Psychiatria Danubina, 2016; Vol. 28, No. 4, pp 343–348 *View point article*

ARTS, BRAIN AND COGNITION

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received: 5.5.2016; revised: 8.8.2016; accepted: 9.9.2016

SUMMARY

Art is a product of human creativity; it is a superior skill that can be learned by study, practice and observation. Modern neuroscience and neuroimaging enable study of the processes during artistic performance. Creative people have less marked hemispheric dominance. It was found that the right hemisphere is specialized for metaphoric thinking, playfulness, solution finding and synthesizing, it is the center of visualization, imagination and conceptualization, but the left hemisphere is still needed for artistic work to achieve balance. A specific functional organization of brain areas was found during visual art activities. Marked hemispheric dominance and area specialization is also very prominent for music perception. Brain is capable of making new connections, activating new pathways and unmasking secondary roads, it is "plastic". Music is a strong stimulus for neuroplasticity. fMRI studies have shown reorganization of motor and auditory cortex in professional musicians. Other studies showed the changes in neurotransmitter and hormone serum levels in correlation to music. The most prominent connection between music and enhancement of performance or changing of neuropsychological activity was shown by studies involving Mozart's music from which the theory of "The Mozart Effect" was derived. Results of numerous studies showed that listening to music can improve cognition, motor skills and recovery after brain injury. In the field of visual art, brain lesion can lead to the visuospatial neglect, loss of details and significant impairment of artistic work while the lesions affecting the left hemisphere reveal new artistic dimensions, disinhibit the right hemisphere, work is more spontaneous and emotional with the gain of artistic quality. All kinds of arts (music, painting, dancing...) stimulate the brain. They should be part of treatment processes. Work of many artists is an excellent example for the interweaving the neurology and arts.

Key words: *arts – brain – creativity - music therapy - neuroplasticity*

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BRAIN FUNCTIONS, CREATIVITY AND ART

Art is a product of human creativity. It is a superior skill that can be learned by study, practice and observation. By means of art it is possible to record or describe objects, events and moments, but it is also possible to express feelings, opinions and attitudes. The Swiss painter Paul Klee said: "Art does not reproduce the visible; rather it makes the invisible, visible." (Giedion-Welcker 1998). Modern neuroscience has the privilege to investigate the processes of artistic performance in a healthy brain by means of modern technology techniques such as functional neuroimaging. Not so long ago scientists could only speculate what brain functions are involved in artistic processes by observing neurological patients. In the process of explaining the secret of creativity, a simplified theory starts with the known fact of cerebral hemisphere dominance; uncreative people have marked hemispheric dominance and creative people have less marked hemispheric dominance (Katz 1978, York 2004). The right hemisphere is specialized, among other functions, for metaphoric thinking, for playfulness, solution finding and synthesizing. It is the center of visualization, imagination and conceptualization, but the left hemisphere is still needed for artistic work to achieve balance by partly suppressing creative states of the right hemisphere and for the executive part of a creative process (Hoppe 1998). Numerous studies investigating the brain function during the visual art activities have shown a very specific functional organization of brain areas. Different parts of visual cortex were activated, depending on the type of picture viewed (colors, objects, faces, position of objects in space, motion or static pictures) (Zeki 1991, 1998, 2004). Marked hemispheric dominance and area specialization is also very prominent for music perception. Both brain hemispheres are needed for complete music experience, while frontal cortex has a significant role in rhythm and melody perception. The centers for perceiving pitch and certain aspects of melody and harmony and rhythm are identified in the right hemisphere. Left hemisphere is important for processing rapid changes in frequency and intensity of tune. Several brain imaging studies have reported activation of many other cortical areas beside auditory cortex during listening to music, which can explain the impact of listening to music on emotions, cognitive and motor processes (Tramo 2001, 2002, Janata & Grafton 2003).

Where it comes from is crucial for some product to become a piece of art: the creativity arising from artist's brain is necessary. But it is also interesting to establish

why a great number of people find a particular piece of art, music, dance or a poem beautiful. The saying "The beauty is in the eye of the beholder" is known from ancient times. Recently, T. Ishizu and S. Zeki conducted a study the results of which have revealed that a beauty experience is indeed in the beholder, though not in the eye, but in the brain. The study included 21 subjects in which brain fMRI scanning was performed during looking at something beautiful or listening to something that the subject liked. The results have shown that during these actions activation of medial orbitofrontal cortex occurred and it is assumed that also other stimuli that person finds beautiful would activate the same area (Ishizu & Zeki 2011). An another experiment from Zeki and Kawabata was aimed at finding the neural correlates of desire; fMRI of the brain was performed while subjects were watching three categories of pictures: events, objects and persons and they had to classify their impressions as desirable, indifferent or undesirable. Each category produced an activity in a distinct part of the visual brain, the superior orbito-frontal, the mid-cingulate, and the anterior cingulate cortex, reflecting its functional specialization. The conjunction analysis of the contrast "desirable – undesirable" revealed an activity in the superior orbito-frontal cortex, with a positive linear relationship to the declared level of desirability. The conjunction analysis of the contrast "desirable – indifferent" revealed an activity in the mid-cingulate cortex and in the anterior cingulate cortex. In the former, the activity was greater for desirable and undesirable stimuli than for stimuli categorized as indifferent (Kawabata & Zeki 2008). As well as for the art experience, Zeki pointed out in his book „A Vision of the Brain" that all human experience is mediated through the brain and is not solely the product of the outside world. He says "The more important the experience, the more it can reveal about the fundamental properties of the brain." (Zeki 1993).

THE INFLUENCE OF MUSIC AND ART ON BRAIN, HEALTH AND COGNITION

The connection between music and brain functioning is not a modern idea. An ancient Chinese book, I Ching: "The Book of Changes/Wisdom", that dates back to approximately 3000 years B.C. contains a saying: "Music has the power to ease the tension within the heart and to lessen and loosen obscure emotions." In the 6th century B.C. Pythagoras was analyzing pleasant tunes and found that they represented particular mathematical relations which he recognized as harmony and he supported using this harmonic music in an attempt to achieve harmony of bodily functions. His followers prescribed specific tunes and dances as a cure for mood disorders (Karamanides 2006).

Using modern technology in science, as was already pointed out, allows an almost direct insight into the changes that music makes in human brain. Music stimulates specific regions of the brain and it affects processes responsible for memory, motor control, timing and language. fMRI studies have shown reorganization of motor and auditory cortex in professional musicians. There are other studies that analyze the changes in neurotransmitter and hormone serum levels in correlation to music. Based on experience and on results of numerous studies, it is easier to understand that music is biologically a part of human life and not just aesthetically (Bever & Chiarello 1974, Otto 2000, Antić 2008, Jensen).

Brain plasticity was mentioned for the first time over one hundred years ago by William James and Ramon y Cajal. "Every man can, if he so desires, become a sculptor of his own brain." (James 1840, Y Cayal 1955). After a long time, during the "Decade of the brain" scientists' interest in brain plasticity rose again and a lot of experiments have shown that brain is capable of making new connections, activating new pathways and unmasking secondary roads. Brain is understandably adaptable during development, but neuroplasticity shows that an adult brain is also adaptable, as a response to new and persistent stimuli or to a lesion (Kaas 1991, Johansson 2004). Music is one of the most frequently investigated stimuli for neuroplasticity and undeniably very strong connection between them exists. A lot of data speak in favor of the exposure of pregnant women and neonates to music promoting the development of the brain and the inner ear of child. The exposure to musical training in early life reorganizes the brain connections with consequently improved coordination and other motor skills (Partanen et al. 2013, Schlaug 2015). Evidences of neuroplastic capacity of adult brain were again provided by music related studies that showed alteration of the auditory cortex after attentive listening to music for three hours a day for a longer period, superior spatial tuning in conductors and changes in motor cortical areas in adult musical learners. It was also found in injured brain (Johansson 2006, Demarin 2014). The most prominent connection between music and enhancement of performance or changing of neuropsychological activity was shown by studies involving Mozart's music from which the theory of The Mozart Effect was derived. The basis of The Mozart Effect lies at the superorganization of the cerebral cortex that may resonate with the superior architecture of Mozart's music (Campbell 2009). Other type of music, described as "brain music" that uses frequency, amplitude and duration of musical sound similar to Chopin music is able to move the brain from an anxious state to a more relaxed state and has positive effect on insomnia and fatigue (www.dhs.gov). The use of music as a cure showed its success in depressive patients after stroke. Sarkamo and colleagues conducted a study involving after stroke patients with mood disorders; one group selected for listening to self- elected

music one hour daily, one listening to language on audio books and control group without listening material. After two months in the group of the music listeners a significantly lower depression rate was registered, as well as lower irritability, inertia and fewer confusion states (Sarkamo 2008). The rehabilitation of stroke patients can be improved by incorporation of music listening in the therapy; the studies show that music stimulation increases blood flow in patients suffering from acute ischemic stroke and therefore enhances the post-stroke recovery (Antić 2012). Music is beneficial not only if listened to, but also if created, especially due to the lack of boundaries such as speech, language, psychological state or motor skills (Spintge & Droh 1992). The prospective study performed on hobby singers has shown the changes of physiologic markers of happiness during singing; the serotonin, norepinephrine and ß – endorphin levels were significantly higher after than before singing and stress hormone epinephrine was reduced by singing. (Biegl 2004). Neuroplasticity of the brain is crucial for rehabilitation of the patients after brain injury and it can be prompted by activity, but also by imaging of activity. In the experiment of Pascal-Leone and co-workers one group of subjects played the piano and the other one had to just imagine that they were playing piano, with their hands being still on the table. Transmagnetic stimulation presented that the active part of the brain was becoming larger with practice and on the fifth day in both groups the activation was similar (Pascal-Leone 2005). A fMRI study presented that watching of dance movement stimulates activation of motor and other brain areas of all after-stroke patients, but in larger extent in patients with dancing experience (ballet or capoeira dancers) (Calvo-Merino 2005).

There is growing evidence that artistic training improves attention and cognition. These insights arise from numerous studies with both children and adults participating and are based beyond simplified understanding that improvement can be expected just from periodical exposure to arts (www.dana.org, Schellenberg 2004). The key point is again activity-dependent neuroplasticity; the focused training in any of the arts, music, dance or drama activates attention networks that are a crucial part in learning and memory process. The attention networks are easier to activate with the type of arts that person is really interested in. Music has a superior effect on brain plasticity, active music training in children for a longer period of time revealed significantly better results on general measures of intelligence, in reading fluency and in performance in the geometry skills compared to results of children that didn't receive training (Hyde 2009, Posner 2009). Practicing some skill increases efficiency of attention networks what besides pure cognitive improvement can enhance the executive attention skills (emotion control, empathy, impulse control…) which are necessary for a successful learning process (Neville 2008).

INTERWEAVING OF THE NEUROLOGICAL ILLNESSES AND THE ART

When a person suffers a stroke, the symptoms depend on the site of injury. If there is right hemisphere lesion, impairment of spatial tasks, left-sided visuospatial neglect, impaired facial recognition and spatial organization and perspective impairment are present. In painting style compensatory changes develop with the creation of the wider scenery of landscapes and larger figural compositions (Bäzner & Hennerici 2007). The German painter Anton Räderscheidt suffered the right hemisphere stroke after which a substantial change in his painting style is evident; noticeable is left sided hemianopia and neglect, and previously very realistically painted figures and persons after stroke are usually deformed, intense and in bright colors (www.raederscheidt.com). Federico Fellini, an Italian film director, painter and cartoonist suffered a stroke at the age of 73 in the right middle cerebral artery territory with the severe left - sided motor and sensory deficits, left inferior quadrantopia, but without anosognosia, prosopagnosia or cognitive deficits. These deficits manifested on his sketches after stroke with the neglect of the left side of drawing area, but after two months the good recovery or compensation of vision is apparent in new drawings with equal amount of details on both sides of the area (Cantagallo & Sala 1998, Dieguez 2007).

In the left hemisphere stroke patient aphasia, right sided hemiparesis and loss of executive functions are present. After starting to use nondominant hand, artistic work of many artists becomes disinhibited, more impressionist or more intense and expressive. Katherine Sherwood, an American painter suffered a severe dominant hemisphere stroke at the age of 44. From then she paints with her left hand and these new paintings differ significantly from pre-stroke work, she herself claims that her early work was constricted, tripped up by conscious intent and recent work unburdened, flows freely from her subconscious, uninhibited by consciousness. She even achieved rather more acclaim and financial success after the stroke (Waldman 2000, Sherwood 2012). After a left hemisphere stroke the Swedish painter and sculptor Carl Fredrik Reutersward also experienced a more disinhibited work, which manifested as the use of brighter colors and „softer" shapes. So, the effect of stroke on artistic performance depends on the site of the lesion; the right hemisphere lesion leads to the left sided visuospatial neglect, loss of details and significant impairment of artistic work while the left hemisphere lesions reveal new artistic dimensions, disinhibit the right hemisphere, work is more spontaneous and emotional with the gain of artistic quality.

In patients with neurodegenerative disorders such as frontotemporal dementia some cases of emergence of creativity and talent are still possible, despite of frontal and temporal lobe atrophy and cognitive impairment

(Miller 1998). The preservation of the frontal and parietal lobes allows planning and execution of the work and patient's art arises from the undamaged parietal and occipital lobes when freed from the inhibition of the anterior temporal lobes; paintings became freer and more original (Miller 1996). Some painters suffering corticobasal degeneration and Alzheimer's disease showed more creative artistic work during their illness, but due to visuoconstructive deficits, spatial errors, changes of color perception and cognitive deterioration, dementia often leads to loss of artistic skills, especially visible in self – portraits, like in William Utermohlen pictures (Blanke 2007). Louis Wain, an English artist, illustrator of children's books suffered from schizophrenia and dementia and during illness his earlier gentle and joyful artistic expression disappeared; shapes became disintegrated and ornament-like (Greicius 2009). With the support of other people some dementia patients can preserve their creative capacity for a longer time and use it as a sort of therapy, especially to alleviate neuropsychiatric symptoms such as depression, agitation, sleep impairment (Chancellor 2014). Willem de Kooning, Dutch abstract expressionist was diagnosed with Alzheimer's dementia at the age of 66 years. Before illness his paintings were usually characterized by womanly curves with multiple dissonant color combinations, but after the first sign of Alzheimer's disease he lost the interest in painting. Eight years after, with the great support of his wife, he started painting again and despite severe cognitive and semantic deficits, and incapacity to perform any of daily living activities, he created abstract compositions and transferred them to canvas (Espinel 1996). These paintings are classified among the most beautiful, sensual, and exuberant abstract work by any modern painter (De Kooning 1995). Other neurological conditions can also be found in artistic work. Epileptic and migraine aura, scotoma scintillans, splitting of image and zig-zag lines in visual field are elements that are continously present in paintings of several artists suggesting their own experiences. Giorgio de Chirico, Greek-Italian painter the founder of the 'scuola metafisica' art movement suffered from migraine and used some of his morbid manifestations, scotoma scintillas and photophobia as a source of his inspiration for his painting. Some scientists were assuming that this is predominantly the result of his migraine and others advocated more for temporal epilepsy theory (Blanke 2003, Bogousslavsky 2003). Hildegard of Bingen was German Benedictine abbess who suffered from migraine and she presented her visual migraine aura in her miniatures (www.relieve-migraine-headache.com). Because of his pictures with splitting faces and specific perception of female faces, it was speculated that Pablo Picasso was suffering from migraine also. Since no data to support this headache theory were found, it was concluded that this way of painting was just the introduction of new painting style, the Cubist movement (Ferrari & Haan 2000, Haan 2009). Francisco de Goya after developing auto-immune disorder, Vogt-Koyanagi syndrome, affecting inner ear and the uveal tract changed the way of painting. Instead to create portraits he started to paint pictures with motives as a shipwreck, prison, lunatic asylum or a fire at night (library.thinkquest.org). Vincent Willem van Gogh, a Dutch postimpressionist artist suffered from several illnesses. Many hypotheses have been put forward including epilepsy, bipolar disorder, sunstroke, acute intermittent porphyria, lead poisoning and Méni?re's disease. In 1928 the temporal epilepsy theory was introduced and it was assumed that a number of the motives in his pictures described epileptic aura (in Der Beeck 1982, Carota2005). One theory explains his famous preference for yellow by use of large amount of absinthe and by digitalis used for epilepsy treatment in 19th century; the overuse of digitalis leads to retinal dysfunction, xanthopsia ("yellow vision") and absinthe contains chemical thujone, which is toxic for nervous system (Wolf 2005). He most likely suffered from the bipolar disorder with symptoms aggravated by alcohol and absinth abuse and he committed suicide in 1890 (Carota 2005).

Sometimes brain and neurological illnesses itself can be an inspiration for art work. In his book „Brainy Drawings" the Croatian artist Ivan Šarić rises awareness of the brain complexity, neurological conditions and importance of prevention and the right treatment of brain disorders through numerous witty yet engaged sketches of the brain.

CONCLUSION

In the field of visual art it is obvious and encouraging that a disease is not an inevitably debilitating condition. On one side, an illness can seriously restrain living activities, but on the other, the creative side gives new opportunities for something that the conscious mind is not aware of.

The connection between brain and music is strong and bidirectional. As Oliver Sacks, a professor of neurology and a writer who extensively studied the effect of music on human health wrote: "We turn to the music, we need it, because of its ability to move us, to induce feelings and moods, states of mind." (Sacks 2006).

Acknowledgements: None.

Conflict of interest: None to declare.

Contribution of individual authors:

The work is a product of the whole team; all members have contributed to
the conception of the work.
Vida Demarin and Marijana Bosnar Puretić were writing and drafting the work for intellectual content.
Marina Roje Bedeković and Marija Bošnjak Pašić made literature search. All authors gave
final approval of the version to be published.

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