Correspondence

DEAR SIR,

I would like to comment on the content of the paper 'A working theory on the mechanism of hearing' published in Vol. 85, No. 5.

There are many aspects of almost any postulate which can be queried and discussed at length, frequently to no avail. I shall therefore endeavour to keep to factual comment. This is particularly important in the face of a dual-wave hypothesis where apparent divergence of opinion can transpire to be due to little more than semantic differences.

Stylis describes sound waves travelling towards the cochlea apex as being 'squeezed down' to minimize reflections and says that reverberations in a straight cochlea would be significant. This is quite incorrect. Tests with carefully scaled straight cochlea type ducts and representative fluid (Cannell, 1969) have not revealed any such reflection or reverberation.

Stylis further asserts that the reason for the basilar membrane being wider and less taut at the apex is to compensate for reduced intensity of the pressure wave due to dissipation in the length of the cochlea. A series of model tests has proved that the width and thickness of a membrane at the distal end of the type of model referred to above are closely related to the frequency of pressure wave to which the membrane responds at this location.

Regarding non-fixation of the cilia to the tectorial membrane it is very interesting to note that in a coincidental paper proffering a new theory of hearing (Tiedemann, 1971)—based on more detailed observations—the diametrically opposite conclusion is arrived at! Despite this factor, Stylis' suggestion that the cilia act as tuned resonators will not bear investigation. Since the natural frequency of the cilia will, in broad terms, be proportional to root diameter and inversely proportional to length both of these parameters would have to vary by 10 times, and in opposite directions, throughout the cochlea in order that the full audio range could be accommodated. Furthermore, guessing the mean density of the cilia tissue to be about 10^3 kg./m^3 and its modulus of elasticity to be about 10^9 N./m^2 the natural frequency for the known size of cilia, connected only at their roots to the hair cells is of the order of 4 mega Hertz. If on the other hand, the cilia act as untuned resonators they are merely the ultimate transducing element in a mechanically excited chain of structures—and this is the widely accepted viewpoint. If the cilia do not act as tuned resonators then at least some are probably attached to the tectorial membrane, the question 'How could they withstand the pulling and pushing . . . if they were fixed?' having no substance unless the magnitude of the forces can be quantified in terms of the resistance of the structures to mechanical damage.

Finally, it is not possible for anyone with a knowledge of the mechanics of vibration to accept the preferred explanation for 'clarity of hearing reception'. It is not possible to initiate and terminate vibrations instantaneously as implied by Stylis. A vibration which is characteristic of the exciting source builds up from the moment of initiation and decays following removal or cancellation

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of the source. The decay is particularly important in this case since it is asserted that the vibration is halted by 'pushing the cilia against or into the tectorial membrane'. Not only will this indisputably leave a decaying transient (which will admittedly decay more rapidly for the inversely tapered cilia than it would for an equivalent constant section cilium) but, the cilia giving rise to neural action by virtue of mechanical stress on the hair cells, arrest of the motion by contact with the tectorial membrane will give rise to additional stress on the hair cell over and above that caused by the initial acoustically-related vibrational stress.

The Stylis theory may be a useful package whereby it is possible to develop some qualitative comprehension of the functioning of normal and defective ears but it cannot withstand anything more than superficial investigation.

Yours faithfully,

V. Marples.

REFERENCES

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DEAR SIR,

Thank you for drawing my attention to the letter from Dr. Marples of the University of Warwick. So the pundits *do* object.

I recollect the essential features of my Duplex Theory of Hearing (Stylis, 1971) in which I postulate the following.

1. Two wave motions are produced by the stapes footplate.
   (a) True sound waves.
   (b) A gross pressure wave (a 'near field effect').
2. The basilar membrane is deflected by the latter wave which causes the travelling wave of von Bekesy. This carries the hair cells to and from the tectorial membrane.
3. The cilia of the hair cells are not fixed to the tectorial membrane.
4. The cilia act as tuned resonators to receive the frequency of the true sound waves.
5. Two factors are necessary for the transduction of sound vibrations to electrical energy.
   (a) Exposure of the cilia to endolymph.
   (b) Vibration of cilia.
6. The function of the tectorial membrane is that of dampener as well as a protective medium for the cilia from the hostile endolymphatic environment.
7. Loudness is a complex function of:
   (a) Amplitude of movement of the cilia;
   (b) Degree of freedom from the gelatinous layer of the tectorial membrane.
   (c) The various relationships revolving about the type of movement of the basilar membrane and the rods of Corti, and the relative exposure of the various rows of hair cells.

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