A new model explains why we perceive sounds when they are conducted through the skull

June 27 2014

(Medical Xpress)—The ear is an important organ that allows us to perceive the world around us. However, very few of us are aware that not only the ear cup but also our skull bone can receive and conduct sounds. Tatjana Tchumatchenko from the Max Planck Institute for Brain Research in Frankfurt and Tobias Reichenbach from Imperial College London have now developed a new model explaining how the vibrations of the surrounding bone and the basilar membrane are coupled These new results can be important for the development of new headphones and hearing devices.

Our sense of hearing, which is the ability to perceive sounds, arises exclusively in the inner ear. When sound waves travel through the air and reach our ear canal they cause different regions of the basilar membrane in the inner ear to vibrate. Which regions of the membrane they vibrate depends on their frequency. It is these microscopic vibrations of the membrane that we perceive as sound. However, the inner ear is surrounded by a bone that can also vibrate.

With the help of fluid dynamics calculations Tchumatchenko and Reichenbach have now discovered that the vibrations of the bone and basilar membrane are coupled. In other words, they can also mutually excite each other.

This gives rise to fascinating phenomena which, thanks to the new model, can now be understood: For example, two sounds with slightly different frequencies that arrive in the inner ear at the same time can overlap and excite the same regions on the basilar membrane. In this case, combination tones, or so-called otoacoustic emissions, are produced in the inner ear through the nonlinearity of the membrane. Precisely how these sounds leave the inner ear and how they spread inside the cochlea is currently a matter of scientific debate. "In our study we have shown that the combination tones can leave the inner ear in the form of a fast wave along the bone surface, and not, as previously assumed, by a wave along the basilar membrane," explains Tatjana Tchumatchenko from the Max Planck Institute for Brain Research.

Moreover, the new model proves that the travelling waves along the basilar membrane can be generated by both the vibrations of the cochlear bone and the vibrations of the air inside the ear canal. "Our results provide an elegant explanation for this long-known but poorly understood observation," says Tobias Reichenbach from Imperial College London.

These results will help advance our understanding of the complex interaction between the dynamics of fluids and the mechanics of the bone. This understanding can prove essential for ever more fascinating future clinical and commercial applications of bone conduction, such new-generation hearing aids and combinations between headphones and glasses.

More information: Tatjana Tchumatchenko & Tobias Reichenbach. "A cochlear-bone wave can yield a hearing sensation as well as otoacoustic emission." *Nature Communications*, 23. Juni 2014 (DOI: 10.1038/ncomms5160)

Provided by Max Planck Society