Enhanced Response To Music

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New Studies Show Factors Responsible For Enhanced Response To Music

(Society for Neuroscience) -- In new studies, scientists are uncovering the factors responsible for an enhanced brain electrical response to music; the effects on the brain of growing up in a musical or non-musical environment; and which areas of the brain process different aspects of music including speaking and singing. One study finds that positive emotions induced by pleasant music can have an analgesic effect on people, pointing to a possible role for music in pain management therapy.

"Music touches almost every cognitive ability that neuroscientists are interested in -- not only the obvious auditory and motor systems involved in perceiving and playing music, but also multisensory interactions, memory, learning, attention, planning, creativity and emotion," says Robert Zatorre, PhD, of the Montreal Neurological Institute.

Researchers are investigating many different aspects of music and its effect on the brain. A great deal of work has already been done to characterize the brain's response to musical patterns, but now researchers are beginning to focus on more complex issues, such as how the patterns may change as a function of a person's knowledge or training in music. "Among the most promising research is that involving the development of musical abilities, because this will tell scientists how the nervous system adapts to influences from the environment," says Zatorre.

"In turn, the way that training and learning interact with genetic factors that predispose certain neural traits to develop will clearly be a source of much interest for future study." All of this research may one day lead to new rehabilitation therapies for people recovering from stroke or neurological disorders--and to more effective methods of educating children.

Young children, especially those who grow up in homes where music is often heard, can develop an enhanced brain response to musical stimuli -- a response characteristic of other children about two years older, according to a recent study from McMaster University in Hamilton, Ontario. The study also found that one year of formal music training does not increase the response.

"Our findings indicate that enhanced responses to musical stimuli can be expressed at a very early age," says Larry Roberts, PhD, a professor at McMaster University. But this doesn't necessarily mean that genetic or prenatal factors are the cause of the response, he adds. Such responses are known to be neuroplastic -- in other words, people, even nonmusical ones, can be trained to develop them.

"Most of the children that we observed with an enhanced brain response to music came from homes where their parents or sibling played a musical instrument, so that they had heard a lot of music before they began playing an instrument themselves," Roberts says. "Their early exposure to music in the home may have been responsible for the enhanced responses we observed in their brains."

For their study, the researchers enlisted seven 4- and 5-year-old children who were enrolled in Suzuki music training. Six of the children received training in piano and one on the violin. Before the music lessons began and again a year later, after each child's first recital, the researchers measured the children for a brain response known as the P2 auditory evoked potential, which is detected in brain waves recorded from sensors placed on the scalp. Neurons that generate the P2 response are located in a region of the auditory cortex known as the secondary auditory cortex, and are activated about 0.15 seconds after acoustic signals have reached the brain.

Previous research has shown that P2 brain responses evoked by musical tones are enhanced in adult professional musicians and in adult amateur musicians who play an instrument for personal enjoyment. The study is the first one to examine these brain responses in children receiving musical training.

"We found that P2 brain responses evoked by piano tones in our pianists were larger than those seen in control children, but that P2 responses to violin and pure tones did not differ between musical and nonmusical children," says Roberts. "On the other hand, the P2 response of our one violinist to the violin tone was two times larger than responses evoked by the violin tone in any other subject in the experiment."

Interestingly, the responses in the Suzuki group of children were the same on the first and second measurements, which meant that one year of formal music training had no effect. At both measurements, however, the Suzuki children showed responses that were equal to children about two years older than them.

The next step in this research is to determine whether enhanced P2 responses are observed when children are trained on novel auditory tasks with which they have had no prior listening experience.
Experiments of this type can separate the effects of acoustic experience on auditory brain development from those of intrinsic genetic or prenatal factors. By using appropriate auditory stimuli, it's also possible to evaluate whether acoustic experience modifies neural activity in the primary auditory cortex as well as in the secondary auditory cortex.

Last year, scientists from Beth Israel Deaconess Medical Center and Harvard Medical School in Boston, Massachusetts, launched a first-of- its-kind study that will be following children for at least three years as they begin and advance through musical studies. "We seek to understand what happens in the brain both structurally and functionally as the children grow and develop and achieve varying levels of musical expertise," says Gottfried Schlaug, MD, PhD, the principal investigator of this research.
This study may help determine whether early music training has any effect on the brains of children and their cognitive development.
Previous research in adults has shown that the brains of musicians are structurally different from those of non-musicians, but it's not known whether these differences have been there since birth or developed over time as a result of the musicians' specialized training. Prior research in children has shown that music training can heighten certain visual-spatial skills, yet the neural basis of this enhancement is also unknown.

Schlaug and his colleagues are tracking the children's progress through a series of cognitive and musical tests and through periodic, high-resolution structural and functional magnetic resonance imaging (fMRI). fMRI measures regional changes in oxygen concentration levels in the blood, thus indicating which parts of the brain are being used for particular mental tasks. Structural MRI measures regional volume of gray and white matter in the brain. A total of 73 five- to seven-year-old children were enrolled in the study and divided into three groups:

An "Instrumental" group, consisting of 41 children (17 girls and 24 boys) who were just beginning to study piano or a string instrument;

A "Non-instrumental" group, consisting of 14 children (5 girls and 9 boys) who either participate in singing/movement and music theory (fundamentals of music) classes or receive intensive music instruction in school, but do not study or practice a particular instrument; and

A "Basic" music group, consisting of 18 children (8 girls and 10 boys) who receive only one, standard, 30- to 45-minute general music class per week and do not participate in any other musical activities.

So far, baseline data gathered from subjects as they began their various music studies show no behavioral or cognitive differences among the groups. In addition, no structural or functional brain differences have been seen among groups. "This means that it is unlikely that the cognitive and brain differences described in adult musician/non-musician comparisons exist in children before they begin music training," says Schlaug. "Further, these results make it more likely that we will be able to detect the effects of music training during subsequent intervals of data collection." The first of the study's annual follow-up sessions will take place later this fall.

One portion of this study is being conducted by Katie Overy, PhD, at Harvard Medical School. She and her colleagues have designed an fMRI experiment that examines which parts of the brains of young children (aged 5 to 7 years) are activated when the children attempt to discriminate between simple rhythms and melodies. This is the first brain imaging study to make such a comparison in young children.

Previous studies involving adults have suggested that rhythmic aspects of music are processed predominantly in the left hemisphere of the brain, while harmonic and melodic aspects of music are processed predominantly in the right hemisphere. "Our results show some support for the idea that different regions of the brain are specialized for processing different aspects of music," says Overy. "We found that children show signs of this hemispheric specialization, although the pattern doesn't appear to be as strong as that reported in adults."

The lateralization effect may grow stronger as the children grow older, Overy adds. "Their brains may not be fully specialized yet," she says. The next stage of this research will be to examine the musical listening skills of older children and adults, with and without musical training, to see if their activation patterns differ from those of young children. "We'll be very interested to see whether or not the brain becomes more lateralized for rhythmic and melodic processing with age and level of musical experience," Overy says.

At the Tokyo Metropolitan University of Health Sciences, researchers have discovered that although the left hemisphere of the brain may be important for language and the right for music, singing and speaking share a common neural network that includes many different areas of the brain. "Language has some musical components and vocal music has some language components," explains Yoko Saito, lead author of the study. "They share a common network in the brain."

These findings may help scientists develop more effective methods of rehabilitation for people recovering from illnesses and injuries that affect the brain.

For their recent studies, Saito and her colleagues used fMRI to record the brain function of 20 right-handed volunteers as they performed different singing/speaking tasks: 1) singing along with a singing voice; 2) singing alone; 3) listening to a singing voice; 4) speaking along with a speaking voice; 5) speaking alone; and 6) listening to a speaking voice. The song used in the study was "Sea Song," which is commonly-known in Japan.

"The aim of our study was to disclose the neural networks involved in singing and speaking," says Saito. The researchers found that singing and speaking share many areas of the brain, including the auditory area (temporal lobe) in both hemispheres, the motor area for the mouth and face (frontal lobe) in both hemispheres, and language specific areas in the left hemisphere. They plan to next examine which areas of the brain are involved when music is performed without words--such as when humming a melody or playing an instrument.

Other scientists are discovering why music has the ability, as the playwright William Congreve wrote, "to soothe the savage breast." New research from the University of Montreal has demonstrated that positive emotions induced by pleasant music can have an analgesic effect on people, helping reduce their perception of pain. These findings suggest that music may have a role to play in clinical settings.

For their most recent study, the Montreal researchers enlisted 25 volunteers to evaluate 30 musical excerpts for their pleasantness/unpleasantness (valence) and their calming/stimulating properties (levels of arousal). The three most pleasant and the three most unpleasant excerpts, matched to have similar levels of arousal, were then selected. The pleasant excerpts included classical, pop and jazz/pop music; the unpleasant excerpts mainly consisted of contemporary dissonant music.

The selected musical excerpts were then played for 12 new volunteers while they received 6-second applications of various degrees of heat (from 40.0ºC to 48.5ºC) to their forearms. The volunteers were asked to rate the intensity and unpleasantness of each application of the heat.

"Our subjects felt as much as 20 percent less pain when they were listening to the pleasant music than when they were listening to the unpleasant music -- or when no music was played," says Mathieu Roy, a doctoral candidate at the University of Montreal and lead author of the study. "Interestingly, however, listening to pleasant music didn't affect how they rated the non-painful stimulation [40.0ºC] -- a finding that rules out the possibility that the pleasant music was more distracting than the unpleasant music."

The implications of these findings are two-fold, Roy says. "They obviously strengthen the notion that emotions can modulate our pain experience," he says. "They also support the idea that listeners really feel the emotions expressed by music rather than just coldly perceiving the sounds -- an issue that is far from reaching consensus in music psychology."