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The place of neuroscience in social rehabilitation pedagogy

Abstract: The aim of this work is to find a place in social rehabilitation pedagogy for the use of neuroscientific research by discovering its importance in the process of social rehabilitation. In the beginning, some theoretical considerations on biology as a basis for the psychological and behavioral functions of humans were cited. Then the areas of pedagogy were presented where the importance of neuroscientific research has grown in recent years. In the next part, attention was drawn to the discussion in the literature on the subject of social rehabilitation. Then, literature and neuroscientific empirical studies were analyzed, in which direct and indirect relations between neuroscience and social rehabilitation were observed. Finally, an attempt was made to locate neurobiology at the borderline of sub-fields of pedagogy and a conclusion was presented on the usefulness of neuroscientific research for cognitive and therapeutic purposes.
Key words: neurorehabilitation, biopsychosocial criminology, neurotherapy, social rehabilitation, criminology

Introduction – biology as a basis for human development

Weaving neuroscience into other fields of science is a recently noticeable trend not only in terms of popularization of science, but also in the academic community. The fascination with the functioning of the human brain has made this subject very attractive recently. The closer the discipline is to the sphere of the human psyche, the more it seeks to relate to neuroscience. This applies not

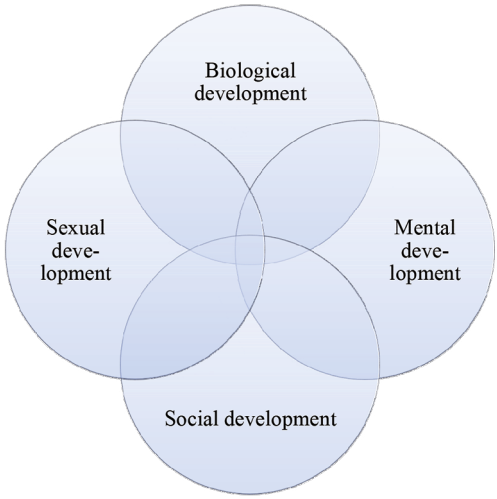

Fig. 1. Spheres of human development and their interactions
Source: Woynarowska, Kowalewska, Izdebski, Komosińska 2010, p. 24.

only to psychology, but also to cognitive science, sociology, criminology and finally pedagogy. Already in the first sentence of the foreword to the textbook "Biomedyczne podstawy kształcenia i wychowania" ("Biomedical fundamentals of education and upbringing"), B. Woynarowska wrote that "Biomedical issues are an important element of interdisciplinary education of teachers and educators" (Woynarowska 2010b, p. 10). She then emphasizes the essence of a holistic approach to pupils and students, taking into account biomedical issues (Woynarowska 2010b, p. 10), which can help to understand interactions with another human being, the environment and their impact on human ontogenetic development (Kowalewska 2010, p. 150).

There is no distinct current in pedagogical sciences that is closely related to the above assumption. There is, however, a theory quoted by S. Kunowski, according to which "internal (genetic) factors are genre-differentiated and spontaneously come to the fore at the right time and in the right order, creating different upbringing substrates in which quantitative changes occur as well as subsequent qualitative maturation" (Kunowski 2004, p. 195). This theory is called the "layer theory of human development". Each "layer" provides the foundation for the next one and develops by meeting the needs typical of the given stage (given layer). These layers include:

I. the biological layer that forms the body,
II. the psychological layer that develops the psyche,
III. the sociological layer that forms the social person of the pupil,
IV. the cultural layer that makes develops the cultural creator in man,
V. the spiritual/world-viewing layer that shapes spirituality and its religious-moral side (Kunowski 2004, p. 197).

Already at the beginning of the analysis of the above theory it is noted that biological development is the foundation for the further development of man in the psychological, social, spiritual and cultural sphere. According to S. Hessen, who laid the foundation for this theory: "man is an element of nature and develops according to its laws characterized by determinism, evolutionism and mechanicism" (Cichosz 1996, p. 22). Moreover, S. Hessen did not deny the existence of the spiritual dimension of man, which is difficult to grasp by scientific methods. An important interpretation of the layer theory of human development is the opinion of I. Jazukiewicz that "Since human development concerns several spheres, the upbringing, preparing for self-upbringing, should cover them all" (Jazukiewicz 2018, p. 47), and thus also the biological sphere and the human neurobiology that falls within its scope.

Neuroscientific research in pedagogy

Attempts to integrate neuroscience with pedagogy are relatively young and not yet fully developed. Although biomedical issues in pedagogy were mentioned as early as the turn of the 18th and 19th centuries (their authors were, among others. G. Piramowicz and J. Śniadecki), they concerned not so much human neurobiology as physical health in general (Woynarowska 2010a, p. 16). It is only in recent years that publications on the relationship between neuroscience and pedagogy in its many aspects have begun to appear. M. Kaczmarzyk, a biologist who deals with neurodidactics, in his book entitled „Szkoła Neuronów" ("Neuron School") describes the discoveries of neuroscience thanks to which he explains the incomprehensible and considered harmful behaviors of teenagers resulting from the peculiar development of the nervous system (Kaczmarzyk 2017, pp. 13–176). K. Mazurkiewicz, on the other hand, cites the possibilities of using the achievements of neuroscience in improving the quality of learning (Mazurkiewicz 2015, pp. 269–277). J. Zielińska describes the possibilities of using neuroscience in special pedagogy (Zielińska 2013, pp. 23–34). Finally, in her work titled "Proces resocjalizacji w perspektywie dorobku neuronauk" ("The process of social rehabilitation in view of the achievements of neurosciences"). I. Mudrecka raises the issue of using neurobiological knowledge in order to "(…) transform one's own personality, which (as a process) is initiated by a socially maladjusted individual in order to find more effective relations with themselves and their social environment" (Mudrecka 2015a, p. 16), thus redefining the concept of social rehabilitation.

Social rehabilitation in various conceptual perspectives

In the definition of social rehabilitation, both the PWN Dictionary of Polish Language and the PWN Encyclopedia expose its educational character (Słownik ;

Encyklopedia), however, the Encyclopedia also indicates its therapeutic and, more precisely, psychocorrectional goals. Rehabilitation according to L. Pytka is "a set of caring, educational and therapeutic measures against people who violate legal norms, but also moral norms in an open and closed environment" (Pytka 2000, p. 35). A similar definition is given by K. Pierzchała, adding the meaning of "development in socially maladjusted people of changes in the area of self-awareness, self-upbringing and self-reflection" in the process of social rehabilitation (Pierzchała 2017, p. 95). M. Konopczyński points out that social rehabilitation is primarily a process of developing and creating potentials (Konopczyński 2014, p. 19). These processes are to be dealt with, among others, by social rehabilitation pedagogy, whose "ambition (…) is not only to describe and explain certain processes occurring between the educated and the educator in the process of upbringing, but above all to modify those personality parameters or those behaviors which are described as unfavorable, harmful, defective, pathological or disastrous for the individual or the society" (Pytka 2005, p. 11).

The personality parameters sensu stricte should be dealt with by psychology, but in the context of social rehabilitation, the words of P. Stępniak should be recalled, who states that social rehabilitation is not the subject of interest of psychology (Stępniak 2017, p. 329). Thus, social rehabilitation pedagogy is faced with the problem of whether to deal with what was originally the origin of its function (i.e. re-education) or to take up the challenge of a holistic approach to the social rehabilitation process. The encouraging thing about this second version is L. Pytka's approach, who in the field of social rehabilitation pedagogy sees not only educational and caring issues, but also "therapy, i.e. treatment of disorders, dysfunctions, restoring the normal conditions of the bio-psychological unity of the ward" (Pytka 2005, p. 187). L. Pytka rightly notes that such an approach goes far beyond the common sense of social rehabilitation (Pytka 2005, p. 187). The term "biopsychological" may evoke associations of psychological-medical interventions, and as P. Stępniak emphasizes, refraining from pedagogical interference in this type of therapy is an expression of common sense due to the lack of competences of pedagogues for this type of activities (Stępniak 2017, p. 323). No wonder, then, that pedagogues are careful in their approach to peri-medical subjects, as well as in combining medical aspects of functioning of the human psyche (psychiatry, neurology or neuropsychology) with pedagogy. It is indicated, however, that the basis for human behavior (including its disorders), the change of which is to be dealt with by social rehabilitation pedagogy, is, among others, neurodynamics (Duch 2017). This term means communication between different parts of the nervous system (Merriam-Webster Dictionary). S. Kunowski has long since pointed out that the educational development of a person is connected with the life of their body (Kunowski 2004, p. 55). Pointing out the importance of the biology of upbringing, he stressed that "the nervous system, reacting to sensory stimuli with the reflexes of the spinal cord, the drives

of subcortical centers and conscious and voluntary movements (praxis) of the cerebral cortex, evokes processes and mental experiences, coordinates the activities of the whole body, introducing communication with the environment" (Kunowski 2004, p. 55). Taking into account the above considerations, one should consider whether it would be worthwhile to enrich the knowledge of pedagogues with biological mechanisms of human behaviors not only for the purpose of using this knowledge in practice, but also to understand the etiology of the behavioral disorders with which they work (or rather against which they work) and to develop the ability to cooperate with representatives of other sciences dealing with the issue of social rehabilitation.

Neuroscientific research in the context of social rehabilitation

The neuroscientific context of changing social behaviors is taken up by the aforementioned I. Mudrecka. The ability to change behavior is related to the ability to reorganize neurons in the brain, i.e. neuroplasticity (Mudrecka 2015a, p. 18). The brain's plasticity consists in the fact that the nervous system, in addition to triggering mechanisms of response to stimuli, undergoes permanent modification under their influence. According to J. Konorski's concept of neuroplasticity, the nervous system contains not only currently active nervous connections, but also those which, being inactive for a long time, can be made under the influence of a change in the physiological condition of the body. Such a change can take place, for example, during the learning process or the development of conditional reflexes. The brain's ability to reorganize neurons is also important in case of brain damage. Thanks to neuroplasticity, the functions of damaged areas can be taken over by other centers in the brain (Sadowski 2007, p. 29). J. Vetulani claims that brain plasticity results in plasticity of behavior (Vetulani 2014, p. 87). J. Rostowski also draws attention to the importance of neuroplasticity in shaping human behavior. He claims that neural plasticity is the basis for "the acquisition of various forms of individual and social behaviors" (Rostowski 2012, p. 57). He also distinguishes cognitive neuroplasticity, which uses creative strategies to raise the individual's position both in intellectual, emotional and social dimensions (Rostowski 2012, p. 57). I. Mudrecka points out that the presence of the neuroplasticity phenomenon inspires a certain "pedagogical optimism" in relation to people undergoing social rehabilitation measures, as it proves that it is never too late to change (Mudrecka 2015a, p. 17).

An important point in considering the usefulness of neuroscientific research for social rehabilitation should be to explore the issue of social neuroscience. This term developed in the 1990s and it focuses on how the functioning of the brain mediates social interactions (Cacioppo et al. 2010, p. 676). The representatives

of this trend recognize that social interactions have a significant impact on the functioning of the brain and body, affecting both the neural, neuroendocrine, metabolic and immunological spheres, of which the brain is the central regulatory organ, susceptible to external stimuli (Cacioppo et al.). 2011, p. 123). Social neuroscience emphasizes the importance of understanding how the brain and body affect social processes and how social processes affect the brain and body (Harmon-Jones, Winkielman 2007, p. 4). By investigating the biological mechanisms underlying social processes and behaviors, representatives of social neuroscience attempt to improve the theory of social behaviors, and, on the other hand, use social constructs to develop the theory of neuronal organization and functions (Cacioppo et al. 2007, p. 99). This is done using brain imaging techniques, of which functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) are the most common.

Categories of research using (fMRI) include, among others, the issue of social cognition, which is "necessary for adequate social functioning, establishing social relations or interpersonal verbal and non-verbal communication" (Rostowski 2012, pp. 182–183). According to J. Rostowski, social cognition concerns the process of perception and processing of stimuli, excitement and the environment, while social functioning is the way an individual acts in a social environment, using social skills or abilities such as cognitive and interpersonal abilities, which are necessary to maintain correct social behavior and positive interpersonal interactions (Rostowski 2012, p. 184). Functional magnetic resonance imaging is based on the monitoring of brain activity based on the change in blood oxygenation in its examined area (Neuroscience and the law [2016]). The more active the area is, the more oxygen is used in it, which can be observed with an fMRI scanner.

Electroencephalography (EEG) is a method of measuring the brain's bioelectrical function by means of a device (electroencephalograph) which records the signal by means of electrodes placed on the patient's scalp using a special paste to facilitate conduction (Thompson, Thompson p. 51). During the EEG examination, the amplitudes and frequencies of brain waves are measured, which reflect unconscious physiological processes taking place in the brain (Thompson, Thompson 2003, p. 51). The quantitative analysis of the EEG recording is QEEG, also called "brain mapping". The name comes from the fact that by processing the EEG signal by appropriate algorithms it is possible to obtain "colorful brain maps" showing the data obtained from EEG registration. Both the EEG, QEEG and fMRI examination allows to observe brain activity in different research situations.

Observation of the activity of individual brain areas during the placement of the examined person in a specific situation or performing a given task allows for an indicative outline of the areas whose increased activity may be related to the processing of a given group of information and the reaction to it. For example, the human ability to infer about other people's goals, intentions and desires is related to the activity of the temporoparietal junction and partly of the medial

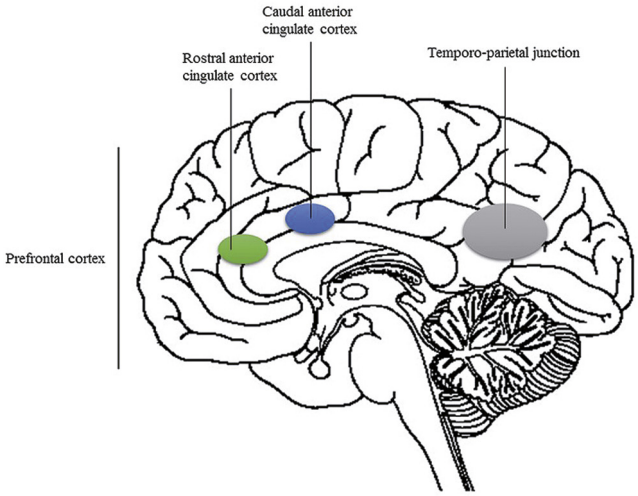

Fig. 2. Brain centers related to cognitive activity
Source: Own study based on: Ferrez, Millan 2007, p. 11; Fąfrowicz, Marek 2008, p. 151; Narkiewicz, Moryś 2014, p. 204.

prefrontal cortex. The activity of the medial prefrontal cortex is more closely related to inferring about more permanent conditions of other people, such as their beliefs and norms (Rostowski 2012, p. 182). Attention, novelty, specificity, conflict situations and decisions are related to the activity of the posterior part of the cingulate cortex, while emotions, evaluation of depression or pain situations and the postures are related to the activity of the anterior part of the cingulate cortex (Rostowski 2012, p. 183).

The anterior part of the cingulate cortex is one of the most important areas of the cortex for cognitive processes, which by many researchers is identified with the attention enforcement system (Fąfrowicz, Marek 2008, p. 149). This system is active, inter alia, in situations "requiring corrective actions related to errors made" (Fąfrowicz, Marek 2008, p. 150). This statement may be crucial in considering the usefulness of neuroscientific research results in social rehabilitation.

Decision making in the neurobiological literature is most closely related to the activity of prefrontal areas. Apart from processes concerning perception and reception of stimuli, their functioning also influences the initiation of actions and their course (Sadowski 2007, p. 562). Damage to these areas may result in the reduction or in the inability to control one's behaviors and anticipate their consequences. Frontal lobe dysfunction and damage to the orbital-frontal areas are indicated as probable causes of aggression in criminal behaviors (Brower, Price 2001, p. 726). Neurological studies show that the occurrence of impulsive

aggression may be the result of abnormal functioning of the anterior part of the cingulate cortex (Goodman et al. 2004, pp. 116–117). Damage to orbital gyri is associated with serious personality disorders (Narkiewicz, Moryś 2014, p. 317). Personality disorders are also one of the groups of symptoms characteristic for frontal lobe syndrome (Sadowski 2007, p. 559), including prefrontal region damage. Patients affected by this syndrome show "lack of concern for the future, euphoria, lack of initiative, proclivity to joking" (Sadowski 2007, p. 560). As B. Sadowski writes: "(…) damage to the frontal lobes violates the cerebral mechanisms on which human intelligence and personality, and thus the basic attributes of human thinking, depend." (Sadowski 2007, p. 563).

Some theories suggest that the prefrontal cortex and limbic system areas constitute an interconnected network whose functioning is regulated by both emotional and intentional behaviors, so that damage or dysfunction in any of these areas results in problems with the regulation of emotions and subsequent difficulties in inhibiting unwanted behaviors (Bechara, Van Der Linden 2005, p. 734). The dorsolateral prefrontal and orbital-frontal cortex receive signals from the amygdaloid body and other medial temporal areas and can therefore integrate sensory information with affective signals (Schoenbaum et al. 2003, p. 859). Damage to limbic regions associated with prefrontal cortex function negatively affects cognitive and emotional processes, and memory (Damasio 1996, p. 1414).

The activity of the limbic system is closely related to the management of drives and emotions as well as memory processes (Narkiewicz, Moryś 2014, p. 309). The structures of the limbic system include, among others cortical centers (the entorhinal cortex, the periamygdalar field, the olfactory knob, the olfactory bulb and the hippocampus), the cingulate gyrus, the orbital gyri, the amygdaloid body, the hypothalamus, the nucleus accumbens, the septum pellucidum and neurochemical systems: noradrenergic, dopaminergic, cholinergic and serotonergic systems (Sadowski 2007, pp. 386–398).

One of the most important elements of the limbic system from the point of view of the analysis of emotional processing is the amygdaloid body. This structure is located in the frontal lobe area. The amygdaloid body mediates the regulation of fear, defensive reactions, emotional learning and motivation (Cardinal et al. 2002, p. 321). Studies carried out by A. Raine et al. over two decades ago show that abnormalities in the functioning of the amygdaloid body are characteristic of deranged killers (Raine et al. 1997, p. 495). In aggressive criminals, researchers noted a reduced volume of the amygdaloid body (Wong et al. 1997, p. 49), and linked it to the development of aggression (Pardini 2014, p. 73). In criminals with psychopathic personality, reduced activation of the amygdaloid body during processing of affective stimuli (Kiehl et al. 2001, p. 677), and increased activation of the amygdaloid body while viewing negative visual content was observed in antisocial subjects (Muller et al. 2003, p. 152).

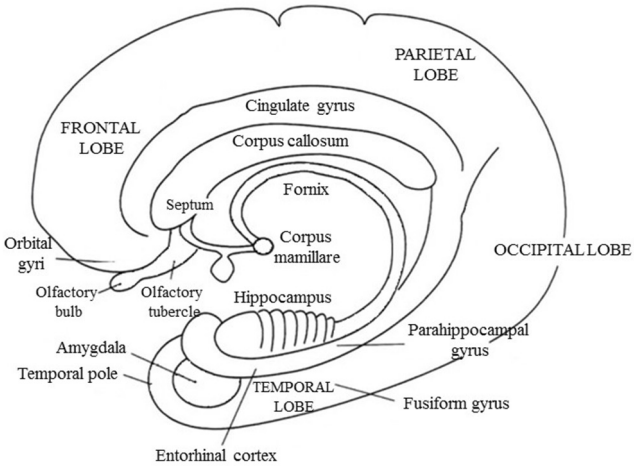

Fig. 3. Structures of the limbic system against the anatomical structure of the human brain
Source: Sadowski 2007, p. 387.

Impaired functioning of the amygdaloid body in particular impairs the ability to create associations that strengthen stimuli, making it difficult to associate harmful actions with the pain and suffering of others (Glenn, Raine 2008, p. 465). The activity of the amygdaloid body has an impact on the recognition of the importance of stimuli and giving them positive or negative values (Narkiewicz, Moryś 2014, p. 320). Research by Adolphs et al. on the recognition of a wide range of facial expressions, including emotions, shows that the functioning of the amygdaloid body plays a significant role in processing stimuli of both emotional and social importance (Adolphs et al. 2002, p. 1264). The immaturity of the amygdaloid body may therefore be the cause of incorrect recognition of emotions and emotional mimic expression, as evidenced by studies on teenagers (Qin et al. 2012, s. 7941–7946). Moreover, patients with amygdaloid body injury show an impairment in the recognition of mimic reactions related to fear (Adolphs et al. 1994, p. 669). Studies show that the key components of the neural circuits underlying formation of association and contextual processing during fear conditioning are the amygdaloid body and the hippocampus (Maren 2001, p. 919).

The hippocampus is a layered structure (Isaacson 2004, p. 1119) resembling the shape of a sea horse (Johnston, Amaral 2004, p. 455). In humans, it is fully developed only in the temporal lobe (Narkiewicz, Moryś 2014, p. 310). The hippocampus is characterized by numerous connections with structures that control the drive and emotional activities (Sadowski 2012, p. 508). The transmission of information from the cerebral cortex to the hippocampus takes place via the entorhinal cortex (Narkiewicz, Moryś 2014, p. 313), and damage

to both these structures (the hippocampus and the entorhinal cortex) may cause amnesia (Narkiewicz, Moryś 2014, p. 310).

There are many reasons why the hippocampus is an interesting structure for research among scientists from different medical fields. Although hippocampus functions are usually associated with memory, its functionality is not limited to this sphere alone. The hippocampus and the related structures are an attractive research area for psychologists analyzing memory processes, physiologists observing neural and synaptic plasticity, clinicians investigating neurological background of diseases such as epilepsy and Alzheimer's disease, and scientists working on neural networks (Andersen et al. 2007, p. 3). One of the most popular areas of research on the hippocampus is the study of the relationship between its volume and behavioral disorders (Zetzsche et al. 2007, p. 152), traumatic experiences (Smith 2005, p. 798), or specific nosologic units (Walker et al. 2007, pp. 769–801).

Research on the morphology of the hippocampus reveals certain characteristics of certain groups of people. The results of A. Raine et al. suggest that asymmetries in the anterior part of the hippocampus are likely to occur among convicts with psychopathic personality (Raine et al. 2004, p. 185). Moreover, these asymmetries may occur without affecting the total volume of the grey substance of the hippocampus (Boccardi et al. 2010, p. 438). Changes in the hippocampus can disrupt the conditioning of fear (Laakso et al. 2001, p. 187). In addition, the hippocampus is part of the limbic system, which takes part in the control of behaviors in borderline personality disorders (Zetzsche et al. 2007, p. 150). Studies have shown that in patients with these disorders, the volume of the hippocampus is lower than in the control group (Zetzsche et al. 2007, p. 150). A similar property was observed in people with post-traumatic stress syndrome (Smith 2005, p. 798), depression (Bremner et al. 2000, p. 115) and social phobia (Irle et al. 2010, p. 126). Experiments on rats have shown that reduced hippocampal volume may also be characteristic of individuals who do not interact with others (Kalman, Keay 2017). This research can be the basis for understanding the importance of proper functioning of the hippocampus in the context of social relations.

Social relations and interactions between people in their highly social lives are also linked to the search for and experience of reward (Bhanji, Delgato 2014, p. 61). As people live a "social life", the rewards they seek and experience are linked to social interactions and relationships with other people. In addition to valued non-social prizes such as food and money, social outcomes such as approval and praise from others are also important to people. Experiencing the reward shapes human behavior, and the prospect of being rewarded motivates one to choose activities that could lead to greater benefits (Bhanji, Delgato 2014, p. 61). From a neurobiological point of view, the system responsible for regulating these mechanisms is the so-called reward system.

The reward system is a set of brain structures covering brainstem structures and other subcortical areas related to behavior control and motivation. These

structures include the bottom field of the brainstem cover, the nucleus accumbens (Jabłonowska-Lietz et al. 2012, p. 277) and part of the orbital-frontal cortex (Stach 2012, p. 78). The reward system is a part of the limbic system. Research shows that altered functions of the reward system, manifested by reduced pleasure or interest in previously liked activities or reduced motivation or drive, are noticeable in abused children (Guyer et al. 2006, p. 1059) and can also lead to severe depressive disorders (Naranjo et al. 2001, p. 781). The activity of the limbic system is stimulated by neurotransmitters, which include dopamine, serotonin, noradrenaline and endogenous opioid peptides (Jabłonowska-Lietz et al. 2012, p. 277).

Dopamine is the neurotransmitter whose level correlates with pleasure and therefore plays an important role in the functioning of the reward system. The reward system is based on the activity of dopamine pathways – the mesolimbic one, in which dopaminergic neurons are located in the bottom part of the cover of the brainstem and end in the nucleus accumbens of the forebrain, and the mesocortical one, in which dopaminergic neurons located in the bottom part of the cover end in the orbital-frontal cortex (Stach 2012, p. 78). Dopaminergic dysfunction is associated with a number of different mental disorders such as mood disorders, fragmentation of thought processes, schizophrenia, schizotypal disorders, problems related to the abuse of psychoactive substances, affective disorders, psychomotor hyperactivity disorders (ADHD), and a tendency to behave in a destructive manner (Rodriguiz et al. 2004, p. 185). Most of these conditions are accompanied by abnormal social reactions. Studies suggest that abnormal functioning of dopaminergic pathways may affect the susceptibility to hyperactivity and aggressive behaviors (Rodriguiz et al. 2004, p. 185).

Oxytocin is an important neurotransmitter for establishing social relations. Oxytocin is synthesized in secretion cells (i.e. producing the secreted hormone) of the supraoptic nuclei of the hypothalamus from where it is transported to the posterior pituitary (Villee 1977, p. 580). They are stored there and then released (Rodriguiz et al. 2004, p. 580). The longest known area of functioning of oxytocin is its participation in processes related to childbirth and motherhood, i.e. stimulation of uterine muscle spasms and milk secretion (Rodriguiz et al. 2004, p. 585), as well as its influence on mother-child attachment (Kendrik 2000, p. 112). More recent studies show that oxytocin affects the psychosocial aspects of human life including the processing of social stimuli, social decision-making, social behaviors (MacDonald, MacDonald 2010, p. 16) and social memory[1]. Research also shows a high impact of oxytocin on shaping prosocial behaviors (Striepens

[1] Social memory is defined as the ability to identify and remember people. This type of memory allows the animal to determine whether it is appropriate to avoid interaction with the other animal or to get involved in the situation. This choice depends on the social context in which the animal finds itself. Data from many species suggest that both oxytocin and vasopressin are important for the neuroregulation of social memory (Caldwell 2017, pp. 3–4).

et al. 2011, p. 445). Oxytocin administered nasally contributes to improvement of human communication (Schneiderman et al. 2014, p. 1534), improvement of social cognitive capacity (MacDonald et al. 2013, p. 2831), stress reduction (Cardoso et al. 2013, p. 399), reduction of vulnerability in people with high social anxiety (Clark-Elford et al. 2014), and most importantly, from the point of view of social rehabilitation – increase of emotional empathy (Hurlemann et al. 2010, p. 5005). For these reasons, oxytocin is becoming increasingly known as a "pro-social" neuropeptide with therapeutic potential in the treatment of social, cognitive and mood disorders in humans (Hurlemann et al. 2010, p. 4999).

Vasopressin performs similar functions to those described above. It is a hormone secreted by the suprachiasmatic nuclei (Wójciak et al. 2012, p. 1044) and paraventricular nuclei of the hypothalamus (Narkiewicz, Moryś 2014, p. 304). Like oxytocin, vasopressin plays a key role in determining social behaviors in both humans and animals (Zink et al. 2011). This is due to the participation of vasopressin in the regulation of aggression, social communication and social recognition (Albers 2011, pp. 283–292). However, the research on the importance of vasopressin in shaping pro-social behaviors in humans needs to be further expanded, as most of the available experimental results are mainly animal-related.

Neurobiology of social relationships tries to identify the neuronal, hormonal, cellular and genetic mechanisms underlying social behavior and thus understand the links and influences between the social and biological levels of organization (Cacioppo et al. 2010, p. 676). Success in this area is therefore not measured in terms of contribution to social psychology, but rather in terms of the specification of the biological mechanisms underlying social interactions and behaviors, which are among the main concerns of 21st century neuroscientists (Cacioppo et al. 2010, p. 676). Given the importance of these factors in the process of social rehabilitation, the essence of including neuroscientific issues in it should primarily take into account learning about the primary, biological mechanisms that control the human psyche. Moreover, thanks to a deeper understanding of these mechanisms, neurobiological interventions in the form of neurotherapy could be used as supportive therapies in the process of social rehabilitation. Perhaps the effectiveness of such measures would be beneficial in terms of strengthening existing social rehabilitation methods.

Summary – neuroscience in pedagogy and social rehabilitation

On the basis of the considerations contained in this paper, the combination of neurobiological knowledge and solutions with pedagogy could be placed on the borderline between experimental pedagogy and practical pedagogy. Experimental pedagogy studies "the laws that govern the course of biological, psychological,

sociological or cultural phenomena, entangled with- and related to upbringing" (Kunowski 2004, p. 38), while practical pedagogy observes, collects and studies educational experiences, and it develops didactic and methodological experiences (Kunowski 2004, p. 38). In relation to neuroscience, the experimental dimension of pedagogy may be reflected in learning the neurobiological mechanisms related to the human psyche, learning about oneself, learning about the world, looking at and responding to reality. This is important for establishing and maintaining the social relationships that are related to the ability to learn and assimilate the prevailing rules, principles, customs and standards of conduct. Disorders in this area often result in problems, and sometimes in the inability to establish proper social relationships (as in the case of a dissocial personality, commonly referred to as a psychopathy (Mudrecka 2015b, p. 17), violation of the rules of social life or, finally, social maladjustment (Koch-Kozioł 2018, pp. 51–80). Hence, the function of neuroscientific research is particularly important for social rehabilitation processes. The practical dimension may in turn be expressed in therapeutic interventions, supporting existing methods of social rehabilitation.

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