How the brain processes musical hallucinations

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A woman with an "iPod in her head" has helped scientists at Newcastle University and University College London identify the areas of the brain that are affected when patients experience a rare condition called musical hallucinations.

Sufferers persistently perceive music, as if they were hearing it with their ears, when no music is actually being played. Initially they often mistake the experience for actual music playing and while musical hallucinations can occasionally be a symptom of a neurological or psychiatric disorder, it is usually caused by hearing loss in people who are in normal physical and mental health.

Dr Sukhbinder Kumar from the Institute of Neuroscience at Newcastle University, lead author of the paper published in *Cortex* said: "We found that a network of brain areas, that are usually involved in processing of melodies and retrieval of memory of music, were particularly active during hallucinations of music in the absence of any sound or music being played externally."

Nearly one in ten people suffer from tinnitus which is technically an auditory hallucination, in which tones or buzzing noises are heard following hearing loss. However in a small number of people with hearing loss these hallucinations take the form of music, but until now the brain mechanisms underlying this process were poorly understood.

This study by researchers at Newcastle University and University College London and funded by the Wellcome Trust has looked in depth at one sufferer of the condition and pinpointed the regions of the brain involved in producing the hallucinations. These findings could lead to a better understanding of the condition and possibly treatments in the future.

Musical hallucination

Sylvia, 69, a maths teacher who is also a musician with perfect pitch, started to go deaf about 20 years ago after a viral infection. Then about eleven years later she experienced a sudden acute hearing loss and severe tinnitus and her musical hallucinations developed after this. Due to her musical knowledge Sylvia was able to notate what she was hearing.

Initially the condition was irritating and affected Sylvia's sleep, but she learnt to live with it. "I did everything I could to get rid of them but they persisted, always in a minor key and therefore a bit depressing," she said.

"Eventually the number of notes increased until they seemed to be parts

of tunes. One day I recognized something and, once I had done so, more and more phrases from classical music appeared in my brain."

Among the pieces of music that Sylvia was hearing in her hallucinations was Gilbert and Sullivan's HMS Pinafore, as well as music by Bach. Amazingly Sylvia found that by playing music herself, she was able to alter the music in her hallucinations.

"I can change the hallucination playing in my head to the music I am practising. This is particularly the case with the music of Bach - the hallucination will pause and then a whole page will start to play in my head, gradually curtailing itself until just a phrase remains and is repeated. That might then repeat a thousand times a day. It is as if I have my own internal ipod."

Sylvia's experience is fairly typical, though the condition occurs just as often in non-musicians, and sometimes starts abruptly rather than slowly developing as in her case.

How we hear

As Sylvia's hallucinations could be manipulated by playing an external piece of music that allowed the researchers to understand what was happening in her brain during hallucinations. They first identified pieces of music that suppressed her hallucinations and these pieces were then played to her while her brain activity was being monitored using magnetoencephalography MEG), which measures magnetic fields around the scalp as the brain processes information.

During normal perception of music what we actually 'hear' is a complex interplay of the sound entering the ear and our brain's interpretations and predictions. Normally the strength and quality of the input from the ear is so high that it dominates what we actually perceive however the brain

fills in the gaps when the ears do not provide enough input.

"With hearing loss, as in Sylvia's case, the signal from the ear becomes weak and noisy, like a poorly-tuned radio. The brain's predictive mechanisms therefore have to work very hard to make sense of what we are hearing. What we have found is that these processes sometimes end up running away with themselves to cause hallucinations," said author Dr William Sedley also of Newcastle University.

Dr Kumar added: "This also explains why listening to an external piece of music suppresses hallucinations. When external music is playing the signal entering her brain is much stronger and more reliable, which constrains the aberrant communication going on in the brain areas during hallucinations."

This new understanding of musical hallucinations may provide better treatment in the future as Newcastle University's Professor Tim Griffiths, professor of Cognitive Neurology who lead the study explained: "It might be possible to disrupt the abnormal communication between the brain areas using brain stimulation, or to use pharmacological treatments to disrupt chemical transmitters that drive communication between them.

"Better hearing aids also appear to help suppress hallucinations, so we would advise people experiencing musical hallucinations to seek medical attention, if for nothing more than to ensure they have the best available hearing aids."

Dr John Williams, Head of Neuroscience and Mental Health at the Wellcome Trust, says: "This case is extremely fascinating, but the condition is relatively rare. However, it is unusual cases such as this that can give us profound insights into how the brain works and, one hopes, lead to potential new treatments to improve the patient's life."

More information: Sukhbinder Kumar, William Sedley, Gareth R. Barnes, Sundeep Teki, Karl J. Friston, Timothy D. Griffiths, A brain basis for musical hallucinations, *Cortex*, Available online 16 December 2013, ISSN 0010-9452, dx.doi.org/10.1016/j.cortex.2013.12.002.