

## **A Narrative Review of Infectious Music.**

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Seeing a patient in my neurology practice with temporal lobe epilepsy who described ‘music in his head’ led to me to recently seek to review the neurophysiologic and clinical features of musical intrusions more generally. In addition to three highly cited reviews on earworms that I have referenced in the text (1-3) I also used the search term ‘earworms’ and its synonyms ‘Involuntary musical imagery, musical intrusions, brain worm, sticky music, musical obsessions, stuck song syndrome and musical imagery repetition in Pubmed, PsycINFO, Google Scholar and Scopus to search for additional recent studies that were not included in the reference lists in these reviews. 15 relevant resources were identified of which 14 described original research. Details of these studies and their findings are provided in an evidence-based table ( see supplementary material) and been included in the preparation of this narrative review. Virtually all the papers on earworms in contrast to musical

hallucinations are to be found in the psychology, humanities and neuroscience literature, and are mostly based on self-reporting and small case series of healthy people.

Earworms are fragments of music that are heard in the mind and seem to replay over and over again as if jammed in playback mode. They are a normal involuntary cognitive event or 'itch' that occurs at least once a week in most healthy young adults. Although they may give a subjective experience of being something special and out of the ordinary, they result from normal cue-driven chained semantic memory recall. It has also been suggested on the basis of functional MR studies that the primary auditory cortex acts as the imagination's portable media player and obeys similar neural principles to visual imagery (4)

Most earworms last for between 15-30 seconds and usually consists of a single repeated musical phrase or a chorus accompanied by lyrics. Recent and repeated exposure to music and memory triggers used to reactivate previously heard music are predisposing factors and up-tempo musical passages with closely spaced intervals, long notes and common melodic contours seem to be particularly infectious. Mind wandering or day dreaming and an individual's mood are considered to be important cues. Sometimes musical imagery is reactivated voluntarily by musicians in the course of rehearsing or while composing music using notational audiation (see Beaty et al supplementary evidence-based table). For most people they are neither disagreeable or frightening and some people even report humming along to them(1-3)

Although less than one in ten people with earworms find them irritating, practical means for suppressing them have received a great deal of attention in the literature. Chewing gum, listening to talk radio, doing puzzles or listening over and over to the song that has triggered the earworm are some suggested strategies. It has been postulated that certain 'attention seeking' tunes have the capacity to subvert a 'short length of recording tape' called the phonological loop that continuously stores fragments of auditory information in the

left primary auditory cortex(1-3). In much of the psychological literature the term involuntary music imagery has been used synonymously with earworms with the erroneous implication that all forms of musical intrusion including musical hallucinations are equivalent.

Musical obsessions are similar to earworms but the internal music tends to be more intrusive, repetitive and refractory. Sometimes they last for hours and may be described as a very distressing, almost continuous sound track. A song may be imbued with a special meaning and a fear of hearing it from an outside source can lead to avoidance behaviour such as reclusiveness or wearing ear plugs to blot out exposure to catchy ring tones or muzak. In contrast to earworms they usually occur in people with obsessive fears, depressive ruminations and health anxiety.

Musical hallucinations are much more uncommon and are most often reported by socially isolated elderly people with hearing difficulties (analogous to the Charles Bonnet Syndrome in the visually impaired ). They may occur in association with unformed sounds (tinnitus) and verbal auditory hallucinations (hearing voices). They can also occur rarely in depression, schizophrenia and organic and drug-induced psychoses and as in my patient with complex partial seizures may be an early sign of temporal lobe damage. They are more persistent, unfamiliar and frightening and less repetitive and suppressible than earworms. They are also much less likely to include lyrics and are more commonly viewed as of 'one's own creation' and to have an external origin(5). A disinhibition of the areas involved in musical imagery through the reduction of external auditory input has been suggested as a possible mechanism for their cause(6). Musical hallucinations temporally linked to seizures are extremely rare. A recent review revealed only 24 convincing case descriptions (4 auras, 14 ictal and 6 post and interictal)(7).

I was reminded of earworms 17 years ago when my colleague and friend Oliver Sacks, in one of our regular meetings in London, told me he was researching earworms, or as he preferred to call them brainworms, for his book *Musicophilia*. He considered them to be the acoustic equivalent of visual after-images and speculated that the ubiquity of music in modern life may have increased their frequency. The first descriptions he had managed to unearth in the English literature were in Edgar Allen Poe's essay 'The Imp of the Perverse' published in 1845 and in Mark Twain's 1876 short story, 'A Literary Nightmare.' In both of these stories the involuntary musical imagery was disturbing to the individual(2).

My own engraved earworms come unannounced often when I am relaxed or when I am at wakeful rest. They are welcome snatches of songs that are part of the symphony of my life. They may arouse me and sometimes they entrain my walking. Each lasts for only ten seconds but they usually occur in salvos over several hours.

On an unremarkable Thursday morning in 1981 I left home heading for East Finchley subway station with the melodic leaps of Jackie Wilson's 1973 floor filler '[Because of You](#)' running through my head ("Do I love you? Do I love you? Do I love you? Indeed I do"). The first new referral in clinic that day was a woman in her early fifties who presented with a tremor of the hands that had begun to interfere with her ability to hold a cup and saucer without spilling the contents. She had first noticed a shake two years earlier and she told me it was getting slowly worse.

She had a maternal grandmother who had developed a tremor in her seventies and there was an uncle also on her mother's side who she thought might have a head tremor. She was not taking any drugs known to cause tremor and her general practitioner had written in her letter that the thyroid function blood tests were normal. The character of her tremor and its temporary improvement following an alcoholic drink supported my provisional diagnosis of essential tremor. The Jackie Wilson earworm returned as I began my examination. I wrote

down that she had a coarse symmetrical tremor of the outstretched hands and a mild intention tremor. Her handwriting was large and tremulous and she found it difficult to draw an Archimedes screw. As she was dressing I went back inexplicably to inspect her eyes. Although I had only ever seen a Kayser-Fleischer ring in textbooks I thought I could make out a crescent of dark discolouration at 12 o'clock and 6 o'clock on the surface of her cornea. Despite the unusual age of presentation and the tremor that suggested essential tremor rather than Wilson's disease, blood and urine copper studies and a liver biopsy confirmed the diagnosis.

For several months afterwards I was silently triumphant but after the glory had faded I began to wonder what it was that made me go back and look at the patient's eyes. To practise medicine is to have a permanent feeling you've forgotten something. Flashes of inspiration in medicine also usually turn out to be wrong or are found to have a logical explanation but I have reluctantly been forced to acknowledge an emotional sixth sense lurking subconsciously in my clinical method. Although it flew against my innate scepticism I became convinced that I would have missed the correct diagnosis if Wilson's disease had still been called hepatolenticular degeneration or later renamed ATP7B proteinopathy. I have no way of ever proving that my Jackie Wilson earworm was a meaningful coincidence or a flashbulb reminder but I like to think that at least what transpired was an example of soulful neurology at work, and worth writing up these many years later for its clinical utility.

Figure: A Kayser-Fleischer ring from the author's private collection

## References

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See supplementary material for evidence based table and additional references