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# PART I MUSIC

## 1. NEURO-PSYCHOLOGICAL BENEFITS OF MUSIC EDUCATION

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**Abstract:** *The importance of music for the development of society and the individual has been proved over time in a variety of educational and cultural situations. The cortical representations of musical functions (such as melody, harmony, absolute pitch, timbre, rhythm, music memory, and music emotions) offer new perspectives on the implications that musical training has on the development of the brain. Multiple studies have showed that musicians exhibit hyper-development of certain areas of their brains and obtain better results when motor skills, visual tasks and music related processing abilities were tested.*
**Key words:** *music training, brain, cortical areas*

### 1. Introduction

Music is a powerful and important factor in the educational system. The success of our dynamic society will ultimately depend on how well we develop the capacities of our children, not only to earn a living in a vastly complex world, but to live a life rich in meaning. Music education benefits both student and society. It benefits the student because it cultivates the whole child, gradually building many kinds of literacy while developing intuition, reasoning, imagination, and dexterity into unique forms of expression and communication. This process requires not merely an active mind but a trained one. Music education also helps students by initiating them into a variety of ways of perceiving and thinking. Their goal is to connect person and experience directly, to build the bridge between verbal and nonverbal, between the logical and the emotional to gain an understanding of the whole.

Learning music also benefits society because the students of the music disciplines gain powerful tools for: understanding human experiences, learning to adapt to and respect others' ways of thinking, working and expressing themselves, analyzing nonverbal communication and making informed judgments about cultural products and issues, and learning artistic modes of problem solving, which bring an array of expressive, analytical, and developmental tools to every human situation. In a world inundated with bewildering array of messages and meanings, music education also helps young people explore, understand, accept, and use ambiguity and subjectivity. All students deserve access to the rich understanding that music provide, regardless of their background, talents, or disabilities. The idea that music education is just for "the talented" and not for "regular students" can be a stumbling block. Clearly, students have different aptitudes and abilities in music,

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but differences are not disqualifications. Music is a way of growing, of developing as a person; it is not only a matter of high performance.

In the same time, teachers, policy makers and students all need explicit statements of the results expected from a music education, not only for pedagogical reasons, but to be able to allocate instructional resources and to provide a basis for assessing student achievement and progress. Following this idea, MENC (The National Association for Music Education of USA) created The National Standards for Music Education. These standards define the purposes and activity of music education using the following dimensions: singing, alone and with others, a varied repertoire of music; performing on instruments, alone and with others, a varied repertoire of music; improvising melodies, variations, and accompaniments; composing and arranging music within specified guidelines; reading and notating music; listening to, analyzing, and describing music; evaluating music and music performances; understanding relationships between music, the other arts, and disciplines outside the arts; understanding music in relation to history and culture.

The psychological advantages of music education are distributed in a vast area: self-esteem, increasing memory, self-expression, socialization, increasing academic performance, teamwork, structure, organization, and discipline, enjoyment, motor control etc. Many studies showed that playing music improve reading and verbal skills through improving concentration (Levitin, 2005). Also, the famous “Mozart effect” researchers (Rauscher, 1997) demonstrated that music is a way of increasing the ability to solve spatial reasoning tasks, which are crucial for higher brain functions like complex Mathematics, chess and science.

## 2. Cortical Representations of Musical Functions

Lately we have begun to gain a firmer understanding of where and how the music is processed in the brain. Studies of patients with brain injuries and imaging of healthy individuals have unexpectedly uncovered no specialized brain center for music. Rather music engages many areas distributed throughout the brain, including those that are usually involved in other kinds of cognition. The active areas vary with the person’s individual experiences and musical training. Although the right hemisphere of the human brain has been traditionally viewed as the “musical hemisphere”, there is evidence from patients with brain damage and from functional imaging studies that our perception of music emerges from the interplay of neural pathways in both the right and left hemispheres, some specific to music, others not. Also, Hassler (1990) found gender differences in the lateralization of musical processing, suggesting that female subjects in general have a lower dominance of the left hemisphere than male subjects.

### Melody

The first controlled studies were neuropsychological investigations on dichotic listening which showed a left hemisphere dominance for language perception and a right hemisphere dominance for melody perception (Kimura, 1961; 1964). Latter researches (Bever and Chiarello, 1974) modified these findings by showing that the right hemisphere advantage for melody perception is only true for non-musicians, but not for subjects with musical experience, who analyze musical structures with left hemisphere dominance in a more analytical and non-holistic way than non-musicians. These differences between musicians and non-musicians have been confirmed further by studies (Peretz and Morais, 1980; Hassler, 1990) that showed a significant to a left hemisphere dominance in subjects with musical experience or with an analytical and attentive way of listening to musical structures.

## Harmony

It is astonishing how early in life musical competence can be demonstrated. By 4 months of age, babies prefer consonant musical intervals to dissonant musical intervals. Even if an infant's preference for consonant intervals has been influenced by 6 to 7 months of exposure in the womb, it is likely that the human brain enters the world primed to extract the spectral and temporal regularities that characterize popular music. Developmental psychologists are joining forces with ethnomusicologists to investigate whether babies weaned on non-Western music also prefer consonant intervals like major thirds (Tramo, 2001).

Imaging studies of the cerebral cortex found greater activation in the auditory regions of the right temporal lobe when subject are focusing on aspects of harmony. PET (positron-emission tomography) imaging conducted while subjects listened to consonant or dissonant chords showed that different localized brain regions were involved in the emotional reactions. Consonant chords activated the orbitofrontal area (part of the reward system) of the right hemisphere and also part of an area below the corpus callosum. In contrast, dissonant chords activated the right parahippocampal gyrus (Weinberger, 2006). Also, increased cerebellar activation was observed when listeners had to detect errors in melodic or harmonic structures of musical pieces.

## Absolute pitch

Using both structural and functional brain imaging, researchers found increased cerebral flow in the (left posterior) dorsolateral frontal cortex in subjects with perfect, or absolute, pitch who were presented with musical tones. When subjects were asked to differentiate between major and minor keys, both groups (absolute pitch and controls) had activity in the left posterior DLF (dorsolateral frontal) region, but controls had additional activity in the right inferior frontal cortex, a region of the brain related to memory. This would suggest that subjects with absolute pitch do not need to access working memory mechanisms when they perform this task (Gagnon, 1998).

Furthermore, the researchers discovered a significant anatomical distinction between subjects with absolute pitch and those without: the volume of planum temporale in the left hemisphere was bigger in subjects with absolute pitch, controls. The left planum temporale is also involved in language processing.

## Rhythm

Studies of rhythm have concluded that one hemisphere is more involved, although they disagree on which hemisphere. The problem is that different tasks and even different rhythmic stimuli can demand different processing capacities. For example, the left temporal lobe seems to process briefer stimuli than the right temporal lobe and so would be more involved when the listener is trying to discern rhythm while hearing briefer musical sounds.

Recent evidence from patients with epilepsy suggests that different regions of auditory cortex process different aspects of rhythm. The belt and parabelt areas in the right hemisphere discriminate local changes in note duration and separation, whereas grouping by meter involves mostly anterior parabelt areas in both hemispheres. When you tap out a rhythm with your finger, motor areas in the frontal cortex are, of course, active. But they are also active when you are just listening and preparing to tap. The particular brain areas that are active in right-handed individuals preparing to tap depends on the type of rhythm: for metrical rhythms, which have beats that are evenly spaced at integer ratios (1:2, 1:3), left frontal cortex, left parietal cortex, and right cerebellum are active. For non-metrical rhythm (1:2.5), which are harder to tap out, more of the cortex and cerebellum are involved, with a shift in frontal cortex activation to the right hemisphere (Tramo, 2001).

## Music memory

Studies after hemispheric anesthesia revealed a specific role of right temporal lobe structures in mediating memory for music (Evers, 1999). Other research has indicated that short term recognition is greater when a melody conforms to a tonal scale than when it falls outside this idiom. Similarly, memory for pitch is enhanced when presented within a tonal context. In other words, the retention of information is dramatically improved when the material is hierarchically structured. Tonal knowledge provides a pervasive schema or "grammar" for encoding and remembering pitch and melodic information.

Other findings point to differential contributions of the left and right mesial temporal lobes to melodic memory, with specificity of the right mesial temporal lobe emerging for melodic learning within a tonal musical context (Wilson, 2008). In 1998, Ray Dolan and his colleagues at University College London trained human subjects by teaching them that a particular tone was significant. The group found that learning produces the same type of tuning shifts seen in animals (Weinberger, 2006). The long-term effects of learning by retuning may help explain why we can quickly recognize a familiar melody in a noisy room and also why people suffering memory loss from neurodegenerative diseases such Alzheimer's can still recall music that they learned in the past.

Music recognition is a complex procedure that implies multiple processing components. Damage to one or many of these components produces music agnosia. Such a neurologically based deficit is characterized by the inability to recognize music in the absence of sensory, intellectual, verbal and memory impairments (Peretz, 1996). According to Peretz, music agnosias may have either a perceptual melodic basis (characterized by the failure to encode melodic information properly, defined by sequential variations of pitch), or an apperceptive basis (the long-term memory representations may be spared by the brain damage although the traces are no longer accessible by auditory input), or an associative basis (the breakdown can spare most perceptual abilities but interfere with the recognition process by damaging the network of the long-term memory representations of music). The surgical repair of aneurysm located on the middle cerebral artery is associated with music agnosia, especially when the right insula is damaged (Ayotte, 2000).

**Music emotion**

The areas in the brain where we hear music are partially segregated from those where we feel it. If a melody is played correctly on the piano with the right hand while the left hand plays off-key notes an octave below, infants in the audience would start to squirm, and most adults, finding it unpleasant, would sustain increased activity in the right medial temporal cortex and left posterior. If the left hand played the correct accompaniment, most adults, finding it relatively pleasant, would enjoy increased activity in the right orbitofrontal cortex. Whether the music is pleasant or unpleasant, the auditory cortex, which has connections with these regions, is working away in both hemispheres. It remains to be seen whether subtle melodic or rhythmic manipulations that color musical aesthetics involve the same brain regions (Tramo, 2001).

In 2001, Anne Blood and Zatorre used mild emotional stimuli, those associated with people's reactions to musical consonance versus dissonance, to specify brain regions involved in emotional reactions to music. An example is middle C (about 260 Hz), and middle G (about 390 Hz). Their ratio is 2:3, forming pleasant-sounding "perfect fifth" interval when they are played simultaneously. In contrast, middle C and C sharp (about 277 Hz) have a complex ratio of about 17:18 and are considered unpleasant, having a rough sound. The same researchers found out, when they scanned the brains of musicians who experienced chills of euphoria while listening to music, that music activated some of the same reward systems that are stimulated by food and addictive drugs.

## 3. Brain Development through Music Education

Early musical training seems to shape the young brain, strengthening neural connections and perhaps establishing new ones. Just as some training increases the number of cells that respond to a sound when it becomes important, prolonged learning produces more marked responses and physical changes in the brain. Musicians, who usually practice many hours a day for years, show such effects; their responses to music differ from those of non-musicians. They also exhibit hyper-development of certain areas in their brains. The effect of training was most apparent in the corpus callosum, the four-inch-long bundle of nerve fibers that connects analogous structures in the hemispheres (Schlaug, 1995). Because each hemisphere controls movements on the opposite side of the body, rapid communication between them is crucial for coordinating the fingering of, for example, a Bach fugue. Among musicians who had started their training before the age of seven, the corpus callosum was 10 to 15 percent thicker than in non-musicians or even in late-blooming musicians. A heftier corpus callosum may improve motor control by speeding up communication between the hemispheres.

Musicians may display greater responses to sounds, in part because their auditory cortex is more extensive. Schneider (2002) reported that the volume of the auditory cortex in musicians is 130 percent larger. The percentages of volume increase were linked to levels of musical training, suggesting that learning music proportionally increases the number of neurons that process it. Moreover, musician's brains devote more area toward motor control of the fingers use to play an instrument. For example, the brain regions that receive sensory inputs from the second to fifth fingers of the left hand were proved to be significantly larger in violinists. These are precisely the fingers used to make rapid and complex movements in violin playing. In contrast, there is no enlargement of the areas of the cortex that handle inputs from the right hand, whose fingers have no special movements.

Increased sizes of certain parts of the brain in musicians bring out the advantages of enhancing abilities in activities related to music, or not. In music performance, musicians frequently attain extremely precise timing control. This has been demonstrated in several contexts. Wagner (1971) assessed the rhythmical precision of playing a C-major scale in professional pianists. He found at a required speed of about sex key-strokes per second a standard deviation of 6 to 10 ms in a group of 11 pianists when calculating the temporal deviations of 30 subsequent key-strokes. Additionally, Stoesz (2007) determined that enhancement of musician's local processing abilities is not domain-specific, but extends to processing non-musical, visual stimuli. In her study, musicians outperformed non-musicians on the Group Embedded Figures Test and on Block Design. More than that, Musician's ability to copy drawings of physically impossible objects accurately was also superior to that of non-musicians. The results provided converging evidence that extensive music training is specifically associated with superior visual processing of local details, beyond any benefits it may have on verbal intelligence.

## 4. Conclusions

At an applied level, research investigating the relationship between music training and visuospatial/constructional skills, specifically, could contribute to advances in the fields of education and cognitive rehabilitation. Overall, findings indicate that music has a biological basis and that the brain has a functional organization for music. As research on music and the brain continues, we can anticipate a greater understanding not only about music and its reasons for existence, but also about how multifaceted it really is.

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