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THE ART: NEUROSCIENTIFIC APPROACH

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SUMMARY – Scientists have for centuries tried to localize and define artistic talent. Modern diagnostic techniques that enable visualization and measurement of brain morphology and function are positron emission tomography (PET), magnetic resonance imaging (MRI), functional transcranial Doppler (fTCD) and some biochemical methods. In the majority of people, the left hemisphere is dominant, but the right hemisphere is considered to be creative, visual, imaginative and intuitive. Right hemisphere is associated with musical skills and good three-dimensional orientation. It is also associated with good coordination and athletic skills. Creative people have less marked hemispheric dominance. Using the functional (fMRI) technique, the activation of visual cortex while watching different kinds of compositions was visible; the specific pattern of cortical activation was identified for looking at the landscapes, portraits, abstract compositions or different combination of colors. For music perception, the interplay of activity on both sides of the brain is necessary. In the right side, the centers for perceiving pitch, certain aspects of melody, harmony, timbre and rhythm are placed, and in the left side the processes of rapid changes in frequency and intensity, both in music and words are taking place. Adaptation of the brain, i.e. brain plasticity can arise upon listening or performing music. It is possible to use music, painting and dancing as an aid in the treatment of somatic, neurologic or psychiatric disorders.

Key words: *Neuroscience – trends; Art; Beauty; Esthetics; Brain – physiology; Cultural characteristics*

Introduction

Scientists have tried for centuries to localize and define artistic talent. Since the introduction of modern medical technology, rapid development in the field has been achieved, yet the art is not possible to oversimplify and to define it just as a sensorimotor function. During the past decades, in the field of art it was discovered that specific changes in the brain functioning occur while listening to the music, playing an instrument or dancing, as well as while watching colors or specific types of paintings. Until 1950, only five scientific papers in the field of neuroscience on the cognition and consciousness were published, and till 2000 this number multiplied to up to more than 1800 papers. The reason for such a great difference certainly lies in the rapid and large development of medical technology that is able to show not only the morphology of the brain, but also the function of certain brain areas, sometimes even in real time[1]. Modern diagnostic techniques that enable visualization and measurement of brain morphology and function are positron emission tomography (PET), magnetic resonance imaging (MRI), functional transcranial Doppler (fTCD), and some biochemical methods.

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Functional Localization of Art

The background of most human motor, sensory, cognitive and emotional activities lies in the brain hemisphere dominance. It has been found that in ev-

ery person actions directed from one hemisphere are predominant; it is named hemisphere dominance. In the majority of people, the left hemisphere is dominant (90%). The center for speech is located in this hemisphere and it is responsible for logical thinking, mathematical skills, writing and organization skills, whereas the right hemisphere is considered to be the creative side of the brain, the 'visual' hemisphere, where centers for artistic expression, creative thinking, imagination and intuition are located. Right hemisphere is associated with musical skills and good three-dimensional orientation. It is also associated with good coordination and athletic skills[2-4]. Results of the studies show that uncreative people have marked hemispheric dominance, whereas creative people have less marked hemispheric dominance. There is a dilemma whether the right brain hemisphere is dominant in the artists or the hemisphere dominance does not even exist in these persons. Many examples show that left hemisphere suppresses creative states and processes. Some patients with left-sided brain lesions (Alzheimer's dementia, stroke, etc.) subsequently developed artistic skills for playing a musical instrument, painting or dancing[5-8]. Katherine Sherwood, Professor of Art, suffered a severe dominant hemisphere stroke, but she continued to paint with her left hand and her post-stroke paintings significantly differed from the paintings before the stroke and were described as being uninhibited by consciousness[9].

Functional Localization of Visual Art

Visual art is a very interesting field to study. Using the fMRI technique, the activation of visual cortex while watching different kinds of compositions was visualized and a specific pattern of cortical activation was identified while looking at the landscapes, portraits, abstract compositions or different combinations of colors[10,11]. The visual cortex has functional localization. Different areas are responsible for different tasks, e.g., V4 area for colors, V5 area for motion, there are separate areas for objects, faces and recognition of the position in space[11-13]. Specific patterns of activation in visual areas of the brain were recorded on the tests using different combinations of colors, which could explain why some famous artists often used the same combinations of colors. Why we do like some colors, could be explained by results of the studies that discovered neural pathways between the visual cortex and the limbic system responsible for emotions[14]. The results of additional studies could help understand the artistic skills of painters and sculptors. In one of these studies, persons were tested by visual, tactile and kinesthetic stimuli, and were asked to classify the stimuli as new ones or already experienced ones. Results showed that only one type of stimuli was enough to get familiar with some object. In the test, the cube that was first presented as a tactile stimulus was classified as a familiar one after it had been presented only as a visual stimulus. It could possibly explain how a person can transfer his visual impression or scene by motor functions of his hands onto the canvas, producing a painting, or on some material producing a sculpture[15].

Brain Perception and Processing of Music and Rhythm and Brain Plasticity

In the field of music, modern technology also made great breakthrough in understanding the perception of sounds, rhythm and influence of music on the body, mind and emotions. The interplay of activity on both sides of the brain is necessary for the perception of music. In the right side, the centers for perceiving pitch, certain aspects of melody, harmony, timbre and rhythm are placed, whereas the processes of rapid changes in frequency and intensity, both in music and words are taking place in the left side. For complete perception of rhythm, both the left and right sides are necessary. Frontal cortex plays a major role in the rhythm and melody perception[16,17].

Using the fMRI and fTCD, it is possible to show the cerebral activity pattern associated with music perception. This pattern is different in musicians and non-musicians[18,19]. In musicians, activation of the left dominant secondary auditory areas in the temporal cortex and left posterior dorsolateral prefrontal cortex occurs on passive listening to the music, whereas in non-musicians the activation occurs in the right dominant secondary auditory areas on the same task. Also, the fTCD study showed different brain hemisphere activation patterns in musicians and non-musicians on listening to the music[20]. Studies showing that changes in terms of adaptation of the brain, i.e. brain plasticity, can arise upon listening or performing music have urged interest in the impact of music. Brain plasticity occurs in different periods of human life. The first one

is recorded during development of the child's brain, when external stimuli influence the fetal, neonatal and child's developing brain. In children, strict cerebral hemisphere dominance for music and rhythm does not exist. These centers develop with age, which can be influenced by external sound stimuli. So, in every child it is possible to discover and develop musical talent. Besides plasticity during brain development, the brain of an adult person can also be 'plastic'. Restructuring of cortical centers was found in persons playing an instrument for years, especially in the centers for perception of music and motor cortex. The part of the motor cortex responsible for finger movements is for this reason much larger in a professional pianist than in other people. Brain plasticity is also present in injured brain; the use of proper stimuli makes recovery of the lost function possible by activation of other healthy parts of the brain cortex. Music is one of the frequently used stimuli for induction of brain plasticity processes, e.g., listening to rhythmical melodies and learning to play a musical instrument. Studies have demonstrated that some areas of the motor cortex are activated while listening to the music, although the person was completely still. A similar situation occurs while imagining some tune or rhythm. It is considered that music has a complex influence on human brain, motor and sensory areas, which could explain why music is a drive for dancing, singing or expressing emotions by mimicking and gestures[21,22].

Conclusion

Even from the neuroscientific point of view, art is beautiful. The value of the studies described is not only in the comprehension of the way the brain works, but also in the possible implementation of art in healing processes, in the potential use of music, painting and dancing as an aid in the treatment of somatic, neurologic or psychiatric disorders.

References

1. NYBERG L. Functional neuroimaging of cognition: state-of-the-art. Scand J Psychol 2001;42:163-5.
2. KATZ AN. Creativity and the right cerebral hemisphere: towards a physiologically based theory of creativity. J Creat Behav 1978;12:253-64.
3. YORK GK. The cerebral localization of creativity. In: ROSE CF, ed. Neurology of the arts: paintings, music, literature. London: Imperial College Press, 2004:1-9.
4. HOPPE KD. Hemispheric specialization and creativity. Psychiatr Clin North Am 1988;11:303-15.
5. ESPINE CH. De Kooning's late colours and forms: dementia, creativity and the healing power of art. Lancet 1996;347:1096-8.
6. MILLER BL, CUMMINGS J, MISHKIN F, *et al*. Emergence of artistic talent in frontotemporal dementia. Neurology 1998;51:978-82.
7. MILLER BL, PONTON M, BENSON DF, *et al*. Enhanced artistic creativity with temporal lobe deterioration. Lancet 1996;348:1744-5.
8. GAZZANIGA MS. Consciousness and the cerebral hemispheres. In: GAZZANIGA MS, ed. The cognitive neurosciences. Cambridge, Massachusetts: MIT Press, 1995:1391-404.
9. http://ist-socrates.berkeley.edu/~sherwood/sherwood/sherwoodhome.html.
10. PUCE A, ALLISON T, ASGARI M, GORE JC, McCARTHY G. Differential sensitivity of human visual cortex to faces, letterstrings, and textures: a functional magnetic resonance imaging study. J Neurosci 1996;16:5205-15.
11. ZEKI S. Neural concept formation and art: Dante, Michelangelo, Wagner. In: ROSE FC, ed. Neurology of the arts: paintings, music, literature. London: Imperial College Press, 2004:13-41.
12. ZEKI S, WATSON JDG, LUECK CJ, *et al*. A direct demonstration of functional specialization in human visual cortex. J Neurosci 1991;11:641-9.
13. ZEKI S, MARINI L. Three cortical stages of colour processing in the human brain. Brain 1998;121:1669-85.
14. ZEKI S. The modularity of vision. In: ZEKI S, ed. Inner vision: an exploration of art and the brain. Oxford: Oxford University Press, 1999:58-70.
15. SOLSO RL, RAYNIS SA. Transfer of prototypes based on visual, tactual, and kinesthetic exemplars. Am J Psychol 1982;95:13-29.
16. TRAMO MJ. Biology and music. Music of the hemispheres. Science 2001;5;291(5501):54-6.
17. TRAMO MJ, SHAH GD, BRAIDA LD. Functional role of auditory cortex in frequency processing and pitch perception. J Neurophysiol 2002;87:122-39.
18. JANATA P, GRAFTON ST. Swinging in the brain: shared neural substrates for behaviors related to sequencing and music. Nat Neurosci 2003;6:682-7.
19. BEVER TG, CHIARELLO RJ. Cerebral dominance in musicians and nonmusicians. Science 1974;185:536-9.
20. ANTIĆ S, JENSEN U, LOVRENČIĆ-HUZJAN A, VUKOVIĆ V, MUKHTAROVA R, FERREIRA SAO SILVA SANTOS SV, TREVINO RG, JURAŠIĆ MJ, MOROVIĆ S, DEMARIN V. Changes of cerebral hemodynamics during music perception: a functional transcranial Doppler study. Acta Clin Croat 2006;45:301-7.

21. JOHANSSON BB. Music and brain plasticity. Eur Rev 2006;14:49-64.

22. JOHANSSON BB. Brain plasticity in health and disease. Keio J Med 2004;54:231-46.

Sažetak

UMJETNOST: NEUROZNANSTVENI PRISTUP

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Stoljećima znanstvenici pokušavaju lokalizirati i definirati umjetnički talent. Pozitronska emisijska tomografja (PET), funkcionalna magnetska rezonanca (fMRI) i funkcionalna dopler sonogafija (fTCD) su moderne dijagnostičke metode koje omogućavaju vizualizaciju moždane morfologije i funkcije. U većine osoba dominantna je lijeva hemisfera, dok se za desnu hemisferu smatra da je kreativna, vizualna, intuitivna i zadužena za maštu, dobru trodimenzionalnu orijentaciju, koordinaciju, športske i glazbene vještine. U kreativnih osoba dominantnost hemisfera je manje izražena. fMRI omogućuje registriranje aktivacije vidne kore za vrijeme promatranja različitih kompozicija poput pejzaža, portreta, apstraktnih kompozicija i kombinacija boja. Za percepciju glazbe potrebna je suradnja obiju hemisfera. U desnoj hemisferi se registrira ton, melodija, ritam i harmonija, dok su centri za brzu promjenu frekvencija u lijevoj hemisferi. Glazba potiče procese neuroplastičnosti. Glazbu, slikarstvo i ples moguće je koristiti kao pomoćno sredstvo u liječenju somatskih, neuroloških i psihijatrijskih poremećaja.

Ključne riječi: *Neuroznanost – trendovi; Umjetnost; Ljepota; Estetika; Mozak – fiziologija; Kulturalne značajke*