Efferent effects on click-evoked otoacoustic emissions in humans

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1. INTRODUCTION

If auditory afferent pathways have been extensively studied, the function of the auditory efferent system is still almost unknown. However, during the last few years some tools have been described for studying a subsystem of the olivocochlear system, the medial olivocochlear system (MOC), which originates from cells located in the medial regions of the superior olivary complex (Warr and Guinan, 1979), and which innervates the outer hair cells. The M.O.C. can be sound-activated and a contralateral auditory stimulation suppresses auditory responses, as with afferent nerve-fibre responses (Buno, 1978; Murata et al., 1980; Liberman, 1989) and otoacoustic emissions in animals (Puel and Rebillard, 1990) and humans (Collet et al., 1990; 1992; Froehlich et al., 1993; Ryan et al., 1991). Outer hair cells being involved in the genesis of otoacoustic emissions (OAEs), the latter are well-suited to a more direct study of the MOC.

The aim of this paper is to examine the influence of efferent effects on otoacoustic emissions in humans using contralateral auditory stimulation to elicit medial olivocochlear system response. Although an effect has been described on spontaneous otoacoustic emissions (Mott et al., 1989; Moulin et al., 1992) and on acoustic distortion products, (Chery-Croze et al., 1993; Moulin et al., 1993) we shall describe only the effects on evoked otoacoustic emissions (EOAEs).

2. GENERAL METHODOLOGY

EOAEs are always recorded from one ear, with an acoustic stimulation being sent to the opposite ear (Fig. 1). The stimulus to elicit EOAEs can be a non-filtered click (presented in either the linear (Collet et al., 1990) or non-linear mode (Veuillet et al., 1991; Berlin et al., 1993 a)), or a tone pip (Veuillet et al., 1991). The contralateral stimulation can be white noise (Collet et al., 1990, 1992; Froehlich et al., 1993; Ryan et al., 1991), narrow band noise (Veuillet et al., 1991; Berlin et al., 1993 a), clicks (Veuillet et al., 1991; Berlin et al., 1993 a) or pure tones (Berlin et al., 1993 a). The greatest (and the most sensitive) effect is obtained with white noise.

3. MAIN RESULTS IN NORMAL SUBJECTS

3.1 Influence of Contralateral Intensity

EOAE amplitude decreases under contralateral noise (Fig. 2). This decrease is intensity dependent (Collet et al., 1990): the greater the contralateral auditory stimulus intensity, the greater the decrease in EOAE amplitude. With white noise, as soon as it becomes audible, EOAE amplitude decreases. This effect is thus very sensitive. Cross-talk has been ruled out by demonstrating an absence of decrease in subjects with total unilateral hearing-loss, when contralateral sound is sent to the deaf ear.
Fig. 1 Contralateral auditory stimulation and otoacoustic emissions.

Fig. 2 Influence of contralateral intensity on EOAE amplitude.

3.2 Influence of the Middle Ear
The role of the middle-ear is more controversial. Even so, the presence of an effect in patients without acoustic reflex is an argument against an exclusive role for the middle-ear (Veuillet et al., 1991; Berlin et al., 1993 b). Moreover, this effect is frequency-specific (Veuillet et al., 1991), and this cannot be explained in terms of the middle ear.

3.3 Influence of a Section of the Olivocochlear Bundle
The suppression disappears in patients with vestibular neurotomy (Scharf et al., in press; Williams et al., 1993), which suggests that it disappears after section of the olivocochlear system, as the OCB travels within the inferior vestibular nerve. Numerous arguments tend to show 1) that the middle-ear cannot explain all the results, 2) that the medial olivo-cochlear system can explain all the results and 3) that an interaction between the medial olivo-cochlear system and middle-ear cannot be absolutely ruled out.

3.4 Interindividual Variability
The decrease in OAE amplitude shows a great interindividual variability (Collet et al., 1992), also to be seen in animals (Liberman, 1988). This variability might explain some psychoacoustical variability.

3.5 Influence of Age
There is controversy as to whether age-effect findings are to be explained in terms of the MOC or else as a consequence of the alteration of OEs. In preterm babies, the effect is absent or weak (Morlet et al., 1993) and in the elderly the effect is smaller (Castor et al., in press).

3.6 Influence of Sleep
Sleep does not alter this suppression effect, but, at the onset of sleep, some subjects fail to show any decrease of OAEs under contralateral stimulation (Froehlich et al., 1993).

3.7 OAE Spectrum and Suppression Effect
Finally, the spectrum of EOAE frequencies is not uniformly altered. The decrease at frequencies around 4 kHz is very slight or absent (Veuillet et al., 1992).

4. MAIN RESULTS IN PATHOLOGY

4.1 Sensorineural Hearing Loss
It is quite possible to explore the medial olivocochlear system in patients if they have 1) EOAEs present and 2) no or little contralateral hearing loss, allowing a 30 dB SL stimulus to be sent without interaural attenuation. In the case of presbyacousia, the suppression effect is similar to the effect obtained in younger patients with similar audiograms (Castor et al., in press). No significant differences have been found between sensorineural hearing-loss and noise-induced hearing loss.

4.2 Hyperacusis
Alterations of the efferent effect have been described for some hyperacusies (Collet et al., 1992) as well as in autism (Collet et al., 1993 b).

4.3 Tinnitus and Otoneurology
Initially a slighter suppression effect seemed to
have been shown in the ear with tinnitus compared to the other ear in unilateral tinnitus (Chery-Croze et al., 1993). However, this turned out to be a statistical effect and the tinnitus sub-group of tinnitus with OCB alteration remains to be characterised.

As for otoneurology, alterations of the OCB pathway seem to be related to a weak to zero suppression effect.

5. CONCLUSIONS

Although the function of the efferent system is still almost unknown, the association of contralateral stimulation and EOAEs offers a tool for studying the medial olivocochlear system in humans and is promising from both fundamental and clinical points of view.

REFERENCES


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