

Internal Listening and Musical Creativity: A Study of Brain Function

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Abstract: The *relevance* of the chosen research topic lies in the fact that inner listening plays a fundamental role in musical creativity and performance. In the context of contemporary music education and performance practice, there is a growing interest in understanding the processes that occur in the musician's brain during musical perception and recreation. This study aims to expand knowledge of the relationship between inner hearing, brain function and musical creativity. The *aim* of this paper is to study the influence of inner hearing on the process of musical creativity and to identify the neuroscientific mechanisms underlying this interaction. The *object* of the study is the inner hearing of musicians, and the subject is the relationship of inner hearing with musical creativity and brain functions. The *scientific* novelty of the study lies in the integrated approach to the study of inner hearing from the point of view of neuroscience and musical creativity, which allows us to update the ideas about the influence of inner hearing on musical activity. The *structure* of the thesis includes an introduction, two main chapters touching upon the key aspects of inner hearing and its connection with brain functions, as well as a conclusion summarizing the results of the research.

Keywords: Musical creativity, Performance, Brain functions.

1. The Fundamental Role of Inner Hearing in Musical Performance

1.1. Definition and meaning of inner hearing

Internal hearing is the ability to hear and represent the sounds, melodies, harmonies and rhythms of music without external acoustic stimuli. It includes the ability to clearly perceive information such as pitch, tone and timbre. This ability to perceive and perform music is very important because it allows musicians to visualise and plan a piece of music in advance before they begin to play it, or while they are music-making.

The importance of inner hearing to musical performance cannot be overemphasized. The inner ear is a complex and sophisticated organ with unique physiological and functional characteristics that allow it to respond sensitively to sound. Musicians with a well-developed inner ear are not only able to reproduce musical works accurately, but also improvise, translate music into other tonalities, understand and interpret musical texts more deeply. This article examines the mechanisms of the inner ear's influence on musical intelligence and the changes it can cause through the lens of musical creativity. According to Sloboda J.A. 1985, the inner ear is closely related to musical intelligence and creativity.

Musicians improve their memory for music by actively using their inner hearing through the ability to reconstruct musical pieces in their brains, which is considered a highly effective method of memory training (Hallam S. 1995). Inner hearing refers to the sound system that people develop through their inner experience and which has unique individual characteristics. Furthermore, advances in inner hearing have played a key role in the development of empathic and emotional responses to music, allowing performers to more skilfully feel and communicate the emotion and uniqueness of a piece of music.

One of the key techniques for developing the inner ear is

solfeggio, a training programme aimed at developing musical ear skills, covering sight singing, aural perception and tonal training. It enables the learner to understand the relationship between music and other disciplines and to acquire relevant skills. The solfeggio programme aims to develop the ability to internally express the sound and form of music, which is absolutely essential for professional musicianship.

Thus, the ability of inner sense of hearing is a fundamental skill that musicians need not only to help them interpret music accurately and expressively, but also to gain a deeper understanding of the inner structure and emotional depth of music. In the process of learning music, in order to improve students' external sense of hearing, we should start by stimulating their senses to the deep meanings of musical works, and guide them to listen, experience and comprehend with their ears, so as to achieve the goal of enhancing their aesthetic ability in music. In order to develop this ability, we need to make systematic efforts, which is an integral part of music education.

1.2. Types of inner hearing: melodic and harmonic inner hearing

Performance in musical practice can be used to categorise inner hearing. The physiological and psychological activities of the subject of musical aesthetics, such as breathing and heartbeat, affect the perception of inner hearing. The two main types of inner hearing include melodic inner hearing and harmonic inner hearing. Each has its own unique form of expression and combines with the other two forms to create new content. These types of inner hearing reveal different differences in musical perception and information processing between musicians and listeners.

The main duty of the harmonic inner ear is to represent harmonic constructions in music. Thus, the harmonic inner ear is one of the most important and indispensable means of understanding the harmonic characteristics of a piece of music. It gives the listener and the performer the opportunity

to comprehend and present in his mind harmonic sequences, chords, their roles and connections in music in a new way. The importance of harmonic inner ear cannot be overemphasized for musicians who specialise in playing harmonic instruments such as piano, guitar and organ, as well as for composers and arrangers who are responsible for working with the harmonic weave of a piece of music.

To develop melodic and harmonic inner ear, we need to use different teaching strategies and methods. To improve melodic hearing, we can practice singing by ear, intoning unaccompanied melodies, memorizing and playing melodic phrases. Harmonic hearing is developed through chord recognition exercises, music and harmony analysis, accompaniment exercises, and melody and voice training.

The two different types of inner ear play an integral and central role in music education and the professional life of musicians, which not only enriches their performance skills but also develops their creative abilities.

2. Interactions Between the Brain, Inner Hearing and Musical Creativity

2.1. Neuroscientific perspectives on inner hearing: how the brain processes musical information

The innate ability to hear is undoubtedly one of the most fascinating parts of human musical perception and cognitive expression. It has a significant impact on our understanding of the meaning of musical compositions and allows us to better understand the emotions and subtext expressed in them. Thanks to the rapid development of neuroimaging and other experimental techniques, modern neuroscience has made significant progress in studying how the brain processes musical information and generates internal auditory images.

The neural networks of the brain located in the primary and secondary regions of the auditory cortex in the temporal lobe of the brain are functionally interconnected through interactions between neurons and are therefore highly complex. Here, sound signals are initially analysed from which basic musical attributes such as pitch, tone quality, loudness and duration are extracted [1]. These attributes are transmitted to higher sensory neurons through neural mechanisms and affect the corresponding areas. Further processing of the musical information takes place in the associative auditory areas, resulting in a more complex perceptual image related to the recognition of melodic, harmonic and rhythmic patterns [2].

However, music perception is not limited to auditory analysis. This role is realised through the activity of the cerebral cortex. A large number of scientific studies have confirmed that auditory and motor areas of the brain closely interact when processing musical information [3]. Thus, when listening to music or playing it, premotor and motor cortical areas associated with planning and controlling movements are activated in the brain. This indicates a close connection between music and movement, which is initially embedded in the rhythm and rhyme of music [4].

The emotional core of the brain, especially the amygdala and limbic system, play an equally important role in music perception. The effects of music on emotion are mainly through specific areas of the cortex, including the insula, prefrontal lobes, and parahippocampal gyrus. Music has a

special ability to stimulate strong emotional responses ranging from happiness and joy to sadness and nostalgia. Music also affects emotional memory, language processing and attention, thereby altering mental states. Results of neuroscientific studies have shown that these responses correlate with the activation of ancient subcortical structures responsible for processing key emotional stimuli [5].

For professional musicians, the phenomenon of inner hearing is of particular interest. Music is the result of sensory signals generated by the cerebral cortex and transmitted to various parts of the body, which cause appropriate physiological activity. Numerous scientific studies indicate significant structural and functional differences in the brains of musicians and non-musicians [6]. In addition, musicians are more prone to convert visual signals into auditory signals than other types of people. After long-term music training, the auditory and motor cortex becomes thicker and the interaction between different parts of the brain increases, making the processing of musical information more efficient [7]. In addition, musicians can perceive the acoustic environment through the visual system, such as hearing the tones produced by instruments and seeing the colours of objects. Musicians have increased activity in both auditory and motor areas when they listen to or play music, and when music appears in their brain [8]. This means that a musician's auditory system is uniquely bright, detailed, and tunable.

2.2. Music, emotion and inner listening: emotional coding in the brain

Music has a special ability to stimulate and convey a wide range of emotions - from deep sadness to boundless joy, from quiet melancholy to euphoric delight. The emotional information contained in music is not only perceived, but also affects other systems of the human body in different ways. Music's ability to resonate deeply with our emotional world underlies its lasting effects on the human mind and makes it a unique area of neuroscientific research [9]. Therefore, it is crucial to analyse, understand and explain the different emotions embedded in musical compositions and their mutual transformation processes. In recent years, neuroscience has made significant advances in the study of how the brain processes the emotional content of music and the links between these processes and auditory sensations.

Numerous scientific studies indicate that the perception of musical emotions is influenced by a complex interaction between auditory, limbic and prefrontal brain regions [10]. The frontal lobe is one of the most important visual cortices compared to the other hemispheres of the brain. When you listen to emotionally charged music, it not only triggers the primary and secondary auditory areas responsible for acoustic analysis, but also activates structures of the limbic system such as the amygdala, hippocampus and cingulate gyrus. It can also influence the activity of a number of other higher brain regions by modulating the limbic system. These structures play a critical role in processing emotionally relevant stimuli, forming emotional memories, and eliciting emotional responses.

Of particular interest is the role of the amygdala in the perception of musical emotions. The amygdala, as an important brain region, is thought to be involved in many different emotion regulation processes. Numerous scientific studies have shown that amygdala activity increases when people listen to emotionally charged music, especially when confronted with negative emotions (e.g., sadness, fear, and

anger) [11]. The fact that amygdala activity is related to the depth of emotional experience implies that the amygdala plays a key role in expressing the emotional meaning of musical stimuli [12]. In addition, many researchers have found that the amygdala is also involved in modulating other brain regions such as the hippocampus, and that these neural pathways may contribute to our understanding of the relationship between emotional changes and behavioural responses. Interestingly, in people with anosognosia (inability to perceive music), amygdala activity is reduced when listening to emotional music, which may explain their problems with musical experience [13].

In addition to limbic structures, prefrontal brain regions, particularly the orbitofrontal and medial prefrontal cortex, are also involved in the processing of musical emotions. In addition, the limbic system of the brain modulates the processing of different types of information by sound signals. These specific areas play a critical role in several aspects of emotion regulation, impulse control, social perception and self-awareness [14]. The prefrontal lobe mainly consists of areas such as the inferior frontal gyrus, inferior temporoparietal lobe and superior temporal gyrus in which the frontal lobe plays an important role. During music perception, the behaviour of prefrontal areas depends on the emotional content of music and is related to a person's subjective pleasure and the significance of musical stimuli [15]. In addition, the prefrontal cortex can influence other brain functions or behavioural patterns through neural connections between different parts of the brain. Many believe that the prefrontal cortex modulates limbic and auditory areas from top to bottom and that it provides us with cognitive evaluations and influences our emotional responses to music.

Convincing data were obtained when studying the emotional perception of music in people with mental illness, particularly depression and anxiety. When this group listened to emotionally meaningful music, especially melodies filled with sadness and anxiety, amygdala activity increased and prefrontal cortex activity decreased [16]. In addition, it was found that people with depression and anxiety listened to sad or happy melodies more than normal people. This may indicate problems with emotion regulation and increased sensitivity to unfavourable stimuli characteristic of these disorders. In addition, we found similar changes between depressed and anxious people and normal people. From another point of view, the use of music therapy techniques based on specific musical effects can be effective in correcting affective disorders, improving emotional state and returning brain activity to normal [17].

Modern neuroscience has shown that music perception and expression rely on a complex network of interactions between different brain regions. Of these, hearing is the most important sensory pathway for musical perception. The inner ear hearing encompasses all aspects of musical processing, from acoustic analysis to symbolic coding. Musicians' brains show neuroplastic changes reflecting their ability to adapt to musical practice. However, there is a lack of data supporting the psychological and physiological responses underlying these findings. An in-depth study of this area could reveal neurocognitive processes underlying music perception, imagination, and creativity, further understanding the enigmatic part of the human brain related to music creation and interpretation.

2.3. Scientific approaches to inner ear training: strategies for enhancing musical performance

Inner hearing - the ability to represent and process musical images in the brain - is one of the key skills that determine a musician's level of musicianship and creativity. As living conditions improve and tastes grow, more and more people are turning their attention to learning music and shifting their focus to developing good inner ear. The development of inner ear not only enhances the level of musical performance, but also helps to deepen the knowledge and feeling of music, as well as aids the process of memorising and interpreting musical works [18]. At present, many primary and secondary schools in China still use traditional concepts and teaching methods based on suggestion in music education, and do not pay due attention to the study of the laws of students' inner auditory development. Therefore, developing effective strategies for teaching inner ear has become a major challenge in the field of music education and psychology.

Mental rehearsal, also known as "mental rehearsal", is one of the most common and well-studied strategies for developing the inner ear. It achieves its training effect by mimicking the human auditory process. This technique involves the systematic mental performance of a piece of music or a part of it without reproducing the actual sounds [19]. It requires the performer to express the thoughts and feelings that the composer is trying to convey through his or her imagination. The musician should endeavour to demonstrate numerous aspects of performance, including pitch, rhythmic structure, dynamic expression, manner of articulation, sound quality and the resulting sense of movement, in as vivid and refined a manner as possible [20]. As a result, the performer gains both a good auditory performance and a sense of musicality, which contributes to their all-round development. Numerous studies have confirmed that periodic mental practice improves musical accuracy and fluency, deepens musical memory, and increases musicians' confidence on stage [21].

Musical dictation is another important method of training the inner ear that is widely used in solo singing and music theory. Musical dictation involves gaining an understanding of the musicality of different styles of musical works by listening to them. The technique of musical dictation involves the use of hearing to capture melodies, rhythms or sound sequences of voices or instruments [22]. It is oriented towards auditory stimuli and produces the desired sensory impression by processing the acoustic signal. This method helps to develop students' ability to accurately perceive and remember musical information by allowing them to express tonal and rhythmic relationships in the brain and to convert auditory images into symbolic musical notation [23]. In addition, musical dictation is one of the effective means of developing hearing. Frequent practice of musical dictation not only helps to strengthen the auditory abilities of the inner ear, but also develops analytical and listening skills that enhance the sense of harmony and rhythm.

It is worth emphasising that the effectiveness of inner ear training depends largely on the systematicity and regularity of lessons, as well as on the musicians' personality and their ability to learn. Motivation and emotional involvement play an equally important role in the creation of psychomusic [24]. In addition, other aspects such as music therapy and auditory-verbal rehabilitation have an impact on the inner ear.

Therefore, the optimal strategy for developing the inner ear should be tailored to the individual and flexibly incorporate many different approaches and pathways.

Thus, modern science provides us with a vast array of methods and techniques aimed at training the inner ear and enhancing musical expression. These methods include not only traditional mental exercises and musical dictation, but also innovative means using computer technology and neural interfaces. The most important of these are also methods that mimic the physiological processes and mechanisms of the inner ear by reorganising the functional structures of the brain. Although these methods differ from each other, they all have one main goal - to develop a vivid and detailed imagination of music in the auditory space of the inner ear, as well as the ability to freely process musical images and transform them into real sounds. Such teaching methods have been studied many times, but for various reasons they have not been widely used or even considered ineffective or harmful means. Given the central role of inner hearing in musical activity, further optimisation of these methods and their introduction into the practice of music education is certainly an urgent and promising task.

3. Conclusion

The relationship between inner hearing and neurocognitive mechanisms is crucial for understanding music. Inner hearing is essential for human understanding of music, and exploring its role in composition and improvisation is fascinating. However, there are theoretical shortcomings in the inner ear system that need to be addressed through interdisciplinary research integrating music psychology, neuroscience, and pedagogy. Innate hearing is a key component of musical ability, influencing perception, understanding, and creativity. A deeper study of this phenomenon may reveal new patterns of interaction between the brain, consciousness, and music, and help us understand the physiological and psychological responses to music perception. Given music's role in personal growth and spiritual balance, this research has both theoretical and practical significance.

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