Listening to Music

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AJNR Am J Neuroradiol 2010, 31 (9) 1549-1550
doi: https://doi.org/10.3174/ajnr.A2076
http://www.ajnr.org/content/31/9/1549

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Charlotte Gainsbourg, an actress and singer, daughter of that famous late 1960s couple (Serge Gainsbourg and Jane Birkin) has a new music CD out. It is called *IRM* (MR imaging in French) as is the hit song it contains. Ms Gainsbourg had a waterskiing accident that led to her having to undergo several brain MR imaging studies, an experience that apparently inspired her (and her producer, Beck) not only to title her album as such but also to use gradient-like sounds as a part of the rhythm lines in many of her songs (particularly in *IRM*). Having been inside the magnet several times, I wondered how this could possibly work well, but now that I have listened to the CD, I like it. The contents of the booklet that comes with it are also somewhat surprising: It contains several MR angiography views of the circle of Willis (presumably Gainsbourg's) as well as patient identifiers from the alphanumeric information of the study that include her name, date of birth, medical record number, etc, clearly a Health Insurance Portability and Accountability Act violation. Gainsbourg and Beck are not the first modern musicians to borrow from MR imaging; other rock groups are called MRI, Tesla, The Magnetic Fields, and the more intriguing MRI Resident Research Orchestra and Rock Band.

The nature of music is universal across all cultures, but the fact that I liked her CD is a matter of perception. Functional MR imaging (fMRI) has been used to study music perception in humans.[1] Music perception involves the processing of several activities that mainly include the following: 1) musical syntax, 2) musical meaning, 3) auditory working memory, and 4) emotional aspects.

Music plays an important role in brain maturation as it relates to communication and social, cognitive, and emotional development. Similar brain regions are used for the processing of music and language.[2] So, it makes sense to start musical education at the same time we start learning a language. Music processing in the brain takes place mainly in the inferior frontal gyrus, orbital frontolateral cortex, anterior insula, ventrolateral premotor cortex, anterior and posterior superior temporal gyri, superior temporal sulcus, and supramarginal gyrus. Activation by fMRI is seen in both hemispheres but differs with the subject's age and degree of musical training. Children show right-sided activations similar to those seen in adults, but on the left side, they show a lesser degree than adults, particularly in the prefrontal and temporal areas and in the supramarginal gyrus. More musically trained individuals show stronger activations in the frontal operculum and superior temporal gyrus, regardless of age. That both trained and untrained individuals show comparable brain activations may help explain the wide popularity of music: Our brains are wired for music, or, in other words, our brains are very interested in music. Not only is our cerebrum interested in music, but our cerebellum is also interested in it. Patients with cerebellar degeneration have impaired fine discrimination of pitch, whereas healthy individuals use their cerebellum mainly when processing rhythm (including pattern, tempo, meter, and duration).[3]

It is interesting that one does not have to listen to music to activate many of the aforementioned areas. Simply thinking about it suffices (remember, deaf musicians such as Beethoven and Smetana wrote great works simply by imagery).[4] Additionally, you can only tune an instrument if you can imagine how it should sound. Motor imagery is directly linked to auditory imagery: For example, pianists practice by imagining their hands on the keyboard. Imagery also plays an important role when music is spontaneously improvised.

Improvisation is an important part of music (for example, in jazz). In 1 study, 11 professional pianists were asked to either improvise or reproduce music by using a small piano keyboard specifically designed to fit inside a 1.5T unit.[5] During both activities, similar activations were found, but there was a trend for a larger motor output during reproduction of music and for activation of the right dorsolateral prefrontal cortex and the premotor and auditory areas. The importance of this study is that it shows that fMRI may be used to investigate the brain during the act of creation, probably one of the most important activities defining humans.

Because classically trained pianists are not prone to improvisation, what happens with jazz pianists who, according the nature of that genre, need to constantly improvise? Jazz musicians improvise extemporaneously during their solos, and that is why no 2 jazz performances are ever identical. In a different study, 6 highly trained jazz musicians were asked to spontaneously improvise by using a nonferromagnetic keyboard while inside a 3T unit.[6] Data obtained showed that during improvisations the lateral prefrontal cortex deactivated while there was focal activation of the medial prefrontal cortex. It appears that music creation can happen outside of conscious awareness and beyond volitional control. When people say a musician appeared to be in a "trance" while playing, they are not far from the truth. Deactivation of the lateral prefrontal cortex also occurs in altered states of consciousness such as hypnosis, meditation, and daydreaming. Also during intense musical pleasure, the limbic system deactivates (inhibitions and self-censoring are turned off).

"Pleasant" and "unpleasant" music elicits different emotional reactions. In another fMRI study, the consequences of listening to permanently dissonant (unpleasant) and consonant (pleasant) music were studied.[7] A surprising result related to the temporal dynamics linked to pleasant music. In all areas of the brain involved in listening (except for the hippocampi), increased activations occurred with time. Confirming that the amygdalae are activated during instances of negative emotional valences, unpleasant music activated the anterior and mesial temporal lobes, while pleasant music resulted in decreased activations or deactivations in the same areas. Music has the capacity to up- or down-regulate neuronal activity in identical areas of the brain. These studies are of enormous interest to the music industry in the prerelease testing of new music. Fortunately, it is not that simple to find out which songs will appeal to most people because what is considered musically pleasant or unpleasant varies significantly among cultures.

The social context in which music is listened to or played also has a role in brain activation. It seems that when musicians sing together, they activate different and more parts of their brains than when they do it alone. Jarvis Cocker, a British pop star and front man for the group Pulp, had fMRI studies after singing alone or in a duet. His brain was reported to be more "active" after the duet, a finding probably related to the coordination needed and the emotional involvement that singing with another entails.[8] The ultimate consequence of all these electric and chemical activities elicited by music and particularly by playing an instrument is that of morphologic changes in the brain.

Learning-induced cortical plasticity results in changes in the primary motor and somatosensory areas: That is, repeated tasks lead to expansion of cortical representations. Professional violinists show enlargement of the left-hand representation in their sensorimotor cortex.[9] This expanded representation is more prominent in those individuals who learned to play the violin when very young. Indeed, brain reconfiguration can occur very quickly. Structural changes in the brain have been documented after only 15 months of musical training during early childhood.[10] Trained pianists show differences in the somatotopic hand area on the right central sulcus compared with controls, and these differences are marked when training began early.[11]

Of course in the case of Ms Gainsbourg, identifying the morphologic aberration (which apparently was a hematoma) was much easier than perhaps attempting to identify what makes her a good singer and an excellent actress. "Can you see a memory, register all my fear, on a flowchart disappear, leave my head demagnetized, tell me here the trauma lies, in the scan of pathogen, the shadow of my sin?" go the lyrics of *IRM*. To many patients undergoing an MR imaging study, it may seem a haunting experience, and it is unclear if Ms Gainsbourg found the MR imaging noise unpleasant or pleasant, but from her album, it seems that she did find it musical.

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DOI 10.3174/ajnr.A2076