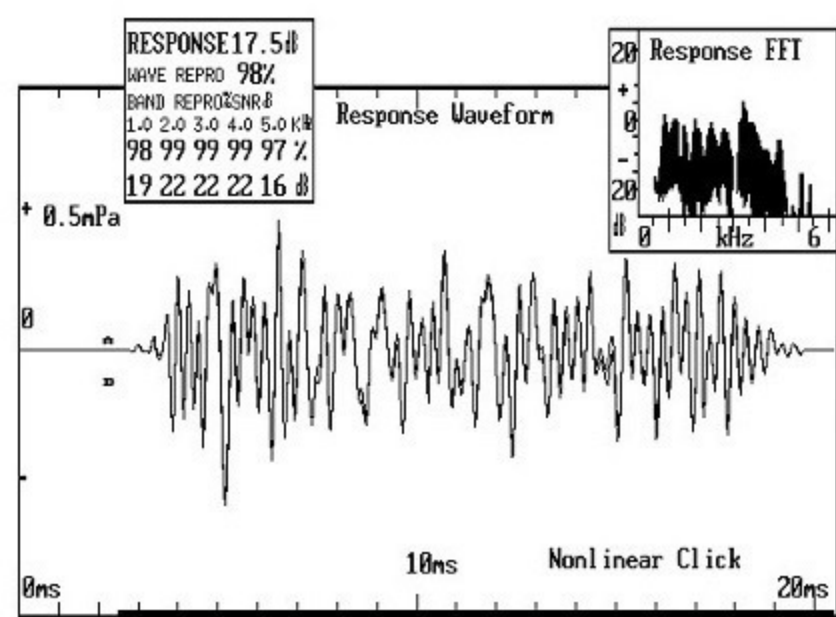
Figure 1: SEOAEs (recorded between 60 and 80 ms after the start of stimulation) and TEOAEs (between 2.5 and 20 ms after the start of stimulation) in each ear at T1 and T2); TEOAEs and SEOAEs were bilaterally present and reproducible and remained unchanged at T2. The signal-to-noise ratio was 6 dB with a reproducibility greater than 90% over the entire spectrum.

Figure 2: TEOAEs modifications with and without CAS for each ear at T1 and T2 (fusion of curves of the three measurements). On the left, the MOCS appeared to be effective (low amplitude TEOAEs) at T1, but this effect was inverted at T2 (increased amplitude of TEOAEs). A weak effect was observed on the right.

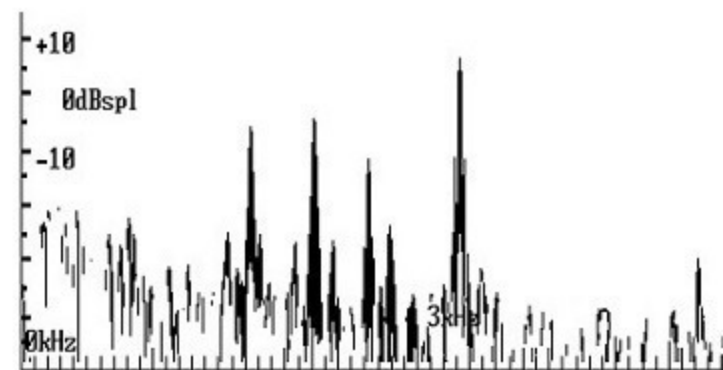
Figure 3: Arithmetic mean amplitude of TEOAEs for 3 recordings obtained with and without CAS for each ear at T1 and T2. The MOCS appeared to be relatively ineffective in the right ear, but a completely inverted pattern was observed in the left ear between T1 (suppression) and T2 (activation).

Mean values for 20 age-matched children with normal hearing (dB)					
	Mean	Standard deviation	Standard error	Maximum	Minimum
RE	1.232	0.769	+/- 0.172	3.2	0.3
LE	1.357	0.726	+/- 0.162	2.78	0.27
Mean values for the patient (dB)					
RE (T1)	-1.13		+/- 0.22		
RE (T2)	0.43		+/- 0.23		
LE (T1)	7.3	+/- 0.06			
LE (T2)	-2.53	+/- 0.18			

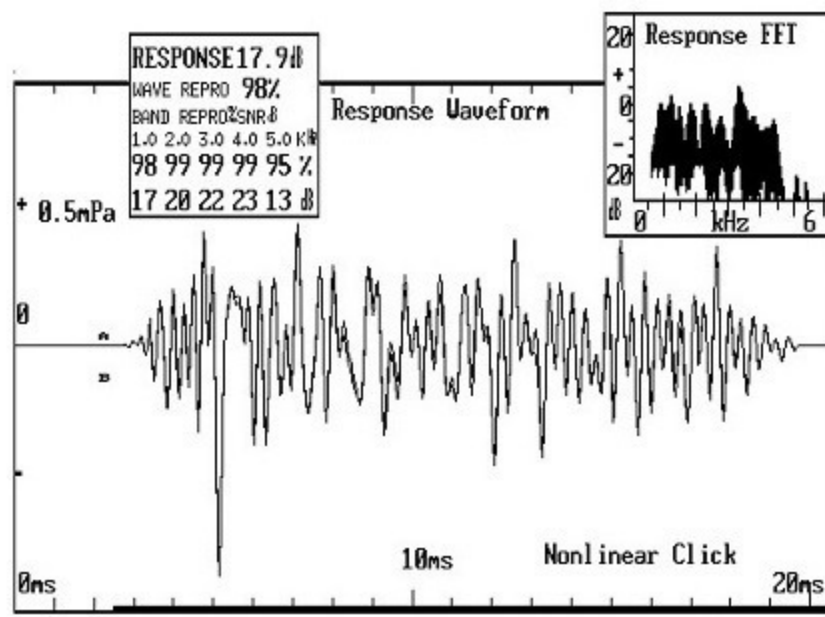
Table 1: Normal values of the contralateral suppression effect obtained in a group of 20 children without learning disability and the values obtained in the patient, for each ear.



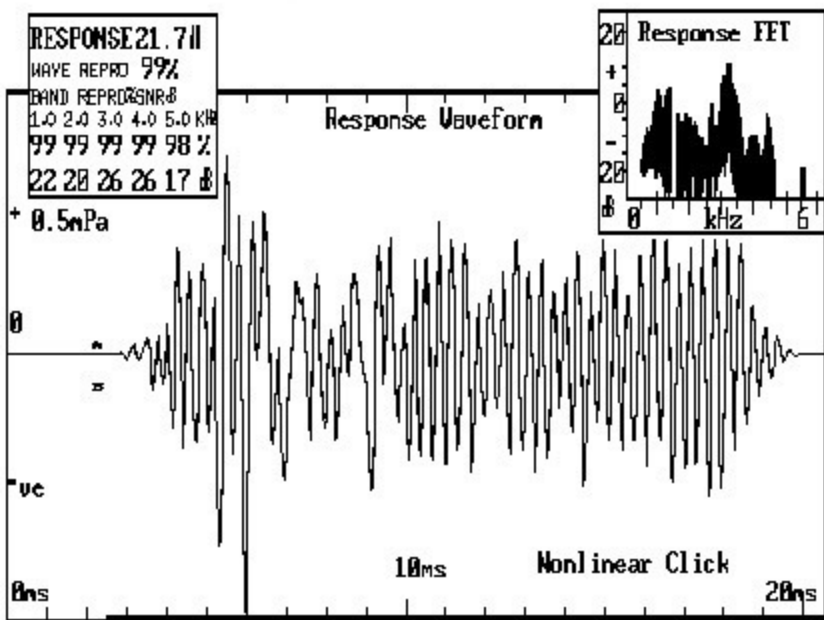
SEOAE RIGHT EAR (T1)



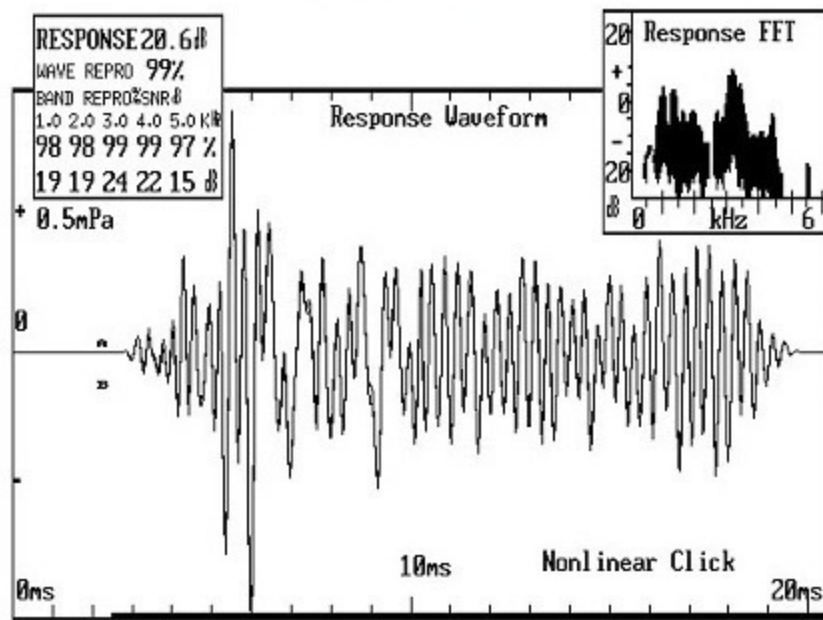
TEOAE RIGHT EAR T1



TEOAE RIGHT EAR T2

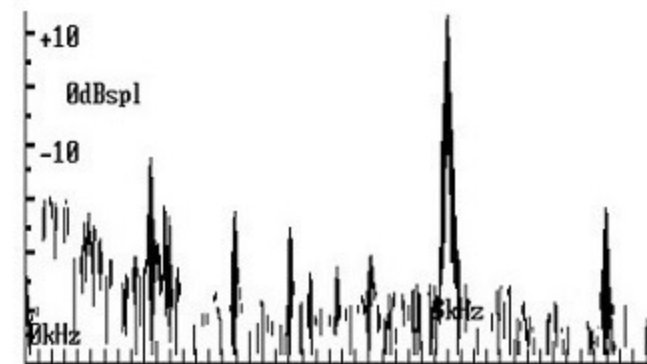


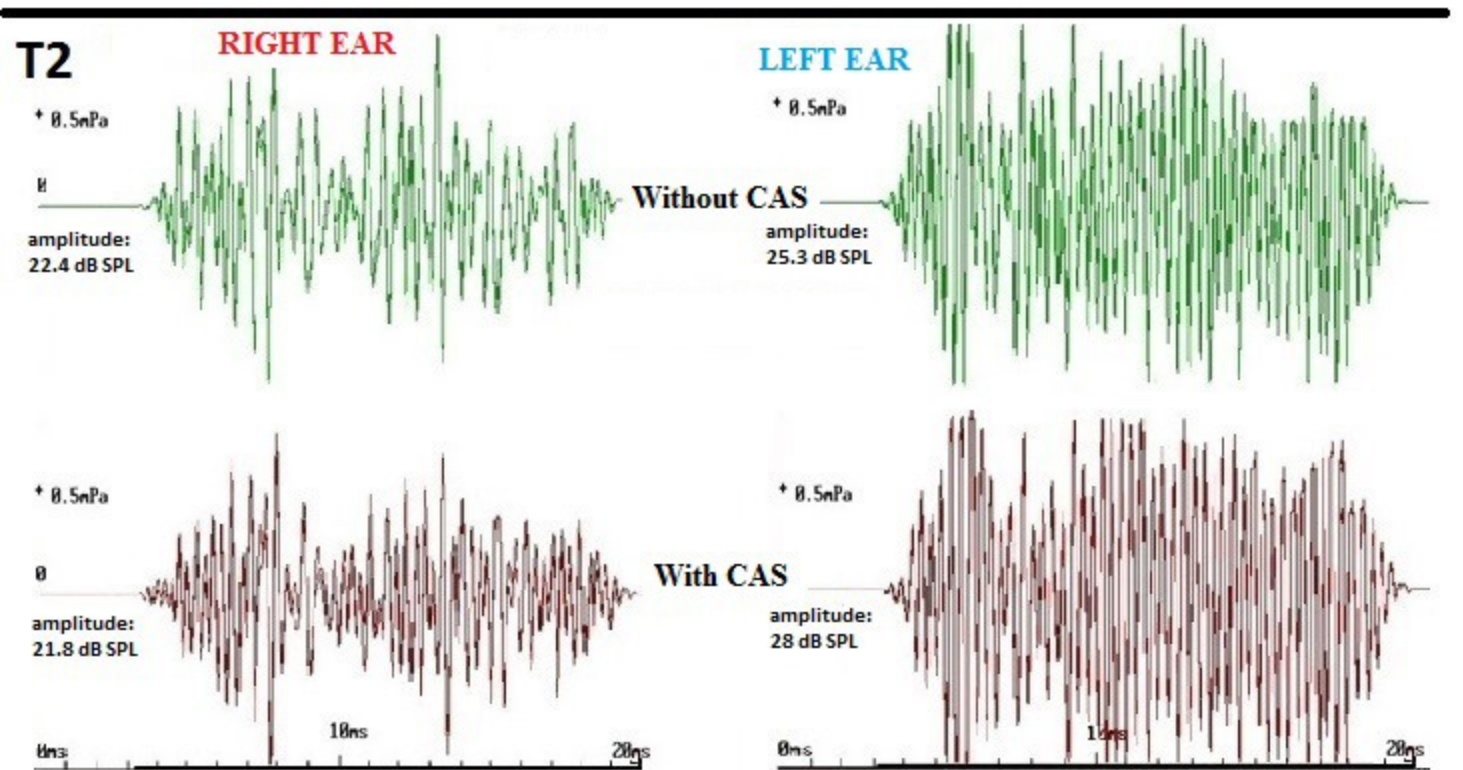
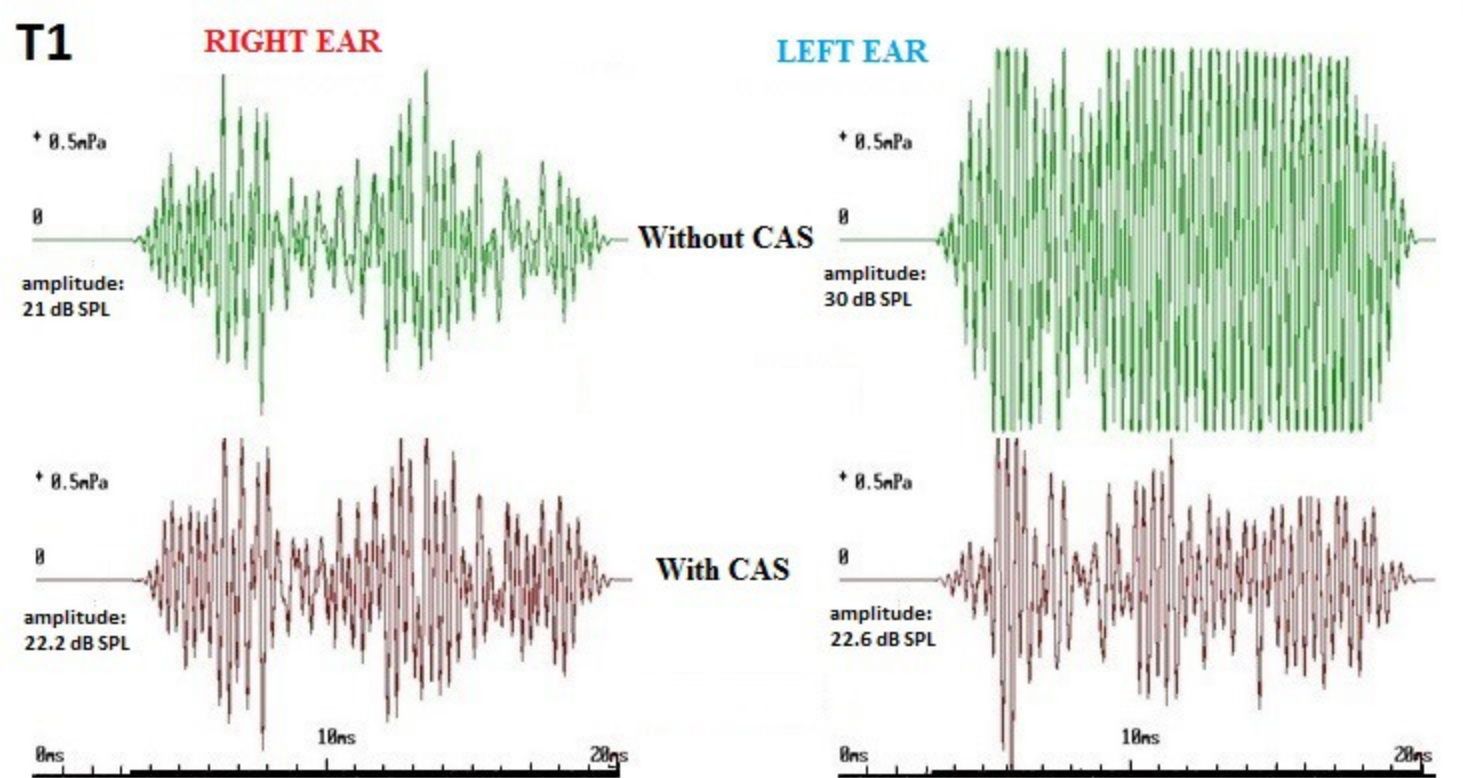
TEOAE LEFT EAR T1



TEOAE LEFT EAR T2

SEOAE LEFT EAR (T1)





TEOAE's amplitude (dB SPL)

