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Thesis

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IMPACT OF SENSORIMOTOR TRAINING WITHIN INSTITUTIONAL FRAMEWORKS ON SENSORIMOTOR DEVELOPMENT, AUDITORY AND VISUAL LEARNING ABILITIES OF CHILDREN AGED 5-8

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1. Introduction

1.1 Topicality and importance of the thesis' choice of topics

School difficulties, learning, behavioural and integration disorders (BTM), special educational needs (SNI), are significant problems in education systems around the world. This is also the case in Hungary. In the 2001/2002 school year, 13% of students had SNI or BTM. In the 2016/2017 school year, 23% of students received such a rating.

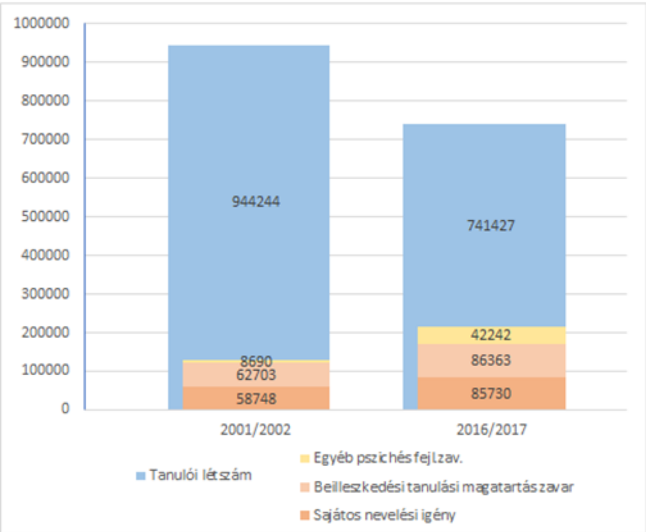
? 

Figure 1 Evolution of student numbers from the 2001/2002 academic year to the 2016/2017 academic year (2001/2002= 944244, 2016/2017=741427), as well as changes in the number of SNI, BTM, and pupils diagnosed with a developmental psychological disorder from the academic year 2001/2002 to the academic year 2016/2017

Data shows that the proportion of pupils with SNI and BTM has increased compared to the total number of primary school pupils. In the 2016/2017 school year, almost one in four primary school pupils had either SNI or BTM. This figure does not include the number of pupils with "minor" learning problems or who do not reach specialists.

It is unclear what is behind the increased proportion of SNI and BTM pupils. One possible explanation is a change in the criteria formulated by law. While the law in force in 2001/2002 designated categories SNI-A and SNI-B according to whether the derogation is due to organic reasons or not, the law in force in 2016/2017 does not make such a difference. Classification into the SNI category considers the prognosis of the problem. Children in the SNI-B category in the 2001/2002 school year were mainly rated BTM in the 2016/2017 school year. This should result in a reduction in the number of pupils with SNI and an increase in PUPILS with BTM. The number of BTM students has increased, but so has the number of SNI pupils. The more accurate diagnostics may also have caused an increase in the number of pupils with SNI and BTM. In any case, the fact that 23% of children have either SNI or BTM, which is undoubtedly a high value, is a cause for concern.

In connection with the above problem, in search of a solution, scientific knowledge about sensorimotor development is expanding worldwide. More research results will be published. Advances in neurology, neuropsychology, and imaging techniques contribute to a clearer picture of the relationship between sensory and motor development and the impact of sensory and motor functions on cognitive functioning.

Numerous studies emphasize the relationship between persistent reflexes and learning difficulties, behavioural and attention disorders (Blythe, 1992; Taylor, Houghton, and Chapman, E. 2004; Damasceno, Delicio, Mazo, Zullo, Scherer and Damasceno, 2005; Blomberg, Dempsey and Phua, 2008; Bob, Konicarova and Raboch, 2013; Gieysztor, Choińska, and Paprocka-Borowicz, 2018; Rašić Canevska, 2019; Pecuch, Gieysztor, Telenga, Wolańska, Kowal and Paprocka-Borowicz, 2020; Goddard, Duncombe, Preedy and Gorely, 2021).

The relationship between vestibular maturity and specific learning abilities has been studied and found to be related (Quirds, 1986; Dordel and Breithecker, 2003; Niklasson, 2012). I want to highlight Julio B. Quiros's longitudinal study of 1902 children, which confirmed the link between vestibular immaturity and learning difficulties. The three-year study proved that the movement coordination, balance perception, language development, reading and writing skills of immature children lag behind those who are most mature (Quiros, 1976).

Fine motor movements and eye-hand coordination are also associated with vestibular maturation. An immature vestibular function may cause difficulties in learning to read and write, among others (Huettig, Auxter, and Pyfer, 2001).

Since the vestibular system's role is emphasized in the formation of muscle tone, it is also essential to have intact vestibular functioning in the setting of the child's posture. If the nervous system does not adjust muscle tone most economically in order to be able to hold the body against gravity, then the regulation of the posture takes more energy away from attention and focus. Therefore, children cannot focus properly on a task, either in time or depth (Cheatum and Hammond, 2000). Posture setting, attention, and focus are also critical in the learning of instrumental music, leisure, or competitive sports. Effectiveness is influenced by the functioning of the vestibular system (Cheatum and Hammond, 2000).

…The maturity and functioning of the vestibular organ also affect auditory perception. Due to immature vestibular function, children are unable to locate the sound source despite that the auditory organ is functioning correctly. Although they don’t have any eye problems, they are unable to properly focus and follow moving objects or a row of letters while reading (Cheatum, Hammond, 2000).

Inadequate muscle tone adjustment also causes the retention of the tongue-moving muscles, which leads to speech formation and swallowing problems (Cheatum and Hammond, 2000).

The sensorimotor immaturity causes immature behavior patterns, the effects of which are equally evident in learning, behavior and integration (Cheatum and Hammond, 2000; De Jager, 2009; Goddard, 2015; Jaiswal and Morankar, 2017).

Children whose nervous systems for some reason mature more slowly than their peers, should begin development exercises before starting school which stimulate the maturation of the nervous system (Blomberg, Dempsey, and Phua, 2008). More research has been launched in this regard. Among other things, Romanian children with immature nervous systems were examined in foster care, then adopted or mediated to foster parents (Eagleman, 2016). The goal was to‘mature’ the nervous system. It has been found that the nervous system remains sensitive to sensorimotor maturation, but sensitivity decreases over time. The nervous system of children adopted before the age of 6 reacted faster and adapted better than those who were taken out of the children's home around the age of 12 (Zeanah, Gunnar, McCall, Kreppner, and Fox, 2011). Based on their observations, the authors voted in favour of the principle of "the earlier, the better."

If we look at the sensorimotor maturity data of the 772 children aged 5-8 years involved in this study, we can see that the result is just over 50% of full maturity. In the light of the test results, the sensorimotor development of children is justified. In particular, the integration of infantile reflexes, the maturation of the vestibular system, and the development of sensorimotor coordination and movement coordination are priority tasks.

Based on this, the problem that my doctoral research deals with is as follows:

Is it possible to develop the nervous system of children aged 5-8 years with sensorimotor exercises and institutional frameworks to such an extent that it has a measurable effect on learning abilities?

In order to answer these research questions, and to support or question the accuracy of the hypotheses, sensorimotor training took place in kindergarten and school groups of children in the affected age group (5-8 years old) for 6-8 months. To facilitate this, I developed an independent program based on the deep literature background in this field; I prepared the teachers working in the groups in detail for the task, organized the measurements, and collected the necessary data. We measured the children's sensorimotor development level before and after the development program in both a research group and a control group. Additionally, we measured their auditive and visual skills after the intervention.

1.2 Objectives of the research

The research is an impact assessment, primarily to examine whether sensorimotor exercises carried out within institutional frameworks have a measurable effect on the maturation of the nervous system, and therefore on specific auditory and visual component abilities necessary for learning, the proper level of development of which is essential for a successful start to school. Further:

1. One of the objectives of the research is to propose a series of exercises that have proved to be successful and easy to perform for preschool teachers and primary school teachers, which can be easily integrated into the framework of preschool and school activities, to help the development of the nervous system in pre-schoolers and schoolchildren aged 5-8 years, and to prevent the development of more serious problems.

2. Another goal of the research is to demonstrate that the development tool we created is suitable for preschool and school (first and second grade) use.

3. To show how children aged 5-8 years are affected by major sensorimotor blocks to development. The research shows spontaneous biological maturation in the studied age group. The results are comparable to international data from previous research.

4. Building on the foundations in the literature, using earlier research findings, the compilation of a series of exercises (tests) for measuring sensorimotor maturity visual and auditory partial abilities in domestic conditions.

5. Explore relationships between sensorimotor maturity and the development of specific visual and auditory partial abilities (using the developed test).

6. To answer whether a properly compiled sensorimotor training improves the sensorimotor condition of children to a greater extent than that of children who do not do the exercises.

7. Find out if sensorimotor training affects the development of specific visual and auditory partial abilities.

2. Methods used

2.1 Methods of empirical testing

In my research, I used quantitative research methods to examine and compare children's sensorimotor state and auditory and visual partial abilities. I used the Statistical Package for the Social Sciences (SPSS) to perform descriptive statistical calculations and hypothesis tests, and Excel to determine impact sizes. I sought to apply large samples to collect data as widely far as possible. I used a systematic, rules-based, uniform measurement. In each case, the results were quantified, so their mathematical-statistical processing became possible (Boncz, 2004).

The measurements were made under controlled conditions, and I tried to exclude undesirable effects (Szokolszky and Palatinus, 2004). Both the input and impact assessments could be carried out quickly; sensorimotor measurement required 20 minutes per child, visual partiality test required 30 minutes/child, and auditive partiality test required 30 minutes/child.

Due to the nature of the topic, the research is part of a normal scientific nature (Kuhn, Judge, and White, 2000) and partly applied. Normal science tests theories that suggest a link between integration, learning, behavioural problems, and low levels of sensorimotor development (McPhillips and Sheehy, 2007; Goddard, 2009; Doidge, 2009, Konicarova et al., 2013; Bilbilaj et al., 2017; Pecuch et al., 2021; Hickey and Feldhacker, 2021; Sigafoos et al., 2021; Goddard et al., 2021). Auditory and visual abilities play a role in the relationship as "intermediary factors."

The results measured on the relatively large sample (experimental group:704, control group: 68 people) proved to be sufficient to support the theoretical and educational statements outlined in the hypotheses, which can be formulated because of the study of the literature, as well as based on my own educational experience. Because of the ordinal nature of the data, I used non-parametric procedures such as the Mann-Whitney test, the Wilcoxon test, the Kruskal-Wallis procedure, and the studies related to the calculation of Spearman's rank correlations (Nahalka, 2000). In each case, I also determined the effect size and the significance levels. In the research methodology literature, solutions using hypothesis studies alone to analyse differences, changes, and effects have long been heavily criticized (Cumming, 2014). I also identified the appropriate impact sizes in all difference and relationship studies. Due to the ordinality of the variables, I determined the cliff delta effect size often used in non-parametric procedures (Macbeth, Razumieczyk and Ledesma, 2011). The Kruskal-Wallis procedure was also necessary for comparing the age groups of the children (Nahalka 2000).

2.2 Variables used in empirical research

In the empirical research, I examined the many "elementary" components of sensorimotor development visual and auditory abilities, from which I created variables of an "aggregate" nature, to analyse the development in sensorimotor maturity of children, as well as the relationship of visual and auditory abilities to sensorimotor functions that can be considered more "elementary". The study examined three leading general indices measuring a child's development:

1. *Sensorimotor development (both input and output measurement)*

   - Reflex profile
   - Vestibular maturity
   - Movement coordination
   - Multichannel attention

2. *Development of visual capabilities (output only)*

- Graphomotor maturity and development of body schema
- Shape-to-background discrimination
- Level of form detection and reproduction
- Perception of spatial position, differentiation of directions, information signals
- Relativity of spatial situation
- Visuomotor coordination
- Visual memory

3. *Development of auditory capabilities (output only)*

- Delayed verbal memory
- Relation vocabulary, the formation of spatial orientation in language
- Auditory serial memory
- Auditory serial detection
- Correct use and interpretation of words and other parts of the language (grammar)
- Conceptualisation (description of categories)
- Opposites

2.3 Test tools

Examination of reflex profile

The reflex profile test was carried out as recommended in the following literature:

- Unlock Brilliance Learning Disabilities 2018. Prof.
- Quantum Reflex Integration (Brandes)
- Reflex Testing Methods (Fiorentino)
- Integrative Therapy for Neurodevelopmental Disorders: Module 1-4 Copyright: 11/30/2018 (CST)
- Melillo, R. (2018). Integrative therapy for neurodevelopmental disorders: Connecting primitive reflexes and brain imbalances to polyvagal theory to improve learning, behavior, and social skills. PESI Inc., Eau Claire, WI. Retrieved March 03, 2021, from

https://www.pesi.com/store/detail/26048/integrative-therapy-for-neurodevelopmental-disorders

Examination of vestibular function

Six types of tests were used:

- Static balance test: closed and open-eye "Flamingo test" on the left and right feet (total 4 tests)
- Dynamic balance test: "Tightrope walker - test."
- Left rotated post rotation nystagmus test

The operation of the vestibular system has been tested as recommended in the following kinds of literature:

- https://testsforsports.com
- Cheatum, B.A. and Hammond, A.A. (2000). *Physical Activities for Improving Children's Learning and Behavior*. Human Kinetics, Champaign, II.

Examination of sensorimotor coordination

I relied on the following literature and my own experience when compiling the tasks:

- Hodapp, R.M. (2012). *International Review of Research in Developmental Disabilities*. Academic Press. (TMD Test)

Examination of multichannel attention

I based my work on the tasks described in the following study.

- Nicolas és Gagnon: Towards a reliable measure of motor working memory: Revisiting Wu and Coulson's (2014) Movement Span Task. Royal Society Open Science.

The criteria for compiling the series of tasks examining visual and auditory abilities. I used the following literature during the tasks examining visual and auditory abilities:

- Juhász, Á. (2007). Logopédiai vizsgálatok kézikönyve (Manual of speech therapy tests). Budapest: Logopédia.

- László, Á.M., and Kóbor, Gy. (2009). Beszédértés (Speech comprehension). Budapest: Ton-Ton.

The training is for children aged 5-8 years. Each session took 15-20 minutes. Each occasion, if possible, started with a player element and ended with a game. The training consisted of both continuously recurring elements, e.g.reflex integration exercises, and continually changing elements, e.g. sensorimotor movement coordination development. I suggested doing 3-5 sessions a week. The total duration of the training was 6-8 months, depending on the number of repetitions per week.

3 The hypotheses

The following hypotheses of the research, if their confirmation can be significantly supported, validate the usability of the development system which we created for this research. However, they also confirm the theories presented in the prior literature. There are four main groups of hypotheses, the first group of which contain hypotheses I. and II. which relate to the effectiveness and effectiveness of the applied development practice system. On the one hand, they describe a significant improvement in their development indicators. On the other hand, they indicate that children in the experimental and control groups initially at the same level can be measured because of development, making a significant difference in favour of those in the experimental groups in terms of individual indicators.

Hypotheses only state the existence of significant deviations; there is no indication of causal relationships. The statistical procedures used are not in themselves suitable for detecting causal relations. The claim that development in experimental groups can be detected while in control groups is not theoretically justified, and the results of quantitative studies only support these theories but do not support them.

The second group of hypotheses contains Hypotheses III. and IV., which describe correlations between certain variables as "co-relationships". The third group contains hypothesis V., and the fourth group contains hypothesis VI. which describe a higher level of development of visual and auditory abilities in children in development. These hypotheses support – or challenge – the theory that sensorimotor development affects the development of visual and auditory abilities, which in turn affects the development of problems significant for school learning and school life.

4 Summary of results

When evaluating the hypotheses,

4.1) It could be demonstrated that sensorimotor development indicators increased significantly in the experimental groups while performing the exercises, while this did not occur in the control groups (central hypothesis I, sub hypotheses I/1 to I/4).

Variable	**Input measurement average (%)**	**Output measurement average (%)**	***Z* value of the Wilcoxon test**	**Significance level of the Wilcoxon test**	**Effect size**
Reflex profile	53,4	75,9	-15,024	$p < 0{,}001$	0,714
Vestibular development	40,1	56,7	-13,984	$p < 0{,}001$	0,664
Development of movement coordination	37,9	59,4	-16,511	$p < 0{,}001$	0,784
Development of multichannel attention	40,2	63,9	-9,978	$p < 0{,}001$	0,469
Sensorimotor development	**43,3**	**62,7**	**-17,588**	$\mathbf{p < 0{,}001}$	**0,836**

Table 1. Average of percentages expressing sensorimotor development and its components in input and post-development output measurements for children in the experimental groups (number: 443), change in significance level determined by Wilcoxon test

Variable	**Input measurement average (%)**	**Output measurement average (%)**	***Z* value of the Wilcoxon test**	**Significance level of the Wilcoxon test**	**Effect size**
Reflex profile	48,3	49,4	-0,228	n.sz.	0,01
Vestibular development	40,4	43,4	-1,460	n.sz.	0,06
Development of movement coordination	40,1	43,7	-1,790	n.sz.	0,08
Development of multichannel attention	37,4	40,9	-0,986	n.sz.	0,04
Sensorimotor development	**42,0**	**45,1**	**-1,358**	**n.sz.**	**0,06**

Table 2. Average of percentages expressing sensorimotor development and its components in input and post-development output measurements of children in control groups (number: 63), change in significance level determined by Wilcoxon test

4.2) In the experimental group, the sensorimotor development indicators did not differ from those seen in the control groups at the beginning of development, while by the end of development, the results of the children in the experimental groups were significantly better than those of the children in the control groups (central hypothesis II, sub hypotheses II/1 - II/4).

	Input measurement		**Output measurement**	
Variable	**Z-value and Significance level**	**Effect size**	**Z-value and Significance level**	**Effect size**
Reflex profile	*Z* = -1,420; n.sz.	0,109	*Z* = -7,447; *p* < 0,001	0,572
Vestibular development	*Z* = -0.956 n.sz.	0,052	*Z* = -3,960; *p* < 0,001	0,306
Development of movement coordination	*Z* = -0.766 n.sz.	0,036	*Z* = -4,136; *p* < 0,001	0,321
Development of multichannel attention	*Z* = -0.605 n.sz.	0,005	*Z* = -6,208; *p* < 0,001	0,289
Sensorimotor development	***Z* = -0.015 n.sz.**	**0,012**	***p* < 0,001**	**0,483**

Table 3. Comparison of sensorimotor development and component measurements for input and output measurements in children in experimental and control groups, Mann-Whitney test, and values of impact sizes (number of children in experimental groups 443, total number of control groups 63)

4.3) The indicators of sensorimotor development are significant, not negligible, and positively related to the development of visual and auditory abilities on the one hand (main hypothesis III/1, sub-hypotheses III/1 to III/4, main hypothesis IV/1, subsites IV/1 to IV/4).

Sensorimotor development and its components	**Visual abilities**			**Auditory capabilities**		
	Spearman's correlation coefficient	**Significance level**	**Effect size**	**Spearman's correlation coefficient**	**Significance level**	**Effect size**
Reflex profile development	0,314	*p* < 0,001	0,099	0,369	*p* < 0,001	0,136
Vestibular development	0,509	*p* < 0,001	0,259	0,518	*p* < 0,001	0,268
Movement coordination development	0,484	*p* < 0,001	0,234	0,525	*p* < 0,001	0,276
Development of multichannel attention	0,361	*p* < 0,001	0,130	0,495	*p* < 0,001	0,245
Sensorimotor development	0,542	*p* < 0,001	0,294	0,605	*p* < 0,001	0,366

Table 4. For a combined sample of children in the experimental and control groups, the Spearman correlation coefficients between sensorimotor development variables in output measurement and variables in visual and auditory abilities, their significance level and impact dimensions (sample size for visual ability is 422, for auditory abilities 391)

4.4) In experimental groups, visual and auditory abilities development at the end of development is significantly higher than in control groups (hypotheses V and VI).

Variable	Average score of children in experimental groups	Average score of children in control groups	Value of Mann-Whitney test	Mann-Whitney's test significance level	Effect size
Body schema	3,45	2,86	-2,954	*p* <0,001	0,228
Shape-to-background distinction	4,17	4,06	-1,346	n.sz.	0,096
Form detection	2,23	2,19	-0,961	n.sz.	0,064
Differentiation of directions	5,11	4,62	-1,755	n.sz.	0,128
Relativity of spatial situation	2,63	2,70	-0,712	n.sz.	0,040
Visuomotor coordination	2,69	2,76	-1,011	n.sz.	0,058
Visual memory	4,45	4,46	-0,098	n.sz.	0,006
Visual abilities	**24,87**	**23,65**	**-2,384**	***p* < 0,05**	**0,188**
Delayed verbal memory	4,74	2,92	-5,276	*p* < 0,001	0,418
Relational vocabulary - spatial orientation	4,43	4,10	-1,577	n.sz.	0,122
Serial memory	1,33	0,71	-3,229	*p* < 0,01	0,243
Auditory serial detection	1,45	0,97	-3,459	*p* < 0,01	0,267
Grammar	5,29	5,05	-2,727	*p* < 0,01	0,197
Conceptualization	3,92	3,74	-0,659	n.sz.	0,051
Opposites	4,40	4,23	-1,273	n.sz.	0,098
Auditory capabilities	**25,83**	**21,71**	**-4,506**	***p* < 0,001**	**0,360**

Table 5. A comparison of the development of visual and auditory abilities of children in experimental and control groups using the Mann-Whitney test, Z-values, significance levels, and impact sizes

5 The theoretical background of the results obtained

The results obtained during the research are consistent with the research results. Sensorimotor integration cannot be fully achieved without primitive reflexes of sufficient quality and intensity (Hickey and Feldhacker, 2021). These reflexes allow the baby to grip objects and materials affecting the palm of his hand, thereby obtaining tactile stimuli. With the help of the sucking reflex, you get food and experience the first tastes. He turns his head where his arm extends so that his gaze not only looks forward but also turns his head sideways, which allows more room for visual perception. His muscles adapt to the gravitational field with the help of head-setting reflexes, which allows normal muscle tone to develop (Katona, 2001; Grigg, 2018).

Proper muscle tone is indispensable for posture, movement development, clear hearing and vision, speech development, and spatial perception (Katona, 2001; Melillo, 2011; Bob, Konicarova, and Raboch, 2013;).

How well the body functions depend on the active cooperation of movement and perception, since sensory perceptions, vision, hearing, palpation, vestibular perception, together with changes of location and position, represent a two-way connection with the outside world. Depending on the degree of maturity of the functions inherent in the functioning of the human brain, age-appropriate behavior develops (Katona, 2001; Zafeiriou, 2004; De Jager, 2009).

Once primitive reflexes have fulfilled their function and are no longer needed, they are inhibited by the cerebral cortex (Zafeiriou, 2004; Sigafoos et al., 2021). In normal development, they are replaced by more mature postural reactions that accompany our lives throughout our lives. Accurate, adequate postural reactions ensure muscle tone adjustment, proper balance, good posture, and movement coordination. The functional maturation dynamics of the central nervous system allow for the acquisition of higher levels of cognitive skills, so they will also have a role in learning processes and social interactions (Hickey and Feldhacker, 2021; Sigafoos et al., 2021; Goddard et al., 2021).[1]

In preschool-age and around the age of starting school, brain plasticity is extremely powerful. Not only do existing synapses strengthen in the central nervous system, but new connections are built up. New sensory stimuli and movement increase the

[1] The recent research results show that more than 90% of children aged 4-6 years have at least one persistent infantile reflex (Gieysztor; 2018; Piecuch et al., 2020; Hickey and Feldhacker, 2021; Goddard, 2021).

production of BDNF (brain-derived neurotrophic factor) in the brain, which supports synaptogenesis in the hippocampus (Doidge, 2009).

The hippocampus, which plays a crucial role in learning and memory processes, is an ancient cortical structure indirectly related to all sensory and association areas of the cerebral cortex. Information from all senses reaches this brain area and integrates. Eventually, they return to the neocortex, the most advanced part of the cerebral cortex, to be stored there for the long term. Although memory traces are stored in other specific areas of the cerebral cortex in the long term, the hippocampus contains memory traces and associates various sensory information (Freund, 2005). BDNF stimulates synapse formation in the hippocampus and activates the basal ganglia, the area of the brain involved in cognitive processes such as decision-making, behavioural shifting, procedural learning, working memory, executive functions, and targeted movement. (Doidge, 2009; Diamond, 2013).

Exercise increases the production of BDNF and increases oxygen support, improving the oxygen supply to the brain. The movement has a stimulating effect on the sensory and motor cortex of the brain, thereby affecting the quality of perception and muscle tone regulation affecting all muscles of the body (Doidge, 2009).

A sign of high levels of neuromotor maturity is improved movement coordination and the ability to control physical activity, including inhibition delay. Controlled movement inhibition allows them to sit still and focus on a specific task (Goddard et al., 2021).

Experience shows that the process outlined above is often delayed or cancelled. In this case, primitive reflexes result in involuntary motor responses that affect the quality of motor skills (Chandradasa and Rathnayake, 2020; Bilbilaj, et al., 2017). The problem is further exacerbated if the child moves little or is exposed to inadequate quality and quantity (Doidge, 2009).

This can be explained by the fact that overcoming persistent reflexes requires increased control and insufficient production of BDNF in the central nervous system. The problem most often manifests itself in movement coordination, perception, balancing disorders, clumsiness, learning difficulties, lack of attention, poor memory, and behavioural dysfunctions (McPhillips and Sheehy, 2007; Goddard, 2009; Konicarova et al., 2013; Bilbilaj et al., 2017; Pecuch et al., 2021).

When compiling sensorimotor exercises, it had to be considered that the training includes exercises which on one hand facilitate the integration of primitive reflexes (Melillo, 2011; Gieysztor, 2018) and on the other hand support sensorimotor integration and the skills and abilities whose development and development were hindered by persistent infantile reflexes.

The results obtained during the impact assessment proved the effectiveness of the training, confirming the theory that movement and sensorimotor development, affects the development of cognitive operations, self-image, fine motor and large movements, laterality, space perception, and eye-hand coordination. In addition, socialization has an impact in many areas. Movement tasks strengthen control and self-control functions, attention concentration, endurance, and the ability to exert one's effort. Working in pairs leads to concrete experiences to learn the child's self-limits, the partner's perception, and the development of cooperative skills. "Even in the case of milder neurological impairments, movement can be the starting point and the right tool." (Porkolábné, Páli, Gregorius and Pintér, p. 8, 1996; Melillo, 2011; Konicarova and Bob, 2013; Grzywniak, 2017).

It is worth saying a few words about age as a background variable. Concerning the development of the reflex profile, it can be seen that the development is rapid between the ages of 4 and 6, but after six years, it slows down significantly. In terms of vestibular maturity, motor coordination, and multichannel attention, progress is faster between the ages of 4 and 6, but a slight slowdown can be seen here after 6. Then, by the age of 8, a significant jump occurs again. We can say that with age, sensorimotor abilities improve. However, when we compare the results of the experimental and control groups after development, there is a clear difference in development in favour of the experimental group.[2] The sensory-motor development resulting from the training far exceeds the changes experienced with age. Learning, behavioural and integration problems manifest themselves mostly during the school years. Perception blocks, disturbances, incorrect pencil grip, eye-hand coordination disturbances, hypotonic muscles, difficulty focusing, and lack of post-rotation nystagmus (to name a few "minor" problems) usually occur in kindergarten or at the beginning of school learning and is visible only through apparent "slowness" of the child or distracted

[2] See Table 3.

attention. Over time, problems from multiple origins surface in illegible writing, difficulty comprehension, text creation, and spelling errors. Phenomena that can be examined using neurophysiological and developmental psychology methods appear as specific pedagogical problems.

A gap between the child's possible and actual performance at school leads to frustration, anxiety, and discomfort, depending on the personality type. They have a bigger or smaller significant deviation from learning and school. The probability of this should be reduced as much as possible. To avoid more severe problems, preventive tools are needed, which can be placed in the hands of kindergarten teachers, teachers, and teachers to be part of the educational work.

Of course, the "the sooner, the better" principle applies here as well. To prepare for schoolwork, sensory and motor development should be included in the children's lives no later than the last year of kindergarten.

6 List of publications on which theses are based

Abdelkarim, O., Ammar, A., Chtourou, H., Wagner, M., Knisel, E., Hökelmann, A., és Bös, K. (2017). Relationship between motor and cognitive learning abilities among primary school-aged children. *Alexandria Journal of Medicine*, *53*(4), 325–331. https://doi.org/10.1016/j.ajme.2016.12.004

Adkins, D. A. L., Boychuk, J., Remple, M. S., és Kleim, J. A. (2006). Motor training induces experience-specific patterns of plasticity across motor cortex and spinal cord. *Journal of Applied Physiology*, *101*(6), 1776–1782. https://doi.org/10.1152/japplphysiol.00515.2006

Affisati, F., Echazarra, A., Givord, P. és Schwabe, M. (2019). *Programme for International Student Assessment (PISA). Results from PISA 2018. Country Note Hungary*. OECD, Paris. Retrieved January 30, 2021, from https://www.oecd.org/pisa/publications/PISA2018_CN_HUN.pdf

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). APA, Washington, DC

Association for Children with Learning Disabilities (1986). *ACLD description: Specific learning disabilities.* ACLD Newsbriefs, 15-16.

Ayres, J. (1979). *Sensory Integration and the Child.* Western Psychological Services, Los Angeles, CA.

Balázsi I., Ostorics, L., Szalay B. és Szepesi I. (2010). *PISA összefoglaló jelentés. Szövegértés tíz év távlatában.* Oktatási Hivatal, Budapest. Retrieved January 30, 2021, from https://www.oktatas.hu/pub_bin/dload/kozoktatas/nemzetkozi_meresek/pisa/pisa_2009_osszfogl_jel_110111.pdf

Balleine, B. (2019). Review for "bases of Jerzy Konorski's theory of synaptic plasticity". https://doi.org/10.1111/ejn.14532/v1/review2

Bateman, B. (1965). *An educational view of a diagnostic approach to learning disorders*. In: Hellmuth, J. (szerk.) *Learning disorders* (Vol. 1). Special Child Publication, Seattle. 219-239.

Berényi, M. és Katona, F. (2014). Fejlődésneurológia. Az öntudat, a kommunikáció és a mozgás kialakulása. Budapest: Medicina.

Berquin, P.C., Giedd, J.N., Jacobsen, L.K., Hamburger, S.D., Krain, A.L., Rapoport, J.L. és Castellanos, F.X. (1998). Cerebellum in attention-deficit hyperactivity disorder: a morphometric MRI study. *Neurology, 50*(4), 1087-1093.

Bilbilaj, D. S., G, D. A., & S, D. F. (2017). Measuring primitive reflexes in children with learning disorders. *European Journal of Multidisciplinary Studies, 5*(1), 285. https://doi.org/10.26417/ejms.v5i1.p285-298

Blomberg, H., Dempsey, M. és Phua, S. S. (2008). *Movements that heal: Rhythmic movement training and primitive reflex integration*. Beyond the Sea Squirt.

Blythe, P. (1992). *A physical approach to resolving learning difficulties*. Institute for Neuro-Physiological Psychology, Chester.

Bob, P., Konicarova, J. és Raboch, J. (2013). Persisting primitive reflexes in medication-naïve girls with attention-deficit and hyperactivity disorder. *Neuropsychiatric Disease and Treatment, 9*, 1457-1481. doi: 10.2147/ndt.s49343

Brown, R. D. (2018). *Neuroscience of Mathematical Cognitive Development: From Infancy Through Emerging Adulthood*. Springer.

Bushnell, E. és Boudreau, J. (1993). Motor development and the mind: The potential role of motor abilities as a determinant of aspects of perceptual development. *Child Development, 63*(4), 1005-1021. Retrieved January 30, 2021, from https://pubmed.ncbi.nlm.nih.gov/8404253/

Cantell, M.H., Smyth, M.M. és Ahonen, T. P. (1994). Clumsiness in Adolescence: Educational, Motor, and Social Outcomes of Motor Delay Detected at 5 Years. *Adapted Physical Activity Quarterly, 11*(2), 115–129. doi:10.1123/apaq.11.2.115

Capute, A.J., Palmer, F.B., Shupiro, B.K., Wuchtel, R.C., Ross, A. és Accurdo, P. J. (1984). Primitive Reflex Profile: A Quantitation Of Primitive Reflexes In Infancy. *Developmental Medicine & Child Neurology, 26*(3), 375-383. doi:10.1111/j.1469-8749.1984.tb04456.x

Capute, A.J. és Accardo, P.J. (1991*). Developmental Disabilities in Infancy and Childhood.* Paul Brooks, Baltimore, MD**.**

Chaddock, L., Hillman, C. H., Pontifex, M. B., Johnson, C. R., Raine, L. B., és Kramer, A. F. (2012). Childhood aerobic fitness Predicts cognitive performance one year later. *Journal of Sports Sciences, 30*(5), 421–430. https://doi.org/10.1080/02640414.2011.647706

Chaddock-Heyman, L., Erickson, K. I., Kienzler, C., King, M., Pontifex, M. B., Raine, L. B., Hillman, C. H., és Kramer, A. F. (2015). Correction: The role of aerobic fitness in cortical thickness and mathematics achievement in Preadolescent Children. PLOS ONE, 10(9). https://doi.org/10.1371/journal.pone.0138166

Chandradasa, M., és Rathnayake, L. (2020). Retained primitive reflexes in children, clinical implications and targeted home-based interventions. *Nursing Children and Young People*, *32*(1), 37–42. https://doi.org/10.7748/ncyp.2019.e1132

Cheatum, B.A. és Hammond, A.A. (2000). *Physical Activities for Improving Children's Learning and Behavior*. Human Kinetics, Champaign, II.

Csapó, B. (2003). *A képességek fejlődése és iskolai fejlesztése*. Akadémiai Kiadó, Budapest.

Damasceno, A., Delicio, A. M., Mazo, D. F. C., Zullo, J. F. D., Scherer, P., T.Y. Ng, R., és Damasceno, B. P. (2005). Primitive reflexes and cognitive function. Arquivos De Neuro-Psiquiatria, 63(3a), 577–582. https://doi.org/10.1590/s0004-282x2005000400004

Diamond, A. (2000). Close interrelation of Motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development*, *71*(1), 44–56. https://doi.org/10.1111/1467-8624.00117

Diamond, A., Barnett, W. S., Thomas, J., és Munro, S. (2007). THE early YEARS: Preschool program improves cognitive control. *Science*, *318*(5855), 1387–1388. https://doi.org/10.1126/science.1151148

Diamond, A. (2013). Executve functions. *Annual Review of Psychology*, *64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Doidge, N. (2009). *The brain that changes itself: Stories of personal triumph from the frontiers of Brain Science*. Scribe Publications.

Dordel, S. és Breithecker, D. (2003). Bewegte Schule als Chance einer Förderung der Lern- und Leistungsfähigkeit. *Haltunk und Bewegung*, *23*(2), 5-15. Retrieved January 30, 2021, from http://dms-portal.bildung.hessen.de/zfs/bewegungsfoerdernde_schule/links /dordelbreithecker.pdf

Đorđić, V., Tubić, T., és Jakšić, D. (2016). The relationship between physical, motor, and intellectual development of preschool children. *Procedia - Social and Behavioral Sciences*, *233*, 3–7. https://doi.org/10.1016/j.sbspro.2016.10.114

Dwyer, T., Sallis, J., Blizzard, L., Lazarus, R. és Dean, K. (2001). Relation of Academic Performance to Physical Activity and Fitness in Children. *Pediatrics Exercise Science, 13*(3), 225-237. Retrieved January 30, 2021, from https://journals.humankinetics.com/view/journals/pes/13/3/article-p225.xml

Eagleman, D. (2016). *The brain: The story of you*. Canongate Books, U.K.

Elliott, J.G. és Gibbs, S. (2008). Does dyslexia exist? *Journal of Philosophy of Education, 42*(3-4), 475–491. doi:10.1111/j.1467-9752.2008.00653.x

European Commission (2018). *Country Report. Non Discrimination. Hungary 2018.* European Commission, Brussels. 49.

European Commission (2018): *Education and Training Monitor Hungary Factsheet*. European Commission, Brussels. Retrieved January 30, 2021, from https://ec.europa.eu/education/resources-and-tools/document-library/education-and-training-monitor-2018-hungary-factsheet_en

Freund, T. (2005). *Lassú frekvenciájú agyhullámok és zajszűrés a hippocampusban*. Retrieved January 14, 2022, from http://epa.niif.hu/00600/00691/00013/pdf/EPA00691_magyar_tudomany_2005-01_007-011.pdf

Gieysztor, E. Z., Choińska, A. M., és Paprocka-Borowicz, M. (2018). Persistence of primitive reflexes and associated motor problems in healthy preschool children. *Archives of Medical Science*, *1*, 167–173. https://doi.org/10.5114/aoms.2016.60503

Ghanizadeh, A. (2011). Predictors of postural stability in children with ADHD. *Journal of Attention Disorders*, 15(7), 604-10.

Goddard, S. (2009). *Attention, Balance and Coordination: The, A.B.C of Learning Succes*. John Wiley & Sons; Hoboken, NJ, USA.

Goddard, S. (2015). *Reflexek, tanulás és viselkedés. Betekintés a gyermeki elmébe: A tanulási és magatartási problémák nem-invazív megoldása*. Medicina Könyvkiadó Zrt., Budapest.

Goddard Blythe, S., Duncombe, R., Preedy, P., és Gorely, T. (2021). Neuromotor readiness for school: The primitive reflex status of young children at the start and end of their first year at school in the United Kingdom. *Education 3-13*, 1–14. https://doi.org/10.1080/03004279.2021.1895276

Grigg, T. (2018). *The influences of a primitive reflex integration programme within the classroom : teacher/parent perspectives and student results.* (thesis). University of Canterbury, Christchurch, New Zealand.

Grzywniak, C. (2017). Integration exercise programme for children with learning difficulties who have preserved vestigial primitive reflexes. *Acta Neuropsychologica*, *15*(3). https://doi.org/10.5604/01.3001.0010.5491

Gyarmathy, É. (1998). Tanulási zavarok szindróma a szakirodalomban. *Új Pedagógiai Szemle, 43*(10), 59-68. Retrieved February 12, 2021, from http://epa.oszk.hu/00000/00035/00020/1998-10-lk-Gyarmathy-Tanulasi.html

Hammil, D.D. (1990). On Defining Learning Disabilities. *Journal of Learning Disabilities*, *23*(2), 74–84. doi: 10.1177/002221949002300201

Hámori, J. (1975). *Az idegrendszer fejlődése és a mozgásszerveződés kölcsönhatása 6-18 éves korúaknál.* Tanulmányok az ifjúság testi neveléséről. Sport, Budapest.

Hickey, J., és Feldhacker, D. R. (2021). Primitive reflex retention and attention among preschool children. *Journal of Occupational Therapy, Schools, & Early Intervention*, 1–13. https://doi.org/10.1080/19411243.2021.1910606

Huettig, C., Pyfer, J., és Auxter, D. (2001). *Gross motor activities for young children with special needs*. McGraw-Hill.

Illingworth, R.S. (1987). *The development of the infant and young child: Normal and abnormal.* Churchill Livingstone, London.

Iverson, J. (2010). Developing language in a developing body: The relationship between motor development and language development. *Journal of Child Language, 37*(2), 229-261. Retrieved January 30, 2021, from http://www.pitt.edu/~icl/publications/Iverson_2010.pdf

Jackson, H. (1884). *Croonian Lectures: On the Evolution and Dissolution of the Nervous System. The Lancet*, *123*(3161), 555–558. https://doi.org/10.1016/s0140-6736(02)22511-8

Jaiswal, M. és Morankar, R. (2017). Understanding Primitive Reflexes and Their Role In Growth And Development: A Review. *International Healthcare Research Journal, 1*(8), 243-247. doi:10.26440/ihrj/01_08/123

Juhász, Á. (2007). *Logopédiai vizsgálatok kézikönyve*. Logopédia, Budapest.

Katona, F. (2001). *"Az öntudat újraébredése": a humán idegrendszer ontogenesise*. Medicina, Budapest.

Konicarova, J. és Bob, P. (2012). Retained Primitive Reflexes and ADHD in Children. *Activitas Nervosa Superior, 54*(3-4), 135-138. doi:10.1007/bf03379591

Konicarova, J. és Bob, P. (2013). Principle of Dissolution and Primitive Reflexes in AD HD. *Activitas Nervosa Superior, 55*(1-2), 74–78. doi: 10.1007/bf03379598

Könyvesi, T. (2018). *Köznevelési Statisztikai Évkönyv*. (T. Hagymásy, Trans.) (Vol. 150). Budapest: Emberi Erőforrások Minisztériuma. Retrieved from https://www.google.com/search?q=KÖZNEVELÉSI STATISZTIKAI ÉVKÖNYV 2016/2017&oq=KÖZNEVELÉSI STATISZTIKAI ÉVKÖNYV 2016/2017&aqs=chrome..69i57j33.1223j0j7&sourceid=chrome&ie=UTF-8

Kranowitz, C.S. és Miller, L.J. (2012). *Zűr-zavaros gyermek: Az érzékelési rendellenesség felismerése és kezelése*. Dunakeszi: Studio Nagy BT.

László, Á.M. és Kóbor, G. (2009). *Beszédértés*. Budapest:Ton-Ton.

Leppert, M. L. O. C., Shank, T. P., Shapiro, B. K., és Capute, A. J. (2016). *The capute scales: Cat/CLAMS - a pediatric assessment tool for the early detection of mental retardation and communicative disorders*. Johns Hopkins University. Retrieved January 15, 2022, from https://jhu.pure.elsevier.com/en/publications/the-capute-scales-catclams-a-pediatric-assessment-tool-for-the-ea-3

Máčaj, M., és Žovinec, E. (2013). Az agy fejlődését befolyásoló tényezők és a beszéd fejlődése. *Módszertani közlemények, SZTE Egyetemi Kiadványok*. (53) 2. 1-5.

Malina, R. M., Bouchard, C., és Bar-Or, O. (2004). *Growth, maturation and physical activity*. Human Kinetics.

Mann, M. D. (2021). The nervous system in action. Retrieved December 28, 2021, from

McDonnell, M. N., Buckley, J. D., Opie, G. M., Ridding, M. C., és Semmler, J. G. (2013). A single bout of aerobic exercise promotes motor cortical neuroplasticity. *Journal of Applied Physiology, 114*(9), 1174–1182. https://doi.org/10.1152/japplphysiol.01378.2012

McEvoy, M. (1970). *The role of persistent primitive reflexes in learning difficulties: An evaluation of a new causal theory of dyslexia*. (Disszertáció) Trinity College, Dublin. Retrieved February 26, 2021, from http://www.tara.tcd.ie/handle/2262/79670

McPhillips, M. és Jordan-Black, J. A. (2007). Primary reflex persistence in children with reading difficulties (dyslexia): A cross-sectional study. *Neuropsychologia, 45*(4), 748–754.

McPhillips, M., Hepper, P. G., és Mulhern, G. (2000). Effects of replicating primary-reflex movements on specific reading difficulties in children: a randomised, double-blind, controlled trial. *Lancet, 12*(355), 537-541.

Melillo, R. (2011). *Primitive Reflexes and Their to Delayed Cortical Maturation, Under Connectivity and Functional Disconnection in Childhood Neurobehavioral*. *F. R. Carrick Institute for Clinical Ergonomics, Rehabilitation, and Applied Neurosciences, 1*(2), 1–36.

Melillo, R. (2015). *Disconnected kids: The groundbreaking brain balance program for children with autism, adhd, dyslexia, and other neurological disorders*. A Perigee Book.

Mesterházi Zs. (2019). A tanulási nehézségek típusai. In Mesterházi Zs. és Szekeres Á. (szerk.), *A nehezen tanuló gyermekek iskolai nevelése*. Egyetemi tankönyv a Gyógypedagógia szak Tanulásban akadályozottak pedagógiája szakirány számára. (63-68, 88-92). Budapest: ELTE Bárczi Gusztáv Gyógypedagógiai Kar.

Nahalka, I. (2020). Konstruált tudás. 2. Kézirat

National Advisory Committee on Handicapped Children. (1968). *Special education for handicapped children* (First Annual Report). Department of Health, Education, & Welfare, Washington, D.C.

National Joint Committee for Learning Disabilities. Learning disabilities: Issues on definition. Unpublished manuscript. (1981). Available from Drake Duane, NJCLD Chairperson, c/o The Orton Dyslexia Society, 8415 Bellona Lane, Towson, Maryland 21204.

National Institute of Health (1960). *The Central Nervous System and Behavior: Translations from the Russian Medical Literature.* U.S. Department of Health, Education and Welfare Public Health Service. Princeton, NJ. Retrieved January 30, 2021, from https://books.google.hu/books?id=fJjsAsfGLIIC&printsec=frontcover&hl=hu&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Nicolson, S.E., Chabon, B., Larsen, K.A., Kelly, S.E., Potter, A.W. és Stern, T.A. (2011). Primitive Reflexes Associated with Delirium: A Prospective Trial. *Psychosomatics, 52*(6), 507–512. doi: 10.1016/j.psym.2011.06.008

Niklasson, M. (2012). Could Motor Development Be an Emergent Property of Vestibular Stimulation and Primary Reflex Inhibition? A Tentative Approach to Sensorimotor Therapy. In: Shittiprapaporn, W. (szerk.) *Learning Disabilities*. InTech, Rijeka. 241-274. doi:10.5772/31726

Oktatási Hivatal (2019). *PISA 2018. Összefoglaló jelentés.* Oktatási Hivatal, Budapest. https://www.oktatas.hu/pub_bin/dload/kozoktatas/nemzetkozi_meresek/pisa/PISA2018_v6.pdf

O'Regan, J.K., (2009), *Sensorimotor approach to (phenomenal) consciousness*. In: Baynes, T., Cleeremans, A. és Wilken, P. (Eds), Oxford Companion to Consciousness, pp. 588-593, Oxford University Press, Oxford, UK.

Pecuch, A., Gieysztor, E., Telenga, M., Wolańska, E., Kowal, M., és Paprocka-Borowicz, M. (2020). Primitive reflex activity in relation to the sensory profile in healthy preschool children. *International Journal of Environmental Research and Public Health, 17*(21), 8210. https://doi.org/10.3390/ijerph17218210

Pinczésné Palásthy, I. (2006). Tanulási zavarok I. *Módszertani közlemények 46*(1), 1-8. Retrieved February 19, 2021, from http://digit.bibl.u-szeged.hu/00100/00164/00221/modszertani_046_001_001-008.pdf

PISA2018 CN HUN.pdf. https://www.oecd.org/pisa/publications/PISA2018_CN_HUN.pdf

Porkolábné Balogh, K. (1990). *Módszerek a tanulási zavarok csoportos szűrésére és korrekciójára.* Iskolapszichológia 17. ELTE, Budapest.

Porkolábné Balogh, K., Balázsné Szűcs, J., Szaitzné Gregorits, A. és Páli J. (1996). *Komplex prevenciós óvodai program: kudarc nélkül az iskolában: óvodai fejlesztő program a tanulási zavarok megelőzésére*. Országos Közoktatási Intézet, Budapest.

Pecuch, A., Gieysztor, E., Wolańska, E., Telenga, M., és Paprocka-Borowicz, M. (2021). Primitive reflex activity in relation to motor skills in healthy preschool children. *Brain Sciences*, *11*(8), 967.

Quirds. J. B., (1986). Diagnosis of Vestibular Disorders in the Learning Disabled. *Journal of Learning Disabilities, 9* (1), 39-47. doi: 10.1177/002221947600900108

Quiros, J. B. (1976). Significance of Some Therapies on Posture and Learning. *Academic Therapy*, *11*(3), 261–270. https://doi.org/10.1177/105345127601100301

Rašić Canevska, O. (2019). Persistence of primitive reflexes and associated problems in children. *Годишен Зборник На Филозофскиот Факултет/The Annual of the Faculty of Philosophy in Skopje*, *72*, 513–522. https://doi.org/10.37510/godzbo1972513rc

Rentschler, M. (2008). The Masgutova Method of Neuro-Sensory-Motor and Reflex Integration: Key to Health, Development and Learning. In: Wenberg, S. és Rentschler, M. (szerk.) *Masgutova*. Retrieved February 26, 2021, from http://ekladata.com/bAsITI2Fy9Zarlub6yDSm1Oj4M8/article_Masgutova_Method.pdf

Sigafoos, J., Roche, L., O'Reilly, M. F., és Lancioni, G. E. (2021). Persistence of primitive reflexes in developmental disorders. *Current Developmental Disorders Reports*. https://doi.org/10.1007/s40474-021-00232-2

Sigmundsson, H. (2005). Disorders of motor development (clumsy child syndrome). In: W. W. Fleischhacker (Author), *Neurodevelopmental disorders*. Wien: Springer.

Taylor, M., Houghton, S., és Chapman, E. (2004). Primitive reflexes and attention deficit/ hyperactivity disorder: Developmental origins of classroom dysfunction. *International Journal of Special Education*,19, 23-37.

Taylor, M. H. (2003). *Primitive reflexes and attention-deficit/hyperactivity disorder: Developmental origins of classroom dysfunction.* International Journal of Special Education. https://eric.ed.gov/?id=EJ852040.

The unlock brilliance way. (2016, November 01). Retrieved March 03, 2021, from https://www.solvelearningdisabilities.com/unlock-brilliance/

Touwen, B.C.L. (1984). Primitive reflexes-conceptional or semantic problem. In H.F.R Prechtl (Ed.), *Continuity of neural functions from prenatal to postnatal life.* Oxford, Great Britain: Spastics International Medical Publications.

Voelcker-Rehage, C., Niemann, C., Hübner, L., Godde, B., és Winneke, A. H. (2016). Benefits of physical activity and fitness for lifelong cognitive and motor development—brain and behavior. *Sport and Exercise Psychology Research*, 43–73. https://doi.org/10.1016/b978-0-12-803634-1.00003-0

Von Hofsten, C., és Rosander, K. (2018). The development of Sensorimotor intelligence in infants. Retrieved February 11, 2021, from https://www.ncbi.nlm.nih.gov/pubmed/30031439

Wassenberg, R., Feron, F. J., Kessels, A. G., Hendriksen, J. G., Kalff, A. C., Kroes, M., Hurks, P. P., Beeren, M., Jolles, J., és Vles, J. S. (2005). Relation between cognitive and motor performance in 5- to 6-year-old children: Results from a large-scale cross-sectional study. *Child Development*, *76*(5), 1092–1103. https://doi.org/10.1111/j.1467-8624.2005.00899.x

Wepman, J., Cruickshank, W., Deutsch, C,Morency, A., és Strother, C. (1975). *Learning disabilities. In N. Hobbs (Ed.), Issues in the classification of children, Vol. 1, 300–317. San Francisco: Jossey-Bass.*

Wiener-Vacher, S. R., Hamilton, D. A., és Wiener, S. I. (2013). *Vestibular activity and cognitive development in children: Perspectives*. Frontiers. https://www.frontiersin.org/articles/10.3389/fnint.2013.00092/full.

Yewchuk, C., és Lupart, J. (2000). Inclusive Education for Gifted Students with Disabilities. *International Handbook of Giftedness and Talent,* 659-670. doi:10.1016/b978-008043796-5/50047-4

Zafeiriou, D. I. (2004). Primitive reflexes and postural reactions in the neurodevelopmental examination. *Pediatric Neurology*, *31*(1), 1–8. https://doi.org/10.1016/j.pediatrneurol.2004.01.012

Zsoldos, J. M., és Sarkady, K. (2001). *Szűrőeljárás óvodáskorban a tanulási zavar lehetőségének vizsgálatára Msst (Meeting Street School Screening Test - Mssst): Meeting Street School Szűrőteszt*. Budapest: ELTE Bárczi Gusztáv Gyógypedagógiai Főiskolai Kar. 3-9.

8 My publications on the subject

Sarlós, E. (2020). The effect of sensorimotor training on the sensorimotor development of children aged 4-8 and on the learning abilities of children aged 5-8. *INTED2020 Proceedings*. https://doi.org/10.21125/inted.2020.2189

Sarlós, E. (2019). THE frequency of PERSISTENT baby reflexes which INFLUENCE learning skills among children aged 4 to 8. *EDULEARN19 Proceedings*. https://doi.org/10.21125/edulearn.2019.0377

Sarlós, E. (2019). A szenzomotoros fejlesztés hatása a 4-8 éves gyerekek szenzomotoros fejlődésére, illetve az 5-8 éves gyermekek tanulási részképességeire. *A 16 éves PEME XIX. PhD - Konferenciájának előadásai.* Budapest: Professzorok az Európai Magyarországért Egyesület 287-298.

Sarlós, E. (2018). Influence of sensorimotor exercises on learning abilities. *ICERI2018 Proceedings*. https://doi.org/10.21125/iceri.2018.0983

Sarlós, E. (2018). *Konferencia 2018 / Conference 2018*. II. Nemzetközi Neuropedagógiai Konferencia, Budapest, 2021 / International Conference on Neuroeducation II, Budapest, 2021. Retrieved September 26, 2021, from http://hatorszag.hu/konferencia-2018-conference-2018/.

Sarlós, E. (2017). A szenzomotoros felmérésre épülő Fókuszált Szenzomotoros Tréning hatása a gyermekek tanulási képességeire a nagycsoportos óvodások körében. *VI. Interdiszciplináris Doktorandusz Konferencia 2017 Tanulmánykötet.* Pécs: Pécsi Tudományegyetem Doktorandusz Önkormányzat 473-489

Sarlós, E. (2021). A szenzomotoros érettség és az auditív, vizuális részképességek közötti összefüggés az 5-8 éves gyerekek esetében. In *Tizennyolc éve az európai Magyarország tudományos megújulása és a fiatal kutatók szolgálatában* (pp. 193–202).

Sarlós, E. (2021). To Investigate the Association between Vestibular Maturity and Partial Auditory Abilities in Children Aged 4-8 Years. In *Proceedings of The 2nd Global Conference on Education and Teaching* (pp. 26–33).

Sarlós, E. (2021). Investigating the Association Between Retained Primitive Reflexes and Partial Visual Abilities in Children Aged 4–8 Years. In *Proceedings of The 4th International Conference on Advanced Research* (pp. 187-196).