

## The Musical Brain Conference 2014

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

Friday 24 October 2014, Senate House

#### TRANSCRIPT

##### *Mozart and Musical Memory* – Prof Jessica Grahn

**IAN RITCHIE:** Now I'm really delighted to welcome Jessica Grahn back to the Musical Brain fold. During our 2010 conference on Robert Schumann, she gave an account of current findings in music neuroscience, the effect on the brain of thousands of hours of music practice, for example, and the particular ways in which Schumann suffered and was treated. Those of you who heard her speak then will know that we are in for something really special, and memorable, of course. Thank you, Jessica, for making the journey, all the way from Canada, and for being with us today to share your insights and to guide us through the rest of the morning.

**JESSICA:** Absolutely it's a pleasure to be here, thank you. Thank you very much for having me, and thank you all for coming to what will be a fascinating day, I think. It is a pleasure to come and talk about musical memory because very early in my graduate career, before I got pulled into looking at the relationships between rhythm and movement, and brain plasticity, I was really interested in musical memory and in particular what was referred to in the field as skill learning, because really that's all we're doing as musicians. It's just a skill we're practicing over and over again. It was fun to revisit some of this literature and then extend a little bit into talking about savants. I'm going to talk a little bit today about memory generally but we have a whole session on memorising just afterwards so I won't go into a tremendous amount of detail. Then I'm going to talk about very interesting examples of memory and I have a video of a savant because I think videos of these sorts of behaviours tell you far more than I ever could, and then we'll talk a little bit at the end about what it is that goes into some of these amazing feats of memory that savants can produce.

First, when we're talking about musical memory, the idea of memory as a single thing is very misleading. There are actually many different types of memory and when we talk about memory, you end up having to prefix all these different types using different words. There is short term memory, which we are not going to talk about too much today, but that's what you use to try and remember, when you looked in your refrigerator and realised you were out of milk, eggs, butter and cheese and you go down to the store and think, what did I need again? That's short term memory. What we'll be talking about today relies on long term memory, and even long term memory is divided into lots of different types. The first type, which is usually what we think of when we think of memory, is episodic and that is our memory for events and specific things that have happened to us, so when I think about the time my parents forgot my birthday because we were moving when I was ten, that's an episodic memory. I have a very clear memory of the events that happened during that day, which did not include a birthday cake, seared in there. So episodic memories are often enabled by an emotional relationship like that. Semantic memory is our memory for knowledge about the world, so at age ten I also learned all of the capitals of the United States. I can't necessarily tell you what

they all are now. I certainly know what some of them are, but I don't remember the process of learning them, I don't remember exactly what the teacher was wearing that day, when she was talking about what the capitals were, but I retained this information about what the capitals were. Our knowledge of how the world works, what words mean and these sorts of things, falls under semantic memory.

The type of memory that is most relied upon for music is what we call procedural memory, which is a type of implicit memory, and this is the memory for doing. We do have episodic and semantic memories for musical memory. I can remember amazing concerts as an episode in my life that really made a big impact on me and I certainly remember what a piano is or what the definitions of piano and forte are but most of what we spend our time as musicians doing is practicing, practicing, practicing and that is the memory for doing that we are trying to instill. In fact, it feels so automatic and unconscious, people often talk about it as motor memory or say it is in their fingers, so it doesn't even feel like the brain is involved, even though it very much is. Musical memory is heavily procedural, and what's interesting about procedural memory is that it uses different areas of the brain than episodic and semantic memory. For this reason, memory for music, and even the playing and performing of music, is often preserved in amnesia and in various dementias, so you will have Alzheimer's patients who are unable to recognise close friends and family, but you put them in front of a piano and the music of their youth comes out. This is something that's quite impressive about procedural memory; it's very resistant often to disruption, unlike other types of memory. If you've ever seen *Memento*, poor Guy Pearce is trying to work out what has happened to his life because what he has lost is his long term memory. He has memory for what has happened just now but he doesn't have any memory for what happened to him yesterday or the day before.

In amnesia, usually you have this type of memory, which can remember how to ride a bike or how to play a piano but you have lost your memory for events in your life. Part of what makes procedural memory so impressive is the amazing things we can do with it, so if you try to explain to somebody how to ride a bike, for example, it's impossible. You can tell them some very basic facts about having to sit on the seat and the pedals go round and push the wheels forward and that lets you go forward and here's what the brakes do, but trying to teach someone to actually get that balance right verbally or through explanation is just about impossible. However, once you do it enough times and you get it, you never forget it. When you look at, for example, piano performance and this learning of the amazing sequences of notes that people produce, one thing that makes this possible is the fact that people are generally not learning random series of notes. Sometimes they are in some types of music but in general that's not the way music or most of the things we use procedural memory for work. They have rules and we group things together. Immediately, when you sit down at the piano, you have black notes and white notes and they are different from each other and can be categorised separately. We have scales, keys, we have chords, and we have all these aspects of music, which help us not to think about every individual single note but groups of notes. That can be a vertical grouping in terms of chords or a horizontal grouping in terms of phrases. We have keys to help us know which of the notes are going to be relevant to us at a particular moment.

These rules and hierarchical organisation are very important for procedural memory because they allow us not to have to think about every single note coming out of our fingers but in terms thinking about whole cadences and chord progressions that lead from one place to the other. Not only musicians do this - we use chunking in our daily lives in lots of ways. I don't

know if you have ever had the experience of someone repeating your mobile phone number back to you but with different spacing between the numbers? It is impossible to recognise. You have no idea if that is your number or not and you have to repeat it back in the spacing that you are familiar with. There is a fabulous Michael McIntyre sketch that I tried to get, to illustrate this very well. Chunking is very important. These long series of digits, numbers we remember on a regular basis, are much easier when we can group it. This is the area code, and then these digits are specific to the number. The spacing I use for mobile numbers is these five and then three and three. We all use that chunking in our daily lives to try to improve our own procedural memories.

Savants will show prodigious memory feats and it is to do with memory learning. There is a lot of practice that goes into savant syndrome. I will tell you a little background around savant syndrome, frequently, but not always, in the context of autism. Nearly half of those who have savant syndrome are also somewhere on the autism spectrum. There are different types of skills, some appearing much more frequently than others, as the prodigious skills that savants have. Music is one of those and we will talk about that today. Savants also tend to show calendar skills. There is a lot of focus on math and there are some people that show incredible mechanical abilities or an obsession with visual art. Now, in terms of music, usually the skill is in terms of performance. Often this is in terms of the piano and that could be because a piano is around and accessible and easy to get sound out of in a straight forward way from the beginning. We don't know if there is something special about piano or it is just ubiquitous. Savants also tend to show absolute or perfect pitch frequently, and that is a real aid to some of the feats of listening to music and reproducing it. They don't have to worry about finding the key first, they are able to sit down and play. However, sometimes you can get composing without performing and there have been reports of savants who actually specialise in picking up new instruments rather than focusing obsessively on one. In fact, there have been reports of up to 22 instruments being played.

Savants are also on a spectrum, and their skills are on a spectrum. The skill ranges from what we call a splinter skill, which is the most common. This is the most basic type where there is just an obsessive preoccupation with the memorisation of music, sports trivia, license plate numbers, maps, the phone book, historical facts or obscure items such as vacuum cleaner motor sounds. There is a whole range of things that can grab their attention. Once they do, they obsessively learn this information. One step removed are the talented savants who are a bit less common. These have some musical, mathematical, or other special skill, which is more highly honed. This is usually an area of single expertise; they don't tend to show broad ranges of expertise. What is conspicuous about them is that they are often very handicapped overall. This particular skill is so impressive given that often the IQ can be very low or their ability to interact socially can be very limited. Then, there are what we call the prodigious savants, which are the rarest. This is a specialist skill or ability that is so outstanding it would be spectacular even to occur in a non-handicapped person. This is someone who has not just a special skill compared to how limited they are in other domain, this is someone whose skill is impressive in any domain. I have a seven minute video of one of the most famous of these types of savants, and again, I think the video says a lot more than I ever could about what a savant's skill can look like.

Video text:

NARRATOR: When Derek is playing the piano, it is hard to believe there is anything he can't

do. Yet when you meet him away from the keyboard, as we first did in London seven years ago, the contrast is shocking. Can you hold up three fingers for me?

DEREK: I can do that.

NARRATOR: Can you hold up three?

DEREK: I don't know how to do it.

NARRATOR: Derek is a musical savant, blessed with a sea of talent in a profound sea of disability. How long have you been playing the piano?

DEREK: It is about a year... no, it wasn't.

NARRATOR: Do you know how old you are?

DEREK: I don't know how old I am, no.

NARRATOR: Today Derek is 31. He grew up in an upper class family, the nephew of Camilla Parker Bowles, now the Duchess of Cornwall but none of that matters to Derek.

Are you having pizza tonight?

DEREK: Pepperoni, what will I have next week?

NARRATOR: Derek's ability to instantly call up any piece of music he has heard, like the YMCA. Can you play that? *[Plays YMCA.]*

I asked him to play a show tune but it isn't just that Derek remembers them, he can transform them effortlessly and seamlessly into the styles of different musicians, like jazz greats. He can switch to Oscar Peterson. *[Plays in a jazz style.]* How about Dave Brubeck? He can whip out a piece and a style book and bring them together and just explode it.

How Derek's fingers can do this, but can't button a button or zip a zipper remains a mystery. There are lots of theories about savants, but few real answers. In Derek's case the problems started early: he was born more than three months premature, weighing just a pound and a half. He hung on but was left blind and with severe cognitive impairment. Derek's father, Nick, says the first thing that really interested Derek was a small toy keyboard.

DEREK'S FATHER: My daughter suddenly said one day he had just played one of the hymns we had in church this morning.

NARRATOR: How old was he?

DEREK'S FATHER: Three. He didn't know, because he couldn't see and noone had told him, that you are meant to use your fingers to play the piano. So he used karate chops and elbows and even his nose, I seem to remember.

NARRATOR: Derek had never met a piano teacher until he literally crashed into one during a visit with his parents to a school for the blind. The teacher was Adam, in the middle of a lesson.

ADAM: Suddenly I got a shove in the back and he pushed me off the stool and started karate

chopping the keyboard.

DEREK'S FATHER: We were terribly embarrassed.

ADAM: I thought he was mad, because it was just chaos and notes and elbow, and suddenly I noticed out of all of that came *Don't Cry For Me Argentina*. I thought, he's not bad at all. Brilliant.

DEREK'S FATHER: Adam rang up and said he would like to teach him.

NARRATOR: He called you and asked if he could teach your son?

DEREK'S FATHER: Yeah.

ADAM: It was as though Derek pushed me off the stool, saying help, I need teaching.

NARRATOR: So it was compassion?

ADAM: It was compulsion I think.

NARRATOR: But how to teach a child who couldn't see, didn't understand much and wouldn't allow anyone to touch his piano?

ADAM: Well I just picked him up and popped him to the other side of the room, and then in the ten seconds I had before he raced back, I could just play. By the time I played, he was back and pushed me off and copied it with karate chops.

NARRATOR: Before long, Derek seemed to get it. This was not someone trying to take away his precious piano - this was someone trying to reach him.

ADAM: I think suddenly he clicked and we could have a conversation in sound, and suddenly it just blossomed.

NARRATOR: So that ability to communicate was revelatory for him?

ADAM: Absolutely. From all the confusion he must have experienced as a child not understanding much language, suddenly here was a language that he could control, he could play with, he could create dialogue. All the things that we normally do with words, Derek did with notes.

NARRATOR: His progress was astounding. After three years of daily lessons Derek was invited to play a few songs at a major charity fundraiser. It was there that Adam first saw the thrill Derek got from performing and from feeling the love of the crowd.

ADAM: When you are on a big stage, the place hits you like a wave. Derek just jumped off the piano stool. He was trembling and excited and elated that people were reacting to his playing.

ADAM: He has been performing ever since, in jazz hall, at benefits, in churches, connecting with audiences in ways most musicians wouldn't dare, taking requests, with a twist.

DEREK: Would you like to have a piece lady?

NARRATOR: My piece is *Ain't No Sunshine*, do you know it?

DEREK: I do know it.

NARRATOR: The twist is that he will play it in any key they chose.

NARRATOR: B major.

DEREK: Oh, wicked.

NARRATOR: And in any style.

DEREK: What style would you like it in?

NARRATOR: Rag time.

DEREK: *Ain't No Sunshine*, B major, rag time.

NARRATOR: Remember, he had no idea what song would be chosen. No rehearsal, new key and new style. No problem. It is breathtaking to watch. Think about all the thinking almost anyone else would have to go through.

DEREK'S FATHER: It is like three computers are working at once, and he can do it straight away without thinking.

ADAM: Sometimes when he's playing he smiles, is that really him enjoying what he's doing.

DEREK'S FATHER: Yeah, sometimes he does something quite funny musically and you can see that little sparkle.

ADAM: He knows he is adorable.

DEREK'S FATHER: I think he's actually pleased with himself.

*[End of video.]*

**JESSICA GRAHN:** That was obviously impressive in ways many of us, even if we spent a lot of time practicing and doing everything we were told by our teachers, could never really hope to achieve. So what enables him to do that? Well it does come down to is a knowledge of musical rules. I remember being shocked the first time a jazz teacher came to our course on aural skills as a piano major. I had been through some painful question and answer sessions but I had avoided the improvisation. I was glued to the score like many classical musicians - the idea that I had to produce something without any help was terrifying. The first thing this person was talking about was needing to learn your keys, your scales, your chords and practice over and over and over again so you can call them up at will. Obviously Derek has that down pat but he's also picked up higher-level rules that he's able to pull out and apply immediately, the rules of particular or space genre. He has managed to extract the rules most of us with musical training get quickly and even those without musical training implicitly understand - the rules of keys and putting chords together. He has managed to pick up many higher-level rules so he can put them together in any way, any time, on demand.

They were right when they said on that video that can there are a lot of series, but not a lot of data, this is true. But it seems to be common, this initial pattern of obsession with some low-

level thing, such as learning keys or scales or being able to play exactly what you have heard and repeat it. This grows as the skill develops to be able to extend it and apply it a little bit more flexibly, up to the point of improvisation. You sometimes see this in visual arts savants as well, they are able to make interesting intricate patterns but they are very structured and rigid and as their skill develops they are able to create more unusual pieces that are not just so rigidly formulated. There has been very few scientific studies of savants and there was one that I managed to find conducted with a savant whose initials were NP. This was back in 1985. He was also a musical savant, with a very low IQ and he was living in assisted care, had almost complete absence of speech and showed many obsessive behaviours. What the researchers were interested in was whether there were any limitations to what he could reproduce, so they gave NP two types of pieces. One was a tonal piece that followed the rules of tonal harmony that most of us have learned and one was an atonal piece that did not follow these rules. For the tonal piece, within four times of hearing it, NP was able to reproduce it accurately. They asked a professional pianist to try and do this and she could get maybe the first 8 or 12 bars after four or five times but that was really it, she then became overwhelmed, whereas NP was able to do the entire piece without any difficulty. 24 hours later, he was still able to reproduce this piece. He had heard it a few times the day before and, the next day, had no problem reproducing it. However, when it came to the atonal piece, by his third attempt, he was still making errors and, in fact, he refused to carry on. He was visibly distressed by his inability to reproduce this piece. This was not something he had really encountered before. Also, what was interesting was that the types of errors he was making are what the researchers called structure preserving. He was making errors that would make the piece more structured, and more tonal, rather than less. He was trying really hard to apply the rules that he knew were important for music to this piece, and when it wasn't working, it was extremely frustrating for him.

Again, I think the data is fairly limited, but even so, people have tried to work out what's going on in the brain when these skills develop, what is it that allows these skills to occur in some people, but not in the general population very often. There's the idea that perhaps there is some sort of right hemisphere involvement, so many cases of savantism are congenital. People are born with it in the context of other problems. As you saw in the video, Derek was born very premature, he had difficulties as a result of that and a lot of premature babies do. One idea is that we know that in healthy people the two hemispheres are actually inhibiting each other a lot of the time. Activity in the right hemisphere suppresses activity in the left hemisphere and vice versa and, in fact, one of the problems you can have if this inhibition is not normal is people make what are called mirror movements. They raise their right hand but they can't just leave their right hand, the left hand has to do the same thing, so any movement that's made is made in tandem. That's because the activity in one hemisphere usually prevents the other hemisphere from doing the same thing but the natural inclination without that inhibition is to move in mirror.

Well, the idea in savant skills is that perhaps, somehow, the damage or dysfunction in the left hemisphere has released or uninhibited and allowed to come forward activity in the right hemisphere and this leads to some of these prodigious skills. Now, this can happen in the womb and one idea about why savantism seems to disproportionately affect males is that male brain development in the womb takes a bit longer. Perhaps if there are any issues that are going to go wrong in the womb, males are going to be more susceptible because the development takes a little bit longer. We know of people who have had a head injury and then

suddenly become obsessed with music or obsessed with art, and usually it is disproportionately left hemisphere head injuries. The idea is that something in the left hemisphere is allowing us to function normally in the world, because inhibition is important, so usually when you see these skills develop, it is in the context of impairments in other aspects of their life. It's not for free, that suddenly someone is able to become obsessed with music and make it part of their life to the degree where they may have never played piano before but now they're concert pianists. It's something about the left hemisphere release of the right hemisphere that might produce this.

We know that when parts of the brain are damaged, you release a tremendous number of neurotransmitters and different chemicals that normally would not be released in that quantity and that may itself allow the brain to be exceptionally plastic for a short period of time, allow some rewiring to occur that may not normally happen in healthy individuals. Unfortunately, most of this is still speculation because savantism is fairly rare, it's hard to study and really there are only a couple of individuals who have gone around the world trying to study savants and look at what is similar across them. The brain data behind that is even more limited. Trying to explain to someone that you're going to put them in this noisy MRI machine when they maybe have absence of speech, or are uncomfortable with human contact, is a very difficult thing to do. However, I'm confident, as with all areas of brain research, that we'll make some progress with this in the next several decades as well.

So finally, just to finish, I'll talk about Mozart. I think we had a pretty good debunking this morning, which was very helpful, because I'm going to say some things along similar lines. I don't do it with the intention of making anybody cry! So obviously, Mozart's musical skills went well beyond an ability to simply memorise pieces and improvise in very limited structural frameworks. He certainly, by the end of his life, had clearly developed far beyond that, but it's pretty likely that his prodigious skills, just like those of savants, are not superhuman. Most of the phenomenal feats, both in child prodigies and in savantism, can be explained by these learning mechanisms that the rest of us use to make sense of our world, the same way we structure our phone numbers so we can remember them, or structure music so we can understand what the rules of our musical culture are. They are operating within that same framework. Now that's not to say they aren't special. What makes them so drawn to learning these particular set of rules, and then obviously being able to do so much to bend and move them beyond what they were born with, or were brought up with, is still very impressive, but it doesn't necessarily require a special brain area or a superhuman function in order to explain it. Thank you very much for your attention.