Study links emotional and neural responses to musical performance

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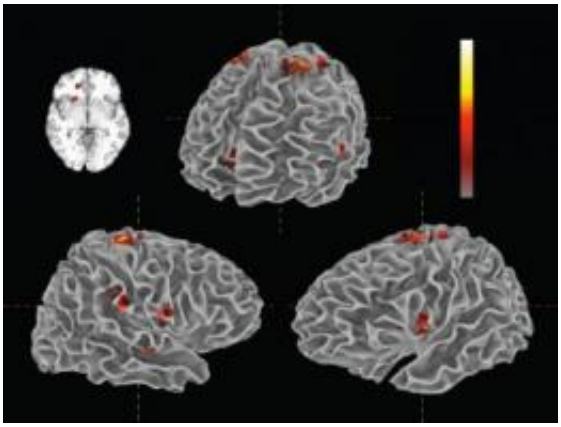

Animation of the real-time changes in neural activity that were time-locked to the tempo fluctuations in a musical performance of Frédéric Chopin's Etude in E major, Op.10, No. 3.

It is well known that music arouses emotions. But why do some musical performances move us, while others leave us flat? Why do musicians spend years perfecting the subtle nuances that bring us to tears? Scientists at Florida Atlantic University have now identified key aspects of musical performance that cause emotion-related brain activity, and they have shown for the first time how these performance nuances work in the brain, in real-time (video).

The study, titled "Dynamic Emotional and Neural Responses to Music Depend on Performance Expression and Listener Experience," published

in the December 16 issue of *PLoS One*, was conducted at the Center for Complex Systems and Brain Sciences (CCSBS) in FAU's Charles E. Schmidt College of Science, in collaboration with University MRI of Boca Raton, a facility located in the Florida Atlantic Research Park that offers a comprehensive range of diagnostic imaging services. Edward Large, Ph.D., the study's principal investigator, and Heather Chapin, Ph.D., the lead author, believe that their study pinpoints how musical performances charge up the brain's emotional centers, and say that their technique will lead to new ways of studying responses to music and other emotional stimuli.

The researchers first recorded an expert musician's performance of Frédéric Chopin's Étude in E- Major, Op. 10, No. 3 on a computerized piano (the "expressive" performance), then they synthesized a version of the same piece using a computer, without the human performance nuances (the "mechanical" performance). Both versions had the same musical elements – melody, harmony, rhythm, average tempo and loudness – and both were recorded on the same piano. But only the expressive performance included dynamic changes in tempo and loudness, the performance variations that pianists use to evoke emotional responses. In the listening study, Large and Chapin used participants with an affinity for music. They combined behavioral analysis with fMRI neuroimaging, a specialized MRI scan which measures change in blood flow related to neural activity in the brain, as participants listened to both performances. The listening study was conducted in three parts. First, participants reported their emotional responses in real-time using specialized computer software. Immediately after providing their emotion ratings, they were placed in the fMRI and instructed to lie motionless in the scanner with their eyes closed and asked to listen to both versions of the music without reporting their emotional response. Immediately following the fMRI, they performed the emotion rating assignment again.

"We deliberately implemented these three steps in our study to ensure the consistency of the emotions our participants reported in the behavioral study with the results of the fMRI," said Large.

The fMRI served as a critical tool to examine which areas of the brain "lit up" in response to the music. The analysis of brain activity compared responses to the expressive performance with responses to the mechanical performance, and responses of experienced listeners with those of inexperienced listeners. It also compared the tempo changes of the performance to the brain activations of listeners in real-time.

The results from this study have confirmed the hypothesis that the human touch of an expressive performance by a skilled pianist evokes emotion and reward related neural activity. Furthermore, musically experienced listeners were found to have increased activity in the emotion and reward centers of the brain.

"Our experienced listeners were not professional musicians, but did have experiences performing music, such as singing in a choir or playing in a band," said Large. "The fMRI data suggests that experienced listeners get a greater charge out of the music, although we can't say from this data whether the increased neural activation is due to their experience or whether these individuals seek out musical experiences because they derive greater pleasure from music."

Perhaps most interestingly, the results also revealed neural activity that followed performance nuances in real-time. These activations occurred in the motor networks of the brain that are thought to be responsible for following the beat of the music and in the brain's mirror neuron system. The human mirror neuron system appears to play a fundamental role in both understanding and imitating action. This system is "fired up" when someone observes an action they can do being performed by someone else.

"It had previously been theorized that the mirror neuron system provides a mechanism through which listeners feel the performer's emotion, making musical communication a form of empathy," said Large. "Our results tend to support that hypothesis."

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