

RELATIONSHIP BETWEEN BALANCING ABILITY AND SCHOOL READINESS

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The developmental level of the nervous system has a very important role in successful learning. The maturation of the nervous system determines the quality of motor coordination and intellectual functions. The lack of the information processing which can be connected to cerebrospinal procedures has a very important role in the development of partial function or partial skill disorders appearing during nursery school years. Although special tests can reveal the malfunction, the different motion development can also call the attention to them. Out of the direct indices of the central nervous system, the most determining area is the maturity of the balancing system. Our research began in September 2005 in Budapest in Meséskert Kindergarten. After parental approval, the motion of 105 children was measured with the test of Basic Therapy (BT). To study school maturity we used the DIFER (Diagnostical Appraising System). The children were rated according to their DIFER index into school mature (n=63) and school immature (n=42) groups. We divided our research into two parts. In the first part of our study we analysed the results of BT. The aim was to compare the motion maturity of these two groups with nine motion groups, focusing on their balancing ability. The aim was to show connections between balancing ability and critical cognitive skills measured by DIFER. In our research the level of the balancing ability was tested also by a special instrument, the Stabilometer, which is a 60X60 cm sized instrument fixed to springs at its four corners attached to a personal computer. The stabilometer fixed the fluctuation of the body-mass-centre. Our aim was to corroborate the differences of the balancing abilities of the two groups with this special instrument. The data analysis was made with StatSoftStatistic program. The results were that the balancing ability of school immature children is weaker than that of their mature mates, especially in the case when they had to execute tasks with closed eyes.

Keywords: central nervous system maturity, school readiness, perception, vestibular system

Literature review

Numerous foreign specialists focus on analysing the connection of motion coordination and partial function disorders. Based on their researches, they emphasize the leeway of motion-development, motor-coordination, and the problem of the sensory processor system out of other symptoms. *Shapiro* and his colleagues (1990) draw attention to the fact that if we notice any deviant development of a child, learning impairment can be diagnosed earlier, thus making better chances of the child to succeed later in school. The partial function or partial ability disorders occurring at kindergarten ages anticipate the learning disorders. How children elaborate the information received is essential in their further schooling. To the difficulty of processing visual and auditive stimulus follows the disorder of speech acquisition and emotional as well as behavioural disorders (Spaller & Spaller, 2006:312-313). If the child does not feel the stimuli in the right order through sensation, if their arrangement, stressing and differentiation are wrong, later, this problem can lead to learning disorders (Csabay, 1998). When the change occurs from kindergarten to school, in favour of achievement, school maturity examinations become important. To diagnose school maturity, a complex and a deep examination of the personality is necessary. School maturity can be described by a complex character which must be determined carefully and by due foresight. Several specialists think that at this age the examination of the maturity of movement is reasonable besides the cognitive maturity (Nagyné, 1997; Lakatos, 2002; Porkolábné, 2004; Getchell, McMenamin & Whitall, 2005).

Perception

The sensory processing ability is in connection with skills important for everyday life. The sensory procession involves the understanding and the modulating of the stimuli and also the organization of the sensory input so a person is able to answer effectively in daily activities situations (Humphry, 2002). The successful execution of motor skills is also greatly determined by healthy sensory processing besides attention and organization. So the effective sensory perception and their integration assist the motor skills, for example the visual, vestibular and tactile systems. The sensory system of the children can foreshow how successful they will be in everyday life. The mature sensory system – which also plays an important role in motion-development – contributes to functional achievement at home, at school and at any other community stage. The developmental level of the motor skills affects perception. In turn, the development of perception is the keystone of the conceptual cognition.

Dunbar (1999) emphasizes the problem of the early identification of the sensory perception; poor sensory processing can affect a child's ability to successfully perform daily activities because of its effect on cognitive, sensory, and motor development. *Parham and Mailloux* (2005) present that the difficulties of the sensory processing go frequently hand in hand with diminished social skills, gross and fine motor coordination, immature playing skills, and the weakness of those skills which are necessary for everyday life. Sixty-eight children took part in the research of *White and his colleagues* (2007). According to their Sensory Profile (auditory, visual, vestibular, tactile and tasting perception) the children were divided into atypical sensory-system and good sensory-system groups. Children were compared on the basis of their motor skills used in everyday life. They found out that motor areas correlated with all sensory areas except the tasting

perception. They got significant connection with the balancing ability, since this sensory system is the closest connection with motion execution. The fine eye-movement disorder of children with learning disability is due to their weaker anticipating skill, caused by the problematic feedback processing ability to outer informations (Weiler et. al., 2000). For this reason, children with learning disabilities execute tasks requiring eye-hand coordination with difficulty. This low performance is explained by poor operation of the cerebellum, that is, motor-coordination and sensory information processing function at a lower level.

Numerous studies confirm also that impaired kinesthetic-feedback and motor-planning are in connection with fine-motor coordination which is an important factor of good results in school. With the passing of the years, these forecaster systems work much more accurately since the processing of the outer perception information becomes faster (van Roon, et. al. 2010). The conversion to the kinesthetic information can speed up acquiring basic cultural techniques. If this conversion is missing, the retardation of the expected development during later school years can affect academic advance (Benbow, 1995; Laszlo & Bairstow, 1984; Levine, 1998).

Vestibular system

In our research we concentrated on examining the balancing ability. Out of the other sensory processing systems (vision, audition, touch, balancing, kinesthesis) the balancing system is supposed to be one of the most determinative area as indicator of the central nervous system's maturity (Katona, 1986; Földi, 2005).

Our vestibular system is one of our most ancient motion-regulator organ. It gets stimuli immediately after birth, but also already during pregnancy (*rapid shift of mother – movements in amniotic liquid*). The myelination of the neurons happens at the earliest stages of development (at the 10th gestational week). It gives signals of its working ability when the foetus turns to the birth-channel. It plays an important part also in the execution of newborn-age-motion-reaction during the 2-3 months after birth (*Moro reflex, Postural reactions*). Producing the so-called elemental movement works in connection with a well-defined stimulus-posture and the vestibular system has a leading role in it.

The vestibular system maturity is proven by postural- (*floating-seating, lifting to sitting position*) and locomotion-movements (*elemental crawling on a slope, crawling, assisted creeping*). These stimulus-postures activate the reception of the vestibulum and medulla oblongata. Stimulus coming from front and back arch-channel launch trunk-and head-movement in which the cerebellum regulates the muscle-tone. At the end of the floating-seating test the optical-orientation reaction gives signs of the vestibular and visual co-operation. The newborn begins adequate reactions to vestibular stimulus-posture. The infant gives signs of his vestibular system working in coordination with the motion-answer, and helps it mature. All this affects the baby's cognitive development (Földi, 2005).

Our vestibular system has more functions; it stabilizes the center of gravity; regulates the eye-movements, stabilizes the face during the head movement; regulates the balance with altering body-posture and position against gravity as well as spatial sensation of the body-posture. These functions are realized by complex reflex-mechanisms. The vestibular impulses are conveyed by a complex neuro-track to the central structures by which these impulses get to the spinal cord, to numerous parts of the brain-stem, to the cerebellum, and supposedly to the temporal cortex. The stabil

status of the human is laying horizontal (in a prone position or lying on the back). Every posture differing from these are unstable status. Supporting the stability needs the fine coordination of sensory and motor system. Several connections of our vestibular system make the complex and common regulation of the vestibular impulses and eye-movements possible. This *vestibulo-ocular reflex (VOR)* assures the continuous fixation which is independent from the head-movement evolving during the maturity of the nervous system. The visual and vestibular system also cooperate closely in regulating the spatial-orientation. Numerous reflexes – connected to body-posture and motion – are based on many connections of the vestibular system with the motor-system (Oláh, 2006, Katona, 2001).

Nursery-school-aged children can balance well, if their vestibular system is mature. A child keeps his balance at motions involving change of direction, space and position. The successful execution of simple static- and dynamic balancing tasks makes the execution of the elemental movement-program of sport-motions possible. These motions first of all need the maturity of the balancing sensation and the kinaesthesia ability (Istvánfi, 2006). The child is able to walk continuously and to balance on elevated surface and on one leg. *Miyahara, Piek and Barrett (2008)* confirm with their results the cooperation and interaction among coordination structure, vision, head-movements and fine-movements. The fine-motor skills need stabil body-posture. Big muscles have to help the working of fine-muscles and the eye-hand coordination which are assisted and regulated by good posture and balance. These findings are affirmed by *Johnson and Williams (1988)* too. In their research they found that fine-motor achievement of children with underdeveloped gross-motor coordination show improvement if their posture is assisted. The harmonious cooperation of bigger muscles, the adequate level of static- and dynamic-balancing ability play an important role in the body-posture stabilization. This is the reason we have to put emphasis on developing these areas even in early childhood. *Case-Smith (2000)* reports that motion-therapists in America stimulate children by vestibular and proprioceptive effects in the interest of helping the organization of information connected to body-posture- a condition elemental to the function of a child. The specific vestibular and proprioceptive stimuli can increase muscle-tone and can affect the stability of the torso which, in turn, directly affects the hand movement of a child. *Tseng and Cermak (1993)* also emphasize the body stability, and the effect of the muscle-tone on hand-writing.

Weak balancing ability can later manifest in reading difficulties (Stoodley et. al., 2005). They found that the result of the balancing tests with open eyes is significantly weaker at children with dyslexia than that of the control group. However the two groups were not different from each other at their closed-eye execution. This result is explained by a weak visual feedback which does not manifest itself at the closed-eyes execution. Beyond balancing tests, they also examined the reading skills of the children. They found connections between the two areas. They hypothesise that the examined motion-ability limits or affects the maturation of the reading skills. Experts emphasized that brain deviation can be hypothesised behind the symptoms of learning and partial-functions disorders, but it cannot be detected clearly. However if a child, who is not yet mature enough, gets into the educational system, learning problems can manifest very early and it becomes more and more difficult to catch up with the others. The function-disorders not discovered in time can lead to learning disorders which are the most common problem among 6-12 year-old pupils.

Method Sampling

We sent letters to four kindergartens of Budapest including the brief overview of the research project. Upon the favourable reception of one kindergarten and making appointments we carried out our survey and measurements. Research began September 2005 in Budapest in Meséskert Kindergarten.

The next step was asking for written parental consent. After these were received we then proceeded with school maturity testing (DIFER). With the help of the motor test of the Basic Therapy the motion of 105 children was tested: 37 girls, 68 boys, age mean was 5,69, age range was: 5,11-7. We divided the children into two groups according to their DIFER index: 1) Those children whose DIFER index was above 60% got into our *school mature* Group – 1 (n=63). This is the control group. Those children, whose DIFER index was below 60% got into our *school immature* Group – 2 (n=42). This is the experimental group.

Objectives, focus and hypothesis

The primary aim of our study was to compare the motion maturity of the school mature (n=63) and the immature group (n=42) and to find out which critical cognitive skills are in close connection with balancing ability.

H₁: We assume that the school mature group performs significantly better at the test examining motion-development.

H₂: We assume that balancing ability is in connection with writing coordination.

H₃: School-mature group should execute significantly better at Romberg test.

Testing

To determine the school maturity, we used DIFER test (Diagnostic Development Analyser System) developed by *Fazekasné, Józsa and Nagy* (2004), which is the only standardized Hungarian measuring tool for diagnosing critical cognitive skills (essential for entering school). The test was given by the special pedagogues working in the 2nd and 3rd year of the kindergarten in April. Areas tested by DIFER were: sociality/SOC, writing coordination/WC, practical coherence/PCOH, listening to speech sound /SA, practical conclusion/PCON, relation vocabulary/RV and elemental counting/EC. The areas get scores. The scores were given in percentage value. The mean of the seven percentages gives DIFER index

We used the motor test of the Basic Therapy constructed by the neurologist *Éva Marton-Dévényi* and her colleagues (1999). We executed the *motion-measurement* in the gymnasium of the nursery-school. The data was collected on an examining-data-sheet. We analysed the motion of the children along 85 parameters, rated to 9 motion-groups (early movement/EM, assymmetric movement/AM, crossed movement/CM, dynamic-balancing ability/DBA, Oseretzky balancing/OS, Static-balancing ability/SBA, jumping-elasticity/JE, fine-motor coordination/FM, spatial movements/SM). Within the motion-groups we rated the motion patterns by defined criteria in a five-point scale. After this the points were summed up. From the score we counted percentage values. The assessment of certain

sub-tasks of the dynamic balancing (see 1st and 2nd tasks) and Oseretzky tasks deviates from the 5-point-scale. At Oseretzky tasks we counted the seconds. Variables:

- *At dynamic balancing ability tasks* children could reach up to 42 points (100%)/DBA
 1. Catching the ball after 180° turn three times to the right and to the left – evaluation – 1 point for every successful execution – altogether 6 points
 2. Catching the ball after 360° turn three times to the right and to the left – evaluation– 1 point for every successful execution – altogether 6 points
 3. Turning around the longitudinal-axis on the floor to the right and to the left.
 4. Turning around the longitudinal-axis in standing position to the right and to the left.
 5. Rolling forward along the latitudinal axis,
 6. Jumping in a zig-zag along a rope (evaluation– 1 to 5 points, altogether 30 points)

- *Oseretzky test* (static-balance) – altogether 84 sec (100%)/OS
 1. Standing with closed legs on tiptoe, with arms on hip. (max. 15 sec)
 2. Standing with closed legs while on tiptoe, with arms on hip and with closed-eyes. (max. 13 sec)
 3. Standing on the left leg with arms on hip (max. 15. sec)
 4. Standing on right leg with arms on hip (max. 15. sec)
 5. Standing on the left leg with arms on hip and with closed-eyes (max. 13 sec)
 6. Standing on right leg with arms akimbo and with closed-eyes (max. 13 sec)

- *Static Balancing Ability* (5 motions, evaluation – 1-5 pint, altogether 25 points)/SBA
 1. Walking on a rope forwards with open-eyes
 2. Walking on a rope forwards with closed-eyes
 3. Walking on a rope backwards
 4. Balancing a bean bag on the head,
 5. Squatter walking

In our research the level of the balancing ability was tested by a special instrument, Stabilometer, the 60X60 cm sized instrument fixed to springs at its four corners attached to a personal computer (Figure 1).The stabilometer fixed the fluctuation of the body-mass-center. In the course of the procedure the children had to complete several tasks, out of which we chose one. Altogether 25 children took part in this part of our research (school immature group: n=13, school mature group: n=12). Their average age was 5 years 8 months. In our non-invasive stabilometer research we were looking for the answer: Which group could execute better the task: school mature of immature? Furthermore we were concerned to know whether there was a difference between the two groups at the closed-eyes execution.

Romberg test: standing with arm lifting to fore-support with open- and closed- eyes for 20 sec. At this trial the personal computer fixed the changing of the body-mass-center in mm.

Figure 1. *Stabilometer*

Discussion of results

We would like to review our results in the order of our hypotheses. We analysed our data with StatSoft Statistic Program.

H_1 : We assume that school mature group will perform significantly better at the test examining motion-development.

Analyzing the independent t-test it can be clearly seen, that the school mature group executed significantly better ($p < 0.05$) at most of the examined motion areas (CA, CM, DBA, OSB, SBA, FM, BS). We examined the balancing ability using several tasks, we measured their dynamic balancing ability (DBA), static balancing ability (STB) and we worked with Oseretzky test (OSB) to study this ability. The t-test pointed out that both static (STB, OSB) and dynamic balancing abilities of school mature children are significantly better than that of the immature group (Table 1).

Table 1. *Significant differences between School mature (n=63) and School immature group (n=42) at Dynamic Balancing Ability Scores/DBA tasks*

Tasks	Mean Control group (n=63)	Mean Experimental group (n=42)	t-value	df	p
Catching the ball after 360° turn	2.11	1.66	2.36	103	0.019
Turning around the longitudinal-axis in standing position to the left	4.17	3.64	2.78	103	0.006
Turning around the longitudinal-axis in standing position to the right	4.19	3.59	3.19	103	0.001
DBA%	78.65	71.33	2.50	103	0.013

We can notice that at the results of our dynamic inquiry (Table 2) the two groups performed at significantly different levels from each-other mostly at those tasks where they had to take a full turn around their vertical axis. Our results indicate that the receptors are stimulated in that case when the head or the body moves or turns. However, no difference between the execution of school mature and immature group at 180° turn can be noticed in this case.

The task becomes really difficult for immature children when they have to execute more than 180° turns. Children had to carry out 360° turn and its multiple in laying position. Significant differences cannot be observed on this task. Turning in horizontal laying position meant a stabile balancing status for them. However, body postures differing from this -turning in standing position, ball catching in standing position- are unstable balancing states for the children. To hold these positions fine cooperation of the sensory and motor system is demanded. The task – catching the ball after a 360° turn – demands complex motion. Its successful execution needs complex perception, namely the spatial perception of the body and the fixation of eye have high priority in this task. There were differences between the two groups in the execution to the left, but in the execution to the opposite direction- to the right, we did not observe significant differences. The results appear to be influenced by another factor of the index of the nervous system maturity: the development of laterality. According to laterality examination, 52 children had evolved one sided laterality, 22 children had oblique and 31 children had not-evolved laterality. Within the evolved laterality only 5 children showed left-sided and 47 nursery-school children preferred their right side at the execution of laterality task.

Table 2. Significant differences between School mature (n=63) and School immature group (n=42) at Oseretzky tasks (unit is secundum)

Tasks	Mean Control group (n=63)	Mean Experimental group (n=42)	t-value	p
Standing with closed legs on tiptoe, with arms on hip (max. 15 sec)	8.63	6.57	2.37	0.019
Standing on the left leg with arms on hip and with closed-eyes (max. 13 sec)	4.60	3.45	2.14	0.034
OSE%	47.42	39.11	2.32	0.022

With the Ozeresztky test we got significant differences at two tasks (Table 3), namely at “balancing closed eyes on tiptoe, with arms on hip” (p=0.019); and “balancing on the left leg with arms akimbo, closed eyes” (p=0.034). We can explain the data of the balancing on the left leg with closed eyes task with laterality, and with the visual feedback. While children balancing on their more skilful leg, the cut off of the visual information is not a problem for them. As they have to balance on their unskilful leg, the visual feedback means a big help in the execution.

Table 3. Significant differences between School mature (n=63) and School immature group (n=42) at Static Balancing Ability tasks scores

Tasks	Mean Control group (n=63)	Mean Experimental group (n=42)	t-value	p
Walking on a rope forward with closed-eyes	3.12	2.71	2.02	0.045
Squatter walking	3.44	2.85	2.63	0.009
STE%	75.36	68.19	2.52	0.013

We measured the static balancing ability (SBA) also with tasks made by *Marton-Dévényi, Szerdahelyi, Tóth and Keresztesi* (1999). It is essential to emphasize that the motion patterns “walking on a rope with closed eyes” ($p=0.045$) and “squatter walking” ($p=0.096$) were significantly difficult for the immature group. Out of these two tasks we could notice a strong significant level at the execution of the “squatter walking”. If no other method is available for checking the balancing ability, the difficult execution of this task can be indicative of the weakness or strength of this specific coordination ability.

H₂: We assume that writing coordination is in connection with the balancing ability.

Our results led to the same findings as *Dewey et. al.* (2002): social development skills of children with coordination impairment is lower. Our investigation only focused on examining the balancing ability. We got significant connections between the balancing ability and social skills (SOC) at every balancing variables in our correlation data analysis (Table 4). There was a significant correlation between writing coordination and the balancing tasks of *Oseretzky*, although it was not a very strong one ($r=0.208$). The fine-coordination of hand makes the acquirement and application of hand-writing possible. This skill can be acquired long after birth, because the regulation needs the myelinization of the right nerve-fibres. Writing-coordination is the specific version of fine-movement. Our investigation confirms the theory that fine-motor-skills – like a straight line drawn between two thin lines – demand not only manual skill, but also attention and stabile body posture. The working of little muscles and eye-hand coordination have to be helped by gross-muscles, which is assisted and regulated by the good posture and balance (*Miyahara, Piek & Barrett*, 2008).

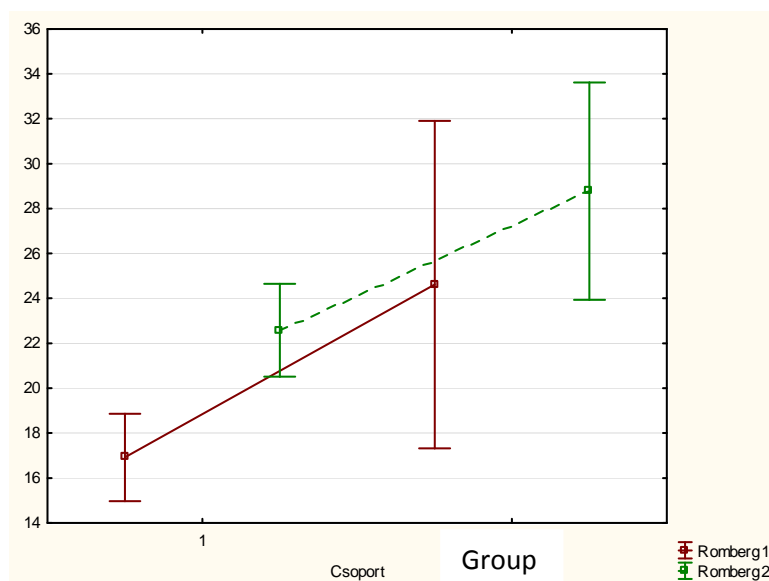
Table 5. Results of correlation survey ($n=105$)

	Soci- ability	Writing Coor- dination	Practical Cohe- rence	Speech Hearing	Practical Con- clusion	Relation Voca- bulaty	Ele- mental Counting	INDEX
DBA%	0,301	0,167	-0,006	0,121	0,068	0,180	0,116	0,209
OS%	0,243	0,208	0,016	0,105	0,076	0,041	0,089	0,194
SBA%	0,348	0,184	0,072	0,157	0,144	0,219	0,046	0,249

At our Stabilometer test we assumed that the school mature group will execute significantly better at Romberg test. At the inquiry of the balancing ability with open- and closed-eyes (*Romberg 1, Romberg 2*) the achievement of school mature and immature children significantly differed from each other. They showed great differences at the balancing with closed-eyes (*Romberg 2*: $p=0.02$) (Figure 2), where the fluctuation of their centre of mass was 22.58 mm for the mature group, while it was 28.76 mm for the immature group. With further analysis, we also found that within the school immature group, we experienced significant differences between the open- and closed-eyes executions ($p=0.036$). On the other hand, balancing with closed-eyes did not mean significantly bigger body-mass-centre deviation for the school immature group. According to the statistical analysis we concluded that while school mature children rely on visual and proprioceptive feedback systems to keep their balance, children with partial

function disorders can have difficulty keeping their balance when not accompanied by the visual system.

Figure 2. Significant differences between School mature (1, n=63) and School immature (2, n=42) group at Romberg tasks (unit is mm)



Discussion and conclusion

In the first part of our study we were looking for the answer to the postulate: in which areas does the motion of school immature children differ significantly from that of the mature group. We demonstrated with statistical analysis that the mature group performed significantly better at the subtasks of the motion test of Basic Therapy, which examines the maturity of the nervous system; their motion development is more advanced than that of the children who performed worse in the school maturity examination (DIFER). The t-test showed that school mature children executed significantly better than the immature group in static and dynamic tasks demanding the maturity of the balancing system. We affirmed the results of *Némethné* (2006): the nervous system maturity level is a very important factor needed for successful learning. The maturity of the nervous system determines motor-coordination as well as the quality and level of the cognitive functions. As for the critical-cognitive-skills, only social skills showed correlation with all balancing variables. Evaluation of social competence is necessary in the early school years. This evaluation should take place between the ages of 4-8 by observing the social activities of the child. On these grounds we affirm that the maturity of the nervous system contributes to the functional achievement at home, in school, and in other public areas. Our correlations with the writing-coordination confirm that stable posture and good balancing ability affects the conformation of the critical skills necessary to writing-learning.

The statistical analysis of our Stabilometer inquiry also certifies our hypothesis: the balancing ability with open- and closed-eyes of the immature children are significantly weaker than that of the mature group. In the course of our Stabilometer survey, we got contrary results to *Stoodley et al.* (2005). They pointed out that balancing results with open-eyes are significantly weaker at children with reading disorder than that of the control group. Their execution with closed-eyes was not worse. They explained this result with

weak visual feed-back which is not present at the closed-eyes-execution. Our task is to examine this area in a more detailed way and with more participants. Until the end of the kindergarten years, it is very important for children to reach the whole formation of the sensory system (Porkolábné, Balázsne & Szaitzne, 2004). The importance of motion has to be emphasized besides other influential factors of school maturity since the origin of the mental and conceptual operations is in practical activities. The operational cogitation evolves from the operations executed motorically. We can influence the conformation of the conceptual cogitation with rich motor connections even from the earliest ages.

The person who can move coordinately, also thinks coordinately. The performance and the automatization of the motion-connections also develop the working of the nervous system not closely connected to motion-coordination. The development of the vestibular system can be solved most efficiently by movement and action games during the period between kindergarten and school. The children are motivated by Physical Education. They like to win; they have to pay attention to their mates and to the rules; they have to remember the movements and the tasks; they have to perceive inner and outer information to organize and execute their motion effectively. With the variation of the action games, we can always create new circumstances and new conditions for them where they can practice movement without slackening their attention and motivation. The cognitive development can be built later upon a stabile nervous system by intensive game development.

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