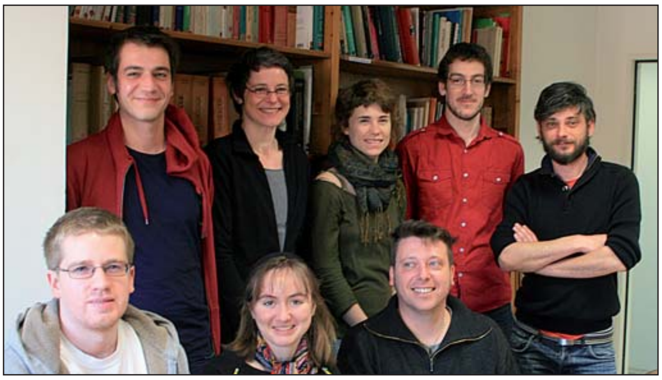
Cognitive neuroscience in Lyon, France

The Sound of Music

Photo: Fotolia/Margo Harrison

How are sounds converted by the brain into meaningful speech or emotional music? That's the question Barbara Tillmann and her team is trying to answer. Through uncovering the mysteries behind auditory perception, she might be able to find ways to apply music in the clinic and, perhaps more interestingly, simply understand what makes music...music.

Sounds are coming to you from many different sources, in countless frequencies, and yet the brain somehow manages to disentangle them from each other, locate their sources and make connections between them. All this happens without any conscious effort on your part. But sounds are not just simple random tones, occasionally they follow certain regularities and obey rules to become what we call language and music. Understanding the cognitive and neural mechanisms that enable humans to perceive, learn and use such complex sounds is the avowed goal of the Auditory Cognition and Psychoacoustic research group (CAP) led by Barbara Tillmann, who I'm about to meet.



***Without music, life would be a mistake...* and there wouldn't be anything for Barbara Tillmann (2nd from left back row) to study.**

The research group has taken up quarters in a glass building overlooking a quiet courtyard in the south of Lyon. Standing in the long hallway, the building looks just like any other university research unit, except that instead of phones ringing, I can hear a short musical piece being played from somewhere, every once in a while. This could, however, just be a figment of my imagination due to my expectations, as Barbara Tillmann tells me. A part of her research focuses on studying how one's implicit knowledge influences one's perception of sounds. "Your brain picks up regularities in the environment just by mere exposure, without necessarily paying attention to them. That is what is called implicit learning", she says.

A world without music?

But before any learning, the brain first has to 'comprehend' sound patterns. And one useful method to study how our 'thinking organ' processes music is to work with individuals who do not understand music. Congenital (tone deafness) or acquired amusia are conditions that leave sufferers incapable of discriminating between different pitches. As a result, amusic people cannot recognise familiar melodies, they cannot hear when someone sings out of tune – they cannot enjoy music as everyone else. Amusics are diagnosed with the Montreal Battery of Evaluation of Amusia (MBEA), a series of tests developed by Isabelle Peretz and colleagues in Canada. Anyone scoring under the cut-off value is considered an amusic.

Neuroanatomically, it's not entirely clear what brain areas are responsible for the processing of music. But primary (the right anterolateral part of Heschl's gyrus) and secondary auditory cortices as well as the limbic system are rather obviously involved. Voxel-based morphometrical studies revealed that amusics have, amongst other things, a reduction in white matter concentration in the right inferior frontal gyrus, resulting in an "impoverished communication" between the inferior frontal cortex and the right auditory cortex (*Brain*; 129(10):2562-70).

Musical memory defects

But back to Lyon. A few years ago, Barbara Tillmann and her colleagues started gathering a pool of amusics. With the help of the subjects, they were able to carry out various experiments like studying their short-term memory. Interestingly, congenital amusics show normal performance in remembering verbal material – a list of words. Change the list to a series of tones and they do not remember much (*Brain Cogn*, 71(3):259-64). Subsequent experiments looked at how amusics fared when presented with a tonal language like Mandarin Chinese, in which the meaning of a word depends on the used tone. Unsurprisingly, the amusic volunteers had great difficulties telling pairs of tones apart. Tillmann and co. concluded that "pitch deficit of amusia is not limited to music but may compromise the ability to process and learn tonal languages" (*Front Psychology*, 2:120).

To better address the specificities of amusia, like, for example, whether amusics have a deficit in processing musical chords or to what extent the regularities of a particular musical system can be learned and internalised in such individuals, Tillmann also uses a so-called 'musical priming' paradigm. "The basic design consists of a prime context, like the first seven chords of a chord sequence and a target event, the last chord. The relations between prime and target are systematically manipulated. For music, this manipulation concerns tonal relatedness or tonal functions as defined by music theory", explains Tillmann. Applying this methodology to her amusic volunteers, she found "a deficit in congenital amusia for chord processing (...) but despite this deficit, amusic individuals have internalised sophisticated syntactic-like functions of chords in the Western tonal musical system" and thus "could develop expectancies for musical events" and maybe even enjoy them (*Cortex*, 2012 Jan 13. [Epub ahead of print]).

Good excuses

But, I wondered, what do all these results mean outside the lab? "What's different in everday life is that there's context, semantic information. Amusics can use all the other cues and even if they miss something they can blame it on something else like, I didn't hear that because someone opened the door", Tillmann says.

The Auditory Cognition group that besides Tillmann comprises two more researchers, Fabian Perrin and Nicolas Grimault, shares the building with another team that focuses on olfaction. This side-by-side of auditory and olfactory groups might seem strange but the two have actually collaborated on joint projects. Gathering a group of professional chefs from the famous Institut Paul Bocuse in Lyon, along with a group of professional musicians they carried out experiments addressing different cognitive aspects of artistic features, like imagination and creativity. They compared the brains of professionals with lay controls electroencephalographically to see differences when imagining different odours or the sounds of instruments and found that professionals "rely more on their right hemisphere" (Poster Presentation at the 35th Annual Meeting of the Association for Chemoreception Sciences, April 2012).

Coming back to the emotivity of music, Tillmann believes that the emotional aspect of music could be related to an interplay between what the listeners expect to hear and what they actually hear: "You expect it there but the composer gives it to you somewhere else. From this interplay between the developing expectations and how they are fulfilled, emotional moments could arise."

The musical drug

Besides its indisputable psychological effects, can music perhaps be of any help in neurological disorders, too? Different studies have shown that merely listening to music engages motor regions as well as auditory areas, even in non-musician listeners. This coupling of the auditory and motor systems becomes especially apparent in the context of musical training. Brain imaging techniques have shown how the brain changes over a short time when a non-musician learns to play an instrument. Additionally, magnetoencephalography on professional pianists revealed that, for them, just an auditory stimulus is enough to activate the neuronal representation of finger movements in the primary motor cortex, in the complete absence of any action or planning to perform (*J Cogn Neurosci*, 13(6):786-92).

Employing this phenomenon in the applied clinical research, Tillmann and her colleague Eckart Altenmüller at the Institute of Music Physiology and Musicians' Medicine in Hannover, Germany, investigate the effects of musical training on the rehabilitation of stroke patients, who have acquired motor disabilities. The project involves a training programme, in which stroke patients with motor deficits learn to play the piano or electronic drum pads. The aim is to see whether such music-supported training can significantly improve motor rehabilitation of patients, judged by the speed, precision and smoothness of their movements.

"It's an example of what the field of neuroscience of music is now doing". Tillmann tells me about possible applications of music in clinical research, "You can use music to boost the brain, to stimulate sensory processes, attention and memory, or motor function, for example, in aphasic or in patients with Parkinson's disease."

European network for music and brain

In 2010, Tillmann and others created a European network for music and the brain: "The idea is that we have different European partners and every partner has a PhD student, who studies this topic. The goal is to have what you would call neuroscience informed rehabilitation techniques." Called EBRAMUS, for Europe Brain and Music, the framework covers three main topics: rehabilitation of auditory functions and language deficits, benefits of music in learning and memory, and the use of music in motor rehabilitation.

Leaving Lyon, I have learned that music is so much more than just a soft background noise in a long hallway. Music is not only an important part of our lives, it's good medicine, too.

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