Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 3, 9693 - 9699

A Comparative Study of Music on The Development of Human Brain Functions in China and Foreign Countries

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Abstract

The human brain, as the commander of the human body, is the most complex organ in terms of structure and function, and its plasticity has become a focal point of interest for scholars in China and abroad in recent years. In the past, there was a misconception that the brain network could only change during the critical period of development, and that the number of nerve cells would only decrease in adulthood. However, over the past few decades, Chinese and foreign scientists and scholars have continued to support the idea that the human brain is plastic, and in particular, studies have shown that music can have an impact on brain structure and function. This paper summarizes the literature on music as an example and analyses the effects of music on human brain function, with a view to providing references for more in-depth studies in the future.

Keywords: Music; human brain; function; music education

There used to be a misconception that brain networks could only change during critical periods of a person's development, and that nerve cells would only decrease in adulthood. However, research over the past decade or so has continued to support the idea of brain plasticity, which means that the human brain changes its function and potential neural circuits in response to environmental changes as well as input and stimulus information. Music is an art and a common human language. People from different countries, races and cultural backgrounds can create their own music. Human brain plasticity can be divided into structural plasticity and functional plasticity, which are interrelated and inextricably linked. Functional brain imaging studies have shown that long-term musical training not only causes changes in the activation site and degree of activation of the brain, but also promotes the development and shaping of the brain's nerves, which can improve the overall intelligence, emotion, and aesthetics of the human brain. Therefore, exploring the effects of music on the structure of the human brain is crucial to understanding the plasticity of the human brain. This is not only conducive to exploring the value of music in overall human development, potential development and healthcare, but also to promoting innovation and reform of music education based on brain science.

I. The development of a 'musical brain' through music

"The 'musical brain' is genetically predisposed, with a small area in the upper left eye known as the functional music area, indicating that musical ability is innate in humans. However, musical training can lead to neurological remodelling of the brain, altering areas of the brain and perhaps even enlarging the size of a particular area, thus improving musical composition and appreciation. Musical imagination emerges from the process of mindful appreciation of music. It has been shown that the areas of the brain that are active when people imagine music with lyrics and music without lyrics are integrated differently depending on whether or not lyrics are added to the music. The results of this research are widely used in practice.

For example, singing can be used to restore fluent speech for people who stutter and for people with aphasia.

Musical memory can also activate different areas of the human brain. In one study it was found that when subjects were asked to recall familiar musical melodies, the superior middle frontal gyrus and precuneus were active bilaterally, with the right side being more active. When unfamiliar melodies were recalled, the frontal regions were more active bilaterally.

The above studies suggest that while there are certainly genetic and innate factors in the musical abilities of the human brain, acquired influences also play an important role in the development of neural pathways in the human brain.

2. The effect of music on the cognitive function of the human brain

Research in brain and cognitive neuroscience shows that people receive various kinds of information from the outside world into the brain through various sensory organs such as vision, hearing, smell, taste, and touch, which activate different brain areas and form different thinking representations. The cognitive function of the human brain refers to the ability of the human brain to process, store and extract external stimuli in order to acquire knowledge. It includes the ability to perceive, remember, pay attention, think, and imagine. Research has long found that different areas of the brain are responsible for different functions. For example, the cerebral cortex has functional areas for motor, language, auditory and visual functions. These functional areas are closely linked to each other to perform a number of human brain functions and behaviours. The complex neural network of the human brain suggests that the development of human brain functions is necessarily influenced by the constraints or facilitation of other functional areas. The basic elements of music are pitch, rhythm, and chords. They integrate and mobilise different areas of the brain by stimulating neural activation patterns that facilitate the development of human brain function. Different types of music and individual musical backgrounds also have different effects on the human brain.

2.1 Music improves memory

Barbara Stein's experimental studies have shown that musical stimulation can alter the secretion of certain neurotransmitters and peptide hormones, thereby improving memory. Music psychobiologist Rong X. W. found that musical stimulation increased and decreased the secretion of the posterior pituitary pressor AVP (4-8) in the brain, increased the transcription level of the "immediate early gene" c-fos by 600-fold, increased the transcription level of the cortical and hippocampal nerve growth factor (NGF) by 2-fold, and increased the transcription level of the liaison gene by 2-fold. Increases transcription levels of NGF genes in the cortex and hippocampus by a factor of 2, increasing the number of neurons and synapses in the contact cortex by 1/5 to 1/3（Cui,2004）.Chinese scholar Yang Hua conducted an experimental study on working memory task completion for musicians and non-musicians, and the results showed that musicians had faster reaction times than non-musicians, both with and without a tonal background music, implying that music training has a facilitating effect on working memory capacity (Zhou & Zhang, 2002).

2.2 Music improves figurative thinking skills

Physiological psychology research shows that the left brain uses concepts and algorithms for abstract thinking, while the right brain uses imagination, intuition, and inspiration for figurative thinking. Binaural split-listening techniques reveal that music activates both the left and right hemispheres of the brain, with both the right brain primarily responsible for pitch perception and working memory, and the left brain responsible for the recognition of temporal

components of music such as rhythm. (Andrade & Bhattacharya, 2003). However, studies by R. C. Gur et al. have also shown that music activates the right hemisphere and thus stimulates creativity (Zhou & Zhang, 2002).

Similar studies have been conducted by Chinese scholars. Li Enzhong and others applied functional MR imaging (fMRI) to detect asymmetry in functional brain activity. They concluded that language stimulation activated mainly some left-brain areas, with a few right brain areas being activated. However, with musical stimulation, the right brain was overwhelmingly activated, much more than the left-brain areas (Li et al., 1999) The study by E. Lee and others is in full agreement with the findings of Zatorre (Zatorre et al., 1994).

2.3 The "Mozart effect" in music

In 1993, Frances H. Rauscher and Gordon Shaw conducted an experiment with 84 university students. According to the study, students in the experimental group scored 8%-9% higher on the Spatial-Temporal Reasoning Test after listening to Mozart's sonatas for 10 minutes (Sousa, 2005). The study suggests that people who listen to Mozart's sonatas regularly can improve their spatial reasoning skills. However, the existence of the "Mozart effect" has been debated in China and abroad. Some studies suggest that music has a stimulating effect on people's cognitive abilities, while others suggest that music has no or little effect on people's intelligence. For example, Christopher Chabris's experiments at Harvard University disproved this idea. He conducted 16 experiments and found that listening to Mozart's sonatas had almost no effect on improving academic scores.

The "Mozart effect" was once the subject of a wave of research in China. For example, Liu Zhengkui et al. found that music improved language and English scores, and that music students outperformed ordinary children in these two areas, with significant differences; however, the difference between the mathematics scores of music students and ordinary children was not significant (Liu et al., 2003).

3 The effect of music on the human brain's emotions

Emotion reflects the psychological experience of whether a person's perception of objective things meets his or her needs. In a study, Brad and Chattori concluded that music stimulates pleasure and passion in the human nerve centre, which they believe comes from the dopamine secreted by nerve cells (Yan Bo, 2013). A Russian study also confirmed that a person spending an hour a day listening to music can completely change the way the brain reorganises itself, extracting EEG information from the subjects, showing that brain waves are also in the alpha wave state for an increased amount of time and that brain synergy is enhanced (Domschke et al., 2005).

Chinese scholars Shen Wang Chaohui and Dong Jingfei used the SP03 brain up and down mapping instrument to stimulate music in the tested group, and the experimental findings showed that upbeat music was closely related to its increased activity, power enhancement and functional control effects in improving negative emotions (Wang & Dong, 2017).

4. The effect of music on the aesthetic function of the human brain

Aesthetics is the activity of creating and appreciating beauty that is carried out by human beings to satisfy their spiritual needs. The aesthetic function of the human brain consists of four aspects, namely, feeling beauty, appreciating beauty, evaluating beauty, and creating beauty. In his experiments, Braun found that the prefrontal cortex and amygdala were simultaneously excited at high levels during musical aesthetics, and that the amount of serotonin secreted by the subject's brain increased proportionally. Thus, serotonin content neurons are closely related to aesthetic activity in humans (Domschke et al.,

2005). In his study of the aesthetic perception of music in the brain, Dreddip found that when musicians have the best experience of their favourite music, high-frequency synchronous oscillatory waves of 40 Hz appear successively in the ventral medial median area and dorsolateral median area of the prefrontal brain, suggesting that the ventral medial median area of the prefrontal brain acts as a higher-order emotional response centre during the aesthetic experience, forming a new aesthetic imagery and sends this conceptual information to the lower cortex, among others, to regulate sensory, memory, emotional and imaginative activities (Bhattacharya et al., 2001) .

Chinese scholars Chen Lijun and Wen Qi conducted an experimental study on the aesthetic experience generated during music appreciation. Their research concluded that music genres can induce different kinds of aesthetic experiences. Slow music in a major key induces the aesthetic experience of "joy" and "sorrow"; fast music in a major key induces the aesthetic experience of fear and anger; slow music in a minor key gives people the aesthetic experience of sadness or despair; fast music in a minor key triggers the aesthetic experience of "joy". The aesthetic experience of "joy" (Chen et al., 2012).

5. Music as a treatment for brain deficits and mental illness

Chinese and foreign studies have shown that music can influence the cognitive, emotional, and aesthetic functions of the human brain, as well as drive both the left and right hemispheres of the brain to participate in musical activities, thus promoting the development of left and right brain functions. These specific functions of music have led to the research and use of music as a therapeutic tool in clinical treatment.

Scientists first experimented with individuals with brain deficits and found that: a patient with autism, who needed parental care, had delayed language development, and had difficulty communicating, had an amazing memory for music; a famous composer, who had a stroke that damaged the left temporal lobe area, was unable to distinguish speech and could not understand language. But the music he composes is no different from what he did before.

These phenomena suggest that the musical functions of the human brain are not affected by the decline in human intelligence; rather, one part of the human brain function is damaged while another part is still available. The compensatory role of human brain function and the shaping function of music, provide the theoretical and practical basis for music therapy.

In the 1950s, the United States was the first country to establish a music therapy association, and music therapy emerged as a new discipline. Music therapy has since been well tested in paediatrics, surgery, psychiatry, cardiovascular medicine and even dentistry.

In the early 1980s, music therapy was introduced to China from the West as an emerging discipline, thus beginning the development of music therapy in China. 1979 saw the first use of music therapy at Shenyang 202 Hospital. They combined traditional acupuncture and electrotherapy to create and design a music electro-acupuncture instrument and a music electro-therapy instrument, which were applied to clinical treatment with obvious efficacy. Currently, music therapy in China has been applied to the rehabilitation and treatment of people with mental health, psychosomatic diseases, geriatric diseases, children (autism, autism), foetal education, maternity, drug addicts and prison inmates. In China, music therapy is not only used to treat illnesses, but is also widely used in self-care. A range of music with Chinese characteristics, such as wellness music, foetal music, sleep-aid music, music electrotherapy and music electro-acupuncture, is increasingly accepted as an aid to self-emotional regulation and self-stress reduction.

6. Research findings

How does music affect the human brain? How does it enter the human brain and in what form does it exist? Psychologists, aestheticians, and scholars from all over the world have been exploring this question, trying to decipher the "black box" of the brain. With the development of cognitive science, neuroscience and brain function testing techniques, scientists and scholars have come to grips with a large number of codes that link the arts to the human brain. A growing body of research suggests that music has more than just an emotional impact on people; it can subtly alter the structure and function of the brain, with positive effects on brain development. The process of learning and creating music 'nourishes' the nervous system, including sensory integration, attention, cognition, emotion, and movement, and promotes brain development.

There is a wealth of research in China and abroad on the effects of music on human brain function. In general, the research is not in sync with each other in terms of both methodology and findings. Foreign research is ahead of the curve, with more results and a broader scope; quantitative research conducted in China started later, but has been followed by continuous validation, and bold application and exploration, with some results. Driven by multidisciplinary knowledge and high technology, the research paths of Chinese and foreign researchers have converged, and the research results are both universal and cross-cultural in character, showing the following characteristics.

6.1. There is complete agreement between Chinese and foreign research findings on the effects of music on the brain functions of hearing, somatosensory, motor, visual and memory. For example, it improves memory capacity; activates the right hemisphere of the brain and enhances the ability to think imaginatively; improves the ability to hear language; and so on.

For the effect of music on language skills. The findings of both Chinese and foreign studies are generally consistent. For example, music can boost English language performance, but the effect on language performance is controversial. The reason for this may be that music has a greater impact on listening and a smaller impact on grammar, reading and writing.

Studies by both Chinese and foreign scholars have involved discussions about whether music affects academic achievement and intelligence. The studies agree that the effect of music on intelligence and on academic achievement is uncertain, but that music has a facilitating effect on certain abilities in intelligence. For example, listening skills, English language achievement, etc. There are several possible reasons for this: for one thing, many experiments have used IQ or academic achievement as a test of intelligence. But intelligence includes a wide range of abilities. IQ, which characterises intelligence, reflects only one aspect of intelligence; it does not encompass the other aspects of intelligence. Therefore, by reducing intelligence to a number, experimental results are bound to be biased. Secondly, academic performance is a direct reflection of the effectiveness of academic work, the degree of knowledge acquired in a particular area, and an indirect reflection of learning ability, which is not related to intelligence. The level of intelligence is a necessary but not a sufficient condition for good academic performance, so using academic performance to evaluate a person's intelligence does not necessarily reflect the actual situation. Thirdly, developmental psychology suggests that there are 'critical periods' for the development of various human abilities, so the age at which music training begins will certainly have a different impact on the functioning of different areas of the brain. Likewise, the duration of the stimulus has a different effect on brain function, so the age of the subject and the duration of the music training in the experiment can be a confounding factor in the outcome of the test. However, scientific research takes into account

both individual differences, but seeks more general probability of effects. In this sense, there is no doubt about the role of music in promoting intelligence.

6.2 Regarding the effect of music on the emotional function of the brain, the findings of Chinese and foreign studies are consistent. That is, musical experiences can significantly alter brain waves and thus affect mood, stimulating pleasure and passion in the central nervous system; alpha waves can stimulate latent abilities, enhance memory effects, and bring out inspiration and creativity.

6.3 There is little research in China on the effects of music on the aesthetic function of the brain, and the focus is on the aesthetic mechanisms of the brain. However, the few research findings show the consistency of findings between Chinese and foreign studies.

6.4. The efficacy of music therapy in improving human brain function, among other things, has been consistently affirmed in China and abroad. Due to differences in country, ethnicity, culture and economic conditions, there are still differences in the concept, application, and treatment methods of music therapy in China and abroad, especially in China where the popularity and dissemination of music therapy is far from universal. As people's knowledge of music and the human brain continues to deepen, and as Chinese and foreign cultures continue to mingle, there is still vast scope for future research in music therapy. In the future, China can explore music therapy with Chinese characteristics in combination with traditional Chinese medicine and explore the medical value of Chinese music in depth, in addition to learning from foreign research results. This should be a topic that needs to be explored in Chinese music therapy in the long term.

As can be seen from the above, the scope of research on the relationship between music and the human brain is now spreading among scientists and scholars in China and abroad, and the research methods are becoming more and more advanced, providing many favourable conditions for further research on music perception and music composition in relation to specific neural networks. We have reason to believe that our understanding of the impact of music and human brain function will become more three-dimensional, and that research results can help musicians, educators and medical practitioners find ways to strengthen their special musical abilities.

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