The Musical Brain Conference 2014

Mozart and the Power of Music: Memory, Myth & Magic

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TRANSCRIPT

Brainwaves and Sonification – Nigel Osborne with Prof. Michael Trimble and Prof. Dale Hesdorffer

DALE HESDORFFER: First I want to thank the organisers for their invitation, I'm very excited to be here and talk a bit about seizures and music. I'm going to talk about two sides of one coin, one is the ability of music to provoke a seizure, musicogenic epilepsy, and the other is the possibility that music acts as therapy in people who have seizures. The latter part is a lot weaker in what's been done than the former. So for most people with epilepsy, the transition to a seizure occurs spontaneously due to mechanisms that are not well described, but for a sub-set of people with epilepsy, there is a trigger that provokes a seizure, where seizures are stimulated by exogenous stimuli, so music, whether sung, played or heard, is one of these aspects. Non-musical sounds like a horn also can provoke seizures and there are other things such as reading, eating, looking at something, photosensitivity due to light, and television induced seizures.

Musicogenic epilepsy is very rare indeed. More than one in 700 people in the Royal Navy have epilepsy and there is an incidence of 1 in 10 million people in the general population, this is very small to the incidence of epilepsy overall, 50 or 60 per 100,000, so this is a rare phenomena. The musical stimulus is closely associated with the seizure. Usually this is due to one particular piece of music, not lots of different music, and the music is usually heard for a few minutes before the seizure actually occurs. In people with musicogenic epilepsy, seizures in the absence of music are very rare, and other music may be heard without actually provoking a seizure. Almost 75% of patients with musicogenic epilepsy have temporal lobe epilepsy, most of them have a right-sided seizure focus, and music may activate many of the structures in the limbic system, including emotional factors, and this makes it rather difficult to tell whether it's actually the music or the emotional impact of the music that actually provokes the seizure. Women are more affected than men, 54% of people with musicogenic epilepsy are women and 46% men, and this is entirely the opposite of all epilepsy. The mean age at onset is 28 years, so the incidence of epilepsy is very high in young children, it comes down at about age 20, it stays down for a while, and at about age 60, it rises well beyond the people who are under one year of age, so we're somewhere in the middle of the incidence curve for epilepsy. This is an image from a study that looked at silence and did fMRI imaging and then music and fMRI imaging, and you can see, as Michael Trimble has discussed, that the temporal lobes are activated. Now, the temporal lobes are particularly epileptogenic even for people who don't have musicogenic epilepsy so it's possible that this activation by music may lower seizure threshold in a particular group of people, but we don't actually know the answer to that.

What are the characteristics of music that provoke seizures? Well, effective musical stimuli, you can see here, span the range, classical, melodic, rhythmic, but melodic and rhythmic together seem to be the most commonly effective musical stimuli, and piano music and organ music are more likely to stimulate musicogenic epilepsy than other kinds of music. This is a range, from different studies when the pieces are mentioned, of musical examples that give rise to a seizure, so it's classical music, it's jazz, it's pop music, it's just a very large span, and in part that is because the specific piece of music that's played is what has the impact in most cases but not all. I'll tell you of a case that is quite different. The type of effective stimulus is most likely to be familiar and with an effective content. There are some people who respond only to novel music, and many who respond to a specific piece. In some studies, because of the particular sample that has been assembled, people have thought that professional and amateur musicians are most at risk, but when you look across many studies, that does not seem to hold up.

Musicogenic epilepsy has been known about since the 16th century, J. Scalinger described a person whose seizures were triggered by the sound of a lyre and Shakespeare wrote, “Some men there are love not a gaping pig, Some that are mad if they behold a cat, And others, when the bagpipe sings i’ th’ nose, Cannot contain their urine.” This is actually a sign of a convulsive seizure, where urinary incontinence is quite common. Then there's a case of the Chinese poet, Jinchin Kyo. This is a case where there is novel music, unfamiliar music that gives rise to musicogenic epilepsy, this particular patient had three seizures provoked by novel melodies and musical tones. Here is the seizure, constriction in the throat followed by pallor, and if prevented from leaving the music hall, the patient would have a seizure with biting of the tongue, a convulsive seizure, where the body is shaking. However, and this is very interesting, an unproven thing, when the patient grew accustomed to the melody, the seizure no longer occurred, so it might be possible to stop musicogenic epilepsy. Such a study has not been attempted, but this is one instance in which this happened, and then there is the case of the Russian music critic, Nikonov, who published the book *Fear of Music.* His first seizure occurred at a performance of Meyerbeer's opera *The Prophet*. He became tremulous, sweated excessively and developed a twitch in his left eye, a violent headache and loss of consciousness followed. Then he had other seizures, due to different types of music, and a few notes of music would actually trigger a seizure. He became very anxious, phobic, apprehensive of hearing any music and he was known in sort of a humorous way by people who knew him to run away from a marching band.

This is a case of musicogenic epilepsy, but it's not Mozart or Beethoven, this is from YouTube. It was the only example that I was able to find, and I'll tell you a little bit about him and then try and get to the salient points. This is a young man who responds to sounds with seizures, as well as to music and he inadvertently picked up his sister's iPod and heard this song by Justin Bieber and he had a seizure. Then to experiment, he tried to listen to it again, and he had another seizure and here’s that bit.

[CLICK HERE to play video.]

SPEAKER FROM YOUTUBE: I'm epileptic, I have had seizures for about 20 years now on and off, and my seizures are induced by different auditory signal tones: whistles, bells, ringing, different pitches, and loud abrupt noises. While listening to my sister's iPod I discovered something kind of intriguing. One song in particular that induced a seizure was Justin Bieber's *As Long As You Love Me* and I've done it two times now, and I'm going to show you what happens when I listen to the song. I'm an epileptic, it's probably pretty dangerous, but I want to show you so I can get some answers and try to find out why this happens to me. So here goes. I'm going to sit down on the couch while it's on.

[End of video.]

DALE HESDORFFER: There's a little bit where he has fast forwarded YouTube, before the seizure starts. So he responds to sounds with seizures as well as to music. He inadvertently picked up his experiment and he tried to listen to it again and had another seizure. I think you have to listen to it.

[Video plays.]

DALE HESDORFFER: There is a little bit where he has fast forwarded YouTube before the seizure starts. He goes into a full convulsive seizure from that. You will see because it is taking the music stimulus enough time to trigger the seizure.

Now I'm going to turn to music as therapy in epilepsy. There are some really small studies, case studies that have looked at this and there are other alternative explanations for them. I'm going through them as a possible idea for epilepsy. So music as epilepsy therapy is associated with the status epilepticus. It lasts for 30 minutes and is a medical emergency, treated in the ER and ICU. Music has been seen to decrease seizure frequency in those people who are unresponsive to medication. Most importantly I think, because this gives you the underlying physiology, music also is able to normalise the epileptic form EEG in two studies.

The first case is of a 22-year-old man who had traumatic brain injury and developed epilepsy as a resultative, status epilepticus, and he was in a medically induced coma for five days to no effect at all. His family gave informed consent to add *Sonata for Two Pianos* for 30 minutes each day. The EEG was monitored before and after the music was played, and the people who read the EEG did not know if they were looking at the EEG before the music was played or after the music was played. After five days of music, the EEG improved and he was weaned off the medications that had put him in a medication-induced coma. He recovered from his coma and continued to use music as therapy. Now it is possible he already had five days of coma and had status epilepticus. It is possible it would have resolved on its own after five days. It is also possible the music had an effect. We don't know, it is a single case. But there is improvement in refractory seizure, seizures that do not respond to medication.

People have continuous seizures, this is a 56-year-old man with laughing seizures, sometimes convulsive, which sometimes led to whole-body shaking, due to a hypothalamic tumour, a benign tumour in the brain. He had surgery but he was still seizing after the surgery. Then he learned about the therapeutic effect of Mozart's music and he started to listen to Mozart. Very shortly thereafter he found he had no further convulsive seizures. He continued to have the laughing seizures but they were no longer very disruptive outbreaks of laughter, but only little smiles. Again, it is very hard to see from the one case study whether it is the music having an effect or whether other mechanisms are operating to change the seizure frequency and the type of seizure. This is a different case. This is an eight-year-old girl with Lennox-Gastaut Syndrome, a catastrophic epilepsy where many seizures occur each day. Here, the same Mozart was played for ten minutes per hour for each hour she was awake. What you see here is in the first four hours of the day she had nine seizures and the last four hours of the day she had four seizures. This is a decrease in seizure numbers, which is a statistical fact. The duration of her seizures also dropped. In the second day they were not playing the Mozart at all anymore, but in a 24-hour period she only had two seizures. This is a developmentally disabled child and so this is more likely to possibly be correct. The big problem with this is the counting of seizures and the degree to which the parent was counting and if they had certain anticipation.

This is clearer, here is normalisation of the EEG from Mozart, with two studies and there was a decreased number known in epileptic abnormalities in the presence of the music and also a decrease in sub-clinical seizures, seizures seen on the EEG but not visible. This was with the Mozart but not old time pop tunes or the music of Phillip Glass. You can see the epilepsy community have paid a lot of attention to the title of the talk with Mozart music before lunch. Music clearly stimulates the brain; we know that from Professor Trimble and his talk. Music itself may normalise the epileptic form of EEG. We don't know what might be special about Mozart, and it might be any music that might do equally as well or also not have an effect. I'm going to provide a little segue into Nigel's talk, by providing an EEG sonification example. That is what I would define as the musical representation of a physiological process. This is from people in California.

[**CLICK HERE to play audio.]**

JOSEF PARVIZI: I am Josef Parvizi. I am an Associate Professor at Stanford University. What we are about to hear is the sound of the brain in three states. The first state is the normal brain activity, with the normal heart rate in the background. The second state is the seizure activity when hundreds of thousands of neurons fire together, fast and rhythmic, and the heart rate is clearly up. The third state is the post-victal state when all the neurons that we're firing together have become very tired and they are having a very loud and slow pattern of activity, during which the patient is usually confused and disoriented and cannot think clearly.

You hear the sound of the brain - normal brain activity - in the foreground, and in the background you hear the sound of the heart.

[Sounds changes, becoming faster.]

Now you hear that the sound of the brain is becoming more disorganised, going into more rhythmic and faster activity and the heartbeat has become faster. Here we are in the midst of seizure. As we can hear, the heart rate has become significantly faster and the brain sounds are much more rhythmic, yet the patient is quiet, lying in bed. You may not even notice she's having a seizure. Now the seizure is stopped, you hear these loud noises, as if some forces are coming in to stop the firing of so many hundreds of thousands of neurons together. The brain is tired. The patient is often disoriented and confused and the heart rate goes back to normal.

[End of audio.]

DALE HESDORFER: Nigel tells me he has a more musical description of the same. So I will turn it over to him.

MICHAEL TRIMBLE: Thank you Dale. That was a nice introduction to Nigel who will take this story further. I leave the rest of the stage to you, Nigel.

NIGEL OSBORNE: What I would like to do is pick up the story from sonification, and talk a bit about sonification. I would like to pull it back to brainwaves and then from brainwaves back to the body, very briefly, I promise to do that quickly. Sonification is making things audible that are otherwise visual or unheard, or touch, or scent, and turning them into sound. Why should we want to do that? There is a very good reason. We're better at hearing in detail than we are at sensing in any other way detail. Our brains have the fastest firing systems of neurons in the auditory cortex, the fastest firing communication of the brain is in our hearing. Furthermore, to make that even easier, the slowest energy that we regularly perceive is sound. Light is very fast energy. Sound is relatively slow in relation to light so we have the biggest potential to understand detail, working on the slowest energy. That's why we sonify, that is why we take data that we can't really grasp visually in other way, and we turn it into sound to understand it. It has happened for a long time. Leonardo da Vinci found even when he couldn't see ships or they were hidden behind other ships, he could hear at what speed they were coming. He had taken the medium of sound to recognise them properly.

In 1908, Geiger and Müller invented the Geiger counter to sense radiation. There is a tube of inert low-pressure gas, helium, neon, which, in the presence of photon or radiation particles, would generate an ionisation, a small charge, that came up, click. This will be familiar for you, my generation. This is Jet Morgan, Journey Into Space. These are guys in spacesuits making crackling sounds of very dangerous things, threatening to annihilation the species. Here we go. *[Clicks.]* Do you remember the sound. We just heard Geiger and Müller, helium, neon, photons, radiation particles, ionisation and a small charge, which becomes a click. That's amplified. *[Clicking sound.]* I will torture you no more.

I won't waste much time on this, because we're really short of time, but Edmund Fournier in 1913 invented this system to be able to sense printed words, so that blind people could read. What he did was he used selenium, a chemical agent, from Selene, the moon, which has a property of changing its resistance to current when there is light. So Fournier very cleverly did this, he discovered that if you had eight sensors configured like this, he could capture whatever letter, if it would be an A, B, C. You could change the shape of it with eight points, so he put each of those eight points with selenium and those were connected to oscillators. When the eight points read a white, it switched off the oscillator, and when it read the black part of the print, it put it on, so then people could hear the letters - a very simple sonification. Well, not so simple, but there we are.

Now, coming to the more contemporary thing of brainwaves, I will just get this out of the way because it will be a distraction, but this is the entrained firing of neurons, neurons firing together in the brain. It is our consciousness, a trace of our thinking, that much we know, in our minds. These neurons function at different speeds, so for example, beta waves will be from 13 to 60 Hertz or 13 to 60 times a second, very fast, and those are associated with alertness and arousal. Alpha waves from 7 times to 13 Hertz, which is kind of relaxed but aware, and we just heard one. Then there is a theta wave, which is even more relaxed, you may even be asleep *[clicks tongue]*, right the way down to deep sleep, and unconsciousness *[slow clicks]*. These are the rhythms of our thoughts. There is a paradox, in that brainwaves are, of course, electromagnetic, but they behave much more like sound than light, they behave like longitudinal waves, they can go through bone. Light gets stopped by surfaces it can't go through, and sound goes through it. It can sometimes even be stronger than what it passes through. Brains share with sound this thing I have just been able to do *[clicks]*, periodicity, longitudinal wave-type structures, and also the fact that there is a sort of continuum between what we would call rhythm and what we would call pitch. This is a thing that is crucially important, this equivalence, when we are talking about music therapy or music medicine and epilepsy, to recognise the intimacy between sound and brainwaves. There is a kind of connection but you wouldn't think of it immediately. If you think of sound, mechanical energy, brainwaves, electromagnetism, how on earth could the domain of the electromagnetic be influenced by the mechanical? Well, if it's behaving in the same way, perhaps it can, or it appears to be.

There is a very important misunderstanding in the area of rhythm and pitch which we should really clear up. There is something that I would call the window of rhythm, I mentioned it once before in a Musical Brain conference. We hear frequencies as pitch. When they are roughly above 20 times a second, 20 Hertz, they become pitch. Below that, they become networks so, in theory, rhythm. So if you take a generator of sound, I will do it with my voice now *[descending singing]*, I've turned a pitch into a rhythm. There is a very important threshold here, the threshold where pitch turns into rhythm. A really good tabla player can play up to 19 Hertz, just the point before rhythm turns into pitch, so in other words we can enact frequency, through rhythm, below the threshold of hearing. That's very important, embodiment. You notice that most brainwaves therefore are within the window of rhythm. There are gamma waves as well that are much faster, but they are connective, in a way, rather than expressive, in the way that these are. The example I think that Dale played was a simple use of the voltage, I think, from the output of EEG. What happens is you have your sensors, electrodes, not going into the head, by the way, there's nothing gruesome here, just sitting politely on the surface of your head. They are a series of switches responding to when there is a charge from the neuron that is firing. Then you have a voltage output that you can use, if you wish, to drive sound, and that's what I think they did, because we heard the heart as well. Another example is to take the same thing and speed it up a bit. Here's a short film from the group in Australia, which will give you some idea of this, also working on epilepsy detection through sound. They are speeding up now, speeding it up 60 times, in other words taking it from the domain of rhythm into the domain of pitch. Why? Because we're better at hearing differences between frequencies in pitch than we are in rhythm. If I go *[fast gabbling]*, it's a bit difficult but *[slow notes]*, which is a same thing, we hear as two discrete things very clearly. This is from Australia. I couldn't get it from them their algorithm but I think they're just using the voltage as well.

[Video plays.]

Initially, for diagnosed epilepsy, what we have done is use a computer to convert visual signals in sound, so that epilepsy can now be diagnosed just by listening to the signal. This is an EEG, which is recording the brain's activity. As you can see, the sequences are repeating about five times a second. In sonification, we slow this down 60 times which makes the signal more audible.

[End of video.]

NIGEL OSBORNE: There we go. I'm guessing they're taking the voltage but there are more elegant methods. One of my former students, Miranda, produced a sonification algorithm that is probably one of the most elegant, one developed in Georgia Tech recently. It was called Fish and Chips, because of the computers, taking the row of fish and detecting vibration from cells and sonifying it using that system. The most common way is to take Fourier transforms, in other words, equations that can be expressed, that have come out from the EEG, and then adjust that into a power spectrum, which becomes a description of both the frequencies and the time. Then you use that to drive some form of synthesiser, a MIDI or so on, a musical instrument digital interface, very common, where the pitches can be identified from the data and then it is turned into a more elegant sound like this, and we also have a nice graphic for this one.

[Synthesizer music plays.]

There is more elegant sonification where we can perhaps hear even more clearly the changes of waveform and frequency. So what's the relevance of this? We can use this in three ways. First of all, diagnostically, as they were describing in the Australian film; in other words, we can use it to use the power of sonification to hear when there are changes in waveforms and we talk about the signs of an approaching epileptic fit or seizure. We can use it diagnostically, it is a warning; that already happens, and that's what the Australia lab is about. We can also use it in biofeedback; we can use regular healthy brainwaves, sonified, to return it to the user in a way that may, as we've seen, and the evidence is developing, entrain the user's own brainwaves to regulate themselves. Music seems to have this function. I can demonstrate a few. The music appears to have this capacity of entrainment and regulation of many aspects of the body, it's maybe why we have it. It was something we created to regulate ourselves and entrain our bodily systems. Certainly in biofeedback work we have a lot of evidence that there are things like this that are occurring. Gruzelier at Imperial College has done a lot of work on this. Finally, the most important thing is that there is something more powerful than biofeedback, and it is music. Music is biofeedback, but of a very processed elegant kind. Many, many things happen in music.

What I am going to do is combine what I was going to talk about before, and I am going to put it all into one briefly. Here is a video using a sensor, showing somebody listening to Holst's *The Planets*, Venus, and seeing how their autonomic nervous system, that is to say the things that drives the heart, among other things, is so intimately affected. We measure it through heart rate and skin conductants. Here is the kind of power and mystery of music. It's not just that music can change the way you feel, it can change your blood pressure, your heart rate, and certain endocrine functions, we know this, and your brainwaves possibly, actually microsecond by microsecond. The skin conductor is at the top, heart rate at the bottom, particularly watch the heart. This is one person listening.

[Video plays.]

What a great piece. I'm very much hoping for Michael and Dale to have been of some assistance for projects in future, in looking at musical therapy for brainwave entrainment to prevent seizures. It will not just be a matter of pulses and memory and pitches, it will be a matter of this too. It is holistic, and it is a multi-polyvalent relationship with a human being that is happening.

Here is an example of Mozart. Here on the right is the Holst you just heard. I have a system that models systems of the lower brain to predict neurophysiological response to music. It is very accurate, I can predict blood pressure, heart rate, and it is very accurate with all of this. Look at the Holst. Here it is in the fluid moment, here is the harmonicity, this is how close it is to the harmonicity. Notice this is how sounds move, one to the other. There is a great work by Stefan Kulz on how one core move to another effects amygdala activity, and we have found it is a harmonicity. Now look at the Mozart, the regularity harmonicity, look at the move from chord to chord, look at the low turbulence and the relatively low brain stimulation, certain heart stimulation, relatively low brainstem, very high gyrus stimulation in terms of harmonicity too and the amygdala pathway - relaxation and joy. We talk about the "Mozart Effect," but there is a difference between the two things. Mozart and the composers of his period worked with a regularity of harmonicity, which is capable of cueing activity and thought. We have just been talking about that, with an even flow of arousal, up and down, up and down, which could well create a state of body and mind that may well be receptive to information, thinking, and gentle action. I'm not making a defence of the "Mozart Effect," but I'm saying that, from our examination, it is pretty clear. These bioactive elements are very clearly different in the music of the classical period. That is where I would like to think that you know for our consideration, together with Michael and Dale, that we come to a point where we can really take decisive action on some of these things. There is really good and important research that has to take place now. We are on a very important threshold. We are going to discover a lot of things in the next year or so. I really hope that you will be our partners, this wonderful group of people will be our partners in this adventure. Thank you very much.

MICHAEL TRIMBLE: Thank you very much Nigel, and Dale, thank you. We have got 15 minutes for discussion and I would like to make it an audience-driven discussion. We have said enough. Hands up, please?

FLOOR: I just wanted to make a remark about the Ravel *Bolero*. Composers have always enjoyed a challenge. There is a Monteverdi madrigal where the end section is a wonderful stream of melody and harmony over something like 88 repetitions of a four-note bass figure. It seems to me that the idea of a ground bass, four notes repeated over and over again, is not that different from endless repetitions of a rhythmic side drum figure in a melody with the orchestration and colour changes. It is one of the greatest examples of virtuosity and orchestration I can think of. It gets the effect, very largely, because the tune itself remains the same.

MICHAEL TRIMBLE: I can't enter into the debate because it is beyond my area of expertise but some people couldn't understand what on earth the man was doing. He was already beginning to show signs of some cognitive problems and they must have thought, in retrospect, this was evidence of it. I think Stephen has dealt with that myth as well as some of the Mozart myths. Clearly he had a semantic dementia and it was a tragic end he had. He had a craniotomy without anaesthetic, pleaded not to have the operation, his friends had to take the decision and died shortly afterwards.

NIGEL OSBORNE: I think also in the *Bolero* I see an abandoning of inhibition. I see no deterioration whatsoever in the fantastic musicianship but rather he is letting himself do something he might usually not. Pinching a pop tune from a Spanish folk tune, if anything, is a kind of benign stage of dementia. I nursed my father through dementia and there was a lovely point where he became joyfully uninhibited in nice ways, and I sense, you know, a shade of inhibition in the *Bolero*.

FLOOR: It seems a bit of a strange thing to say personally but I wanted to share a personal experience with everybody here. I, like a number of people probably, have had a brain accident, in my case I was knocked down by a car. The thing I noticed in the recovery process is just how tired you get. It was like taking all of the things you would expect to do in a week but you could only do about 50% of it, possibly less. There was a problem with Ravel but it could be a different trauma. He was an ambulance driver in the First World War and there could be post-traumatic stress disorder that we don't know about. It is quite possible that what actually was happening with him therefore was concentrated patterns when he could work really well, and then large amounts of time where he was just too tired. What is really interesting about that period around the 1920s is that it doesn't just affect *Bolero* or the Piano Concerto, it affects other works. They were created over a very long period of time and Ravel complains that he just can't concentrate, he can't think, he can't work. I thought I would add that into it.

MICHAEL TRIMBLE: The fact that he had the road traffic accident with the head injury…

FLOOR: That was later.

MICHAEL TRIMBLE: It was 32? That seemed to have been relevant in terms of his final decline. I see a lot of people with head injuries and fatigue is extremely common as a problem and one which lingers for a very long time. Let’s have some more questions.

FLOOR: This is a quick one for Nigel. The sonification of the listeners' response was really, really beautiful and that's a case study, yes? It would be lovely to know if similar patterns are obtained from other listeners?

NIGEL OSBORNE: The project in which I'm involved was actually an industrial project. I'm trying to get money to support work with children, and I’m not doing it in the academic world. We have done the largest study of heart rate and the skin changes and we can predict them pretty accurately. If I had time I would have shown you a prediction of where that was going to go. Interestingly enough, even people of other cultures who do not know the music of Gustav Holst, still have a gasp moment. It is very interesting that the universe is probably more powerful than we give it credit for. Today is about memory, but this is not underestimating the universe.

FLOOR: What interested me is that the patterns are so similar to the results of the joy stick studies where people were asked to respond using a joy stick, which produced a graph of the expressiveness of performances of the Chopin prelude that was used in so many different studies. It was interesting, but would have been lovely to show that people's experience of expressive performance is mirrored by their heart rate and their skin.

NIGEL OSBORNE: We could show that very easily. We have focused more on compositions per say, but we have done different conductors' interpretations. It is very easy to do and also very cheap. Skin conductors and heart rate monitors cost very little. I can build a monitor for 10p. We can do this research without the heavy duty finances that are required for other things.

FLOOR: Michael, you reminded us of the importance of the hippocampus in laying down memory and I understand there are studies that demonstrate that taxi drivers, for instance, have an hippocampus which is increased in size because of the predominance of spatial memory. Do you know of any evidence of the size of the hippocampus being increased by long-term in-depth study of music or singing?

MICHAEL TRIMBLE: Not at all. Mainly studies have to do with shrinkage, when it comes to neurological disorders. The amygdala has been briefly mentioned and is a sort of companion in terms of laying down memories, but from the emotional perspective. There are a number of studies showing increased amygdala activity in association with a heightened emotion, but over periods of time. The difficulty with these studies is you don't know whether you are born with it, or it is state, or trade. We will talk about this in relation to music later on - nature or nurture. The taxi drivers were delighted to know they have bigger brains than passengers, but whether or not they become efficient taxi drivers because of the hippocampus size or it being due to some kind of plasticity, a buzzword, we don't know. Soon most will be using sat-navs and not the hippocampus, it will be the hippocampus on the dashboard! It will be interesting to follow that up really, but it is interesting timing.

NIGEL OSBORNE: Can I cut in there with a quick one, just from the pure amateur point of view. Of course, working with trauma, there is attritional hippocampus. That's probably due to action on the HPA axis, glucocorticoid erosion of it. There is research with rats that demonstrates neurogenesis in the hippocampus through sound and music. Not that it will probably get us very far, but there are bits of evidence that might be the case.

FLOOR: I just wanted to say I happen to be epileptic and I was slightly worried when you played the sound of an epileptic brain that something might happen, but I'm still conscious! I'm very, very glad to say I'm not affected by music, because I adore it. Can I ask Nigel, I would love to know more about measurements of what you called regularities of harmonicity and flow. Maybe it is too detailed to explain now, but perhaps you have a paper you could refer me to.

NIGEL OSBORNE: I shall, in a nutshell. It is attempting to model some of the lower organs of the brain associated with more universal responses to music. Obviously the Heschl's gyrus areas of the motor cortex are modelled as black box, because we don't know the neural circuitry of these things in great detail, and my professional colleagues know far better than I do, but we know enough to black box model them. And it works. We are able to very accurately predict what effect a piece of music will have. That will be useful because we will be in the process of categorising all tracks on the main supplier of music to computers and mobile phones, a company called Omniphone. In a few months we will be able to retrieve neurophysiological predictions from anywhere in the world. If Dale says I want such and such brainwave frequency from China, she will get it. That is what we are doing.

FLOOR: Hello, I'm Veronica, Arts for Dementia. We are trying to re-energise and inspire people in the early stages of dementia, and their carers, through engaging with the arts. I wonder particularly if you could recommend musical exercises and composers, ideal for people in the early stages of dementia, who are just encountering confusion, with which we can lift the fog of the dementia and run regular weekly activities with.

MICHAEL TRIMBLE: I will pass you over to Nigel in one second. Part of my lecture was to point out the different forms of dementia and it seems to me that with people with Alzheimer's dementia, you're probably going to get much further in terms of allowing emotional retrieval and also engagement than maybe if you have a frontotemporal dementia. I have shown there are a number of attributes that are available to people, like Ravel carrying on composing. Of course, there are other forms of dementia as well that you are going to get no joy with whatsoever.

NIGEL OSBORNE: Yes, there are. First of all, I think live and interactive work is very important. Even for those with dementias that are going to slowly erode their emotional capacity, there is a social capacity sometimes still to generate it, so live contact is very important. Obviously, the very obvious thing is that it must be music they know and love, so music of their generation is very important. Then, exploratory journeys around that is the best, but I think that live is tremendously important. There are other problems that come about, but live is also good because very often old people's hearing begin to deteriorate, and it's much nicer to overcome that live than it is by blasting out audio at double the decibels it should be. Live really is, for dementia, one of the best ways through, I think.

FLOOR: Mozart or somebody more challenging?

NIGEL OSBORNE: Music from their lives to begin with, that's my approach, always.

FLOOR: The lovely thing of the *Bolero* is it is repetitive but we want, in the early stage, to challenge.

NIGEL OSBORNE: Yes, challenging is very, very good as well, absolutely. I would just go live as much as possible.

FLOOR: I have a question for Professor Trimble. You mentioned, when you were talking about Parkinson's, the type of music that was helpful was not their preferred music and I wondered if you could say a little bit more about the structural characteristics of music that is helpful and whether it coincided with it being a preferred piece of music that was even better. Also, can they do self-help?

MICHAEL TRIMBLE: Yes, again, it's Oliver Sacks who said most about this, and other people have followed on, but it tends to be obviously very rhythmic and structured. The point about your own music is that studies show that people with Parkinson's Disease got worse when they chose their own music. It's because people started to listen to their own music without having an external structure and rhythm put into the music which actually was driving or somehow unlocking the problems in the basal ganglia in the same way that L-dopa could do. Your own music actually can become quite distracting in that sense, and people got worse. The whole point about the music therapy is that it's not just, oh, play some music and something will happen. As I hope we are pointing out, it has to be thought about carefully and structured and now, of course, physiologically relevant, as Nigel has pointed out.

NIGEL OSBORNE: Also crucial in dealing with Parkinson's at that level is gait - establishing what is the gait and what is the potential and with what kind of tempi, rhythms and energies can we support and help regulate that. Obviously the reason why music works is it's mainly rhythm and it's the same reason why the old railway tracks were used in the old days. Sorry, I know that people probably know this, but the desire to move, because of the lack of dopamine, is deprived of the capacity and it seems that these ancient signals that music and rhythm provide are capable of regenerating that cueing capacity, so it is looking for the cueing capacity, most appropriate for the gait, and needs of the patient at the time.

MICHAEL: We will now have another 15 minute break. Thank you for your attention.