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NEUROPSYCHOLOGY OF CREATIVITY: A MICROGENETIC APPROACH

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SUMMARY

The neuropsychology of creativity is recently understood as a subdiscipline developing on the borderline of being a: (1) medical neuroscience – using clinical and experimental neuroanatomical, neurophysiological, neurobiological, neurosurgical, neurological, neuropsychiatric methods and approaches and (2) social neuroscience – using social psychology and neuropsychology, social linguistics and neurocultural studies to help disabled people. The subject of research into the neuropsychology of creativity is the relationship between creativity and the functioning of the brain (structures and neuronal connections) and the self using the individual, social and cultural mind and modelling these behaviors in relation to the biological organism and the social and cultural environment itself. Neuropsychological research of creativity is directed mainly to discover the brain mechanisms of creativity, to form the theoretical models, to elaborate the methods of diagnosis and therapy of artists with brain damage. A promising model that allows for a better understanding of the creation process, and therefore one offering better assistance to individuals who have never developed or have lost the ability to create due to brain damage, is the microgenetic approach that will be discussed in this article. To introduce the reader to these issues, a case study of an artist with brain damage is presented. It illustrates the importance of performing a syndrome analysis, supported by the neurophysiological studies (neuroimaging studies of the brain, quantitative electroencephalography (qEEG), event-related potentials (ERPs) and sLorette tomography) with the use of neuromarkers to avoid a false diagnosis. It also shows the possibilities of art therapy in the process of rebuilding the creative abilities lost as a result of brain damage, and thus the rebuilding of one's individual, social and cultural Self. However, something that is also important for artists, selected works, especially the most characteristic and significant ones, are also achieving critical recognition. It even happens that they become a part of the world's cultural heritage, are displayed at various exhibitions and are even bought to be hung in the collections of galleries acrosss the world, like in the case of the artist presented in these paper.

Key words: brain damage, brain injury, schizophrenia, neuromarker, art, self, culture

INTRODUCTION

The neuropsychology of creativity, until now, has been considered the science of the relationship between brain and creativity, especially in brain damage persons (Brown 2017). This can be explained by the fact that initially the neuropsychology of creativity was developed in close connection with neurology and neurosurgery. This is evidenced by the classic case reports of artists in the subject literature (Pachalska 1977; 1999; 2003; 2007; 2008; Kaczmarek 1991; Leischner 1991; Leischner & Pendzialek-Langer 1974; Bäzner, Hennerici 2007; Piechowski-Jozwiak & Bogusslavsky 2013). The relationship between brain disease and artistic creativity is particularly complex: neurological conditions after differentiated brain damage can lead to difficulties or even the inhibition of creative work in many areas (Sadana, Rajeswaran, Jain et al. 2017). Brain damage can also influence changes in the creative workshop, the method of creation or artistic style and lead, for example in people with an initial loss of creativity, to surprisingly innovative workshop solutions (Piechowski-Jozwiak & Bogusslavsky 2013; Pachalska, Kaczmarek & Bednarek 2020). In recent years, authors have highlighted the links between the creation process and the self system and the changes that this system undergoes as a result of various brain injuries. New research conducted in this field allows one to redefine this term as well as the subject and purpose of research on the neuropsychology of creativity (Pachalska, Kaczmarek & Kropotov 2021).

The neuropsychology of creativity is recently understood as a subdiscipline developing on the borderline of: (1) medical neuroscience – using clinical and experimental neuroanatomical, neurophysiological, neurobiological, neurosurgical, neurological, neuropsychiatric and (2) social neuroscience – using social psychology and neuropsychology, social linguistic and neurocultural studies to help disabled people, with a particular focus on artists with brain damage (Pachalska 1977). The subject of research on the neuropsychology of creativity is the relationship between creativity and the functioning of the brain (structures and neuronal connections) and the self using the individual, social and cultural mind and modeling these behaviors in relation to the biological organism and the social and cultural environment.[1] It should be stressed that the ability to create new things is not just the domain of outstanding individuals. The creative potential lies in every human being, and whether it is liberated and directed to creating things of a supra-individual significance depends on many conditions and circumstances deserving separate discussion (cf. Brown 2017).

MAIN FEATURES OF CREATIVITY AND CREATION

Creativity is a versatile and abstract human ability which has been defined in numerous ways; its most consensual definition conceptualizes it as an ability to

[1] The human brain does not work in isolation from the body and from the social and cultural environment (Luria 1963).

yield products (e.g., ideas, stories, objects) that are both novel (i.e., original) and useful (Stein, 1953; Sternberg, Lubart, Kaufman, & Pretz, 2005). Cognitively, creativity has been conceptualized as a higher order thinking ability involving analysis, evaluation and synthesis i.e., the creation of new knowledge (Sadana, Rajeswaran, Jainet al., 2017; Abraham 2018).

The main features of creativity **–** in all areas **–** are **novelty**, **originality and precursor**. This is emphasized by numerous definitions of the word, for example: creativity means a product possessing the value of novelty (cf. Brown, 2017). In other words the introduction of something innovatively new and positive for society that goes beyond the familiar and accepted (Zaidel 2014). However, the essence of creativity is not about creating what is not and never was in the work, but rather about re-imagining and transforming what exists and is available to everyone, the discovery of previously unnoticed connections between elements of the studied reality or a new approach to the reality presented in works of art (Pachalska 2007). The task of thinking differently requires generating creative, innovative responses to popular items (e.g., the use of a metal tube). The idea itself is associated with both consciousness and imagination, while searching for possible alternatives requires a greater association of meanings and memory capacity, including semantic memory (Storm and Angello, 2010). Accordingly, Boden (2013) has divided creativity due to product type into:

- *psychological creation* (close in terms of subjective creativity) leads to new creations only for the author;
- *historical creation* (close to objective creativity), which is new throughout history.

The second, and also an important feature of creativity, is **functionality**, sometimes also called utility in the broadest sense. The result of creativity cannot be useless and it is difficult to imagine the situation of creating anything without - even vague and indefinite - the idea of the function of a new product (Brown 2017). This means that the effect of creative activity is to meet specific needs in a way better than the existing ones, sometimes it can even make/evoke the needs not previously known and not felt. It has long been believed that all creativity is intended to multiply good (in the broadest sense) and prevent evil (Pachalska 1977; Williams et al 201). However, also creating seemingly useless things, if it adds a new thread to the resource of good things, promotes development, self-realization, well-being, and even gives pleasure in creating. Creative activity is a way to develop a lifestyle based on self-creation and self-realization (Pachalska, Kaczmarek & Bednarek 2020).

The third, also an important feature of creativity, **is communication**. Kaczmarek (1991) has stated that a symbolic communicative system practiced only by humans, and is argued to have become a fully practiced behavior at a time when early human social groups grew in size and complexity, and communication through language and art promoted cohesion and survival. Luria (1976) pointed out that the roots of creativity reach deep and go beyond communication and social contexts. He assumed that the basic biological needs of animals, the need to preserve physical energy and survival, the occurring threats (illness or

death) can be the main motivators of innovation also in art. Given the adaptive evolutionary processes, it is reasonable to assume that these needs have been woven into the brain's creativity mechanisms in humans (Brown 2017). This means that there is a deep motivation to communicate through art, even if there is no language communication after brain damage. In such neurological cases, the very transition to creation is innovative, but the final product is not necessarily a work of art (Luria 1966; Pachalska 2007; Zaidel 2013c).

THE ESSENCE OF THE CREATIVE PROCESS

The creative process is a weave of unconscious and conscious dynamic states of mind, the essence of which is the artist's search for "non-existent" objects, including signs and their meanings, followed by their processing and final execution of the work. As was stated by Pachalska, MacQueen & Brown (2012) the central property of an original act and the crux of creative thought is a departure from habit or expectancy. This could be construed as a failure of repetition since each recurrence is minimally novel in comparison to its antecedents, in part due to changing sensibility, in part to fluctuations in the resting state. Incessant change is introduced along with continuity in the revival of mental states, in the growth of private experience and the passage of objects in the world. The continuity resolves the sameness of things with novelty in their recurrence. Whether a thing changes rapidly – a film, an argument – or slowly – the self, a rock: the transition over moments is continuous. The paradox is that in spite of continuity, things exist as a single brain/mind state (epoch) of becoming with no gaps in experience or perceptible nature.[2] Things recur and each recurrence is novel though retaining ingredients of the prior single brain/mind state (epoch). The difference between exact iteration, novelty in passage and fresh renewal depends on more than a difference in succession since a world in continuous change is the main source of the disparity, and a self of moderate stability is the arbiter of sameness and difference (see also Brown 2017).

Brain/mind state

In this context it is important to emphasize again that genuine change occurs in the actualization of the brain/mind state (epoch), and that apparent or illusory change occurs in the transition of one brain/mind state (epoch) to another. Genuine change is the becoming-into-being (existence) of an entity – the actualization of a sequence of categories - while apparent change is the progression from one brain/mind state (epoch) of being to another, namely, the observed and presumed causal sequence of events in the world. An epochal state is an instance of being that is inert, its dynamic – becoming – exhausted in its formation. The process of entity creation is complete on the actualization of an epoch of being (category, substance), which on achieving existence passes away in its replacement, while continuity depends on the overlap of epochs.

[2] Even across sleep or loss of consciousness there is felt a continuity of the self.

A transition leading through memory to perception that is apprehended as a *horizontal* sequence from past to present would explain sequencing in action (eg. visual art, music, language), in the world and in the mind (see Fig. 1). Since the duration laid down by the phase-transition enfolds the memorial remnants of prior states that provide the posterior boundary of the now, both perceived and remembered event-series fall within the present duration. In that this account explains order in both memory and perception, it has a parsimony not found in rival theories.

The mental state lays down serial order, yet has a spatial character, actualizing as an epochal whole. The simultaneity or spatial totality of the present epoch distributes into the order it realizes. Regardless of whether temporal order in a mental state develops from the totality of an epoch or an iteration of totalities, in the transition from initial simultaneity (core), through *the before* and after of the phase-transition, to *the now* that arises with a conscious endpoint, the state incorporates three modes of time-discourse:

1. simultaneity, which entails temporal thickness or extensibility;
2. physical passage in the *becoming of the mind/brain state*, which gives mind but is itself mind-independent;
3. a subjective present (past, future) that gives being or existence to the transition.

The simultaneity (1) that is the spatial whole of the core, or the epoch it generates, leads to and embraces a transition over phases (2) that is the bridge to temporal order. This transition, and the duration of the present that is its outcome (3), correspond to the two series of Brown (2015). Since the transition does not exist until it is complete, at which point the entire transition actualizes, every temporal moment or mind/brain state – whether a static picture or an event-sequence – occurs against a backdrop of simultaneity.

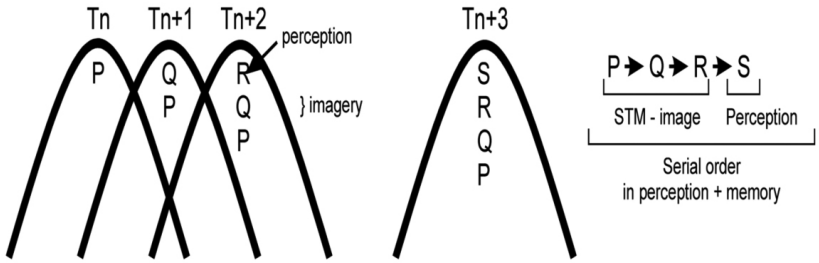

Fig. 1. The perception (P) at Tn is replaced at Tn+1 by another perception (Q), which may resemble or differ from that at Tn. Perceptual stability depends on resemblance; change depends on difference. Within the perception (arrow, R), the mind/brain state at Tn+2 revives Tn+1 almost completely, such that the image of P at Tn+2 is prior to the object (Q), and so on. Over a brief succession of mental states, P, Q and R represent images of past perceptions revived to a decreasing extent in the oncoming present, and graded according to this revival. An eidetic image is a near-complete revival. A memory image is a vague recurrence at some psychic distance from a present object. At Tn+3, the series of images, P, Q and R, forms an order antecedent to the perception (S). The perception and memory of serial order depend on the perception developing out of memory. Serial order occurs within the present, but depends on succession for the layering of prior experience
Source: Pachalska, MacQueen, Brown, 2012

Ordering depends not on perceived succession but the implicit role of succession in the layering of memory and the *replacement* of one state by the next.

But is it possible that serial order is just the perception of linkage made fluid by the rapidity of shifts?

This assumes that a mental state, as an epochal whole, is simultaneous through its phases, with change in the causal shift from one epoch to the next, i.e. in the linkage of states, not their replacement or overlap. We are conscious of the final contents of a state, not the transition from state to state or depth to surface, nor are we aware of interstices in the linkage. Even if temporal order is not dissociable from oncoming and antecedent states, any account based on rapid succession must return to events *within* the state itself.

Consider the phase-transition *within* the state in relation to replacement *across* states. If order is laid down in the distribution of spatial objects, or if it is derived serially from the outpouring of the core, the array of objects in the world would be a static grouping with a leading edge of change, i.e. micro-events fused to an event-sequence in the overlap. An object would then be an incipient event that becomes continuous when the next state appears. The perishing of the state would support the anticipation of the next and avoid reality appearing to the mind as a stroboscopic succession of pictures. If the clock duration of a mental state (say, 50-100 milliseconds) is insufficient to generate serial order within the state, like the flash of a tachystoscope (stroboscope), it might permit a perception of forward momentum. Order and continuity would then depend on the overlap of recurrences (cf. Pachalska, MacQueen, Brown 2012).

Is conscious succession – the sequence of events in observation, or the motion of the world in perception - an illusion of causal transition?

Is it like the *phi* phenomenon, in which illusory change results from the rapid replacement of static images? A series of causal pairs may explain fusion from one state to the next, but not memory of preceding pairs to give a continuous event or narrative. In a motion picture, the impression of continuity in the viewer's mind requires a frequency of around 40 milliseconds per frame, which is close to the estimated duration of a mental state, thus the rate postulated for the replacement. This rate is likely governed by a pacemaker and is relatively constant, but there are individuals with brain damage in whom events appear to be speeded up or slowed down. The acceleration and deceleration of events in pathological cases, as in the speed of a film projector, might reflect the frequency of replacement.

The conclusion of this line of thought is that states are not concatenations of stochastic images, but rather superimpositions on the remnants of predecessors that are embedded as memorial residues. The graded decay of memory is its graded revival in conformance with the occurrent state (cf. Pachalska, MacQueen, Brown 2012).

Emotions

Microgenetic theory[3] – and this has been implicit in much of the foregoing discussion – places emotion almost literally in the center of the process by which drive articulates into objects and acts. The role of emotions is illustrated in Fig. 2.

First, there is pure subjectivity: a core self that wants to survive and strives to avoid pain and discomfort. Then, at the instinctual core, a core or unconscious (Ucs) self forms, and gradually there is opposition between the subject and the objectified portion of the subjective field, i.e. a core subject at one pole, and at the other, the object world, but the object world is not the world of outer events but the objectified segment of a subjective field. Then, out of the Ucs core, a Cs self develops, with an articulation of inner and outer space. Inner space partitions to the Cs self and images. Outer space (that is, the objectified part of the subject's field) also undergoes partition to objects and their affective tone.

An emotion, from the microgenetic perspective, is an inner or subjective feeling, generated by the same process that deposits or actualizes an act or object, namely, the micro-temporal process that leads from the archaic core of the mind/brain state to its outcome at the neocortical surface. The development of

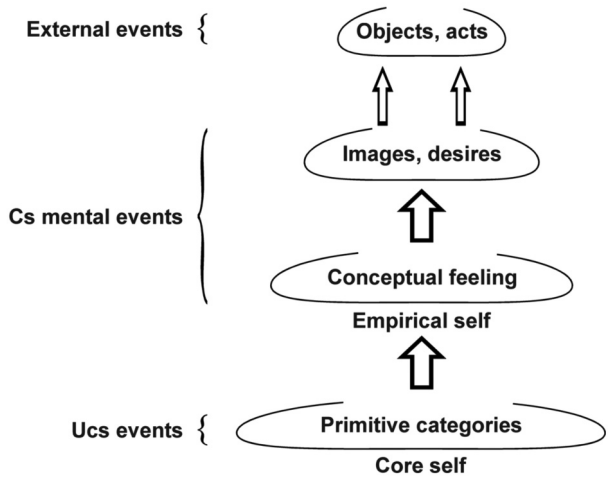

Fig. 2. The fine structure of the mental state. The core self is derived to the empirical self, which in turn leads to objects in the world. Corresponding with the object-development there is a transition from drive through desire (emotion) to object value. The affect-charged category of the core self is the initial drive-representation. This is derived to conceptual feeling, then to object value. The transition from core to world is a continuum; the entire sequence constitutes a momentary mental state or an act of cognition
Source: Pachalska, MacQueen, Brown, 2012

[3] The term "microgenesis" refers to the process by which a mental state unfolds through qualitatively different stages to form the present moment. The temporal extent of this unfolding extends from the onset or genesis of the mental state in phylogenetically older structures, through more recent systems in the evolution of the brain, to the final representation of the content in consciousness or behavior (Brown 2002; Pachalska, MacQueen, Brown, 2012).

an object, action or thought creates feeling within the developmental process. This process, along with the feeling that is its manifestation, constitutes the *becoming* of the object, while the final object, idea or memory that "contains" the process leading to it is its *being,* i.e. the epoch or category that enfolds the feeling. The process that generates a mental content, including perception, creates an internal feeling that, with intense emotion, can spill over to external physiology. The relation of feeling to the final object depends on the phase in the process that receives the major emphasis in the transition. The quality and the intensity of an emotion are determined by an emphasis at a given level and the context at a phase within the actualization process. According to the phase that is dominant for a given cognition, there is a different emotion and a different intensity. In general, enhancement at a deep or early phase gives strong emotions in relation to core needs, while enhancement at a terminal or surface phase gives emotions referred to the object, such as value or worth. At intermediate phases, one has emotions within the category of desire (want, wish, like, dislike, hope, fear, etc.). At an early phase, emotion discharges in the body. At an intermediate phase the emotion, though internal, is directed to a pre-object or image. At a distal phase, the emotion is referred to, *is ingredient in*, the external object.

The brain creates ideas based on insights. The duration of the image depends on a whole range of features, where emotions play the main role. Pleasant events are subjectively perceived as shorter (e.g., meeting with a friend), unpleasant events have a subjectively longer duration (e.g., waiting in the waiting room for a dental procedure). Thus, the event has a more or less arbitrary duration in a series of repetitive brain/mind (epoch) states. The exchange rate is probably constant for each unit. The dynamics of the brain/mind state are associated with changing objects and events, and with our attitude to them. The real change in the mind of the observer is imperceptible.

THE ROOTS OF CREATIVITY

Looking at the fascinating creations of artistic craftsmanship, we wonder how their creators invent such "ready" works. Zaidel (2014) suggests that, given the biological and neurological basis of brain function, human creativity has at least three perspectives:

1. *biological*, which includes innovations related mainly to the needs and motivation of the individual (the roots of creativity run deep and are not necessarily limited to social or communicative considerations);
2. *neuroanatomical,* which includes innovations related to differences between individuals in the size and organization of the brain, the number and quality of neuronal connections and neurotransmitters;
3. *neurological,* which includes innovations related to the consequences of brain damage and their references in visual arts (in artists with brain damage forming various disease syndromes).

Biological underpinning, which includes mainly research on the biological foundations of creation, has been conducted for several years and concerns both animals (Hinde and Fisher, 1951; Benson-Amram and Holekamp, 2012) and humans (Zaidel 2014). Compared to humans, however, innovations by animals are far fewer (Laland and Reader, 2010; Lefebvre, 2013). Given adaptive evolutionary processes, it is reasonable to assume that all of these have become interwoven into the underlying brain mechanisms of creativity in humans (Pachalska 1999; Brown 2017). Nowadays, work is underway on the relationship between gene expression, and behavior, mainly creativity (Pachalska, Kaczmarek & Bednarek 2020). These studies include the conclusion that a person capable of innovation is motivated mainly by biological to survive, which has been linked to other, unique creative abilities.

Neuroanatomical underpinning includes mainly the comparison of the human brain to that of monkeys with fMRI having revealed several corresponding structural and functional networks, but two that are unique to humans (Mantini et al., 2013), that is, the left hemisphere language network and the left fronto-parietal network. Using MRI for brain structural and parcellation analyses, investigators (van Essen et al., 2012) have found a larger left Sylvian Fissure, which includes the parietal operculum, and in the medial temporal cortex, the portion with the lingual gyrus and collateral sulcus (all critical in language functions); in the right side the angular gyrus and dorsomedial prefrontal region. Such asymmetries are not found in other mammals, and could play a functional role in human creativity. In this trend, research is conducted on the relationship of neurotransmitters and creative activity. For example, deficiency of serotonin and related depression promotes the creation of sad works painted in black colors.

Neurological underpinning includes mainly observations of various brain damage effects on the creativity of visual artists. Approximately 80 cases or so with such damage (mainly in one side of the brain, and where the etiology is commonly stroke or brain cancer) have already been described in the neurological literature (Pachalska 1986; 1999; Pachalska 2003; 2009; Kaczmarek 1991; Rose, 2004; Bogousslavsky and Boller, 2005; Zaidel, 2005, 2013a,c; Finger et al., 2013; Mazzucchi et al., 2013; Piechowski-Jozwiak and Bogousslavsky, 2013). They can help show the way to the neuroanatomical and neurofunctional foundations of creativity. The key questions concern post-damage alterations in creativity, as well as loss of talent, or skill (Zaidel 2014).

However, Luria et al. (1966), describing the multifaceted nature of the roots of human creativity, drew attention not only to the above-mentioned perspectives, but also to the system of the self and the artist's identity associated with it (cf. Pachalska, Kaczmarek & Bednarek 2020). It is presumed, that human creativity, both healthy and with brain damage, like many other activities, is usually a response to its various needs associated with the emotional component (cf. Pachalska & Bednarek 2020). In this context, it should be noted that for the artist, creativity in itself is a need, often strong, that requires immediate satisfaction. The artist sees in the world the lack of something, which is a product existing so far only in his

imagination. The very process of creation meets the need to fill this gap, but its satisfaction is only possible after the creation of the work or at least a part of it. Cultural patterns in the brain, which are made aware or unconscious, play a specific role here, but act in individual states of mind as a kind of internal constraint (Pachalska 2019).

RESEARCH IN THE NEUROPSYCHOLOGY OF CREATIVITY

Research in the neuropsychology of creativity has focused on the creative process and neurocultural studies are still in their infancy. Only recently have they joined the empirical aesthetics that was introduced in the 19th century by Gustav Fechner (Fechner 1876). It is difficult to say whether neuroscientists consider this topic worthy of deeper scientific studies, of course with rare exceptions (Pachalska 1999, 2019; Augustin & Wagemans 2012; Pachalska, Kaczmarek & Bednarek 2020).

A number of reports have examined the development of visual artistic ability following degenerative or other types of brain injury (Zaidel 2005; Chatterjee 2006, Pachalska et al. 2013). However, the emergence of *de novo* artistic ability is rarely seen in brain-damaged patients (Pachalska 1977; Pollak, Mulvenna, & Lythgoe 2007; Piechowski-Jozwiak & Bogusslavsky 2013); this is particularly true for patients with traumatic brain injury (Schott 2002; Grochmal-Bach, Pachalska, Markiewicz et. al. 2009; Midorikawa & Kawamura 2015), autistic patients (Sacks, 2004; Baron-Cohen et al. 2009), schizophrenia (Pachalska, Grochmal-Bach, MacQueen et al. 2008) or stroke (Pąhalska 1988, Pachalska, Grochmal-Bach, Wilk et. al. 2008; Kaczmarek 1991; Kaczmarek et al 2003; Code et al 2003).

CASE STUDY

When describing the neurological and neuropsychiatric basis of the creativity of people with various brain injuries, one should take into account the possibility of the co-occurrence of various disease syndromes or the overlapping of symptoms one on another. That is why good syndrom diagnosis as initiated by Luria (1976) is extremely important, supported, if possible, by the designation of the neuromarkers of a given disease entity since very often we are dealing with false diagnoses (Pachalska, Kaczmarek & Kropotov 2014).

It is well known that brain damage can lead to various focal and generalized neurological disorders. There is, however, only one report on the potential changes in artistic output following multiple disorders, that is schizophrenia complicated with head injury and post-traumatic depression (Pachalska et al. 2008). Władysław Wałęga, born in 1940, was a well-established painter, who was diagnosed at the age 18 with schizophrenia[4]. As a part of psychiatric rehabilitative

[4] Full personal information about the patient are presented upon request and with the patient's consent [cf. http://galeriasztukiptneur.pl/]

therapy, he received art therapy, during which he developed sophisticated painting skills, enabling him to become a successful painter widely recognized by critics. He portrayed his own visual hallucinations (Fig. 3), mainly using recollected contents rather than active/ongoing visions, when painting.

One day, while actively hallucinating and feeling able to fly with wings, he rushed into the street and was knocked down by a car. He was unconscious for 5 h, with a brain injury involving the subcortical anterior frontal areas, and with subsequent asymmetric frontal lobe atrophy predominating on the left side (Fig. 4).

After the injury, his painting style changed with a significant reduction in the hallucinatory content. The subjects became more traditional with a selection of hues now dominated by blunt and earthy colors. He also showed signs of perseveration in repeating the reproduction of the same objects or faces.

Over time, his psychiatric condition deteriorated and 10 years after his accident, he had another psychotic burst, also with progressive memory disorder. On detailed neuropsychological assessment, he showed visual memory deterioration, executive dysfunction, and hemispatial neglect (Fig. 5).

The patient took part in an intensive cognitive neurotherapy program run for two years, four times a week. Transcranial direct current stimulation (tDCS) was

Fig. 3. Painting entitled “Laboratory” created before the accident based on the artist’s visual hallucinations
Source: clinical material of M. Pachalska

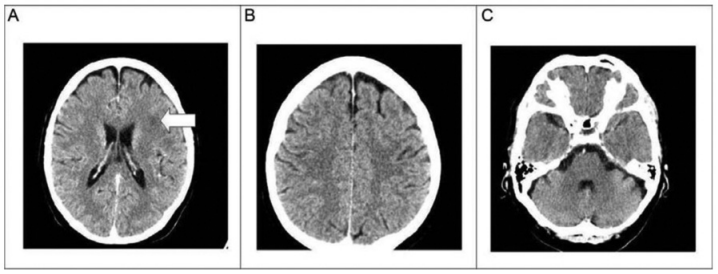

Fig. 4. Computed tomography of the brain done 15 years post trauma. (A) Arrow shows a hypodense subcortical left frontal lesion; (B) asymmetrical cortical atrophy more pronounced on the left; (C) right anterior temporal lobe and cerebellar atrophy
Source: clinical material of M. Pachalska

used to reduce depression in combination with the Therapy of Symbolic Thought (see: Pachalska 1977; 1991, 2003; Kaczmarek, 1991). After a year of therapy, significant improvement in all cognitive functions was obtained. In the painting, the features of side skipping disappeared, but the patient was still signaling his sadness and social isolation (Fig. 6).

The inscription on the engraving "a bird came to advise on something" and the subsequent interpretation of the work by the artist suggests that only a bird can advise on something, because people do not understand his sadness and social isolation.

Fig. 5. A drawing of a person, a house, and a tree showing left hemispatial neglect
Source: clinical material of M. Pachalska

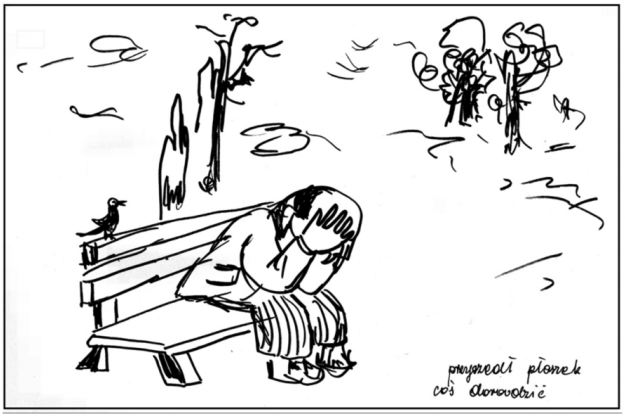

Fig. 6. A drawing of “my illness” showing sadness and social isolation. In the right corner the artist wrote "a bird came to advise on something"
Source: clinical material of M. Pachalska

PREVALENCE OF DEPRESSION AND SCHIZOPHRENIA NEUROMARKERS

Neurophysiological studies (neuroimaging studies of the brain, quantitative electroencephalography (qEEG), event-related potentials (ERPs) and sLORETA tomography[5] (see Kropotov, 2009, 2016) were very useful in the confirmation of his neuropsychological and neuropsychiatric diagnosis.

A comparison of studies conducted before therapy (study 1), after a year (study 2) and after two years of using neurotherapy (study 3) shows significant (even spectacular) changes in the EEG spectra that occurred during all three recordings (see Fig. 7).

It is noteworthy that in the first recording conducted in the examined patient before therapy, slow alpha (about 8 Hz) rhythms obtained from F7 and F8 sites were noted. These slow alpha rhythms reflect a statistically significant deviation from the norms in individual spectra.

Extracting the independent components from the spontaneous EEG recording during the first recording revealed the presence of two independent components generated in the left and right prefrontal cortex respectively (Fig. 8). In the second recording, there was a large loss of alpha rhythm in the left lower frontal cortex, which completely disappeared in the third recording. Earlier research by Kropo-

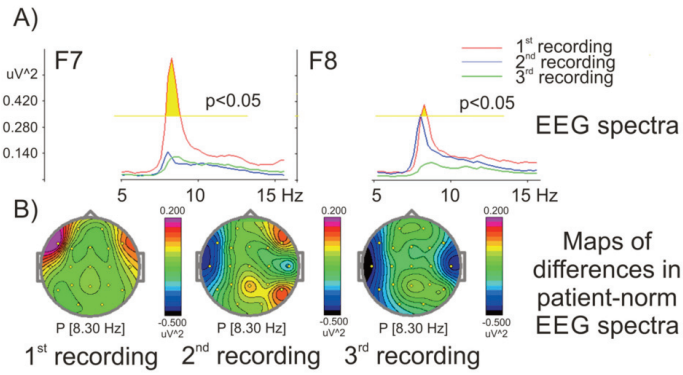

Fig. 7. EEG spectra obtained in the GO / NOGO task in three recordings from the electrodes applied in places F7 and F8, 1 recording - red curve, 2 recording – blue curve, 3 recording – green curve. The peaks in the spectra obtained during the first recording correspond to an alpha rhythm of about 8 Hz. The yellow horizontal line shows the confidence level (p <0.05) in the range of deviations from the normative mean. Maps of EEG spectra with a value of 8.3 Hz during three recordings
Source: Pachalska, Kaczmarek i Kropotov, 2014

[5] The studies described here are looking for the neuromarkers of mental disorders (Kropotov, 2009, 2016; Kropotov et al., 2013, Pachalska et al. 2013; Pachalska and Kropotov, 2020). The concept of neuromarker was defined by Williams et. al. (2005) as a narrower version of the biomarker. In the case of EEG recordings, neuromarkers in the form of amplitude of EEG spectra and ERPs are considered to be two important factors giving insight into the functioning of the brain: spontaneous EEG recording shows the mechanism of cortical self-regulation, while ERP reflects the flow of data at particular stages of their development in the brain.

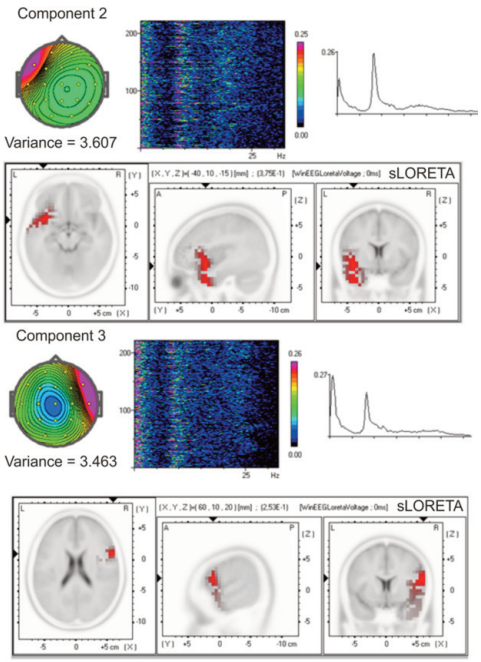

Fig. 8. Independent components extracted from the first EEG record.
A – independent component generated in the left hemisphere.
Top (from left to right) – topography, spectra coded for 4-second periods, calculated for the entire 20-minute recording, averaged component spectra.
Bottom – topography image obtained in sLORETA tomography.
B – independent component generated in the right hemisphere.
Top (from left to right) – topography, spectra coded for 4-second periods, calculated for the entire 20-minute record, averaged spectra of the components.
Bottom: topography image obtained in sLORETA tomography.
Source: Pachalska, Kaczmarek and Kropotov, 2014.

tov et al. (2013) showed that the difference in the ERP wave obtained in the record when performing NOGO-GO tasks can be considered an indicator of the cognitive control. In Figure 8 I present the mean for ERPs wave differences in healthy subjects and in patients with diagnosed schizophrenia from the Human Brain Index (HBI) normative database in Chur, Switzerland. It can be easily observed that the difference in waves from the electrode recording at the Cz point rapidly decreases in patients with schizophrenia. It should be emphasized that the patient under discussion had a wave distribution similar (see Fig. 9, on the right) to patients with schizophrenia (see Fig. 9, on the left), because in all three records a clear delay or reduction of the differences between the waves is observed. At the same time, the positive wave recorded from the electrode placed at T5 did not change.

It can be therefore concluded that the studied patient had a neuromarker of disturbed cognitive control which could be an index of schizophrenia. This is as-

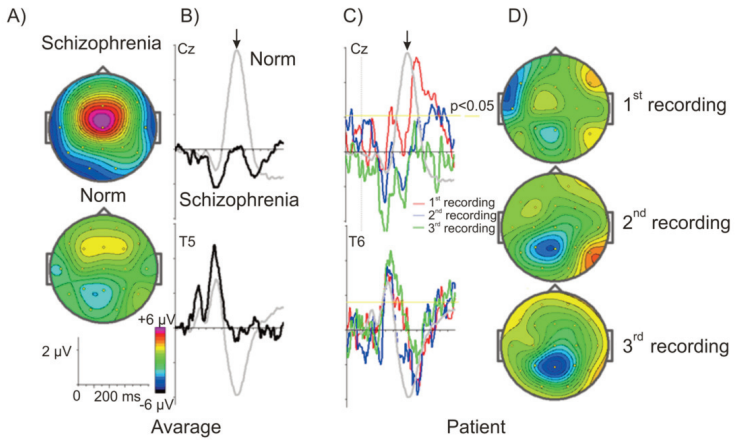

Fig. 9. Differences in ERP waves in NOGO-GO type tasks in the examined patient in comparison with healthy individuals and schizophrenic patients.
A and B – the average of ERP wave differences from the records taken from the electrodes applied at Cz and T5 points in a group of healthy individuals (N = 61) and a group of patients with schizophrenia (N = 28) selected by age, and wave difference maps at 390 ms (marked with an arrow).
C and D – individual differences in ERP waves in three records made in the examined patient from electrodes applied at Cz and T5 points. Right – wave difference maps at 390 ms (marked with an arrow)
Source: Pachalska, Kaczmarek and Kropotov, 2014.

sociated with a decrease in ERPs wave form recording during NOGO-GO tasks. As numerous studies have shown, including mine, this neuromarker occurs in most patients with schizophrenia (Kropotov et al. 2013; Pachalska, Pronina, Manko et al. 2013; Pachalska, Kaczmarek and Kropotov 2014). At the same time, the positive wave recorded from the electrode at the T5 point did not change in study 3. This means that the Therapy of Symbolic Thought did not affect this neuromarker. This means that it can be used to confirm or exclude a diagnosis of schizophrenia (see also Pachalska, Kaczmarek and Kropotov 2014).

It is worth mentioning that the variability of schizophrenia symptoms (acute psychosis), cognitive deterioration and periodic intensification of symptoms associated with previous brain trauma (e.g., periodic depression) may have been related to the content and form of the subsequent paintings painted by this artist. Therefore, his artistic output change is rendered particularly complex and difficult to interpret, given the superimposition of neurological and psychiatric conditions (Fig. 10). This self-portrait was painted a few days after the cast of acute, transient psychotic disorders "according to the ICD-10 code coding F23. During this period, the patient experienced hallucinations, delusions and perceptions. These symptoms started suddenly, had great strength and subsided after 3 weeks. According to the patient, the symptoms were caused by the death of a close friend. It illustrates the artist's state of mind.

The analysis of the work shows that various aspects of the sense of his own self have been disturbed. These include:

Fig. 10. Self-portrait created during the Therapy of Symbolic Thought, a few weeks after acute psychosis
Source: clinical material of M. Pachalska

1. *disturbance in the sense of separateness of the self from the environment* – body fragments of the presented figure leave its borders, merging with the hallucinated external reality, and this reality breaks into its interior, blurring the boundary of the self from the outside world;
2. *disturbance of the sense of unity (identity) of one's self*, which is multiplied, gender identification is disturbed, the character has been placed in a dream-like world. Within and on the border of the body there are still other deformed figures not belonging to the real world;
3. *disturbance of the sense of coherence of the biological self*, its own body has undergone transformations. The picture shows one person representing the artist who has three faces with four eyes and three noses and lips. We also see four hands belonging to no one and mysterious, unidentified beings who invaded the open body of the represented figure;
4. *disturbances of the feeling of having internal content,* both the interior of the figure representing the artist and the background of the image are full of symbolic, hallucinated performances whose meaning remains unclear; some symbols are religious, others refer to dream-like or esoteric (occult) phenomena.

Particularly noteworthy is the fact that subsequent images created in the process of neurotherapy did not bring about a great change in the artist's style of creation. The patient expressed his dissatisfaction with the few sketches he had made for the pictures. The breakthrough in the artist's work occurred when his work was stolen from the exhibition and in compensation he received €1000 from the organizers, which changed his self-esteem and attitude towards the images

he had created. He came to the conclusion that his works were of great value. The award system launched at that time made the artist enthusiastically set about creating further works. During this time, over 30 self-portraits were created in the form of 3 heads (Fig. 11). In his opinion, all these paintings were new and different works. The patient was very happy after painting each of these self-portraits. However, according to critics, this works resembled, to a greater or lesser extent, the first of the painted self-portraits. According to neuroscientists, these were likely to be classified as perseverations associated with damage to the brain's frontal lobes, and disturbances to the working memory.

The above example of patient's creativity shows us the importance of self-awareness, cognitive processes, with particular emphasis on attention and working memory), emotional and executive in creativity. It also indicates the holistic brain activity (Luria 1976, 1979) or equipotentiality (Lashley 1951), its holographic organization (Pribram 1984), and even the function of the brain and mind not only in space and time, but also in a pulsating state in hyperspace (Pachalska 2019), presented in the author's synchronous memory model (cf. Fig. 12).

The spatial arrangement of the model makes it possible to present on the x and y axes the relationship between the general structure of attention and memory systems (in terms of the number, content and complexity of the processed elements) and the period of time necessary to process them. It can be seen that the attention buffers transfer data to the working memory buffers. This system, according to the latest data obtained in neurophysiological studies, processes the smallest number of elements in the shortest possible time: seconds or even

Fig. 11. Perseverated self-portraits created during the Therapy of Symbolic Thought
Source: clinical material of M. Pachalska

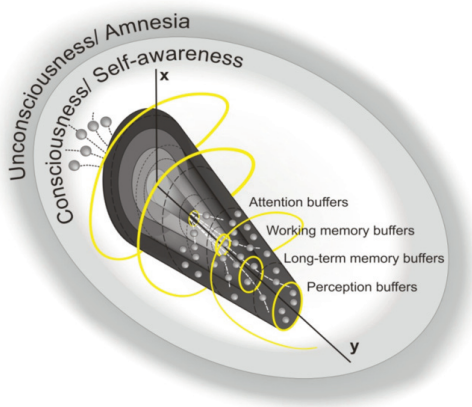

Fig. 12. Synchronous memory model
Source: Pachalska, Kaczmarek and Kropotov 2014, modified.

milliseconds (Kropotov 2009; Brown 2017). As the number of elements of information processed and / or the duration of the processing exceeds a certain threshold, we gradually move from the attention system (several stimuli, several milliseconds) to the working memory system (several to several dozen stimuli, several milliseconds to several seconds and / or minutes) depending on the capacity of the working memory buffer (see also Pachalska, Kaczmarek & Kropotov 2014).

In a similar way, there is a transition from the working memory system to the long-term memory system. The boundary of the transition is difficult to determine precisely and most likely it is actually not very sharp. In the human brain, a continuous process takes place, lasting from milliseconds to entire years when information is remembered, stored, reproduced and forgotten. Also semantic and episodic memory is associated with the number, time as well as the content and complexity of the processed data (see Pachalska 2007, 2008). The differences between these types of memory mainly concern the content of information. Of course, the longest storage time is characteristic of long-term memory, which is why we put it at the basis of the presented model. This is closely related to the organization of one's self in time. Artists with brain damage as a result of the collapse of the memory system may change the style of creation (cf. Schott 2012; Piechowski-Jozwiak & Bogusslavsky 2013) but also they will not be able to change the pattern of creation and will repeat the same pattern in subsequent works (cf. Pachalska 2019).

Returning to the division of creativity by Boden (op. cit.), a work created for the first time, as long as it has features of novelty, can be classified as a historical creation (close to objective creativity), which is new in the entire history of creativity, and even recognized by critics for being transgressive (Toeplitz 1991). The perseverance mechanism associated with damage to the frontal lobes may deprive the artist of this feature and the work will have only the features of psy-

chological creation (close in terms of subjective creativity) leading to new creations only for the author. The patient presented here claimed that he created only new works, but they were, according to critics, new only to him. It is worth noting, however, that from the patient's perspective, many factors influence such a style of creation and its assessment. Perhaps the most important factor is that the patient has difficulties in introducing a new topic to his work. However, the painted works have objectively smaller or larger differences of detail, which illustrate the varied states of consciousness experienced by this patient and painted (more or less consciously) in subsequent works. Therefore, it is difficult to state unequivocally whether we are dealing here only with perseverations and with compulsive returns to the same motif due to brain damage. Before the illness, this artist was a professional with educated skills and artistic self-awareness. He probably also knew that in the history of art there were many artists who repeatedly returned to the same motif and who built their works from repetitive elements – contrary to the common rule that the artist is required to be unique and to create unique works.

As Pablo Picasso claimed, "One would like a man not to be repeated. Repetition is against the laws of the mind, its forward course. " (Toeplitz 1991: 131). Therefore, it is worth taking a closer look at the functions of the repetitions used. Sometimes they were study series, in which the artist penetrated into very subtle shapes and shades of repeated motifs, sometimes also subsequent approximations of the ideal were created in the imagination of the creator. In modern art there is even a fashion for multiplication of the theme. This included, for example, Andy Warhol (1928 - 1987) the well recognized American artist, one of the chief representatives of pop art, known primarily from simple and serial sets with different color contrasts, which included, for example, repeated portraits: Brigitte Bardot, Marilyn Monroe, Elvis Presley, Jacqueline Kennedy Onassis, Marlon Brando, Elizabeth Taylor. Repeatability can become one of the means of expression, fulfilling the functions of either describing the state of modern culture in which stereotype, punch and uniformity dominates, or rebellion against these phenomena, which can also be interpreted as a manifestation of transgression (Toeplitz op. cit.).

The patient example presented above allows us to understand how difficult it is, even for an experienced researcher, to interpret the creativity of a patient with brain damage. It is necessary to take into account the patient's life history, type, place of brain damage and symptoms that have developed as a result of this damage at various periods of time (e.g., the development of post-traumatic emotional disorders, frontal syndrome, including depression and anxiety, and the destabilization of the self system (Pachalska, Kaczmarek & Kropotov 2020). Therefore, one would have to agree with Łuria et al. (1966) that the process of creation is closely related not only to the functioning of the brain, but also to the proper functioning of the individual self system, including the social and cultural one. It depends on the integration and interaction of all types of self and it is closely related to the process of creation.

INTEGRATED SELF SYSTEM AND CREATIVITY

Integrated self system included the individual (objective and subjective) and social (collective and cultural) self (Pachalska 2019). This concept, however should include the minimal (working) and longitudinal (autobiographical) self, which is the basis for the formation of the self system. Therefore, I have developed a modified model of the self system, which requires the nesting of the minimal (working) and longitudinal (autobiographical) self and a change in understanding of the concepts of individual and social self in terms of the thought process (cf. Fig. 13). Therefore:

1. The individual self includes:
   A) The objective self, understood as the organism, i.e., in Goldstein's (1995) approach, the body together with its states and processes occurring in it. The subject self has consciousness, but it lacks self-awareness and meta-consciousness (awareness of mental operations on its own subject). The subject does not express their own thoughts but acts according to ready-made schemes: he/she is not the author of the selves. As soon as you realize the existence of the outside world, your subject self also becomes the object of perception. This process enables the subjective self to be formed;
   B) The subjective (cognitive) self, having consciousness, self-awareness and meta-consciousness, enabling one to know oneself and act in accordance with one's own needs and values as well as the requirements of the environment. He/she has a sense of separateness, autonomy, insight (introspection), the possibility of self-assessment and self-control and creativity

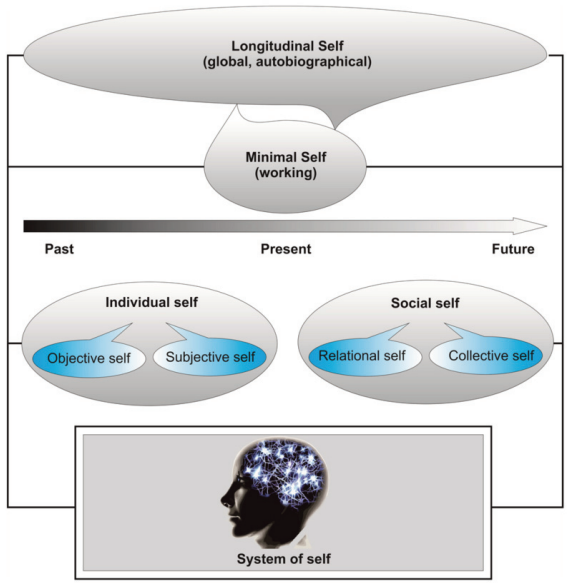

Fig. 13. Modified, process model of the system of self
Source: M. Pachalska (2019).

(see Pachalska 2008). The subjective self conditions the appearance of individual identity.

2. The social self, includes:
   A) the relational self, understood as an image and description of the You –You (interactions), from an individual and social perspective taking into account relationships with other important people and social groups around which, according to Richard Brown (1987), social identity develops.
   B) the cultural self, understood as an image and description of the We – We from an individual and social perspective including nesting in the culture or subculture of a given social group around which cultural identity develops.

The microgenetic approach to the self-system takes into account the concept of the nesting of the minimal (working) and longitudinal (autobiographical) self in the individual and social self in the processual approach, and creates the basis for the development of the self system. It also allows for a better explanation of the disruption or disintegration of this system in people with various kinds of brain damage. It also allows for more effective rehabilitation interactions to be offered to these people (see also Prigatano 2009).

People with brain damage exhibit disturbances in logical or spatial coherence depending on the location of the damage (structures and neural connections) in the right or left hemisphere of the brain. Linguistic representations are more or less disintegrated, which makes creating language constructions more difficult, as a result of which the process of creating ideas about yourself and the world is disturbed, which is why the image of oneself and, as a result, the whole system of the self is disintegrated. Damage to the subcortical structures and connections is also not without significance, however, the picture of disorders is different, something which is described in more detail as detailed in another work (Pachalska, Kaczmarek, Kropotov 2014).

WHAT DRIVES ANYONE TO CREATE?

What goes on in our bodies and minds when we begin to explore creative possibilities? What was the feeling that made a particular person want – so deeply – to create something almost randomly? What in the brain triggers the moment of “rising above” established knowledge, and why are some individuals exceptionally creative: are all questions that are still being explored (Barbey et al., 2013; Jung & Haier, 2013). At the same time, several creativity-related factors have already been identified, specifically brain size in innovative animals (Lefebvre et al., 2004), neurotransmitters (Manzano et al., 2010), intelligence level (Lefebvre et al., 2013; Brown 2017), ecological niches (Lefebvre, 2013), personality and identity attributes (Pachalska 2019).

One of the most important factors, without a doubt, is social recognition variously understood, which activates and strengthening the reward system (Fig. 14).

Pleasant experiences release positive emotions (e.g, joy), because they stimulate the reward system by creating connections from the basal part of the

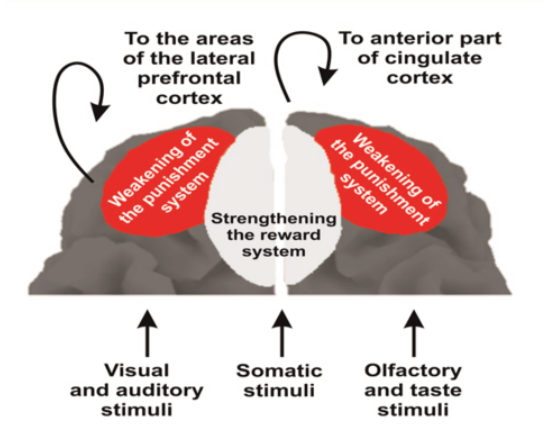

Fig. 14. The reward /punishment system
Source: Pachalska, Kaczmarek and Kropotov 2014, modified

frontal cortex to the anterior (emotional) part of the anterior cingulate cortex of the right and the left haemisphere. At the same time, the punishment system is weakened. The strength and duration of these emotions are associated with the importance of the event for the artist. Therefore, exhibition, and the positive reactions of the audience, might modify the minimal (working) self, and the longitudinal (autobiographical) self, strengthening the significance of a given (negative or positive) event (see: Pachalska 2019).

INDIVIDUAL, SOCIAL AND CULTURAL CONDITIONS OF CREATIVITY

Many years of scientific research has allowed us to conclude that creative abilities are conditioned both in the norm and in pathology by the self system. The conscious Self creates an image of itself and the world in connection with its organism and the socio-cultural arena, especially with its own social group. The organism ensures survival and development, and the socio-cultural arena provides norms and rules of social life as well as cultural values and patterns. In this discourse between various types of an individual, social and cultural self, a unique interpreter of the world is created for each person and for only them (see Gazzaniga 2011). Its creation constitutes the action of related factors (Fig. 15), which include:

1. *the brains and its codes*, i.e., undisturbed electric and chemical code (neuronal connections and neurotransmitters);
2. *the individual mind and its codes*, i.e., mono-specific, poly-specific, hierarchical and creative codes, developing on the basis of cognitive processes (including language and non-language communication) and emotional processes. This ensures metacognition, self-esteem and self-regulation;

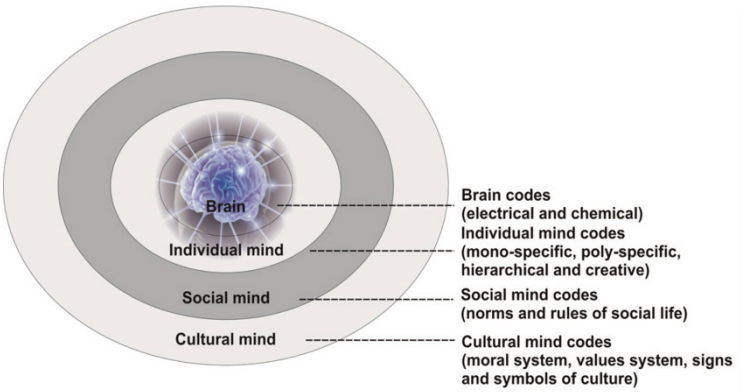

Fig. 15. Hierarchy of brain, individual, social and cultural mind codes
Source: Pachalska, 2019

3. *the social mind and its codes*, i.e., norms and rules of social life ensuring conflict-free functioning and integration with society;
4. The cultural mind and its codes, i.e., recognized as its own moral systems created by nesting in the socio-cultural environment, as well as its own system of values and cultural signs and symbols.

It should be emphasized that individual, social and cultural conditions of creativity are mainly associated with the three basic self-subsystems, that is:

1. *Awareness* that involves asking yourself about our identity: Who am I? In terms of civil law, this means sex, place of birth, origin, occupation, etc. This basic level of consciousness is often disturbed in the event of brain damage.
2. *Self-awareness*, i.e., awareness of myself and the state of my own mind, which is mainly associated with the questions: What am I? And how do other people see me? Answering these questions requires developed introspective skills, i.e., insight into yourself. It is also strongly associated with personality. In the cultural aspect, the way others see us is of particular importance, because this fact significantly affects our self-esteem. This process reflects the popular saying that "other people are our mirror."
3. *Meta-consciousness*, involving the questions: What values do I recognize? What is my place in the world? The answer to the question about recognized values determines our perception of ourselves, the world and our behavior. In turn, the answer to the question about our place in the world has a social and cultural aspect.

Recognized values are strongly embedded in culture and next to other cultural factors influence the shaping of our meta-consciousness. However, they can constitute a kind of self-limitation, which is manifested by various types of fundamentalism. This means that our meta-consciousness is also influenced by cultural conditions, among which should be mentioned a generational and procreative family, a group of friends, belonging to a social group, nationality, regionalism

(cf. Bednarek 2016), professed religion, etc. It should be emphasized that meta-consciousness is closely related to the development of the language system, called by Basil Bernstein (1990) the developed code. In Polish, the developed code concept corresponds to the term literary language (Kaczmarek 2012).

DISCUSSION

A person with brain damage may experience either underdevelopment, destabilization or loss of both self and loss of one or more of the brain codes discussed above, with particular emphasis on the individual, social and cultural mind (cf. Pachalska, Kaczmarek, Kropotov 2020). This changes the creative abilities of this person in a way that is difficult to predict, related to the brain damage itself (Abraham 2018), as well as its consequences and undertaken rehabilitation interventions (Pachalska 2019). She may lose her abilities or already find a new way of expressing herself in creation. Her creation, if it is created at all, can be assessed on a multi-dimensional basis as a work of varying degrees of revealing or not, new and original or not, useful or not, beautiful or not, communicative or not, colorful or not, disturbed (rotations, perseverations, side skipping) or not embedded in culture or not. Many scholars propose different ways of assessing this work, which is discussed in more detail in the monographs by Pachalska, Bednarek & Kaczmarek (2022).

In this context, it should be emphasized that the Lurian approach, which is successfully developed in process neuropsychology (Pachalska, Kaczmarek and Kropotov 2014, 2021) makes it possible to understand that the essence of the discovery is its "reading" by the discoverer. After the act initiating the discovery, it may be given in the form of further attempts to improve and direct it to a specific purpose.

After the act initiating the discovery, it may be given in the form of further attempts to improve and direct it to a specific purpose, often designated by the artist's individuality (see Pachalska 2019). It is not difficult to prove that the self system exerts an influence on the creative act, because the quality of creativity is associated with both neurobiological processes (Abraham 2018), as well as cognitive, emotional and executive processes, as well as with the broadly understood social and cultural background (Pachalska 2020; Pachalska & Góral-Półrola 2021).

CONCLUSIONS

From the clinical neuroscience perspective, it is particularly important to use the creative possibilities of people, especially artists, with various brain injuries in their rehabilitation. In this context especially important is art therapy which might help to rebuild the creative abilities lost as a result of brain damage, and thus to found one's individual, social and cultural Self. However, something that is also important for artists, selected works, especially the most characteristic and significant ones, are also achieving critical recognition. It even happens that they become a part of the world's cultural heritage, are displayed at various ex-

hibitions and are even bought to be hung in the collections of galleries acrosss the world, like in the case of the artist presented in these paper.

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