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The Confirmation of Montessori Postulates in Contemporary Educational Neuroscience

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Abstract

This paper lends insight into the fundamental postulates of Montessori pedagogy and definitions of contemporary educational neuroscience, focusing on the needs and solutions of contemporary didactic approaches. By presenting the results of contemporary researches, the paper connects the achievements of Montessori pedagogic methods and strategies with the scientific indicators of educational neuroscience about the manners of positive impact on the development of an individual. The results of the educational neuroscience research will corroborate the postulates of Montessori pedagogy that state that understanding the developmental stages of upbringing, individual competences, and specificities of each child are important for upbringing. Specific cases will be used to emphasize that, apart from the cognitive competence, it is essential to develop psychomotor and affective competences, meaning that the development of these personality spheres is connected and interdependent. By providing the pedagogic perspective, the paper points to the need for further deliberation on how to shape an optimal curriculum. The paper suggests that various social and technological changes are reasons to consider pedagogic methods, strategies, and approaches of Montessori, which is also supported and substantiated by contemporary educational neuroscience.

Key words: *didactics; Montessori pedagogy; neurodidactics; neuroscience.*

Introductory Considerations

Maria Montessori is considered one of the pioneers of early childhood pedagogy and education with which she contributed to the contemporary understanding of pedagogic principles. She stressed the aim of developing the child's individual

potentials by having it learn and understand actively by making his/her own choices (Isaacs, 2018). The Montessori principle of learning through research was shown to develop independent, self-aware, and curious individuals – "heralds of social change" (Isaacs, 2018, p. 10). Even before she established Casa dei Bambini, Maria Montessori had gained a reputation with her presentations in European conferences for her ideas of learning through the senses. It is, therefore, unsurprising that over 16000 schools across the world have committed to the Montessori ethos (Isaacs, 2018).

Educational neuroscience has enabled a symbiosis between biology, neurology, cognitive psychology, pedagogy, and didactics. The coherency between the aforementioned sciences leads to the conclusion that it is essential to understand the notions which have a decisive impact on the progress and development of new learning strategies when working with children. The interdisciplinarity of educational neuroscience explains the manners in which genetic heritage and formed environment affect learning processes and how educators and teachers may in accordance therewith enhance their practice (Pinel, 2002).

Through her life and work, Maria Montessori created a pedagogy by connecting the achievements of said sciences with specific personal experience. In fact, it can be said that she headed on the path of educational neuroscience by obtaining her degree in medicine in 1896 (Thayer-Bacon, 2012). As she continued with her medical practice by working at hospitals and private offices, teaching at faculties, and conducting research at a psychiatric clinic in a neuroscientific sense, she managed to establish the foundations for the postulates of new pedagogy and didactics. It was her scientific path that helped her use her knowledge of human (child) biology, neurology and developmental psychology to make major discoveries in contemporary pedagogy and didactics. By adopting an approach which was suitable for the age, capabilities and developmental stage of a child, she succeeded in removing the stigma of mental deficiency attached to children at psychiatric clinics, establishing that the problem lay in neglected upbringing. Her later pedagogic work used the same mechanisms of upbringing, thus presenting an upbringing model of contemporary didactics (Thayer-Bacon, 2012). This paper will examine the correlations of the findings of scientific achievements in the pedagogical direction set by Montessori and the ones of contemporary educational neuroscience in order to suggest their interconnection and fascinating interdependence.

Educational neuroscience and how M. Montessori began with human bio-psychology

The earliest beginnings of educational neuroscience are found in the mid-19th-century publication of *The organization of behavior: A neuropsychological theory* by D. O. Hebb (Pinel, 2002). Hebb (2005) shed new light on the deliberations about the interconnection between the psychological functioning and physiology of the brain.

The precursor to educational neuroscience was cognitive neuroscience as the youngest of the disciplines of biological psychology. As a neuroscientific discipline, biological psychology studies the biology of behavior, relationships between psychological processes and fundamental physiological occurrences or, in other words, the phenomenon of the interconnection between the mind and the body (Hebb, 2005). On the other hand, cognitive neuroscience overlaps with disciplines such as physiological psychology, cognitive psychology and neuropsychology in an attempt to answer the question of how cognitive activities are targeted or controlled by neural circuits in the brain. It studies the biological processes and aspects which underlie cognition with special emphasis on neural connections in the brain which are engaged in mental processes (Pinel, 2002). Educational neuroscience examines human behavior in a way to determine what learning environment comprises and which learning processes are substantiated by the natural brain structures. It is guided by the fact that the brain and the body learn consciously, unconsciously and incessantly, which is why the structures of the learning process and the context must adjust to the development of the biological and physiological conditions of the brain (Figure 1).

With the publication of her revolutionary book *Absorbent mind*, Maria Montessori began to analyze the biopsychology of children as early as the period of creation and division of cells. She would reference the two pieces of research conducted 14 years prior to the publication of the book, independently – one in the USA, and the other in England. Montessori drew our attention to the fact that every cell which later forms an organ or organism fundamentally comprises three "walls". Each of the three walls later becomes part of organs. The exterior wall creates the skin, sensory organs, and the nervous system, the interior walls create (internal) organs, and the middle wall is part of the bone and muscle system. Montessori was fascinated by several pieces of information that can be gained from this. One is that the nervous system is made of the same formation as the skin which is connected with the environment through nerves – it takes part in the interaction of information between the organism and the environment, thereby also protecting the organism from the environment. Secondly, cellular structure actually represents the functional reflection of an organism that develops from it because the "walls" are arranged in a relationship to each other (internal organs are protected by the interior layer, while the bone and muscle system connects the skin and the nervous system). Thirdly, the entire human being is actually determined at this stage, as far as genetic predispositions are concerned. Finally, what was a big step for Montessori's scientific and pedagogic postulates, and which was in accordance with the research presented by her colleagues in 1929 and 1930, was that the accelerated cellular development of organs will take place at an exact "point of sensitivity", which will be discussed in later chapters.

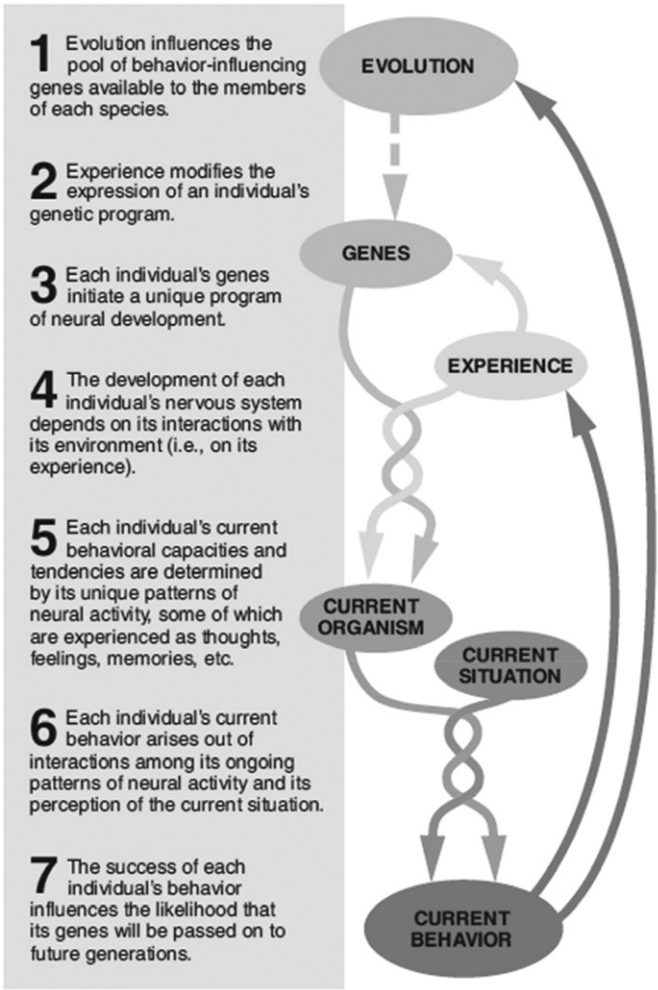

Figure 1. The biology of behaviour as the foundation of educational neuroscience (Pinel, 2002, p. 25)

The role of experience and emotions in acquiring data and shaping behaviour

Educational neuroscience today answers the questions on the operation and functions of the brain thanks to the methods of magnetic resonance imaging. How and why a child uses its brain is determined by the interconnection of billions of well-developed and stabilized neural cells and the ones that are underdeveloped and insufficiently formed. In order for this interconnection to fully form, children must live through as many experiences as possible (Perković et al., 2017; Pinel, 2002).

Therefore, Maria Montessori (1912), referring to developmental psychology and personal scientific experience, emphasizes that early childhood upbringing and education can be steered in the right direction only if we understand child development. She

states that the key developmental stages belong to the period of life up to 18 years of age, stressing the importance of the first three years of life. Beck (2003) adds that the learning speed in children is extremely high during this time. Montessori claims that the cumulative intensity of child's transformations, adaptations, successes and achievements in the first three years of life is equivalent to the intensity thereof from the third year of age until death. She therefore claims that from the developmental (cognitive and pedagogic) viewpoint "the first three years are as long as the entire life" (Montessori, 1989, p. 19). She was among the first pedagogues to advocate the importance of the first six years of life, claiming they were "more significant than studying years, in the sense of education and socialization" (Montessori, 1949, p. 31). This is elaborated in the chapter on the sensitive periods.

Neuroscientists have shown that emotional connectivity and stability are important for optimal brain development, and disorders of emotional relations cause strain in the development as they have an unstable impact on existing neural connections (Beck, 2003). The contributions of research initiatives that connect neuroscience, cognitive sciences and childhood development are by all means foundations for modeling educational practice (Busso & Pollack, 2015; Jurčević & Lozančić, 2018). Van der Meulen et al. (2014) define educational neuroscience as an interdisciplinary or transdisciplinary field whose objective is educational practice and connecting two main disciplines: neuroscience and educational science. Therefore, a neuroscientist's research area includes not only research in neuroscience but also assuming responsibility for the relevance and benefit of neuroscience in upbringing and education (Meulen et al., 2015). Montessori sees two perspectives. In the first she claims that the "system of rewards and punishments", moralizing or emotional manipulation with the purpose of adopting certain behaviour can be fruitful "for five minutes" after which a child returns to his/her previous behavioural pattern (Montessori, 1949, p. 323). Her second perspective, which is in fact the leitmotif of her entire pedagogy, is that the body is a "reflection of the unity of the mind (intelligence), spirit and emotions" (Montessori, 1949, p. 215). Therefore, further in this paper, in the chapter on special sensitivity, an in-depth look will be provided into how an encouraging or insensitive environment contributes to the development of child's competences, or lack thereof.

The sensitive period: What goes on in the brain?

"Sensitive periods are periods in which pronounced tendency is shown towards accepting certain types of stimuli to which the organism reacts spontaneously and which come about periodically during development" (Philipps, 2003, p. 38).

Maria Montessori discusses a special sensitivity that occurs in an exact period of the child's development when the brain is most sensitive to creating new neural links. These links are a genetically preconditioned and internal process in which instincts nudge the child towards a certain activity. Montessori stresses that during this period a sensitized and encouraging environment is very important (Montessori, 1949).

Philipps (2003) also analyzes the significance of the interaction between a child's genetic precondition and social environment in the said developmental stages. In order for us to fully understand that idea, Philipps (2003) explains that during her development, a child accepts new amounts of information from his/her environment which she/he does not only notice and store but also shapes into own cognitions and knowledge. Montessori (1949) agrees when she talks about the importance of an encouraging environment sensitized for the child's (current) needs. In addition, Philipps (2003) explains that reason begins to discern patterns, connections and similarities, and then even the subtle differences between acquired information, by organizing, sorting and labeling certain impressions. Language also becomes involved in labelling, which creates the concept of understanding that leads to creating abstractions. Connections are made between similar experiences, which is what neurologists call creating neural paths for specific types of stimuli: the more experiences, the faster the paths and flow of information on them. If an experience of some kind is missing, the brain dissolves the inactive cells. This is how scientists were able to establish that reason is developed in conceptual form ever since the earliest age (Philipps, 2003).

From birth, human reason organizes and regulates perceptive experiences and the brain undergoes physical alterations under their influence (Philipps, 2003). While still in the uterus, a child initiates the fundamental processes of creating schemes in reason (Montessori, 1949; Philipps, 2003), which will be discussed later on. Montessori refers to these schemes as sensitive periods which she divides into six areas. By following the biology of human development, Maria Montessori divides a child's development into three basic six-year stages up to 18 years of age, further dividing each stage into smaller stages of three years (Montessori, 2007). In each of these periods a child matures in certain developmental areas. What Montessori especially points out is the importance of pedagogic action in identifying the developmental stages. Encouraging the development of child's competences specific to a developmental stage leads to child thriving. If, however, the competences are ignored or timely opportunities missed, the child will have a hard time compensating and ultimately fewer chances of achieving optimal development (Montessori, 1912, 1949). It is said that in certain Montessori developmental periods a child will acquire certain competences easier than in others. Montessori thereby attaches equal importance to the care of not only the cognitive and psychomotor development but also the emotional development of the child. If learning is adapted to the child under consideration of the so-called sensitive period of development in which the child currently is, it is clear that the competences that Montessori attributes to a developmental stage are acquired "with ease and enthusiasm" (Standing, 1983, p. 133).

Spiritual embryonic stage: Categorizations, motoric and language competences

Montessori refers to the first stage – child's first three years of age – as the spiritual embryonic stage when the child acts as an "unconsciously absorbent mind", intensively

and unconsciously "absorbing" experiences that will define his/her behavioural patterns for life (Montessori, 1949, p. 57).

The sensitive period for order appears first in this stage in the first few months of the child's life, becoming particularly evident at around 18 months of age. Montessori interprets it as the need for internal orientation which helps the child understand its environment and make categorizations of what it perceives in order to feel safer, become more oriented and explore (Montessori, 1949).

The sensitive period for movement begins in the prenatal period with the child's movement, stretching and turning in the uterus. After birth, first movements include head-turning, crawling, rolling, grasping at things with arms and legs, putting things in the mouth, sitting, standing, and finally – walking. Unlike adults, whose movements have a particular purpose, children move only to move, as soon as they have acquired a new motoric skill. Montessori stresses the importance of moving in early childhood, ensuring a safe and encouraging environment, and the need to provide children with items they could carry, pull or push in order to develop upper-body motor skills, balance and spatial orientation. According to Montessori, the last part of this stage is fine motor skills development (Montessori, 1949).

The sensitive period for small objects occurs at around 6 months of age. A child is intensely focused on noticing details and very small parts that make up a whole, which helps it to construct an understanding of the world. Montessori refers to it as a "phenomenon related to programming global and individual functional systems in the brain. The perceptive process is programed by unifying all sensory information into a coherent whole, gradually developing the consistency of perceptions" (Philipps, 2003, p. 41). It is in this ever-so mobile period that the child shifts its focus onto small objects such as pebbles, blades of grass or beetles, or whatever it can take ahold of.

The sensitive period for speech begins in the uterus. The child recognizes the mother's voice and sounds from the environment and, from the moment of birth, the child is especially focused on the speech of the closest person in upbringing. By the age of five, the child will have acquired the basic speaking skills and the ability to form sentences in at least one language. During primary education, the child's speech improves as long as the basic speech structures were acquired in the first five years of life. The child unconsciously absorbs language structures, imitates them since birth, and attempts to perfect the language by reproducing it. The child can receive information in several languages at once and simultaneously acquire it in the correct manner. Montessori states that everyday speaking and talking in the child's environment is essential (Montessori, 1949).

Social embryonic stage: How we become aware of ourselves and our environment

Social embryonic stage (a consciously absorbing mind) begins at around the third year of age with the child expressing her/his ability to control her will and becoming

interested in social and cultural aspects of his/her environment. The end of the stage is the acquisition of social competences and individuality, empathy, and readiness to receive a formal education (Montessori, 1949).

The sensitive period for refinement of senses, analyzed from the moment of birth, looks at how the child responds to stimuli through the five senses. The active senses – sight and hearing – are the first and, as the child gradually develops motoric skills, the sense of touch begins to assume a great role, followed by the sense of taste. As soon as the child starts moving, it starts taking things and putting them in the mouth, which reveals a fascinating fact: the development of one sense creates the predisposition for the development of another. In that way, senses complement one another and aid each other's development (Isaacs, 2018; Montessori, 1949; Stoll & Lillard, 2005).

During *the sensitive period for social behavior*, we gain an insight into the human evolutionary aspect: how to shape and sustain a group. Already at the age of 2.5 or 3, the child becomes aware that he/she is a part of a group. She begins to express intense interest in other children of the same age and the child then gradually engages in cooperative play. Montessori believes that this sense of cohesion is not part of education but a spontaneous occurrence managed by sheer instinct. She also emphasizes that all aspects that arise from that instinct (empathy for the group, the feeling and need to belong, social skills development) are products of the long-term process of maturation. With time, the child also adjusts to the social behavior of adults, gradually acquiring social norms (Montessori, 1949).

Ages 6 to 18: Maturation and growing up

Montessori (1949) claims that the periods of childhood (ages six to twelve) and adolescence (ages twelve to eighteen) are non-intense periods of calming down in terms of the child's development. This is the period in which children advance their social skills by acquiring new competences that will develop into cognitive skills in further lifelong learning (Blakemore & Frith, 2005) and academic pursuits. For the cognitive and emotional development to be optimal, scientists say that a trustworthy and supportive person is the most important for the child during this period.

Evidence from the area of psychology and neuroscience

Based on technological developments, neuroscience can today submit additional concrete and tangible evidence of pedagogic postulates put forward by Maria Montessori, by showing the developmental stages of the child's growing up. Jovančević claims that "new technologies have enabled us to understand a whole world, what goes on and what factors affect early brain development. On the one hand, this is what we inherit – genes and program that determine our brain's developmental potentials; but on the other hand, there are external influences that determine to what extent these potentials will develop. Without a harmonized mutual action between the two, there is no harmonized nor complete brain development (2007, p. 2).

We are born with an exact number of neurons, but what makes us so different are the synapses specific to each person (Vasta et al., 2005). This confirms the Montessori's upbringing focused on human individuality (Montessori, 1949). Until the age of three, the network of synapses and neurons keeps growing as long as there is appropriate stimulation. If the latter is absent, acquired synapses disappear. After the age of three, there is a slowed development of synapses which lasts until the age of 20. All the synapses that we do not use disappear (Vasta et al., 2005). Therefore, it is essential to examine, follow and honor the demands of developmental stages and sensitive periods suggested by Maria Montessori, who stresses the significance of an encouraging environment, i.e. the motivating engagement by educators (Montessori, 1949). A child's brain comprises all the brain cells it will ever need in life in order to learn. The brain of a newborn has all the tools required to develop speech, language, balance, coordination, primary functions, and sensory activities. Brain development, growth, and functions are fascinating. During the first six months, the brain is focused on motoric skills and sensory processing for the refinement of the senses (hearing, taste, sight, smell, and touch). All this prepares the brain for more complex learning (Vasta et al., 2005). These findings lead us towards Montessori pedagogy which postulates that a child has predispositions to acquire new and upgrade existing knowledge, whereby it is essential that we know how the mechanism of acquisition works and which brain functions are responsible for it and at which point in time (Montessori, 1949).

Maria Montessori presumes a child's emotional stability is required for optimal development (Montessori, 1949). Chabot and Chabot (2009) emphasize the importance of 'emotional brain' in learning processes, stressing the significance of creating cognitive competences as encouragement for acquiring emotional ones. They believe that learning strategies must first and foremost focus on the understanding of the importance of emotions and emotional competence as key parts of the learning process, which they also refer to as emotional intelligence. Emotional learning begins at a very early age when children discover their wide range of emotions, which develop as they grow. To better grasp the key stages of emotional development and their impact, the mutually connected skills and factors that impact emotional competence, it is essential to take into consideration the brain processes that participate in that complex development. Velički and Topolovčan (2017) point out that emotions are exceptionally important in the learning process and that it is impossible to separate emotion from cognition.

Contemporary research: The links between Montessori pedagogy and educational neuroscience

In accordance with Montessori pedagogy (Montessori, 1949, 1989, 2007), contemporary neuroscientific research shows that children who face deprivation or lack of stimulation of certain functions during formative developmental stages will lack the neurons in that part of the brain. Research has also proven brain plasticity. The human brain can adapt and produce new neurons during its life (Blakemore & Frith, 2005).

During the 1970s and 80s, Yussen et al. (1980) carried out two independent experiments in which they compared four-year-olds from three Montessori and regular preschools ($N = 60$). They followed up on similar research they had conducted in 1976 (cf. White et al., 1976). The children were given three socio-cognitive tasks and two cognitive tasks. According to Piaget (1977), the social environment thought follows the same pattern of cognitive changes as does the physical environment thought. Therefore, the authors believed that their research should include the preschool curricula that affect physical thought by simultaneously altering the child's thought about its social world. By referring to their previous experiment (cf. White et al., 1976), the authors (Yussen et al., 1980) proceeded from the fact that the Montessori program accelerates the acquisition of certain skills in reference to the physical environment, which can also improve cognitive abilities with reference to the social environment. They acknowledge the credit of Montessori didactics in teaching social skills and group activities. Montessori children did well in recognition tasks and the Montessori curriculum affects the development beyond the limitations of cognitive skills acquired during lessons (Yussen et al., 1980).

In an Australian piece of research conducted in Melbourne, Van der Ploeg et al. (2013) introduced activities based on Montessori pedagogy to try and reduce the accompanying negative symptoms in people suffering from dementia. The unsettling behaviour of these patients, such as aimless wandering, roaming around, aggression and insulting, was stressful and difficult to treat. As these conditions arise from pain, depression or psychosis, they are treated with analgesics, antidepressants or antipsychotics, which is why more attention is being shifted to non-pharmacological treatments. The aim of that study was therefore to implement personalized activities based on Montessori principles of interacting one-to-one. Considering the activities carried out, a study was conducted to see if these activities reduce the dementia-caused behaviours significantly more than the relevant control state. Research participants ($N = 44$) were divided randomly into Montessori and control groups two weeks, after which they would switch groups. The results showed that the frequency of undesirable behaviors reduced significantly during Montessori and control activities, compared to earlier ones. During the Montessori activities, participants spent twice as much time focused on an activity than in controlled conditions, and a more positive impact and increased interest by the respondents were also noticed (Van der Ploeg et al., 2013).

The performing functions are cognitive abilities that enable us to mentally manipulate ideas in order to solve problems in everyday life, classifying these abilities into three categories: inhibition, working memory, and cognitive flexibility. If these functions are underdeveloped, misdiagnoses of disorders such as ADHD and other learning difficulties are possible. Montessori pedagogy developed when performing functions were still unknown. Research has shown that Montessori activities encourage the development of performing functions such as waiting, looking for an item in a labyrinth created by children while doing other activities, etc. Research has also indicated that

children that attended Montessori preschools were better at carrying out cerebrospinal processes (Lillard, 2016).

When an adult performs an activity, the same parts of the brain are activated as when children do it. This neural empathy helps to imitate the activity of another person, for example, make the same movements. Credited with that ability are the so-called mirror neurons – visual motor neurons which identify and categorize movements depending on their purpose, attributing that purpose to a certain context (Iacoboni, 2012). Iacoboni (2012) believes that mirror neurons offer a considerably convincing explanation for complex forms of social cognition and interaction, helping to understand actions by other people. This is also what Montessori (1949) discovered through observation and research, and it later turned out that these types of neurons are found in the frontal lobe of the brain. She connected these facts with the importance of the pedagogic role of social interactions and behavior, particularly the activities carried out by educators.

Montessori activities demand movement (Montessori, 2012) and a sensible manipulation of materials as learning aids. Other pieces of research have shown that a lot more systems are engaged in movement than previously thought (Pinel, 2002; Van der Meulen et al., 2015; Van der Ploeg et al., 2013). Apart from the primary motor cortex, movement control includes the interaction between many other brain areas, including basal ganglia, thalamus, hinder brain, and a great number of neurons located within the cerebellum and the brainstem (Pinel, 2002). Montessori established that a child's intelligence can develop to a certain level without the help of its arms, in terms of motoric activities. But if intelligence is developed by the use of arms, the level that the child's intellect then achieves is even higher (Montessori, 1949). She claimed that arms are instruments of human intelligence and that they help in the development of sensory organs and coordination (Montessori, 1949).

Discussion

Many contemporary pedagogues stress that today, perhaps more than ever before, the perspective of upbringing and education needs a change (Isaacs, 2018; Jurčević Lozančić, 2018; Von Hentig, 2003). Hartmut von Hentig (2003) discusses the changes and situation in the world and the society which affects that change. However, some pedagogues emphasize the connection between modern technology and youth development, considering the prevalence of media in the everyday lives of young people and its impact on child psychomotor development (Eret, 2018; Spitzer, 2014). It is important to state that didactic trends must be followed so that we would know how to approach a child with difficulties in the teaching program, especially in terms of inclusion into the regular teaching program which is what most school systems today tend to do (Hastings & Oakford, 2003). It can be stated that the most important thing to consider is not only the child's cognitive development but even more his emotional state, the development of psychological competences, and independency in research (Chabot & Chabot, 2009; Iacoboni, 2012; Montessori, 1949; Velički & Topolovčan, 2015; Perković et al., 2017).

From early on, Maria Montessori showed that the pedagogy of her approach, methods, strategies and didactic materials brings irrefutable results and progress (Montessori, 1912, 1949, 1989, 2007). Today neuroscience proves this in form of tangible scientific indicators of Montessori's deductions of observing the behavior of children (Beck, 2003; Blakemore & Frith, 2005; Busso & Pollack, 2015; Isaacs, 2018; Van der Meulen et al., 2015). The facts of Montessori pedagogy and contemporary educational neuroscience are supported by many pieces of research among different age groups, proving that the individualization of didactic approach can have a positive impact on developmental and behavioral difficulties (Hastings & Oakford, 2003). Further consideration and research must also examine how to use these scientific indicators to shape the curriculum, in which teaching methods and strategies would be selected based on traits, competences, and affinity of the child. This must also take into consideration that for an optimal operation of brain functions there needs to be a unification of simultaneous striving towards the development of cognitive, psychomotor, and affective abilities and skills (Chabot & Chabot, 2009; Montessori, 1912, 1949; Velički & Topolovčan, 2015; Perković et al., 2017).

Conclusion

The framework of Montessori pedagogy, which points to the interdependence and connection of caring for the child emotional development, promotion of his/her motor skills and independence with advancement in his/her developmental stages, were pioneering at the time and supported by numerous scientific research referred to or conducted by Maria Montessori herself (Montessori, 1912, 1949, 1989, 2007). Today, in turn, many scientists in the fields of neuroscience, neurobiology and neurodidactics look for the causal links between behavior and upbringing of the individual and the functioning of the brain (Blakemore & Frith, 2005; Busso & Pollack, 2015; Jovančević & Ježić, 2007; Pinel, 2002).

In contemporary research, Jovančević (2007) recalls that, in the upbringing of an individual, it is necessary to consider the interdependence of child genetic predispositions and (educational) influences of the environment. Today's child (educational) environment necessarily implies digital technology, so it is adviseable for the following research of this area to consider the influence of digital media on the neurological development of the child and the association with the selection of Montessori didactic materials (Eret, 2017; Montessori, 1912; Spitzer, 2014). The individuality of each child along with its developmental environment will cause either development or non-use and, consequently, deterioration of certain synapses. Therefore, the authors point out that the stimulating educational environment and didactic materials appropriate to a child certain developmental stage are the basis of the educator's action (Hebb, 2005; Montessori, 1949, 1989, 2007; Philipps, 2003; Vasta et al., 2005). It is even possible, due to the stimulating environment, to rebuild the brain by adapting or producing new neurons (Blakemore & Frith, 2005). Scientists also point to the fact that today's

neuroscience has proven that the emotional and cognitive development of a child are interdependent (Chabot & Chabot, 2009; Montessori, 1949; Velički & Topolovčan, 2017). Regardingly, socialisation plays an essential role (Iacoboni, 2012). Thus, research in the field of neurodidactics has shown that the implementation of Montessori pedagogy and materials into the educational environment leads to the improvement of the cognitive skills of four-year-olds (White et al., 1976; Yussen et al., 1980), helps dementia patients benefit in favour of concentration and motivation (Van der Ploeg et al., 2013), encourages the development of certain executive functions and cerebrospinal processes (Lillard, 2016), and encourages the development of mirror neurons responsible for the adoption of social skills and patterns of social behavior (Iacoboni, 2012; Montessori, 1949). Maria Montessori's assertion (1949) that intelligence is being developed by sensory organs, motorical abilities and coordination is now backed up by scientists with the latest research. They proved that for motor skills more systems than was previously thought need to be activated (Pinel, 2002; Van der Meulen et al., 2015; Van der Ploeg et al., 2013), that is, the function of many and different brain parts are necessarily associated with movement.

At the moment when the modernisation of education and teaching is considered, and thus the redefinition of the teaching curricula, it will reflect on what science and practice have shown to be effective in modern standards. The success of Montessori teaching methods, procedures and didactic materials, proven by modern research in the field of neuroscience and neurodidactics, can be used as a framework in this process (Iacoboni, 2012; Lillard, 2016; Van der Meulen et al., 2015; Van der Ploeg et al., 2013; White et al., 1976; Yussen et al., 1980). This is especially the case when research indicators show Montessori pedagogy and individualization of the didactic approach as a condition for the positive impact on developmental and behavioural difficulties (Hastings & Oakford, 2003). This work is also an incentive for further considerations on the adaptation of Montessori pedagogy at different levels of the educational system, in particular in terms of the effectiveness of the implementation of digital media and content for potential virtual teaching purposes (Eret, 2017; Spitzer, 2014).

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Potvrde postulata Montessori pedagogije u suvremenoj obrazovnoj neuroznanosti

Sažetak

U ovom radu daje se uvid u osnovne postulate Montessori pedagogije i definicije suvremene obrazovne neuroznanosti, orijentirajući se prema potrebama i rješenjima za suvremene didaktičke pristupe. Prikazom rezultata suvremenih istraživanja rad povezuje dostignuća Montessori pedagoških metoda i strategija sa znanstvenim pokazateljima obrazovne neuroznanosti o načinima pozitivnoga utjecaja na razvoj pojedinca. Rezultati istraživanja obrazovne neuroznanosti potkrijepit će postulate Montessori pedagogije da je za odgojni pristup važno razumijevanje razvojnih faza odrastanja, individualnosti kompetencija i specifičnosti odgajanika. Specifičnim primjerima naglasit će se da je uz kognitivne, bitno razvijati psihomotorne i afektivne kompetencije, odnosno da je razvoj ovih sfera ličnosti povezan i međuovisan. Ponuđenom pedagoškom perspektivom rad ukazuje na potrebu daljnjega razmatranja kako pristupiti oblikovanju optimalnih kurikula. U radu se sugerira da je upravo zbog različitih društvenih i tehnoloških promjena potrebno razmišljati o pedagoškim metodama, strategijama i pristupima Montessori pedagogije, što podržava i potkrepljuje suvremena obrazovna neuroznanost.

Ključne riječi: *didaktika; Montessori pedagogija; neurodidaktika; neuroznanost.*

Uvodna razmatranja

Marija Montessori smatra se jednim od pionira pedagogije ranoga odgoja i obrazovanja čime je pridonijela suvremenom razumijevanju pedagoških principa. Ukazala je na cilj razvijanja individualnih djetetovih potencijala tako da djeca aktivno uče i spoznaju vlastitim odabirom (Isaacs, 2018). Montessori princip učenja istraživanjem je pokazao da razvija samostalne, samosvjesne i znatiželjne pojedince „glasnike socijalne promjene" (Isaacs, 2018, str. 10). I prije nego što je 1907. godine osnovala Casa dei Bambini, Maria Montessori je svojim izlaganjima na europskim konferencijama ostvarila reputaciju na temelju zagovaranja učenja putem osjetila, stoga ne čudi da je danas preko 16 000 škola u svijetu prihvatilo Montessori etos (Isaacs, 2018).

Obrazovna neuroznanost omogućila je simbiozu biologije, neurologije, kognitivne psihologije, pedagogije i didaktike. Koherentnost navedenih znanosti dovodi do

zaključka da je u radu s djecom važno razumijevanje spoznaja koje imaju odlučujući utjecaj za napredak i razvijanje novih strategija učenja. Interdisciplinarnost obrazovne neuroznanosti objašnjava načine kako genetsko nasljeđe i formirano okruženje utječu na procese učenja i kako odgojitelji i učitelji mogu u skladu s tim unaprijediti svoju praksu (Pinel, 2002).

Životom i radom Maria Montessori stvorila je pedagogiju spajajući dostignuća navedenih znanosti specifičnim osobnim iskustvom. Tako možemo reći da je krenula putem obrazovne neuroznanosti 1896. godine time što je postala doktoricom medicine (Thayer-Bacon, 2012). Kako je medicinsku praksu dalje nastavljala radeći u bolnici i privatnoj praksi, držeći nastavu na fakultetima, a zatim i provodeći istraživanje na psihijatrijskoj klinici, tako je, u neuroznanstvenom smislu, dolazila do temelja za postulate nove pedagogije i didaktike. Upravo je ovim znanstvenim putem mogla objediniti vlastita saznanja iz područja ljudske (dječje) biologije i neurologije, odnosno razvojne psihologije kojima je došla do epohalnih otkrića za suvremenu pedagogiju i didaktiku. Pristupom koji je primjeren dobi, sposobnostima i razvojnoj fazi pojedinoga djeteta, skinula je s djece psihijatrijske klinike stigmu mentalno ograničenih utvrdivši da se radi o odgojnoj zapuštenosti. Kasnijim pedagoškim radom upotrijebila je iste odgojne mehanizme i tako postavila odgojni uzor suvremene didaktike (Thayer-Bacon, 2012). Ovim radom proučit ćemo korelacije spoznaja znanstvenih dostignuća u smjeru pedagogije koje nam je već tada predočila Maria Montessori i onih koje nam donosi suvremena obrazovna neuroznanost kako bismo sugerirali njihovu povezanost i fascinirajuću međuovisnost.

Obrazovna neuroznanost i kako je čovjekovom biopsihologijom započela M. Montessori

Sami začetci obrazovne neuroznanosti javljaju se sredinom 19. stoljeća objavom knjige *The organization of behavior: A neuropsychological theory* D. O. Hebba (Pinel, 2002). Hebb (2005) je dao novi pogled na promišljanje o povezanosti psihološkoga funkcioniranja i fiziologije mozga. Preteča obrazovnoj neuroznanosti je kognitivna neuroznanost kao najmlađa grana biološke psihologije. Biološka psihologija kao neuroznanstvena disciplina prvenstveno promatra biologiju ponašanja, odnose između psiholoških procesa i temeljnih fizioloških događaja ili, drugim riječima, fenomena povezanosti uma i tijela (Hebb, 2005). Kognitivna pak neuroznanost preklapa se s disciplinama kao što su fiziološka psihologija, kognitivna psihologija i neuropsihologija kako bi nam dala odgovor na pitanja kako su kognitivne aktivnosti pogođene ili kontrolirane neuronskim krugovima u mozgu. Ona proučava biološke procese i aspekte koji su temelj kognicije s posebnim naglaskom na neuralne veze u mozgu uključene u mentalne procese (Pinel, 2002). Obrazovna neuroznanost razmatra ljudsko ponašanje tako da nastoji utvrditi što čini okruženje za učenje i koji su to procesi učenja potkrijepljeni prirodnim strukturama mozga. Vodi se činjenicom da mozak i tijelo svjesno i nesvjesno uče bez prestanka i zato se strukture procesa učenja

i kontekst moraju prilagoditi razvoju bioloških i fizioloških stanja mozga (Slika 1).

Tako će Maria Montessori još 1949. godine u revolucionarnoj knjizi *Absorbent mind* krenuti s analizom biopsihologije djeteta već od faze stvaranja i diobe stanica. Pozvat će se na istraživanja provedena 14 godina prije publiciranja navedene knjige, a koja su čak i napravljena neovisno, jedno u Americi, drugo u Engleskoj. Montessori nam svraća pozornost na to da se svaka stanica, koja će kasnije tvoriti organ i cjelokupni organizam, temeljno sastoji od tri 'zida'. Svaki od ta tri zida tvorit će kasnije organe. Vanjski zid stvara kožu, senzorne organe i živčani sustav, unutarnji vitalne (unutarnje) organe, a srednji koštani i mišićni sustav. Montessori je fascinirana s nekoliko podataka koje iz ovoga možemo zaključiti. Jedno je da se živčani sustav stvara iz iste tvorevine kao i koža, a koja je nervima (osjetima) povezana s okolinom: sudjeluje u interakciji podataka organizma s okolišem, a ujedno ga od okoliša i štiti. Drugo, da je struktura stanice zapravo funkcionalno odraz kasnijega organizma, s obzirom na to kako su 'zidovi' razmješteni u odnosu jedan na drugog (unutarnji organi zaštićeni u unutarnjem sloju, koštani i mišićni sustav povezuje s kožom i živčanim sustavom). Treće, da je biće kao cjelina zapravo već određeno već u ovoj fazi, govoreći o genetskim predispozicijama. I, na koncu, što će činiti veliki korak i za njezine daljnje znanstvene i pedagoške postulate, a što je bilo u skladu s istraživanjima koji su njezini kolege prikazali 1929. i 1930. godine, da će se ubrzani razvoj stanica za pojedini organ dogoditi u točno određenoj 'točki senzibilnosti', a o tome će još biti riječi u kasnijim poglavljima.

Uloga iskustva i emocija u usvajanju podataka i oblikovanju ponašanja

Obrazovna neuroznanost danas daje odgovore na pitanja o radu i funkcijama mozga zahvaljujući metodama snimanja magnetskom rezonancijom. Kako i zašto dijete koristi svoj mozak odlučuje međusobna povezanost između milijardu živčanih stanica dobro izgrađenih i stabiliziranih i onih koji su nedovoljno razvijene i oblikovane. Da bi ova međusobna povezanost bila u mogućnosti formirati se, djeca moraju imati što je više različito doživljenih vlastitih iskustava (Perković, Opić i Rijavec, 2017; Pinel, 2002).

Slika 1.

Prema tome, Maria Montessori (1912), pozivajući se na razvojnu psihologiju i vlastito znanstveno iskustvo, naglašava da rani odgoj i obrazovanje možemo pravilno usmjeriti tek ako razumijemo razvoj djeteta. Ključne razvojne faze postavlja u period života do 18 godine, a napominje važnost prve tri godine života. Beck (2003) dopunjuje kako je kod djece brzina učenja izrazito visoka. Montessori navodi da je kumulativni intenzitet djetetovih transformacija, prilagodbi, uspjeha i postignuća u prve tri godine ekvivalentan intenzitetu istih od treće godine života pa do smrti. Zato i kaže kako su, prema tome, s razvojnoga (kognitivnoga i pedagoškoga gledišta) „prve tri godine duge kao i cijeli život" (Montessori, 1989, str. 19). Među prvim je pedagozima bila zagovornikom važnosti prvih šest godina života, navodeći ih „značajnijima nego godinama studija,

u odgojno-obrazovnom i socijalizacijskom smislu" (Montessori, 1949, str. 31). Više o tome elaborirat će se u poglavlju razdoblja posebne osjetljivosti.

Neuroznanstvenici su pokazali da je za optimalan razvoj mozga bitna emocionalna povezanost i stabilnost, a poremećaji emocionalnih odnosa donose u razvoj opterećenje i imaju nestabilne utjecaje na već postojeće neuronske veze (Beck, 2003). Svakako su zato doprinosi istraživačkih inicijativa koje povezuju neuroznanost, kognitivne znanosti i razvoj djeteta temelji za oblikovanje odgojno-obrazovne prakse (Busso i Pollack, 2015; Jurčević Lozančić, 2018). Van der Meulen, Krabbendam i Ruyter (2015) obrazovnu neuroznanost definiraju kao interdisciplinarno ili transdisciplinarno polje čiji je cilj obrazovna praksa te povezati dvije glavne discipline: neuroznanost i obrazovne znanosti. Područje djelovanja obrazovnoga neuroznanstvenika zato obuhvaća ne samo istraživanja iz područja neuroznanosti, nego i preuzimanje odgovornosti o primjenjivosti i korisnosti neuroznanosti u odgojno-obrazovnom kontekstu (Meulen i sur., 2015). Montessori o tome govori iz dvije perspektive. Prva je, da „sustav nagrada i kazni", moraliziranje ili pak emocionalno manipuliranje kako bi se usvojilo određeno ponašanje može uroditi plodom „na pet minuta" i zatim će se dijete vratiti svom obrascu ponašanja (Montessori, 1949, str. 323). A druga je, koja se zapravo kao lajtmotiv provlači kroz cijelu njezinu pedagogiju, da je tijelo „refleksija jedinstva uma (inteligencije), duha i emocija" (Montessori, 1949, str. 215). Zato će kasnije, u poglavlju razdoblja posebne osjetljivosti biti detaljno riječi kako poticajna ili pak neosjetljiva okolina doprinosi (ne)razvoju djetetovih kompetencija.

Razdoblja posebne osjetljivosti: što se događa u mozgu?

„Razdoblja posebne osjetljivosti jesu razdoblja u kojima je izražena posebna sklonost primanju određenih vrsta podražaja na koje organizam spontano reagira, a koja tijekom razvoja periodično nadolaze" (Philipps, 2003, str. 38).

Maria Montessori govorila je o posebnoj osjetljivosti koja se javlja u točno određenom periodu djetetova razvoja i upravo je tada djetetov mozak najprijemčiviji za stvaranje novih neuronskih veza. Ona su genetski uvjetovana i unutrašnji su proces u kojem instinkti potiču dijete na određenu aktivnost. Montessori naglašava da je iz toga razloga bitna okolina koja je senzibilizirana i poticajna (Montessori, 1949).

O značaju interakcije djetetove genetske uvjetovanosti i društvene okoline u ovim razvojnim fazama govori i Philipps (2003). Kako bismo to u potpunosti razumjeli, Philipps (2003) objašnjava da dijete tijekom svojega ranog razvoja prihvaća veliku i novu količinu informacija iz okoline, a koju nije dovoljno samo zapaziti i pohraniti nego i oblikovati u vlastite spoznaje i znanja. Osjetne dojmove i informaciju o fizičkoj stvarnosti proširuju emocije i osobni odnos prema njoj. S time se slaže i Montessori (1949) kada govori o značaju poticajne okoline senzibilizirane za djetetove (trenutačne) potrebe. Philipps (2003) zatim objašnjava da razum počinje razlučivati obrasce, veze i sličnosti, a potom i fine razlike među usvojenim informacijama, organizirajući,

razvrstavajući i obilježavajući dojmove. Pridružuju se jezične oznake tim obilježjima čime se gradi koncept razumijevanja koji vodi stvaranju apstrakcija. Oblikuju se veze među sličnim iskustvima pa neurolozi govore o stvaranju neuronskih puteva za određene vrste podražaja: što je više iskustava, put je brži i informacije njime lakše teku. Nema li iskustava određene vrste, mozak razgrađuje neaktivne stanice. Tako su znanstvenici utvrdili da se razum razvija u obliku koncepata od najranije dobi (Philipps, 2003).

Ljudski razum od rođenja uređuje i organizira perceptivna iskustva i mozak se fizički mijenja pod njihovim utjecajem (Philipps, 2003). Dijete još intrauterino započinje temeljne procese stvaranja shema u razumu (Montessori, 1949; Philipps, 2003) o čemu će još u ovom poglavlju biti riječi. Montessori imenuje te koncepte i sheme razdobljima posebne osjetljivosti koje je podijelila u šest područja. Slijedeći biologiju ljudskoga razvoja, Maria Montessori djetetov razvoj dijeli u tri osnovne šestogodišnje faze do osamnaeste godine života, svaku dijeleći na manja razdoblja od po tri godine (Montessori, 2007). Specifično za svaki od tih perioda, dijete sazrijeva u određenim područjima razvoja. Ono što Montessori posebno ističe jest važnost pedagoškoga djelovanja u prepoznavanju razvojne faze. Poticanje razvoja kompetencija specifičnih za razvojnu fazu dovodi do procvata djeteta. Ako se pak zanemare ili propuste pravovremene mogućnosti, dijete će ih kasnije puno teže nadoknaditi, a smanjenih mogućnosti da se postigne optimum (Montessori, 1912, 1949). Kažemo kako će u određenim Montessori periodima razvoja, dijete neke kompetencije usvojiti lakše nego u drugima. Pritom Maria Montessori jednaku važnost daje brizi ne samo o kognitivnom i psihomotoričkom, već emotivnom djetetovu razvoju. Kada se učenje djetetu prilagodi s obzirom na tzv. „senzitivno razdoblje" razvoja u kojemu se nalazi, tada se uočava da kompetencije koje Montessori pridružuje toj razvojnoj fazi djeca svladavaju s „lakoćom i entuzijazmom" (Standing, 1984, str. 133).

Spiritualna embrionska faza: kategorizacije, motoričke i jezične kompetencije

Prvu fazu, koja se odnosi na prve tri godine djetetova života, Montessori naziva „spiritualna embrionska faza", kada se dijete ponaša kao „nesvjesni upijajući um" intenzivno, a nesvjesno, 'upijajući' iskustva koja će mu obilježiti obrasce ponašanja za cijeli život (Montessori, 1949, str. 57).

Razdoblje posebne osjetljivosti za red pojavljuje se prvo u ovoj fazi i to u početnim mjesecima djetetova života, a posebno je očito oko 18. mjeseca starosti. Montessori ga tumači kao potrebu za unutarnjom orijentacijom kod djeteta koja mu pomaže razumjeti okolinu i raditi kategorizacije percipiranoga, da bi se osjećalo sigurnim i da bi se moglo orijentirati i istraživati (Montessori, 1949).

Razdoblje posebne osjetljivosti za pokret počinje u prenatalnom razdoblju gdje se dijete u maternici kreće, okreće i rasteže. Nakon rođenja prvi pokreti očituju se u okretanju glave, puzanju, kotrljanju, hvatanju predmeta rukama i nogama, stavljanju stvari u usta, sjedenju, stajanju i, konačno, hodanju. Za razliku od odraslih, koji kretnje

rade s određenom svrhom, djeca kretnje rade samo da bi se kretala, čim usvoje neku novu motoričku vještinu. Montessori naglašava važnost kretanja u ranom djetinjstvu, osiguravanje sigurne i poticajne okoline i na potrebu za predmetima koje djeca mogu prenositi, vući i gurati kako bi razvijala motoriku gornjeg trupa, ravnotežu i prostornu orijentaciju. Kako ona navodi, posljednji stupanj ove faze je razvoj fine motorike (Montessori, 1949).

Razdoblje posebne osjetljivosti za male predmete javlja se oko šestog mjeseca života. Dijete se izrazito koncentrira na uočavanje pojedinosti i izrazito sitnih dijelova koji čine neku cjelinu, što mu pomaže izgraditi razumijevanje svijeta. Montessori je to uočila kao „fenomen u svezi s programiranjem globalnog i pojedinačnih funkcionalnih sustava mozga. Perceptivni proces se programira objedinjavanjem svih osjetnih podataka u skladnu cjelinu, postupno se razvija konstantnost percepcija" (Philipps, 2003, str. 41). Upravo u toj dobi kada postaje sve više mobilno, počinje usmjerenost djeteta na male objekte kao što su kamenčići, travke ili bube, sve što može dohvatiti.

Razdoblje posebne osjetljivosti za govor počinje već u maternici. Dijete prepoznaje majčin glas i druge zvukove okoline, a od trenutka rođenja prvenstveno je osjetljivo na govor najbliskijega odgojitelja. Do pete godine usvojit će značajne vještine govora i oblikovanja uzoraka rečenica barem jednog jezika. Tijekom primarnoga obrazovanja djetetove se govorne vještine unapređuju, pod uvjetom da je do prvih pet godina usvojena bazična govorna struktura. Dijete nesvjesno upija govorene jezične strukture, oponaša ih od rođenja i nastojati ih usavršiti reproduciranjem. Ono može primati informacije o više jezika istovremeno i pravilno ih simultano usvojiti. Montessori navodi ključnim svakodnevan govor i razgovor u djetetovoj okolini (Montessori, 1949).

Socijalna embrionska faza: kako postajemo svjesni sebe i okoline

Socijalna embrionska faza (svjesni upijajući um) započinje oko djetetove treće godine tako što dijete iskazuje svoju sposobnost da kontrolira svoju volju i interesira se za socijalne i kulturne aspekte svoje okoline. Završetak faze obilježava usvajanje socijalnih kompetencija i individualnosti, empatije i spremnosti za formalno obrazovanje (Montessori, 1949).

Razdoblje posebne osjetljivosti za poboljšanje osjetilnih sposobnosti promatramo od trenutka rođenja i kako dijete prima podražaje kroz pet osjetila. Prvo su aktivna osjetila vida i sluha, zatim postupno, kao se razvija motorika, veliku ulogu ima osjećaj dodira pa slijedi razvijanje osjećaja okusa. Čim se dijete počne kretati i može prinositi stvari ustima, zamjećujemo fascinantnu činjenicu: razvojem jednoga osjetila daje se predispozicija za razvoj drugoga. Tako se osjetila u toj međusobnoj nadopunjuju i potpomažu razvitak (Isaacs, 2018; Montessori, 1949; Stoll i Lillard, 2005).

U *Razdoblju posebne osjetljivosti za društveno ponašanje* dobivamo uvid u evolucijski aspekt čovjeka: kako oblikovati i održati grupu. Već u dobi od dvije i pol ili tri godine dijete postaje svjesno da je dio svojega kolektiva. Ono počinje pokazivati intenzivan

interes za drugu djecu svoje dobi i postupno se počinje igrati na suradnički način. Montessori je vjerovala da taj osjećaj kohezije nije usađen poukom, nego je nastao spontano i njime upravljaju iskonski nagoni. Također je naglasila kako svi aspekti koji iz toga proizlaze (empatija za grupu, osjećaj i potreba pripadnosti, razvijanje pojedinih socijalnih vještina) su produkt dugotrajnoga procesa maturacije djeteta. A s vremenom se dijete prilagođava i društvenom ponašanju odraslih, postupno usvajajući društvene norme (Montessori, 1949).

Od šeste do osamnaeste godine: maturacija i sazrijevanje

Montessori (1949) navodi razdoblja djetinjstva (od šeste do dvanaeste) i adolescencije (od dvanaeste do osamnaeste godine) kao neintenzivna razdoblja smirivanja s obzirom na djetetov razvoj. Ovo je vrijeme unaprjeđivanja socijalnih vještina novim kompetencijama koje će se nastaviti kao kognitivne vještine i u daljnjem cjeloživotnom učenju (Blakemore i Frith, 2005) i akademskoga usmjerenja. Kako bi bio optimalan kognitivni i emotivni razvoj, znanstvenici navode da je u ovom periodu za dijete najbitnija osoba od povjerenja i podrške.

Dokazi s područja psihologije i neuroznanosti

Neuroznanost danas, temeljem razvoja tehnologije, može podastrijeti još konkretnih i 'opipljivih' dokaza postulata pedagogije koju je konstruirala Maria Montessori prikazujući ove razvojne faze djetetova odrastanja. Tako Jovančević kaže „Nove tehnologije su nam omogućile upoznati cijeli jedan svijet i razumjeti što se događa i koji čimbenici utječu na rani razvoj mozga. S jedne strane je riječ o našem nasljeđu; o genima i programu koji određuju potencijale razvoja našeg mozga; no s druge strane, riječ je i o vanjskim utjecajima koji određuju u kojoj će se mjeri ovi potencijali razviti. Bez skladnog međusobnog djelovanja nema niti skladnog i potpunog razvoja mozga" (2007, str. 2).

Rađamo se s točno određenim brojem neurona, ali ono što nas čini toliko različitima su sinapse specifične za svakog pojedinca (Vasta, Haith i Miller, 2005). Time potvrđujemo Montessori usmjerenost odgoja za i prema osobnoj individualnosti (Montessori, 1949). Do treće godine života traje intenzivan rast mreže sinapsi i neurona, naravno, uz odgovarajuću stimulaciju. Ako izostane stimulacija, stečene sinapse propadaju. Nakon treće godine dolazi do usporenog razvoja sinapsi i to traje do desete godine. Sve one sinapse koje ne koristimo, propadaju i nestaju (Vasta i sur., 2005). Prema tome, itekako je značajno proučavati, pratiti i poštivati zahtjeve razvojnih faza i razdoblja posebnih osjetljivosti koje sugerira Maria Montessori, upozoravajući na značaj poticajne okoline, odnosno, motivirajući angažman odgojitelja (Montessori, 1949). Djetetov mozak sadrži u osnovi sve stanice mozga koje će mu ikada trebati za učenje kroz čitavo životno razdoblje. Mozak novorođenčeta ima sve alate za razvijanje govora, jezika, ravnoteže, koordinacije, primarnih funkcija i senzorskih djelovanja. Rast i razvoj mozga i njegove funkcije su fascinantne. Razvoj mozga tijekom prvih šest mjeseci života usredotočen je na motoričke vještine i senzornu obradu za poboljšanje naših pet osjetila (sluh, okus,

vid, miris i dodir). Sve to priprema mozak za veće učenje (Vasta i sur., 2005). Ova nas saznanja usmjeravaju kao i Montessori pedagogija da dijete ima predispozicije da usvoji nova i nadograđuje postojeća znanja, pri čemu je potrebno znati kako djeluje mehanizam usvajanja novih kompetencija te kada su i koje funkcije mozga za to pripravne (Montessori, 1949).

Maria Montessori pretpostavlja emocionalnu stabilnost djeteta za optimalan razvoj (Montessori, 1949). Chabot i Chabot (2009) naglašavaju važnost 'emocionalnog mozga' u procesima učenja naglašavajući stvaranje kognitivnih kompetencija kao poticaje za stjecanje onih emocionalnih. Smatraju da strategije poučavanja trebaju prvenstveno biti usmjerene na razumijevanje važnosti emocija i emocionalnih kompetencija kao ključnoga dijela procesa učenja koji još nazivaju emocionalnom inteligencijom. Emocionalno učenje počinje u vrlo ranoj dobi dok djeca otkrivaju širok raspon emocija i evoluiraju dok rastu. Za bolje razumijevanje ključnih faza emocionalnoga razvoja, njegovih utjecaja, međusobno povezanih vještina i čimbenika koji utječu na emocionalnu kompetenciju važno je uključiti i procese u mozgu koji sudjeluju u tom slojevitom razvoju. Velički i Topolovčan (2017) ukazuju da su emocije iznimno važne u procesu učenja i da je nemoguće odvojiti emocije od spoznaje.

Suvremena istraživanja: poveznice Montessori pedagogije i obrazovne neuroznanosti

U skladu s Montessori pedagogijom (Montessori, 1949, 1989, 2007), suvremena neuroznanstvena istraživanja pokazuju da će djeca koja se suočavaju s deprivacijom ili nedostatkom stimulacije određenih funkcija u osjetljivim razdobljima razvoja imati manjak neurona u zaduženom području mozga. Istraživanja su također dokazala mogućnost plastičnosti mozga. Ljudski se mozak može prilagoditi i proizvesti nove neurone tijekom svog života (Blakemore i Frith, 2005).

Sedamdesetih i osamdesetih godina prošloga stoljeća Yussen, Mathews i Knight (1980) provode dva nezavisna eksperimenta u kojima uspoređuju četverogodišnjake iz triju Montessori i triju tradicionalnih predškola ($N = 60$). Nadovezuju se na slično istraživanje koje su proveli 1976. godine (vidjeti: White, Yussen i Docherty, 1976). Zadana su tri sociokognitivna i dva kognitivna zadatka. Prema Piagetu (1977), misao o društvenoj okolini slijedi isti uzorak kognitivnih promjena kao i misao o fizičkoj okolini. Stoga su autori smatrali kako u istraživanje treba unijeti one predškolske kurikule koji utječu na fizičku misao tako da istovremeno mijenjaju djetetovo razmišljanje o svom društvenom svijetu. Pozivajući se na prethodni eksperiment (vidjeti: White i sur., 1976), autori (Yussen i sur., 1980) polaze od toga kako je pokazano da Montessori program ubrzava stjecanje određenih konkretnih vještina u odnosu na fizičku okolinu, a što može također poboljšati kognitivne sposobnosti s obzirom na društvenu okolinu. Uočavaju zasluge Montessori didaktike u poučavanju društvenih vještina i grupnih aktivnosti. Montessori djeca istaknula su se u zadatcima prepoznavanja dok Montessori kurikul utječe na razvoj izvan samih granica kognitivnih vještina koje se uče tijekom nastave (Yussen i sur., 1980).

Van der Ploeg, Eppingstall, Camp, Runci, Taffe i O'Connor (2013) u australskom istraživanju provedenom u Melbourneu uveli su aktivnosti utemeljene na Montessori pedagogiji kako bi nastojali umanjiti popratne negativne simptome koji se javljaju kod ljudi oboljelih od demencije. Uznemirujuća ponašanja ovih bolesnika kao što su besciljno koračanje i tumaranje, agresivnost i vrijeđanje su stresna i teško ih je liječiti. Kako ona proizlaze iz boli, depresije ili psihoze liječe se analgeticima, antidepresivima ili antipsihoticima, stoga se sve više pozornosti nastoji usmjeriti nefarmakološkim intervencijama. Zato je cilj ove studije bio uvesti personalizirane aktivnosti temeljene na Montessori principima interakcijom jedan-na-jedan. S obzirom na provedene aktivnosti istraženo je smanjuju li one učestalost ponašanja koji su simptomi demencije značajno više od relevantnoga kontrolnog stanja. Sudionici istraživanja ($N = 44$) raspoređeni su slučajnim odabirom u Montessori ili kontrolne grupe na dva tjedna, nakon čega bi zamijenili grupe. Rezultati su pokazali kako su se nepoželjna ponašanja značajno smanjila tijekom Montessori i kontrolnih aktivnosti u odnosu na prethodne. Tijekom Montessori aktivnosti ispitanici su dvostruko više vremena proveli usredotočeni na aktivnost nego u kontrolnim uvjetima, a pokazale su i pozitivniji učinak i povećan interes kod ispitanika (Van der Ploeg i sur., 2013).

Izvršne funkcije su kognitivne sposobnosti koje nam omogućuju mentalno manipuliranje idejama za rješavanje problema u svakodnevnom životu i klasificiraju sposobnosti u tri kategorije: inhibicija, radna memorija i kognitivna fleksibilnost. Ako ove funkcije nisu dobro razvijene, može postojati čak i lažna dijagnoza poremećaja kao što je ADHD i druge poteškoće s učenjem. Montessori pedagogija razvijala se u trenutku dok izvršne funkcije nisu bile poznate. Istraživanja su pokazala kako Montessori aktivnosti potiču razvoj izvršnih funkcija, a to su npr. čekanje, traženje materijala kroz labirint koji su stvorila djeca radeći druge aktivnosti i slično. Istraživanja pokazuju da djeca koja su pohađala Montessori predškole pokazuju bolju provedbu cerebrospinalnih procesa (Lillard, 2016).

Promatranjem odrasle osobe dok izvodi neku radnju aktiviraju se ista područja u mozgu djece zadužena za tu funkciju. Ova neuralna empatija pomaže oponašati radnju druge osobe i napraviti iste pokrete. Za to su zaslužni tzv. zrcalni neuroni. To su vizualno-motorički neuroni koji prepoznaju i razvrstavaju pokrete ovisno o njihovoj namjeri, a tu istu namjeru prepoznaju u sklopu određenoga konteksta (Iacoboni, 2012). Iacoboni (2012) smatra da zrcalni neuroni pružaju prilično uvjerljivo objašnjenje složenih oblika socijalne kognicije i interakcije i pomažu u shvaćanju postupaka drugih osoba. To je otkrila i Maria Montessori (1949) kroz promatranje i istraživanje, a kasnije se pokazalo da se radi o ovoj vrsti neurona frontalnoga režnja mozga. S time je povezala važnost pedagoške uloge socijalnih interakcija i oponašanja, posebice aktivnosti koje izvode odgajatelji.

Montessori aktivnosti zahtijevaju pokret (Montessori, 1912), ali i razboritu manipulaciju materijalima kao pomoć pri učenju. Istraživanja su otkrila da je u pokret uključeno mnogo više sustava nego što se to prije smatralo (Pinel, 2002; Van der

Meulen, Krabbendam i de Ruyter, 2015; Van der Ploeg i sur., 2013). Osim primarnoga motornog korteksa, kontrola kretanja uključuje i interakciju mnogih drugih područja mozga, uključujući bazalne ganglije, talamus, mali mozak i veliki broj skupine neurona smještene unutar srednjega mozga i moždanoga debla (Pinel, 2002). Montessori je tvrdila da se i djetetova nteligencija može razviti do određene razine bez pomoći njegove ruke, misleći na motoričke aktivnosti. Ali ako se razvije rukom, tada je razina do koje dolazi djetetov intelekt još i veća (Montessori, 1949). Tvrdila je da su ruke instrumenti čovjekove inteligencije i da se pomoću njih razvijaju senzorni organi i koordinacija (Montessori, 1949).

Rasprava

Mnogi suvremeni pedagozi naglašavaju da je danas, možda više nego u prethodnim vremenima, potrebno mijenjati perspektivu odgoja i obrazovanja (Isaacs, 2018; Jurčević Lozančić, 2018; Von Hentig, 2003). Hartmut von Hentig (2003) govori o promjenama i stanju svijeta i društva koje na to utječe. Neki pak pedagozi naglašavaju povezanost suvremene tehnologije s razvojem mladih, s obzirom koliko su digitalni mediji zastupljeni u njihovoj svakodnevici, a što itekako utječe na djetetov psihomotorni razvoj (Eret, 2017; Spitzer, 2014). Važno je napomenuti da je potrebno pratiti didaktičke trendove kako bismo znali pristupiti i djetetu s određenim poteškoćama zbog kojih teže prati nastavni proces, posebice ako se radi o inkluziji u redovnu nastavu, čemu su danas mnogi školski sustavi skloni (Hastings i Oakford, 2003). Mogli bismo reći da je pritom najvažnije razmišljati ne samo o djetetovom kognitivnom razvoju, već napose o njegovu emotivnom stanju, razvijanju psihomotornih kompetencija i samostalnosti u istraživanju (Chabot i Chabot, 2009; Iacoboni, 2012; Montessori, 1949; Velički i Topolovčan, 2015; Perković i sur., 2017).

Maria Montessori od samih početaka pokazuje kako pedagogija njezina pristupa, metoda, strategija i didaktičkih materijala donosi nepobitne rezultate i napredak (Montessori, 1912, 1949, 1989, 2007). Danas to dokazuje neuroznanost u 'opipljivim' znanstvenim pokazateljima onoga što je Montessori zaključila promatranjem samog ponašanja djece (Beck, 2003; Blakemore i Frith, 2005, Busso i Pollack, 2015; Isaacs, 2018; Van der Meulen i sur., 2015). U prilogu činjenicama Montessori pedagogije i suvremene odgojne neuroznanosti idu i mnoga istraživanja, među različitim dobnim skupinama ispitanika, dokazujući da je individualizacijom didaktičkoga pristupa moguće pozitivno utjecati na poteškoće u razvoju i ponašanje (Hastings i Oakford, 2003). Sljedeće što se može zaključiti te staviti pod novi obzor jest kako ove znanstvene pokazatelje terba uzeti kao poticaj za oblikovanje kurikula u kojima bismo nastavne metode i strategije birali po osobinama, kompetencijama i afinitetu odgajanika. Posebice ako vodimo računa o tome kako je za optimalan rad moždanih funkcija potrebno objediniti nastojanje za razvoj simultano-kognitivnih, psihomotoričkih i afektivnih sposobnosti i vještina (Chabot i Chabot, 2009; Montessori, 1912, 1949; Velički i Topolovčan, 2015; Perković i sur., 2017).

Zaključak

Okosnice Montessori pedagogije koje ukazuju na međuovisnost i povezanost brige o emocionalnom razvoju djeteta te poticanja razvoja motoričkih vještina i samostalnosti djeteta s napredovanjem u njegovim razvojnim fazama bile su pionirske već u svoje vrijeme, a potkrijepljene brojnim znanstvenim istraživanjima na koje se referirala ili je provela sama Marija Montessori (Montessori, 1912, 1949, 1989, 2007). Danas pak mnogi znanstvenici s područja neuroznanosti, neurobiologije i neurodidaktike traže uzročno-posljedične veze ponašanja i odgoja pojedinca s radom moždanih funkcija (Blakemore i Frith, 2005; Busso i Pollack, 2015; Jovančević i Ježić, 2007; Pinel, 2002). Možemo reći da danas na sofisticiraniji način dobivamo uvid u neurobiologiju djeteta (odgajanika). Suvremenim metodama i znanstvenim pristupima na opipljiviji način možemo proučavati kako se određene razvojne faze pojedinca, ali i utjecaj didaktičkih metoda i postupaka, manifestiraju na neuropsihološkoj, odnosno, neurobiološkoj razini (Hebb, 2005; Iacoboni, 2012; Pinel, 2002).

U suvremenim istraživanjima Jovančević (2007) podsjeća da je u odgoju pojedinca potrebno sagledati međuovisnost genetskih predispozicija odgajanika s (odgojnim) utjecajima okoline. Današnja (odgojna) djetetova okolina nužno podrazumijeva digitalnu tehnologiju pa je za naredna istraživanja ovoga područja uputno razmatrati utjecaj digitalnih medija na djetetov neurološki razvoj i povezanost s izborom Montessori didaktičkih materijala (Eret, 2017; Montessori, 1912; Spitzer, 2014). Individualitet svakog odgajanika uz specifičnost njegove razvojne okoline, uvjetovat će razvoj ili pak neuporabu pa propadanje određenih sinapsi. Zato autori ističu da su poticajna odgojna okolina i didaktički materijali primjereni određenoj razvojnoj fazi odgajanika temelj odgajateljeva djelovanja (Hebb, 2005; Montessori, 1949, 1989, 2007; Philipps, 2003; Vasta i sur., 2005). Čak je uslijed poticajne okoline moguće obnoviti mozak prilagodbom ili proizvodnjom novih neurona (Blakemore i Frith, 2005). Znanstvenici također ukazuju na činjenicu da je današnja neuroznanost dokazala kako je emocionalan i kognitivni djetetov razvoj međuovisan (Chabot i Chabot, 2009; Montessori, 1949; Velički i Topolovčan, 2017). U tome esencijalnu ulogu ima socijalizacija (Iacoboni, 2012). Tako su istraživanja s područja neurodidaktike pokazala da implementacija Montessori pedagogije i materijala u odgojnu okolinu dovodi do unapređenja kognitivnih vještina četverogodišnjaka (White i sur., 1976; Yussen i sur., 1980), pomaže oboljelima od demencije u korist usredotočenosti i motivacije (Van der Ploeg i sur., 2013), potiče razvoj određenih izvršnih funkcija i cerebrospinalnih procesa (Lillard, 2016) te potiče razvoj zrcalnih neurona zaslužnih za usvajanje socijalnih vještina i obrazaca društvenoga ponašanja (Iacoboni, 2012; Montessori, 1949). Tvrdnje Marije Montessori (1949) da se inteligencija do optimuma razvija upravo senzornim organima, motorikom i koordinacijom, danas su potkrijepili znanstvenici najnovijim istraživanjima. Dokazuju kako je za motoriku potrebno uključiti više sustava nego se prije smatralo (Pinel, 2002; Van der Meulen i sur., 2015; Van der Ploeg i sur., 2013), odnosno, kako je s pokretom nužno povezan rad mnogih i različitih dijelova mozga.

U trenu kada se pristupa osuvremenjivanju školstva i nastave, a samim time redefiniranju nastavnih kurikula, razmišljat će se o onome što su znanost i praksa pokazale učinkovitim u okviru suvremenih standarada. Uspješnost nastavnih metoda, postupaka i didaktičkih materijala Montessori pedagogije koje dokazuju suvremena istraživanja s područja neuroznanosti i neurodidaktike mogla bi tome biti okosnica (Iacoboni, 2012; Lillard, 2016; Van der Meulen i sur., 2015; Van der Ploeg i sur., 2013; White i sur., 1976; Yussen i sur., 1980). Posebice ako u istraživanjima nalazimo pokazatelje kako je upravo Montessori pedagogija i individualizacija didaktičkoga pristupa uvjet za pozitivni utjecaj na poteškoće u razvoju i ponašanje (Hastings i Oakford, 2003). Ovaj je rad poticaj i za daljnja razmatranja o prilagodbi Montessori pedagogije za različite razine odgojno-obrazovnoga sustava, a posebice u smislu učinkovitosti implementacije digitalnih medija i sadržaja za svrhe potencijalne virtualne nastave (Eret, 2017; Spitzer, 2014).