LETTER TO THE EDITOR

Annoyance from wind turbines: role of the middle ear muscles

There is a simple, though unappreciated, explanation for the annoyance that some people experience when near a rotating wind turbine or inside an anechoic chamber (Neville Fletcher, AA, 41, 174-175 and Peter Alway, AA, 41, 195). The explanation involves understanding that the ear is not just a microphone, as a lot of people seem to think.

Rather, the ear is part of a sophisticated gain control mechanism. This is not unexpected when you consider its enormous dynamic range – 120 dB or a million million times. No linear detector could work satisfactorily over such a huge input range.

It is known that there is some neural gain control, but there is also a physical gain control mechanism – the “acoustic reflex” involving the middle ear muscles – which is frequently overlooked. The acoustic reflex automatically comes into play at loud sound levels or when you speak, touch your ears or face, or even when you blink, in each case causing the muscles to contract and protect the incredibly sensitive cochlea. If you close your eyes tightly, you can hear a “fluttering” and that is the sound of the middle ear muscles at work. Interestingly, some people are able to contract the middle ear muscles voluntarily. A standard way to evoke the middle ear reflex is to blow a puff of air on the face.

Like all muscles, the middle ear muscles come in pairs – one works against the other in an agonist/antagonistic fashion. In the middle ear there is the stapedius muscle attached to the stapes and the tensor tympani muscle attached to the ear drum, both working together to attenuate sound as it is conducted from ear drum to cochlea.

It is not always appreciated that when the middle ear muscles contract, the pressure in the cochlea – the intracochlear fluids – must rise as the tensor tympani pulls on the ear drum and pushes the stapes into the cochlea (and the round window bulges out). As hypothesized by Gellé in the middle 1800s, this pressure signal is a way by which the cochlea can regulate gain, a mechanism known as the intralabyrinthine pressure (ILP) theory of middle ear action. There is a range of diverse evidence in favour of the ILP theory, work which has been reviewed in Bell (2011).

The ILP theory makes sense of observations of wind turbine syndrome. A low frequency pressure pulse from a wind turbine blade has an enormous amplitude (relative to 20 μPa), even though at about 1 Hz it is below audibility. Nevertheless, a consideration of the physics of pressure waves propagating through air will help us see that that a high pressure signal will inevitably have a direct effect on the ear drum, even if it doesn’t stimulate a suitable nerve ending in the cochlea. When the ear drum moves in response to a large air-borne pressure pulse, this is likely to interfere with the functioning of the ear’s gain control mechanism as the attached muscles try to keep the drum at the middle of its operating range. And that activity will repeat whenever a pulse comes along, about every second in fact. No wonder some people will soon feel “pressure” in their ears, and fatigue may set in. A wind turbine is similar to a constant sequence of “air puffs” blowing against the ear.

The important thing to recognise is the physical movement of the ear drum at about 1 Hz. It’s rather beside the point that a 1 Hz pulse is inaudible because its physical manifestation – motion of air particles – will always lead to ear drum motion. The fallacy, of course, is to say that because wind turbine noise is below perceived sound levels that the sound will have no biological effects and can be ignored. It doesn’t help that normal SPL measurement protocols use an ‘A’ weighting which automatically discounts low frequencies and so tends to sweep the problem under the carpet.

Another way to disrupt the hearing system’s set point is to go into a sound proof room: with no background sound and no output, the hearing system will, as Peter Alway relates, start hunting around for an operating point, a sensation which the owner of the apparatus senses as “pressure” in the ear. Indeed, pressure well describes what is happening, as the middle ear muscles hunt around for a set point for the pressure in the cochlear fluids (with no output signal to provide feedback, the loop is open and the action of the muscles in trying to set the gain is fruitless). Such a mechanism is well explained by the intralabyrinthine pressure theory, but it is not at all apparent from the standard idea of middle ear muscles causing “sound attenuation” in the ossicular chain.

The above explanation needs to be confirmed, but it makes sense of the diverse observations from wind turbines and sound proof rooms. The problem is that middle ear muscles are difficult to observe, and their movements are minute – micrometres and less. Nevertheless, micrometer movements are significant when the intracochlear fluids – which are essentially water – are incompressible. A tiny movement leads to an appreciable rise in pressure.

A similar disruption to the middle ear muscles can be observed in people with Meniere’s disease. Suddenly they have an ‘attack’, which can be seen as a spasm of the muscles. They suffer fluctuating hearing loss (the gain is being shunted up and down), tinnitus (the sensation you get when static ear pressure is applied to anyone’s ear canal), vertigo (when pressure of the intralabyrinthine fluids is abnormal and affects the balance organs in the inner ear), and, of course, “pressure or fullness in the ears” (which, precisely, it is).

In the present discussion of wind turbines, the action of the middle ear muscles and the intralabyrinthine pressure theory which explains their anatomical function deserve more attention. The middle ear muscles are an essential part of an intricate hearing system, although they have become poor cousins to the cochlea. Unless we recognise their essential function, we will, as Peter Alway again relates, begin to doubt the reports of people who “feel pressure” in their ears even though the sound (or lack of it) which causes the problem is inaudible.

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REFERENCES