■ LETTERS TO THE EDITOR

Replay

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To the Editor,

We are grateful to Dr Iranzo Lobera for his critical reading of our article, as well as for his valuable comments. Nonetheless, we feel it is necessary to add a few thoughts.

Throughout the evolutionary ladder, morphology and function have been dynamically linked so as to ensure optimal adaptation to the surroundings, so that it would impossible to separate the influence of one over the other (in this respect, a good example might be the changes that have arisen in the middle ears of whales since their predecessor (*Mesonyx*) left terrestrial life down to their current configuration).[1]

In the article on "The Middle Ear of Birds, etc," we did not prioritize the mechanics of the middle ear over its function, as Dr Iranzo states, as both are on an equal footing since the middle ear is a mechanical system, so its properties and function depend directly on its mechanical characteristics (mass, rigidity, and friction).

Nor did we intend to explain away all of the evolutionary changes that have occurred in the middle-ear muscles of multiple animal species, mammals or otherwise, as this would exceed the lesser goal of our paper to describe the middle ear of a species (ostrich). It is not our aim to explain why birds have only 1 muscle in their middle ear (or why many reptiles with columellar systems lack it), as this goes far beyond our ambitions and other authors have already published sufficient reports on the matter.[2] Our article was only an attempt to study, with the goal of transferring the results to a computerized system, the middle ear of a species with a single ossicle (a characteristic that can be assimilated to the use of a total ossicular replacement prosthesis) in order to understand its mechanical behaviour.

It is true (and perhaps this is the basis underlying Dr Iranzo's reflections on our article), that, on the basis of the findings in the ostrich's middle ear and its mechanical-acoustic analysis in a computerized model, we formulated a hypothesis: the fact that we mammals have 3 small bones in the middle ear as an essential characteristic is not due to random evolution but is intimately linked to the possession of 2 muscles. Having 3 bones in the ear brings with it certain advantages to mammals (dissipation of part of the energy between the joints[3] or fostering their accommodation to sudden changes in pressure), but in audiological terms, it places us in a certain situation of inferiority vis-à-vis species with only 1 ossicle (as the mass is smaller). This begs the question of why we have 3 small bones if the mechanical and acoustic behaviour of only 1 might be similar or (for lower frequencies) even superior. On this point we are aware that some species having a columella in the middle ear (although not all) have only 1 muscle, whereas mammals, with 3 ossicular elements, have 2 (with a greater or lesser degree of development). An analysis of the literature[4-8] on the study of the motor pathways of the muscles in the middle ear of mammals led us to a transcendental finding: the nuclei of the tensor tympani and stapedial muscles are synaptically connected to the olivocochlear pathway and the superior olivary complex (the stapedial muscle) and to the dorsal and ventral cochlear nuclei (the tensor tympani muscle). It does not seem useful in evolutionary terms to develop a complex neuromuscular system in the middle ear of mammals, closely linked with the auditory route, if it lacked any functional implications. What might these be? Striate muscles have an essential function, namely to provide dynamic movement for the bones to which they are attached. This same functionality persists in the ear. When one of the muscles in the ear contracts, it increases the rigidity of the chain, which displaces the resonance frequency towards higher tones. This does not happen only as a mere defence mechanism when faced with an intense sound or prior to vocalization, but rather forms part of a complex and refined system of frequency selection mediated by the muscles, yet intimately linked by serotoninergic pathways[9] to the ascending (cochlear nuclei) and descending (efferent pathway) auditory information.

This function allowing the muscles to move the bones in the middle ear would serve no function if both acted synchronously on a single bone or on 2 (separated by a single joint), as the effects (depending on the force vectors of each) would interfere with each other. On the other hand, if the chain to which the muscles were attached comprised 3 elements and 1 of the muscles were inserted in the first (the hammer) and the other in the third bone (the stirrup), their action would not interfere as the other bone (the anvil) lies between them to individualize their respective actions.

These considerations have led us to develop a working hypothesis whereby what is significant in evolutionary terms in the middle ear of mammals is not the presence of 3 bones (which is merely an epiphenomenon) but rather having

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2 muscles with independent actions related to the afferent and efferent auditory information, meaning that their contraction gives rise to a true selection of frequency prior to the cochlear filter. This theory does not conflict with the classic function of the ear's musculature for the attenuation of the sound caused by the body's own vocalization[3] and extends the functionality of these muscles,[10] which will have important consequences on the current concept of the middle ear and, therefore, our surgical actions on it.

REFERENCES

1. Sirpa Nummela JGM, Thewissen Sunil Bajpai S, Taseer H, Kishor K. Eocene evolution of whale hearing. Nature. 2004;430:776-8.
2. Borg E, Counter SA, Rydqvist B. Contraction properties and functional morphology of the avian stapedius muscle. Acta Otolaryngol. 1979;88:20-6.
3. Hüttenbrink KB. The mechanics and function of the middle ear. Part 1: The ossicular chain and middle ear muscles. Laryngorhinootologie. 1992;71: 545-51.
4. Counter SA, Aldskogius H, Borg E. Collera toxin B-HRP and wheat germ agglutinin-HRP tracing of tensor tympani muscle motorneurons and processes in rabbits. Acta Otolaryngol. 1993;113:43-7.
5. Ito J, Honjo I. Electrophysiological and HRP studies of the direct afferent inputs from the cochlear nuclei to the tensor tympani muscle motoneurons in the cat. Acta Otolaryngol (Stockh). 1988;105:292-6.
6. Itoh K, Nomura S, Konishi A, Yasui Y, Sugimoyo T, Muzino N. Morphological evidence of direct connections from the cochlear nuclei to tensor tympani motoneurons in the cat: a posible afferent limb of the acoustic middle ear reflex pathways. Brain Res. 1986;375:214-9.
7. Lee DL, de Venecia RK, Guinan JJ Jr, Brown C. Central auditory pathways mediating the rat middle ear muscle reflexes. Anat Rec Part. 2006;288:358-69.
8. Billig I, Yeager MS, Blikas A, Raz Y. Neurons in the cochlear nuclei controlling the tensor tympani muscle in the rat: a study using pseudorabies virus. Brain Res. 2007;1154:124-36.
9. Thompson AM, Thompson GC, Britton BH. Serotoninergic innervation of stapedial and tensor tympani motoneurons. Brain Res. 1998;787:175-8.
10. Phillips DP, Stuart A, Carpenter M. Re-examination of the role of the human acoustic stapedius reflex. J Acoust Soc Am. 2002;111:2200-7.

ERRATUM

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