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Voluntary contraction of the tensor tympani muscle and its audiometric effects

Dear Sirs,
In the December 2013 issue of your journal, Angeli *et al.* described a marked reduction in air conduction following voluntary contractions of the tensor tympani muscle.[1] Though the current knowledge about the tensor tympani functions is clearly described, the authors state that a better understanding of the audiometric effects of tensor tympani contractions could aid in the diagnosis of hearing disorders.

At this point, we would like to point out to the authors a booklet – freely available from the Utrecht University Library website – entitled 'Applying physics makes auditory sense', which describes a different hearing paradigm.[2] Based on the content of this publication, we are currently involved in an effort to model various theories of middle- and inner-ear dynamics using a super computer and physical modelling, and look forward to reporting the outcomes within the year.

In this booklet, we situated the so-called 'cochlear amplifier' in the middle ear.

> For the eardrum this means, that by contraction of the musculus tensor tympani the range reduction of signal transfer may vary with an approximate factor 30. Moreover, the setting of the musculus stapedius can also reduce the transfer factor of the lever in the ossicular chain, between the incus and the stapes, by another factor of approximately 30 times. When each of these muscles individually generates maximum signal transfer reduction factors – as a consequence of the average level of the sound energy signal – the combined ratio in deflection between the eardrum and the oval window, which is a product of both factors, will be reduced by a factor of roughly 1000. Finally, this results in a velocity decrease of 1000 times in the perilymph compared to the velocity in the tympanic membrane. However, the pressure that is exerted on the basilar membrane, as a consequence of squaring due to the Bernoulli effect, will be reduced by a ratio of deflection of one million, which equals 60 dB.
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> Completely analogue to the adapting iris diaphragm – which adjusts to increased or decreased light intensity reaching the eye – this automatic sound energy feedback control system continuously protects our auditory sense at the best possible location: at the entrance … [page 39].

> We propose that the musculus tensor tympani and musculus stapedius can modify the amplification ratio of these movements. A gradual increase of sound stimuli thus causes a gradual decrease within that ratio. Under normally varying sound conditions this adaptation is so subtle that it generally cannot be observed without the use of extremely sensitive equipment.
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> This hypothesis seems realistic as, in the event of sudden loud sound bursts, the stapedius reflex … can actually be regarded as an extreme and instantaneous performance of this attenuation principle.
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> The continuous functioning of both of the middle ear muscles suggests that only in abnormal conditions, such as a sudden sound burst caused by a nearby explosion, might the protection mechanism for the delicate inner ear be switched on too late, and is thus rendered ineffective [page 16].

We think that the result by Angeli *et al*., a 30 dB reduction caused by tensor tympani muscle contraction, perfectly fits our theory.

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Authors' reply

Dear Sirs,
On behalf of my co-authors, I would like to thank Dr de Ru and his colleagues for their valuable contribution. In our previous paper, we documented a low-frequency 30 dB reduction in auditory thresholds secondary to the contraction of the tensor tympani muscle. In humans, however, contraction of the stapedius muscle plays the major role in the acoustic reflex in response to high-energy sound stimuli, even if the co-activation of the tensor tympani muscle could theoretically render this attenuation process much more effective.

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