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School functioning of students with neuromotor immaturity

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Abstract:

The objective of the article is to outline the problem of neuromotor immaturity in the context of school functioning. Research on neuromotor immaturity has been reviewed for child development and difficulties at school. It has been established that neuromotor immaturity constitutes an area of interest of scientists in many fields, including neurobiology, medicine, psychology, and pedagogy. Numerous studies provide information on the subject of the presence of a relationship between the student's difficulties in learning and neuromotor immaturity. The scientists reveal that children with problems in reading, writing, and counting show persistent and non-integrated primitive reflexes. The phenomenon is increasingly often observed in students at the stage of the elementary school not only in Poland but also in the world. The awareness of the problem and the expanding knowledge on neuromotor immaturity can contribute to a better understanding of the school difficulties of students and to using preventative measures and effective interventions.

1. Introduction

The child starting school education faces many educational challenges particularly in mastering the skills of reading, writing, and numeracy. Especially significant is that readiness of a child to achieve at school involves more than simply reaching the chronological age for school entry. Achieving success in learning requires many abilities including concentration, attention, sitting still for a determined time, holding a writing tool the correct way and coordination of a series of eye movements which are needed for reading. The above-mentioned activities are connected to motor maturity and postural control.

Researchers and experts in the fields of psychology and pedagogy have observed that children of school age increasingly are showing signs of difficulties in learning (Goddard Blythe, 2004; Grzywniak, 2013; Madejewska, Choińska, Gieysztor, Trafalska, 2016). They are also noticed and increase in difficulties with motor coordination, bodily coordination and balance, a lack of a sense of rhythm, decreased visual-motor coordination, aversion and avoidance of physical games, including difficulties with throwing a ball at a target, problems with jumping, running, etc. (ibid.). The reasons for these difficulties are sought, among others, in persisting and non-integrated primitive reflexes, which provide evidence of neuromotor immaturity. (Pecuch, Kołacz-Trzęsicka, Żurowska, Paprocka-Borowicz, 2018).

Neuromotor functioning is intricately connected with the proprioceptive, vestibular, and postural control systems. These systems correlate with each other in providing a stable base for systems directly connected with visual-motor coordination and visual perception, becoming at the same time an indication of maturity in the functioning of the central nervous system (CNS)(Goddard Blythe, 2015a). In children "maturing of the

nervous system happens spontaneously under the influence of stimuli coming from the environment. The measure of neurological maturity is, hence, the degree of integration of primitive reflexes, among others, the asymmetrical tonic neck reflex (ATNR), the symmetrical tonic neck reflex (STNR) and the tonic labyrinthine reflex (TLR)" (Gieysztor, Sadowska, Choińska, 2017, p. 6). Motor activity is one of the first stages of motor development of humans, and it prepares the child for the achievement of the next functional stages. It also contributes to progressive activation of neural pathways. Primitive reflexes in the moment of achieving full maturity are integrated within the central nervous system (CNS). The above phenomenon enables and conditions the proper development of a human (ibid.).

Each newborn child is equipped with a set of primitive reflexes, which in the first days or weeks of life support development, functioning and adjusting to conditions outside the womb. Physiologically they should appear up to the 6th month of life in normal developing infants, and after fulfilling their role, should be inhibited and replaced by more mature patterns including a specific group of postural reactions (Goddard Blythe, 2015b). Alongside the primitive reflexes, postural reflexes are also important in the development of a child's control of posture, balance and coordination. Postural reflexes appear after the birth and their main task is to achieve a vertical posture and body balance. These reflexes do not disappear but are present throughout the entire life. If there is a lack of integration of primitive and postural reflexes, a child may experience difficulties in aspects of motor development, including proper bodily balance and coordination, and at the stage of school education, difficulties in mastering writing and reading skill may emerge (Grzywniak, 2013).

2. Early infantile reflexes and influence of child development

Below are presented selected early infantile reflexes in a synthesized manner and an attempt is made to relate them to the child development disfunctions.

A persistent Moro reflex can have an affect on emotional development. It is often linked to vestibular dysfunction, thus contributing to motion sickness, poor coordination, and poor body balance. In addition, it can be associationed with visual-motor difficulties and visual perceptual problems such as stimulus bound effect. Children with the Moro reflex may also have difficulties with auditory confusion (resulting from difficulty orientating to sound or hypersensitivity to certain sounds), and may be more prone to allergies and reduced body immunity resulting from higher levels of stress and the physiological response to stress (Goddard Blythe, 2018). A retained Palmar Reflex (hand-grasp) can contribute to excessive muscle tension in the hand and inhibits the development of separate movements of the thumb and fingers (dissociation of the fingers). It negatively influences the development of articulation and manual muscle coordination (Grzywniak, 2013). A persistent asymmetrical tonic neck reflex (ATNR) causes imbalance in distribution of muscle tone on either side of the body when the head is turned one way or the other with effect on motor functions such as walking, marching, or jumping when the head is turned to the effected side It can interfere with crossing the body's mid-line, heterogeneous lateralization, or visual perception disorders (Goddard Blythe, 2018). Galant's unintegrated and persistent reflex (spinal Galant reflex) may cause excessive fidgeting, inability to sit for a specific time, bedwetting, low concentration, and poor short-term memory. Persistentce of the tonic labyrinthine reflex (TLR) contributes to muscle tension abnormalities, resulting in hypotension or hypertonia. In addition to the above, it can interfere with the formation of correct posture and contribute tovestibular and visual-motor disorders. A persistent symmetrical tonic neck reflex (STNR) implies numerous developmental problems, including abnormal sitting posture, reduced eye-hand coordination, difficulties related to speed in adjustment of visual accommodation and is often a factor in what was formerly described as the "clumsy child" syndrome. It also contributes to difficulties in learning to swim (Goddard Blythe, 2018).

In summary, numerous developmental problems that are caused by neuromotor immaturity in which primitive and postural reflexes act as functional mechanisms, can be a source of many failings in everyday functioning.

3. Neuromotor immaturity – definitional approach according to INPP (The Institute for Nero-Physiological Psychology)

"Neuromotor efficiency is a complex functional behavior which is a result of activation of the central and peripheral nervous system, including motor structures, which act through the musculoskeletal system with the cooperation of the signals from the internal and external environment" (Goddard Blythe, 2015b, p. 15). Systems and structures, which are responsible for movement, evolve throughout the entire process of human development. When a child is at a given stage of development, it is expected it will have acquired a commensurate level of maturity in postural and motor skills (sometimes referred to more generally as motor milestones),. It is, therefore, believed that key stages of motor development, such as crawling on the stomach (commando crawling) and creeping on all fours provide external evidence of functional neuromotor maturity (ibid.).

According to the definition of INPP (The Institute for Neuro-Physiological Psychology), the term neuromotor immaturity refers to the occurrence of a syndrome of persistent and non-integrated primitive reflexes in a six-month-old child and older and is characterized by a lack or immaturity of postural reflexes above the age of three and a half years. In other words, the presence of a cluster of immature primitive and postural reflexes beyond key stages in development provide evidence of immaturity in the functioning of the central nervous system (CNS).

The term neuromotor immaturity is understood as omittission or arrest at a given stage of child development. Neuromotor immaturity in the terms of P. Blythe and S. Goddard Blythe is characterized by the occurrence of immature patterns of motor control. Very often they occur in the form of pathological neurological symptoms as well as of a functional or developmental delay of certain neural pathways (Goddard Blythe, 2015a).

It is worth highlighting that people in which neuromotor immaturity is diagnosed can have significant problems with, among others, bodily coordination, balance, visual perception, motor coordination, etc. and these difficulties might constitute a basis for behavior disorders and difficulty in learning. Additionally, very often they result in chronic anxiety and emotional hypersensitivity in adults (Goddard Blythe, 2015b).

Neuromotor immaturity can be more subtle resulting in smaller or bigger problems in everyday functioning. When it occurs in a milder form, minimal developmental disfunctions in the child might prove difficult to observe and diagnose with the results that it may be difficult to apply the right preventative measures. The effects of subtlethe dysfunctions, if unrecognized tend to increase with time resulting time in reduced ability in performance. It is interesting that children with traces of primitive reflexes are often diagnosed with behavioral problems or a weak student syndrome (Goddard Blythe, 2015a).

4. Review of studies on neuromotor immaturity in the context of child development

Ch. Bell and F. Magendie (1823) observed a neural circuit between the brain and the muscles. They discovered that one nerve delivers signals from the brain to the muscles, while the other transfers the sensations regarding the condition of the muscle in the opposite direction. Thanks to their discovery, scientists have proved that it is the brain that feels the sensations and not individual body parts. At this stage, however, they were unable to explain the methods of communication of selected areas of the brain with the body. Only thanks to the Noble Laureate in medicine and physiology Santiago Ramón y Cajal were the missing elements of the theory filled in (1906). Y Cajal discovered the neuron doctrine that is now the accepted basis for modern understanding of neurobiology (Dulewicz, 2018). Y Cajal analyzed the course of nerves that connect the sensory organs such as those that serve the eye and the brain. In his way he was able to prove that individual sensory nerves guide impulses to the inside from peripheral dendrites and axons to the brain. Motor fibers direct the signals in the opposite direction. Their dendrites are in the brain and the spinal cord and the axons are facing the outside in the direction of muscles (Goddard Blythe, 2018).

The experiments of Charles Sherrington (1906) contributed to the understanding of the connection between reflexes and the central nervous system. Sherrington discovered the reflex arc, that is, the way of transferring specific sensory signals via the central nervous system. At the same time, he proved that reflexes

do not function in isolation but are characterized by a cohesive and coordinated system. A. Jean Ayres confirmed his findings when observing children with sensory processing disorders (1979). Ayres author noticed that children with sensory processing disorders also had weakly developed postural reflexes, balance disturbances, and decreased visual control.

Blythe and McGlown (1979) carried out a study in the main goal was to determine whether children participating in remedial (special education needs) classes had developed the motor skills needed to crawl on the tummy (commando crawling) and creep on all fours. The researchers were driven by the belief that if the children did not have neuromotor skills to achieve the basic motor stages in infancy, then when older they will not be able to perform these movements naturally either They also observed that children with specific learning difficulties still had traces of persistent primitive reflexes which should have been inhibited in the first year of life. At the same time, they noted lack of postural reflexes in these children, which should have developed by three and a half years of age, well in advance of starting formal schooling. Further observations revealed that the disturbed schemes of motor development, signs of cross or ambi lateralization (above eight years of age) and problems with visual-motor integration (VMI) and visual perceptionwere correlated with the occurrence of persistent primitive reflexes (Blythe, McGlown, 1979).

In Poland, a research on the influence of reflexes on the development and functioning of children was carried out by A. Pecuch, A. Kołcz-Trzęsicka, A. Żurowska and M. Paprocka-Borowicz among 75 children aged 4-6 years (2018). The study included a group of 75 children aged 4-6 years. These authors discovered persistent and non-integrated early infantile reflexes in children with developmental dysfunctions, alongside deficits in motor and cognitive performance, emotional regulation, fine motor skills, visual and auditory perception, and verbal articulation. They also observed the following reflexes were evident in children with developmental difficulties: tonic labyrinthine reflex (TLR) in 81.33% of children (to a moderate, significant or complete degree); asymmetric tonic neck reflex (ATNR) left-sided – in 53.33% of the subjects, asymmetric tonic neck reflex right-sided – in 61.33% symmetrical tonic neck reflex (STNR) in flexion in 62.67% of the study subjects and STNR in extension in 41.33% percent of children (Pecuch, Kołcz-Trzęsicka, Żurowska, Paprocka-Borowicz, 2016).

Other researchers, M. Madajewska, E. Gieysztor, A. M. Choińska and A. Trafalska (2016) revealed that the tonic labyrinthine reflex (TLR) was the most common aberrant reflex early childhood in children aged 4-7 years. The research involved 131 children from school and kindergartens in Kamienna Góra. The researchers confirmed that there was a necessity to examine children for their neurological maturity and apply early stimulation for children with developmental delays.

Evidence of persistent primary reflexes in children with attention deficit hyperactivity disorder and autism spectrum disorders has also been documented. Researchers have shown that attention deficit hyperactive disorder (ADHD) symptoms can be associated with primitive neuronal mechanisms that interfere with higher brain functions due to insufficiently developed cognitive and motor integration (Konicarov, Bob, Raboch, 2013). Others, (E. Jeżewska-Krasnodębska and J. Krasnodębski, 2018) revealed that the Moro reflex is very often observed in children with autistic spectrum disorders (ASD) and the scale of its severity is highly significant (75-100%). In connection with the above, people with a persistent Moro reflex are prone to over-arousal resulting in a tendency to be fearful, to withdraw from difficult situations and subsequently to manifest difficulties in making interpersonal contacts. These children very often have problems with naming emotions and showing affection and can be overly excited and aggressive (Jeżewska-Krasnodębska, Krasnodębski, 2018).

A literature query and analysis of research conducted over the course of the century allows us to conclude that neuromotor immaturity, in the form of persistent and non-integrated primary reflexes is associated with the occurrence of numerous developmental problems in children. It should be stressed that aberrant reflexes are not necessarily the primary cause of other difficulties, but provide signs of immaturity in the functioning of the central nervous system (CNS), which can point to which methods of intervention might be helpful. Retention of individual reflexes is linked to specific difficulties, and in this context, the use of tests for the presence of primitive reflexes can be a useful tool with which to: identify children for whom neuromotor immaturity is a significant factor underlying their presenting difficulties; to indicate the type and level of intervention that is likely to be helpful; to measure progress as a result of interventions.

5. Review of studies on neuromotor immaturity in the context of school functioning

According to the position of many leading psychologists (Bruner, 1964; Piaget, 1966; Wygotski, 1978), movement is important in the process of development and learning. For example, reading is related to the development of the eye movement control. Writing is associated with complicated neural stimulations, their integration in the cerebral cortex, hand movement apparatus and eye hand coordination. It is based on visual movement control and kinesthetic activities associated with correlated movements of the arm, forearm, wrist, hands, and fingers (Wróbel, 1979).

Analysis of the literature on the subject shows that neuromotor maturity of children in school education has long been an interest and area of research for many scientists. Research by B. Rider (1972) revealed that second grade students with learning disabilities showed a much more pathological reflex model than students without learning disabilities. Comparison of reflex test results with the results of a Wide Range Achievement Test (WRAT) showed that students not showing persistent primary reflexes scored higher in the WRAT test.

The work of P. Blythe showed that symptoms such as rapid loss of attention, difficulty concentrating, short-term memory deficiency are coexist with the non-integrated reflexes of ATNR, STNR, or TLR (Blythe, 1979).

C. Delacato (1963) revealed t students with learning difficulties in his research had not passed through the stages of crawling on the tummy (commando crawling) and creeping on all fours in infancy. In addition, he observed in these children a crossed or bilateral lateralization model.

In 1994, G. J. Wilkinson confirmed the relationship between the pathological primary reflex profile and learning disabilities (Goddard Blythe, 2018). Studies by M. McPhillips, P. G. Hepper and G. Mulhern (2000) provided information on the relationship between reading difficulties and student's motor control with the asymmetrical tonic neck reflex being a significant factor in children with reading difficulties.

In 2001, S. Goddard (2004) examined 54 children who had previously received an independent diagnosis of developmental dyslexia. It was observed that 100% of the students in the sample had persistent asymmetric tonic neck reflex (ATNR) and tonic labyrinthine reflexes (TLR). The Moro reflex was evident in 81% of the subjects, the symmetrical tonic neck reflex in 72%, the spinal Galant reflex in 65% and the Palmar reflex in 55% of the children. In addition, these students exhibited under-developed postural reflexes (Goddard Blythe, 2004). According to the author, "irregularities in early patterns of motor development have an impact on learning higher, more complex skills. Therefore, they can contribute to many problems, including those associated with writing and performing motor activities (ibid., p. 160).

M. McPhilllips and Sheehy (2004) observed that students with the poorest reading results had a significantly higher level of persistent and non-integrated asymmetric tonic neck reflex (ATNR) than in their peers who had mastered reading to a medium or high degree.

JA. Jordan-Black (2005) proved that students' success in reading, writing and mathematics can be predicted based on the assessment of the persistence rate of the asymmetric tonic neck reflex (ATNR).

Polish research by C. Grzywniak from 2006 conducted among schoolchildren revealed vestigial persistent primary reflexes in students with learning difficulties. The author stated that the strength of these reflexes do not diminish with age, but even increase over the years. In addition, she noted that in students characterized by a lower intelligence quotient, persistent primary reflexes occur more frequently and in an intense form (Grzywniak, 2010).

In 2007, C. Grzywniak conducted another study among 57 children aged 6–7 in the context of neuropsychological maturity for school education. The results show that a group of students exhibiting learning difficulties is characterized by adequate or insufficient neuropsychological maturity, while students without learning difficulties reveal high neuropsychological maturity (Grzywniak, 2013).

M. McPhililips and JA. Jordan-Black (2007) found that the presence of persistent primary reflexes is an important predictor of reading nonsense words skills and verbal IQ. This indicates a correlation between persistent primary reflexes and the child's speech. According to these researchers, up to 62% of children with reading difficulties are diagnosed with a high degree of persistent reflexes.

In February 2010, results derived from a longitudinal study set up amongst 1500 children born between 2000 – 2001 in the United Kingdom, found that that subjects who did not reach basic, key stages of motor

development, i. e. sitting without support, crawling on all fours, standing, and taking the first steps at the expected times obtained low results in tests checking their cognitive competence (performance) at age 5 years. These children in relation to people who reached the above-mentioned milestones of motor development in infancy were characterized by a lower level of cognitive skills and a reduced regulation of behavior (Goddard Blythe, 2015a).

A. Gieysztor, L. Sadowska and A. Choińska (2017) examined children aged 4-6 years and 7-9 years in the developmental norm and found that left-sided asymmetric tonic neck reflex (ATNR) occurs in 78% of children at the preschool age and 62% of children at the school age, and right-sided in 62% of children at the preschool age and 60% of children at the school age. In turn, L. Ivanocić, D. Ilić Stosovic, B. S. Nikilc and V. Medenica (2018) examined 256 students aged 7-11 in selected primary schools in Serbia. They showed that difficulties in reading, writing, and counting are much greater in children with diagnosed neuromotor immaturity than in students without developmental delays. These researchers emphasize that neuromotor immaturity makes it difficult for children to acquire basic school skills.

Literature analysis provides a substantial body of evidence to show that neuromotor immaturity affects proficiency in the achievement of school skills. Students with persistent early infantile reflexes have a variety of problems in acquiring basic school skills (Goddard Blythe, 2015b).

6. Conclusion

Difficulties in reading, writing, spelling, and numeracy are problems faced by a modern student. The reasons are multifactorial but there is now an increasing body of evidence to link persistent and non-integrated primary reflexes to educational under-achievement.

An analysis of research in the field of neuromotor immaturity in the context of the student's school functioning shows how widespread this phenomenon is in modern education around the world. Knowledge about neuromotor immaturity, although it is becoming increasingly common, is still fragmentary. Therefore, there is a need for further research and in-depth analysis. There is no doubt that early recognition of neuromotor immaturity signals will allow the introduction and application of remedies that can enable students to better attain the physical foundations need to support the skills of reading and writing.

Numerous researchers alert that the symptoms of neuromotor immaturity correlate with diagnostic indicators of, among others, dysgraphia, dyslexia, dyspraxia, attention deficit disorder (ADD), as well as disorders of perception and motor control. Researchers emphasize that "about 80% of children with a dyslexia diagnosis experience some form of dyspraxia (balance and orientation difficulties and reduced mobility), and the same number of dyspraxia children have some dyslexia symptoms" (Goddard Blythe, 2018, p. 166).

In summary, the issue of neuromotor maturity is extremely important from the perspective of modern science and education. Awareness of this phenomenon will allow assessment of neurodevelopmental readiness in the context of learning, explaining the underlying mechanics of students' disorders and school difficulties, and will also enable the introduction of appropriate preventive and therapeutic measures.

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