THE INTERCONNECTION BETWEEN SOUNDS, MUSICAL MEMORY, AND THE SENSE OF MELODY AND HARMONY

Sherzod Muzaffarovich Mustafoev
Boarding School Specializing in Art of Makam

Abstract: Music is a universal language capable of evoking deep emotional experiences, memories, and associative images. This article explores the neurophysiological and cognitive mechanisms that support sound perception, the formation of musical memory, and the development of a sense of melody and harmony. The role of the auditory cortex, hippocampus, cerebellum, and other brain structures in processing musical information is examined. Particular attention is paid to the interaction between sensory, procedural, and episodic memory in the context of musical experience. Individual differences in musical sensitivity and the influence of training and upbringing on the development of musical ear and harmonic perception are also analyzed.

Keywords: music, neurophysiology, hearing, musical memory, melody, harmony, auditory cortex, hippocampus, brain, perception, musical ear

Introduction. Music has accompanied humanity since ancient times. It is used in rituals, religious ceremonies, therapy, education, and entertainment. However, only in recent decades has science come close to understanding how the brain perceives and interprets musical sounds. What makes a melody memorable? Why can harmony give us goosebumps? And what is the role of memory in the perception of musical structure?

In this article, we will examine musical perception as a complex cognitive process involving the integration of sensory information, memory, emotional response, and cultural experience. We will explore which areas of the brain are responsible for analyzing sounds, how musical memory is formed, and how a sense of melody and harmony develops.

1. Neurophysiology of Sound Perception

1.1. The Human Auditory System

Hearing is the first stage of human interaction with music. A sound wave passes through the outer ear, hits the eardrum, is converted into mechanical vibrations, and is transmitted through the auditory ossicles to the cochlea. Inside the cochlea, the vibrations are converted into electrical impulses, which are transmitted along the auditory nerve to the brain.

1.2. Auditory Cortex

The primary analysis of musical sounds occurs in the auditory cortex, located in the temporal lobes. The primary auditory cortex (A1) is where the initial processing of sound occurs - identifying pitch, loudness, and timbre. The information is then transmitted to the association areas, where sound integration and interpretation occur.

Musical perception also involves other areas of the brain:

- Prefrontal cortex - involved in the cognitive evaluation of music.
- Hippocampus - associated with emotional responses and memory.
- Cerebellum - plays a role in rhythmic perception.

• Motor cortex - is activated when listening to rhythmic music, especially in musicians. 1.3. Lateralization of Functions

Interestingly, in most people, speech and music perception are "split" between the hemispheres: the left hemisphere specializes in language information, and the right hemisphere specializes in musical information. However, professional musicians exhibit a more symmetrical distribution of activity, suggesting brain plasticity.

2. Musical Memory

2.1. Types of Musical Memory

Musical memory is divided into several types:

• Sensory memory - short-term retention of sounds (approximately 1-3 seconds).

• Working memory - allows you to retain and analyze musical phrases, for example when reading sheet music or improvising.

• Long-term memory - includes episodic memory (memories of listening to specific music) and semantic memory (knowledge of musical structures, rules of harmony, etc.).

Procedural memory is also distinguished - it plays a key role in performers, as it is responsible for the motor skills associated with playing an instrument.

2.2. The Role of the Hippocampus

The hippocampus is a central structure involved in memory consolidation. Research shows that listening to favorite music activates the hippocampus, explaining the associative power of music in evoking memories. Music can trigger autobiographical memories - a phenomenon known as the reminiscence effect. Even patients with Alzheimer's disease, who have lost significant memory, are able to recognize familiar melodies.

3. Melody and its Perception

3.1. Melody Structure

Melody is a sequence of sounds of varying pitches, organized in time. Perceiving a melody requires:

distinguishing pitches,

retaining their sequence in memory,

analyzing intonation.

Melodic structure is perceived as a holistic form, similar to how we perceive words in a sentence.

3.2. Melodic Memory

For melody recognition, it is important not only to recognize individual notes but also to remember the intervals between them. Research shows that the human brain is more sensitive to the relative pitch of sounds than to the absolute pitch.

Musical memory is often based on patterns - repeating musical motifs - which facilitates memorization.

4. Harmony and its Perception

4.1. What is harmony?

Harmony is a combination of sounds produced simultaneously. It can be consonant (pleasant) or dissonant (tense), depending on the frequency ratios.

4.2. The Neuropsychology of Harmony

fMRI studies have shown that listening to harmonious music activates areas of the brain associated with pleasure - specifically, the ventral striatum and prefrontal cortex.

The perception of dissonance activates the amygdala, which can cause feelings of anxiety or tension.

Harmony is based on learning - in Western culture, the perception of major keys as "happy" and minor keys as "sad" is shaped in childhood.

5. Emotions and Music

5.1. Musical Emotions

Music can evoke a rich palette of emotions: from joy to sadness, from inspiration to anxiety. These emotions are often mediated by cultural context, personal memories, and perceptual characteristics.

5.2. The Neurochemistry of Pleasure

Music stimulates the release of dopamine, a neurotransmitter associated with pleasure and motivation. This explains why favorite music evokes feelings of euphoria, and why many people use music to self-regulate their mood.

6. Developing Musical Ear and Perception

6.1. Nature and Nurture

The question of whether musical ear is innate or shaped by environmental influences remains controversial. Research shows that:

• Infants respond to rhythm and pitch as early as the first months of life.

• Early music education develops hearing, memory, and coordination.

6.2. Absolute and Relative Pitch

Absolute pitch is the ability to name pitches without a reference. This is a rare phenomenon, more common in people who began musical training before age

7. Relative pitch - the ability to identify intervals and construct chords based on a reference - is more common and actively develops with musical practice.

Music is not only an art form but also a powerful stimulus for the brain. In recent decades, neuroscience has increasingly studied the impact of music on brain structure and function. One of the key concepts in this context is neuroplasticity - the brain's ability to change in response to external experience. Musical training, listening to music, and playing instruments significantly influence neuroplastic processes, promoting both cognitive and emotional development. Neuroplasticity is the brain's ability to change its neural connections, respond to new stimuli, recover from damage, and adapt to new conditions. This process occurs at various levels: from the creation of new synapses to the rewiring of entire neural networks. While it was previously believed that the adult brain is sedentary, it has now been proven that neuroplasticity persists throughout life. Music activates multiple areas of the brain simultaneously. Unlike other activities, it integrates sensory, motor, cognitive, and emotional areas. This makes music a particularly powerful tool for stimulating neuroplastic changes.

For example:

a) The auditory cortex is activated by the perception of pitch, rhythm, and timbre.

b) The motor areas of the brain are activated when playing musical instruments or even simply moving rhythmically to music. c) The limbic system (including the amygdala and hippocampus) is responsible for the emotional perception of music.

d) The prefrontal cortex is involved in analysis, memory, and planning.

Musical Learning and the Brain

Numerous studies show that regular musical training leads to structural and functional changes in the brain. Musicians have:

More developed auditory areas.

A thicker trabecula callosum - the structure connecting the two hemispheres of the brain.

Increased activity in the motor and sensorimotor areas.

Working and long-term memory are improved.

Particularly pronounced changes are observed in those who began music training in childhood. However, even adults who begin music lessons demonstrate significant improvements in cognitive function.

Music and Brain Recovery

Music is used in neurorehabilitation for strokes, traumatic brain injuries, and neurodegenerative diseases. One of the areas is movement music therapy (for example, the rTMS method and rhythmic audio stimulation), which helps restore motor functions.

In patients with Parkinson's disease, music improves motor coordination, and in people with Alzheimer's disease, it helps improve memory and emotional well-being. This is because musical memories are often retained even in the presence of profound amnesia, thanks to special storage pathways in the brain.

Music, Children, and Education

In children, musical training promotes:

• Speech and phonemic awareness development.

• Improved attention and self-control.

• Developing abstract thinking and spatial skills.

Research confirms that children who study music perform better on tests of mathematical ability, memory, and language development.

Conclusion. Music is not just a pleasure but also a powerful factor stimulating neuroplasticity. It promotes brain development, improves cognitive function, accelerates recovery from injury, and helps maintain mental health in old age. Thanks to its versatility and accessibility, music is becoming one of the most effective tools in the arsenal of neuroscience, medicine, and education.

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