Mosquito devices may be used to disperse Australian delinquents—but how do they work?

June 5 2013, by Catherine Mcmahon

Age-related hearing loss starts a lot earlier than you might think, and is exploited in anti-vandalism measures. Credit: locomomo

You may have read last week that, in a bid to curb graffiti, Sydney's State Rail may trial Mosquito devices – technology that emits a high-pitched noise that's audible only to people aged in their early twenties and younger – to drive away would-be vandals. A kind of teenager repellent, if you will.

Depending on your age, you can hear it, or not hear it, here:

The same technology has been used widely across Europe since 2006, and especially embraced in the UK, despite calls for it to be banned as it's claimed to violate the European Court of Human Rights' legislation prohibiting torture.

Ethical aspects aside: how does the Mosquito, and other such devices, target such a specific subset of the population?

As we get older, permanent hearing loss is affected by environmental factors as well as the normal ageing process (known as presbycusis).

Most commonly, hearing loss occurs in the higher frequencies first, gradually extending to the low frequencies as the magnitude of hearing loss increases. And it is the outer hair cells in the hearing organ, known as the cochlea (which looks a little bit like a snail shell), which are the most vulnerable to a variety of insults, including

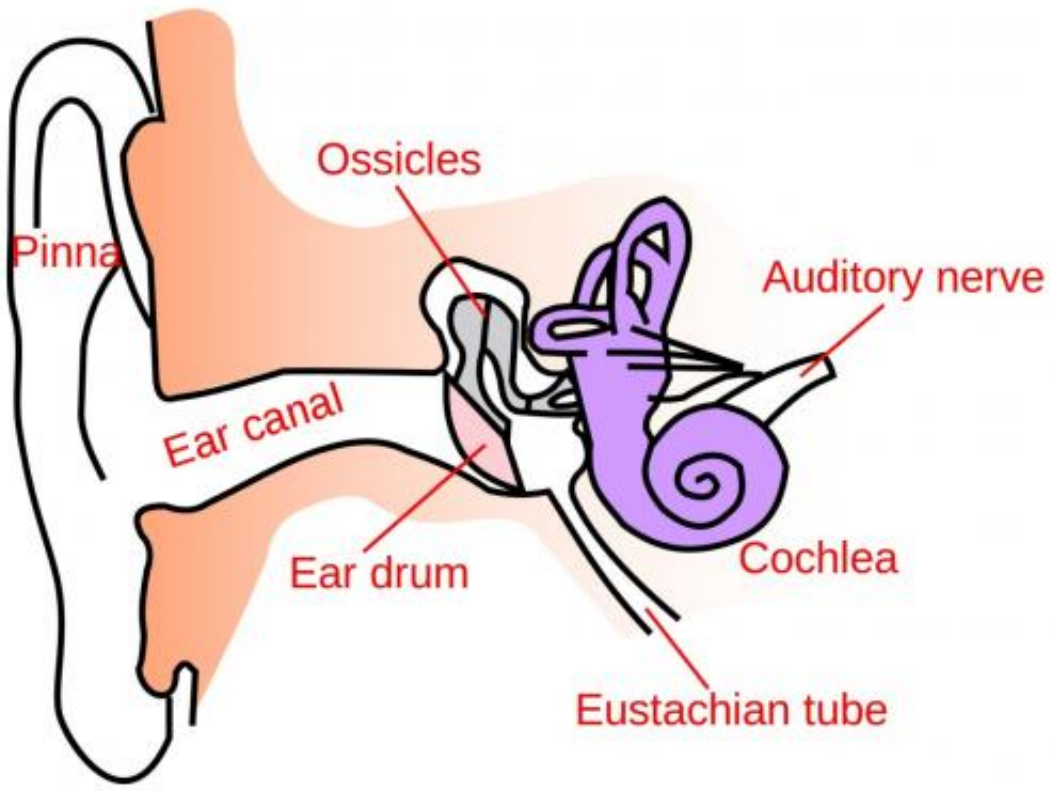
- loud noise
- drugs that are toxic to the ear (such as salicylate which is found in aspirin and quinine found in some antimalarial drugs)
- factors that affect ageing (such as reduced blood flow)

Ear anatomy 101

A sound transmitted through air causes vibration of the eardrum that is transmitted to the cochlea via three small bones, known collectively as the ossicles.

This sets up a travelling wave along a membrane in the cochlea, known as the basilar membrane, which progresses from the base of the cochlea towards the apex. The properties of the membrane gradually change from the base which is stiffer and narrower (and has less mass) to the apex where it is less stiff and wider (with more mass).

These changes in the membrane's properties cause the membrane to be tuned like a piano (known as tonotopic tuning), where high frequencies are located near the base and low frequencies near the apex.



Credit: Wikimedia

A single row of inner hair cells and three rows of outer hair cells sit on top of this membrane.

These are known as "hair cells" because of the tiny hair-like projections that are located on the top of the cells known as stereocilia. The cells move up and down with the vibration of the basilar membrane and the stereocilia are displaced side-to-side.

Inner hair cells, known as sensory cells, are responsible for the conversion of the basilar membrane vibration into an electrical impulse. Outer hair cells are known as motor cells and "twitch" in time with the vibration of the basilar membrane.

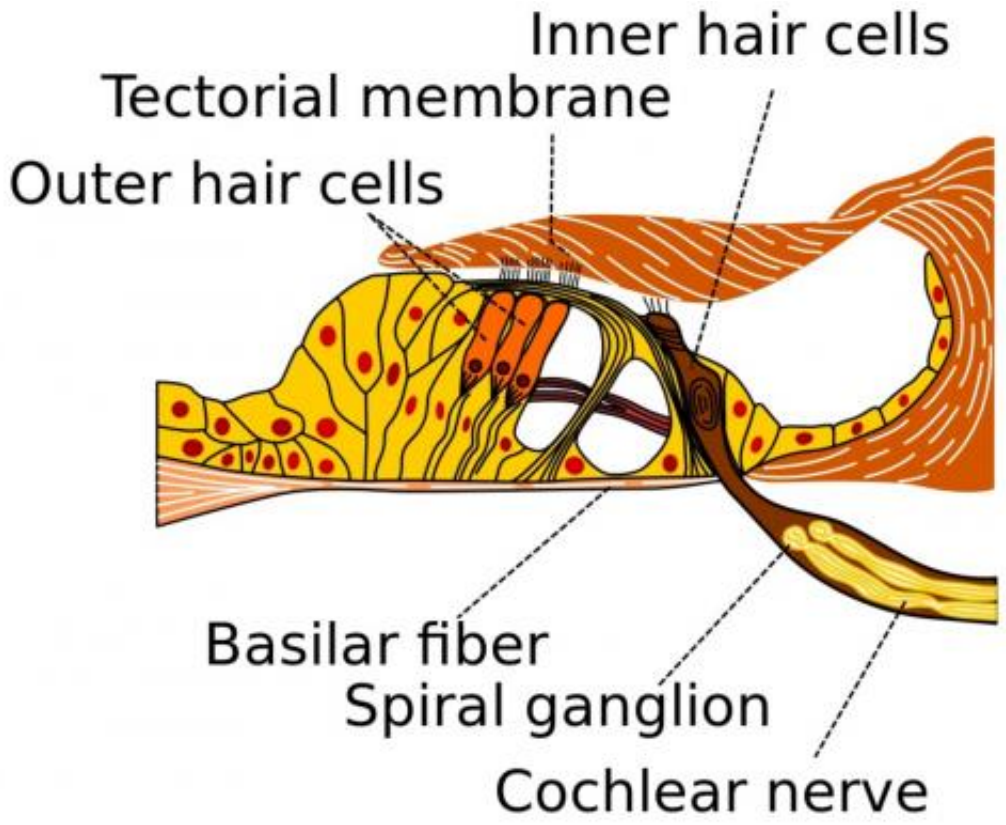
This amplifies the vibration at very discrete areas along the basilar membrane that are related to the frequency of sound presented and provides us with very good frequency discrimination.

We hear when the sound is converted from this mechanical vibration into an electrical impulse which travels up to the auditory part of the brain via the auditory nerve.

Say goodbye to high frequencies

It is the outer hair cells (and, in fact, the stereocilia) which are most physiologically vulnerable to damage. A complete loss of outer hair cells gives a hearing loss of approximately 60 decibels (a moderate hearing loss).

So individuals with a loss of outer hair cells are still able to hear, but usually require amplification from hearing aids to perceive softer sounds in speech.



A cross section of the cochlea. Credit: Wikimedia

The damage or loss of outer hair cells and/or their stereocilia extends from the base, where high frequencies are located, to the apex, where low frequencies are located, creating a typical sloping hearing loss from high-frequency to low.

This decline starts in the late teen years, so it is for this reason that the Mosquito alarm, designed to emit a very high-pitched noise of 17.4kHz, is so annoying to people in their early twenties and younger.

Provided by The Conversation