THE IMPORTANCE OF MOTOR SKILLS FOR THE DEVELOPMENT OF COGNITIVE ABILITIES IN YOUNGER SCHOOL CHILDREN

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Abstract

The close relationship between motor development and cognitive abilities is apparent in children from birth. Motor skills need to be developed continually because their level is related not only to the level of diverse school activities (such as writing, drawing, reading), but also significantly to the development of speech. The aim of the presented research is a more detailed analysis of the relationship of motor skills of a younger school age child to selected areas of cognitive processes and the level of verbal expression. The research group consisted of 200 pupils of the first grade of primary school, the age of 9.87 ± 0.65 years. The Ethics Committee approval was granted for research. Data were obtained using the Cognitive Capability Test (TKS), which maps the verbal component (speech), nonverbal (spatial orientation, symbols) and quantitative (numerical and symbolic) (R. L. Thorndike, E. Hagen, N. France, 2013). The research was carried out as part of the GF_PdF_2019_0003 project. According to the results of the research, significant correlations between the development of cognitive abilities and the level of motor skills of younger school children can be confirmed. The results of the survey are significant in terms of possible pedagogical interventions in the primary school environment.

Keywords: Cognitive process, Motor skills, Primary school children

1 INTRODUCTION

The problematics of the developmental period of a young school age child is a frequent issue in pedagogical and psychological studies. Typical for this developmental period are psychosomatic developmental changes, which are not stormy or revolutionary, the development is rather fluent, with progress in all areas (Langmeier, 1983; Langmeier, Krejčířová, 2006). The child proves his or her own value primarily through its performance, has a sense of diligence and experiences feelings of cooperation and social belonging. Achieving a sense of competence and self-esteem is important against feelings of failure and inferiority. Undoubtedly, the subjective experience with the school has a dominant influence (Erikson, 2015). The younger school age is determined by the first and second structural changes of the organism. After a temporary disharmony at the beginning of the period, the school child appears to be mostly harmonious, but there are large individual differences including gender differences. The biological age does not always correspond to the calendar age, the individual growth and weight graphs often differ. Mostly, we see acceleration in girls' development. Body growth is usually accelerated after school entry, slowing down as well as weight gain (around eight years). Motor development is gradually calming down. Movements are more effective, faster, more accurate, more economical, more coordinated than in pre-school periods; gross and fine motor skills are improving, and visual-motor coordination also getting better (Langmeier, Krejčířová, 2006). In the real world, motor development is part of adaptive behavior and flexibility is the characteristic feature of adaptive behavior (Pellis & Pellis, 2012). Langmeier and Krejčiřová (2006) report that repeated sociometric studies have shown that body strength and coordination play aa important role in the position of a child in a group of peers. Developmental psychologists suggest that motor activities are in fact psychological.

The development of cognitive processes is significantly influenced by school activity and teacher's personality. The child gradually acquires the ability of logical operations and breaks away from authority. Child's logical reasoning is based on specific things and phenomena that can be imaginatively presented, the child prefers to verify the reality around him. According to Piaget and Inhelder (1970), this is a phase of specific logical operations. Cognitive thinking is considered to be the most complex cognitive process. It is an inner mental process that cannot be directly observed. Thinking is generally understood as mental operations with information that can transcend the sensory reality, because operations with developmentally higher cognitive elements such as concepts are applied. These then, as tools of cognition, make it possible for knowledge to develop further. In a broad sense, thinking can be defined as the process of information usage and processing (Nakonečný, 2015; Plháková, 2003). Thinking at a younger school age is based on specific thinking operations (Piaget, 1999). Child already understand the quality persistence of some objects and is able to think deductively. Cognitive abilities are used more flexibly by children, the beginnings of metacognition, when the child deliberately works with their own thinking (Thorová, 2015). The main aspects of thinking in this developmental period are usually reversibility (understanding of the reverse relationship between objects), conservation (property stability), classification (the ability to organize subjects into classes), the ability of inductive logic (generalization), the ability to seriality (sorting and understanding of logical sequence) and decentration (conclusion based on multi-aspect assessment). Child is also capable of transitive inference, which means that by combining information it creates a new logical unit and is able to compare two elements through comparison with the third element (Piaget, 1973; 1999). From the perspective of school practice, the importance of the level and quality of cognitive processes for pupil learning, which has been studied for decades (Mareš, 2013), is confirmed. The importance of connecting cognitive processes and learning can be observed in sensomotoric learning, where the acquisition of motor skills and whole movement structures depends not only on the individual's physical predispositions, but also on other psychological components (cognitive processes, personality traits, etc.). The cognitive phase of senso-motoric skills is significant. Child has to orientate itself in the conditions of the practiced activity, which is difficult for his perception, imagination, memory, attention, thinking and speech, i.e. for all important cognitive processes (Mareš, 2013).

The mathematical competences of children (Borovik, Gardiner, 2007) are also explored within cognitive competencies. Mathematical competences are defined as the ability to use generalization, such as the ability to concentrate on a task for a long time without obvious signs of fatigue, as an instinctive approach to approach problems in different ways, and while the problem is solved, the child should continue to seek an alternative solution (Borovik, Gardiner, 2007). Mathematical skills are important in cognitive abilities and should be learned from childhood with mathematical understanding (Gan, 1982). The level of mathematical skills is influenced by the overall level of cognitive abilities, concentration, motivation, level of graphomotorics in writing numbers (legibly and at the desired tempo), spatial orientation (in geometry, page orientation, in workbook), in older pupils by logic. These assumptions are the basis of the so-called prefixes, from which numerical ideas are formed (i.e., determining the number of elements, understanding the number, number series, numerical operations). Pre-numerical ideas should children create before entering school (Zelinková, 2001; Bednářová, Šmardová, 2011). In terms of education, in addition to verbal understanding, the ability to understand quantitative terms is required, and high demands on the ability to work with numbers require subjects such as mathematics, science, but also accountancy and economics (Thorndike, Haagen, 1998).

It appears that the topic of cognitive abilities in younger school age is a frequent focus of research in relation to diverse variables. Despite this, there are still areas that we consider important to assess. One of these areas is the ability to understand quantitative symbols, the ability to work with numbers as an important prerequisite for the cognitive level and academic achievement of younger school children.

2 METHODOLOGY

The aim of the paper was to assess the level of selected cognitive abilities (in terms of mathematical competencies) in primary school children in the Czech Republic. This paper is part of a wider research (see abstract). In the narrower sense it is currently focused on the assessment of mathematical competencies (numerical battery).

Research questions:

What are the differences in cognitive abilities (in terms of numerical competence) in relation to gender?

What is the level of cognitive abilities (in terms of numerical competence)?

Data were obtained through a modified version of the Cognitive Abilities Test (Thorndike, Hagen, 1986; modified Czech version from Vonkomer, Jílek, 1997), which assess three areas of thinking: verbal, quantitative and nonverbal skills. The test monitors the ability of an individual to work with symbols representing words (verbal component, contains 4 subtests), with symbols representing quantity (quantitative component, contains 3 subtests) and symbols representing spatial, geometric, or image figures (non-verbal component, contains 3 subtests). The ability to work with these components in their relationships is an overall picture of the child's cognitive abilities. For children from the research group, test variant C designed for children aged 9.6 to 11.3 years was used. The achieved rough score (number of correct answers) is converted according to the child's age into the standard age score (SVS) and the corresponding percentile. Differences in the level of mathematical ideas of girls and boys were determined by the t-test.

The research group consisted of 200 pupils (105 boys, 95 girls) at an average age of 9.87 ± 0.65 years attending primary school. None of the children had a handicap. The Ethics Committee of the author’s office - Faculty of Education, Palacký University in Olomouc, approved the aim and design of the research. For the realization of the research, the approval of the management of primary schools and legal representatives / parents of each child was obtained based on their detailed knowledge of the objectives, methods and implementation of the research. Child participation in research was voluntary and free of charge. During the research, ethical aspects of the research work were followed, children's responses were monitored, and their possible questions to the research were answered. Children could interrupt or leave the testing at any time. The anonymity of acquired data was declared to legal representatives (parents) and school managements.

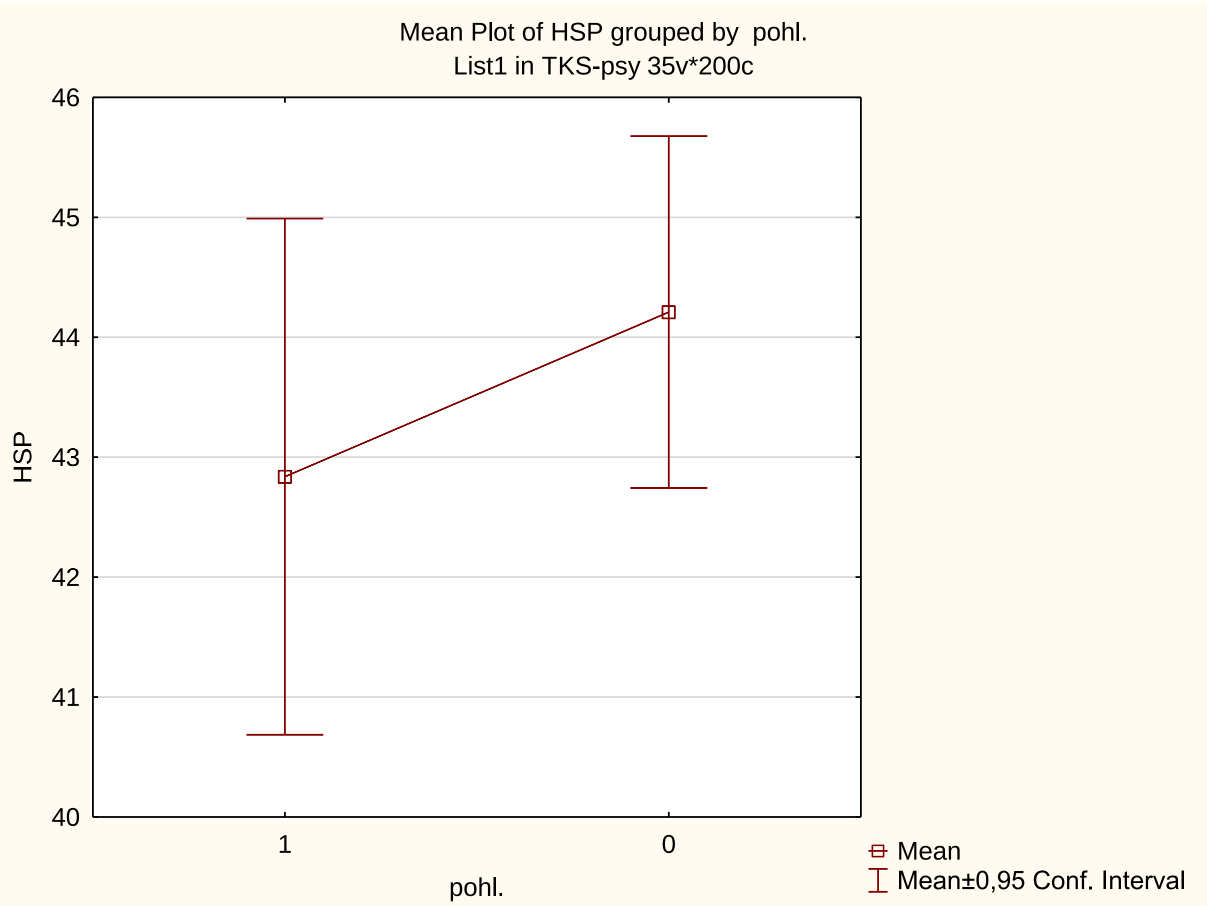
3 RESULTS

The results were processed by frequency occurence and by the t-test statistical method.

3.1 Level of Cognitive Abilities (Numerical Competencies) in Gender Context

The first research question was processed by the T-test. There was no statistically significant difference between the groups of boys and girls (p = 0.307044), so there is no difference in cognitive abilities in terms of numerical competences (see Fig. 1; Tab. 1) in relation to gender (i.e., the variation in the number of boys and girls).

Figure 1. The difference in numerical abilities between boys and girls



ISBN: 978-605-82433-6-1

Legend: Mean 1 = boys, Mean 0 = girls

Table 1. T- test for gender differences - no statistical significance found

	T-tests; Grouping: pohl. (List1 in TKS-psy) Group 1: 1 Group 2: 0										
Variable	Mean 1	Mean 0	t-value	df	p	Valid N 1	Valid N 0	Std.Dev. 1	Std.Dev. 0	F-ratio Variances	p Variances
HSP	42,83810	44,21053	-1,02409	198	0,307044	105	95	11,12008	7,202090	2,383960	0,000026

3.2 The Overall level of Cognitive Abilities - Numerical Competences in Younger School Children

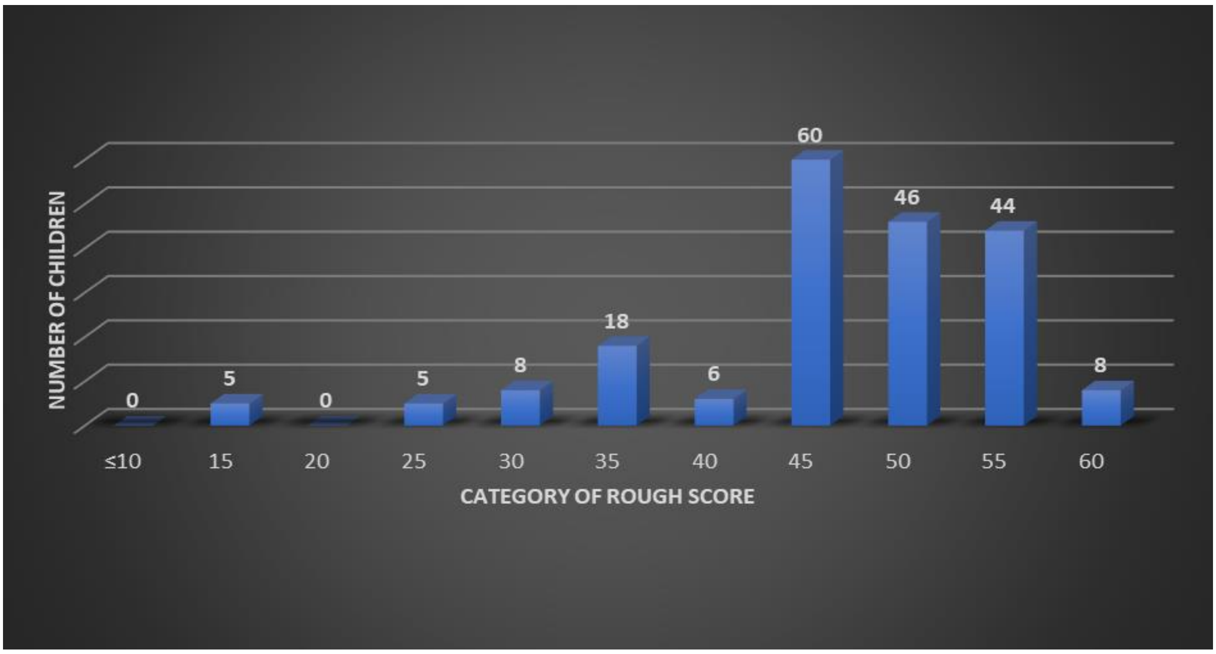
The second research question was processed by frequency occurrence. The frequency occurrence of respondents in individual categories according to the number of correct answers (rough score) in the numerical battery is shown in Table 2 and Graph 2.

Table 2. Frequency occurence of children in individual categories by rough score

	Variable: HSP, Distribution: Normal (List1 in TKS-psy) Chi-Square = 61,10351, df = 6 (adjusted) , p = 0,00000								
Upper Boundary	Observed Frequency	Cumulative Observed	Percent Observed	Cumul. % Observed	Expected Frequency	Cumulative Expected	Percent Expected	Cumul. % Expected	Observed-Expected
<= 10,00000	0	0	0,00000	0,0000	0,04031	0,0403	0,02015	0,0202	-0,0403
15,00000	5	5	2,50000	2,5000	0,22108	0,2614	0,11054	0,1307	4,7789
20,00000	0	5	0,00000	2,5000	1,04651	1,3079	0,52325	0,6539	-1,0465
25,00000	5	10	2,50000	5,0000	3,76950	5,0774	1,88475	2,5387	1,2305
30,00000	8	18	4,00000	9,0000	10,33376	15,4111	5,16688	7,7056	-2,3338
35,00000	18	36	9,00000	18,0000	21,56445	36,9756	10,78223	18,4878	-3,5645
40,00000	6	42	3,00000	21,0000	34,25932	71,2349	17,12966	35,6175	-28,2593
45,00000	60	102	30,00000	51,0000	41,43953	112,6745	20,71977	56,3372	18,5605
50,00000	46	148	23,00000	74,0000	38,16467	150,8391	19,08234	75,4196	7,8353
55,00000	44	192	22,00000	96,0000	26,76162	177,6007	13,38081	88,8004	17,2384
60,00000	8	200	4,00000	100,0000	14,28696	191,8877	7,14348	95,9439	-6,2870
< Infinity	0	200	0,00000	100,0000	8,11229	200,0000	4,05614	100,0000	-8,1123

In relation to the overall performance of respondents' numerical competences, it was found that out of the total number of respondents (200), 148 (74%) respondents achieved average and higher rough scores (RS), which is at least average or higher average performance (according to test standardization, Thorndike, Hagen, 1998). Based on the above mentioned results, it can be stated that the vast majority (74%) of the respondents have a standard (adequate) level of cognitive abilities in terms of numerical competence (Figure 2).

Figure 2. Children divided into groups according to RS of mathematical abilities



ISBN: 978-605-82433-6-1

Legend: Example of achieved rough scores (RS) in the numerical performance of respondents

4 CONCLUSIONS AND RECOMMENDATIONS

The research study is part of more complex research that is basically focused on a more detailed analysis of the relationship between motor skills of younger school aged children and selected aspects of cognitive processes. The paper presents mathematical competences in cognitive processes. We refer to the pre-disposition that the mathematical competences of a young school age child have a crucial place in relation to school success. Mathematical competences are important in the way of concentration on a task for a long time without obvious signs of fatigue, expressing an instinctive tendency to approach problems in different ways, and develop from childhood together with mathematical understanding. Numerical comptetences are therefore necessary for the ability to understand quantitative symbols, the ability to work with numbers, an important prerequisite for the cognitive level and academic abilities of younger school aged children (Gan, 1982; Thorndike, Haagen, 1998; Borovik, Gardiner, 2007).

The research group consisted of 200 children from the first grade of primary school, the age of 9.87 ± 0.65 years. The Ethics Committee approval was granted for the research. The data were obtained within the Cognitive Abilities Test (TKS), which assess the verbal component (speech), nonverbal (spatial orientation, symbols) and quantitative (numerical and symbolic) (Thorndike, Hagen, 1998).

Two research questions were stated in relation to the aim of the research. In the first research question, we searched differences in cognitive abilities in terms of mathematical competences in relation to gender. There was no statistically significant difference between the groups of boys and girls, so there is no difference in cognitive abilities in terms of mathematical competences in relation to gender (i.e. in the variation in the number of boys and girls). This may be a surprising finding, as some authors (Janošová, 2008) state that the current school environment supports the development of such cognitive abilities and skills that are more closely related to girls (e.g. communication) or boys (e.g. spatial orientation, technical skills).

In the second research question, we asked what the overall level of cognitive abilities in terms of mathematical competencies will be. In relation to the overall performance of the respondents' numerical production, it was found that out of the total number of respondents (200), 74% (148) of the respondents achieved average and higher rough scores, corresponding to at least average to above-average level (according to Thorndike test standardization, Hagen, 1998). Based on the above-mentioned results, it can be stated that the vast majority (74%) of the respondents have an average (adequate) level of cognitive abilities in terms of numerical competence (Figure 2). These results seem surprising to us with regard to the findings that show a decrease in cognitive processes in the population (Spitzer, 2004), as well as practical experience of primary school teachers, who confirm rather lower level of numerical production among younger school aged children. The unanswered question therefore remains whether the "diminishing" of the children's numerical production is rather determined by the negative motivation or the loss of the child's natural motivation for knowledge, not by the level and development of cognition. A number of researches show that the motivation of children to acquire new knowledge and to learn gets lower during school attendance (Vágnerová, 2006).

In our opinion an adequate level of monitored factors is an important prerequisite for the successful adaptation of the child to the school environment, including his / her motivation to learn. A good level of mathematical competences in cognitive abilities for younger school children can be the foundation for their natural activity to try new solutions, especially in technical areas. These findings are optimistic despite opinions about reducing Children's cognitive competencies and forcing them to think about school motivation determinants. We are aware of the fact that partial results deserve further in-depth research investigations and more detailed analysis.

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