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Prevalence of cognitive and affective factors influencing mathematical performance

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Children's cognitive ability is the basis of all subject knowledge. It can qualitatively and quantitatively determine the content of the acquired curriculum, and its variation can significantly modify executive functions. There are a number of reasons for underachievement, including problems with genetic origin, parental expectations, the identity of the teacher, the class community, inadequate teaching methods, etc. These factors can trigger anxiety in students and not everyone may have the right coping strategies. The aim of our research is to establish a cognitive ability profile that focuses on the cognitive factors underlying mathematical abilities and the affective factors that influence them. Our research included at 10–15-year-old students in 8 Hungarian primary schools and explored the extent to which symptoms of anxiety affect mathematical performance. Our measuring instruments were the Pedagogical Examination of Dyscalculia and the Math Anxiety Test. The results were examined in the context of mathematical performance. Our research is also relevant in pedagogical practice, because it advances understanding of the cognitive and other psychological processes underpinning children's performance, and thus can help them to achieve the best performance to their abilities more effectively. In this way, we can provide them with mathematical and self-knowledge that is useful in everyday life.

Keywords: cognitive ability profile, mathematical skills, performance, math anxiety

Introduction

Cognitive processes and abilities realize intellectual functioning, the mental processes of perception, memory, and information processing by which the individual gathers information, makes plans, and solves problems (Atkinson & Hilgard, 2014).

Cognitive processes can be divided into two major groups: direct cognitive processes (perception, observation, attention) allow us to perceive the present direct reality that affects us at the moment; and indirect cognitive processes (memory, imagination, thinking) enable the perception and a deeper understanding of a reality that is not currently present, they affect the functioning of the individual based on direct cognitive processes (Meggyesné & Nagyné, 2013).

Thinking is one of the most complex mental processes, its definition poses a difficult task for psychologists (Mayer, 1992, cited in Csépe et al., 2007).

There is a sudden change in the thought processes between early childhood and school age. When children perform specific actions, they perform actions in thought, sort them out, transform them, or make a logical connection between specific objects. Children between the ages of 6 and 12 are not yet able to abstract, so these operations are limited to specific objects or events that have already been seen or actually present. Moving from the stage of specific operations to the stage of formal operations brings a significant change in problem-solving ability. This is when it becomes possible to think about more abstract problems. Children over the age of 12 will be able to systematically rethink logical relationships within problems and solve logical math problems (Cole & Cole, 2001).

Mathematical skills

Mathematics involves a wide range of knowledge that requires the proper functioning of different cognitive systems to acquire and understand, since performing a simple operation such as addition requires a number of theoretical operations (Krajcsi, 2010; Piros & Séra, 2017). Research on the exploration of numerical abilities examines abilities in terms of both average and atypical development. In the focus of the research, in addition to the development of mathematical skills, experts also place great emphasis on the study of the problems occuring in them (Jármi, 2012).

One of the best-known models for the development of mathematical skills is David C. Geary's evolutionary theory of cognitive development (1995), which distinguishes between biologically primary and secondary abilities. Biological primary abilities are innate endowments, such as the recognition of multiplicity in sets of four or fewer elements (Chan et al., 2013; Prado, 2018); understanding more / less quantitative relationships for small numbers; counting, determining the number of sets; and simple arithmetic, which is the sensitivity to change the multiplicity of small sets, the ability to add and subtract. The acquisition of biologically secondary skills, on the other hand, is a slow, deliberate process, acquired by practice, its most important scene is school. Skills can be hierarchically related to each other, so secondary skills are developed on the basis of primary skills, and their acquisition requires the transmission of culture and the institution of education (Geary, 1995; Jármi, 2012; Piros & Séra, 2017). The development of biologically secondary abilities can be well traced in mathematics education. By the age of 6, children can now count to ten and recognize simple operation symbols. By the time they start school, they no longer need tools for simpler subtraction and addition operations, they write and read multi-digit numbers at the age of 7–8, and they multiply and divide by one-digit numbers at the age of 10–11. In summary, it can be stated that in the case of average development in the Hungarian education system, the arithmetic facts, such as addition, subtraction, multiplication, are expected to consolidate in the 4th grade, and the complete development of the same representation network as in adults is expected for the 6th grade (Jármi, 2012; Piros & Séra, 2017).

If we are talking about a different development or developmental lag, we have to compare it to the level at which development is stuck. The norm is the requirements of the school curriculum, the subject of mathematics prescribed at the given grade level. However, this also requires a number of conditions that are not explicitly computationally specific, or even a skill. These are, for example, the ability to comprehend and interpret text, and the metacognitive component of students' thinking, by which they are able to monitor and evaluate their own way of thinking or their task-solving (Csíkos & Szitányi, 2020). Experience gained during practice shows that symptoms of stagnation do not only occur according to the level of development. Therefore, all possible factors should be considered when establishing a diagnosis of a counting disorder, in order to screen out students who do have a count-specific impairment. To help establish the diagnosis and gain a more accurate understanding of mathematical skills, several theoretical models have been developed to explain these disturbances.

The development of numerical abilities also shows significant individual differences in moderately developing children, but these variations – whether due to environmental or genetic reasons or their combined effects, may generate differences in some children which in the light of normal development can be considered atypical, possibly disturbed development (Jármi, 2012; Piros & Séra, 2017).

Effect of stress on math skills and performance

Mathematics is considered a difficult subject by many students, parents and teachers alike. The subject difficulties are mostly attributed to cognitive factors (lack of ability, readiness, practice, and knowledge). Emotional factors are often overlooked, as possible causes of specific learning difficulties. If these emotional problems appear in the mathematical learning process, they can act as a barrier to performance and discourage students with otherwise good ability from learning more mathematics (Szűcs & Mammarella, 2020). Examining the influencing affective factors, it can be concluded that the functioning of cognitive processes, and thus cognitive and mathematical performance, is also influenced by a number of non-cognitive factors. Stress plays one of the most important roles. Its effect on mathematical skills and performance has been demonstrated in a number of studies, as stress can affect all cognitive processes, from the ability to focus attention to decision-making. The effect of stress on mathematical skills may also be influenced by the characteristics of stress events, different aspects of cognitive functioning, and individual differences – such as gender, age, personality traits, stress vulnerability, and coping – also have great significance (Sandi, 2013). The most common situation of stress is a situation that requires a novel response in the process of interaction between the individual and his environment (Kopp & Skrabski, 2003,). Research results show that stress also greatly influences higher cognitive processes, the learning process, the performance of working memory, and the retrieval of previously acquired knowledge. During the experiments, it was discovered that there is a correlation between the intensity of stress, the difficulty of tasks and learning and memory performance. In case of simple problems, a linear relationship was found between intensity and performance, however, an inverted U-shaped curve was observed in solving complex problems The effects of stress can vary depending on intensity, endurance, and cognitive load: it can stimulate but also weaken cognitive abilities. So it only increases performance to a certain extent, and only weakens it under high stress (Sandi, 2013). Negative emotions experienced under stress during the performance of mathematical tasks may affect the successful performance of mathematical operations based on higher-order cognitive abilities (Caviola et al., 2017). Research shows that the effect of anxiety also appears in mathematical performance, despite the fact that, in principle, students have the skills to solve mathematical problems (Nótin et al., 2012).

Math anxiety, working memory and performance

According to the research results, among the cognitive factors determining mathematical performance, the functioning of working memory shows the highest sensitivity to the effects of stress.

In their model of the effects of general anxiety, Eysenck and Calvo (1992) describe that anxiety separates work memory processes. Anxious people turn their attention to their own intrusive, anxious thoughts and worries, instead of focusing on the task at hand. Thus, a specific form of anxiety is mathematical anxiety, which can occur during dealing with numbers and math problems. It elicits an emotional response that later negatively affects learning and performance, and can lead to emotional, physiological, cognitive, and behavioral symptoms of anxiety. Mathematical anxiety is often contextualized with mathematical ability. However, this is wrong, mathematical anxiety cannot be identified, it only affects cognitive abilities, as it impairs math problem-solving ability. When fear of math appears and at the same time an individual's self-esteem is low, it will impede the functioning of working memory, resulting in poorer math performance

A further topic of our research, in addition to exploring the causes and influencing factors, explores the components of mathematical anxiety. According to the most common approach, two factors can be distinguished, the affective and the cognitive components. The affective factor mostly refers to emotions related to mathematics, while the cognitive factor includes the beliefs, attitudes, attributions, and perceived abilities that affect mathematical anxiety (Trezise & Reeve, 2017).

Methods

Our research is based on our previous scientific work aimed at setting up a comprehensive competency profile. Present research allows us to better understand the background of math grading and performance of upper grade students in light of their true abilities.

It is clear from the studies above and from previous research (Szűcs & Mammarella, 2020) that mathematical performance – as measured by grades and the Pedagogical Examination Test for Dyscalculia – is influenced by several factors. Our primary study was to investigate the relationship between affective factors and cognitive performance. The present study presents the frequency of performance and concomitant anxiety and the tests which are used to examine them. Our suggestions are that math anxiety greatly influences performance and the development of cognitive ability levels.

Measuring procedures

The research methods consisted of quantitative assessments, using psychometric analysis. The main line of the research was given by the examination of the ability profile determining mathematical performance, for which we used the first semester test version of the sixth grade of the Pedagogical Examination of Dyscalculia (Diszkalkulia Pedagógiai Vizsgálata – DPV 6 / I), we conducted individual examinations. The students completed a group-based Likert-type questionnaire, the Math Anxiety Test (Matematikai Szorongásmérő Teszt / MSzMT/), to examine affective factors.

For the assessment of the mathematical cognitive ability profile, we chose the measurement method of the Pedagogical Examination of Dyscalculia (later DPV) (Dékány et al., 2020).

It is an individual (therapeutic) pedagogical measurement procedure for the evaluation of basic mathematical skills from the age of 5, which is a revised version of the Dékány - Juhász's Dyscalculia Pedagogical Examination supported by neuropsychological and psychological research. The revised method seeks to measurably differentiate between mathematical underachievement and lag caused by inadequate education or environmental disadvantage, as well as difficulty in math learning and developmental dyscalculia as specific learning disabilities. During the revision of the test, special attention was paid to the clear, precisely formulated, pedagogical approach to developing the questions.

It provides the child with an interpretation of the instruction, if necessary, in order to be able to purposefully examine the focused ability, skill. Thus the error resulting from comprehension and language impairment can be eliminated, as well as the influencing and distorting effect of partial abilities and processes irrelevant to the given task. In the scoring criterion, the emphasis is often on the meaning of the answers and the expected content, ignoring the child's level of language development where possible. We also chose this measure because the study not only measures numerical subfields, but also provides a comprehensive picture of a child's mathematical abilities and skills, as well as non-math-specific cognitive functions, thinking strategies, and compensation mechanisms.

During the revision, an age-appropriate and practical test package we prepared, which includes a detailed and accurate Test Guide, Test Form and Protocol, an Evaluation Table and Tables of Typical Errors, as well as the tangible assets necessary for the inclusion of the examination procedure were also developed and manufactured. (Polgárdi et al., 2018). The main goal of the study is to assess the state of the concept of numbers (abstract, discrete semantic representation), the concept of operations, as well as to map the operation of the underlying basic functions and partial abilities. The measurement procedure examines the separate hypothetical systems of internal representation, the analog quantity system (comparison, approximate calculation, estimation), the arabic numeral format (symbolic system of arabic numerals), the verbal system (arithmetic facts, eg. storage and retrieval of multiplication tables), basic output and input modalities (number processing, eg. writing and reading numbers). Among the components of computational operations, the observation of computational procedures (operations procedures) and conceptual knowledge (arithmetic rules and principles, eg. interchangeability, groupability, inversion) are also important aspects of the study.

In the measurement procedure, emphasis is also placed on the main basic functions (Geary,), the spatial-visual and central execution system (Szűcs et al., 2014), and the working memory (Baddeley, 2012; Szűcs et al., 2014), and also monitoring linguistic aspects, making it easily correlated with individual subsets of the WISC – IV intelligence test. The Discalculia Pedagogical Examination consists of several task groups (subtests), which contain additional sub-points / task groups, keeping the original test units.

Within the sub-points the number of tasks is different. The types of tasks compiled according to the age are based on each other in an analogous way, and the nature and number of the tasks also change according to the age characteristics. Each task is of a responsive nature, requiring an active verbal and / or action or written response, so some tasks may have multiple responses that are acceptable. The calculation tasks of DPV reveal the individual algorithmic operation levels and sequences.

In order to explore and record the sequence of elementary steps, counting techniques, levels of abstraction, thinking strategies, and compensatory procedures, the child is instructed to think aloud and formulate his / her strategy during the study. Thus, through standard questions aimed at objectivity in the measurement procedure, the study director can also collect information about the child's thought processes, metacognitive skills, and non-intellectual factors accompanying the task solution (e.g. motivation, frustration-tolerance). The result of the DPV test provides a structural analysis, within which the backgrounds of individual ability profiles can be explored by analyzing the response patterns.

Although the Pedagogical Examination of Dyscalculia has been developed for the assessment of mathematical skills, as it is in line with the National Curriculum, it also allows for the assessment of age – appropriate knowledge, i.e. informs about the students' mathematical performance, mobilization of cognitive skills and appropriate use in tasks (Polgárdi et. al., 2018).

When examining a subject-related anxiety, not only mathematical manifestations should be considered, but also the symptoms of anxiety should be measured. Taking these aspects into account and on this basis, the staff of the University of Debrecen has developed a new measuring tool with which we can assess all components of mathematical anxiety.

The name of the measuring device: Math Anxiety Test (Matematikai Szorongásmérő Teszt /MSzMT/). The test includes statements, and the student has to decide to what extent he / she can apply them to himself / herself by marking on a seven-point scale (1: Not characteristic of me at all, 7: Totally characteristic).

The test consists of 40 items, organized into two main factors: the first is emotional and physiological symptoms; the second factor includes items of cognitive symptoms: attitudes, attributions, and beliefs. Emotions that emerge during the learning of mathematics are subjective, such as fear, anxiety, restlessness, or just the opposite: a heuristic experience, joy, a sense of happiness. Anxiety often manifests itself in physical symptoms, with nausea, vomiting, abdominal pain, diarrhea, palpitations, shortness of breath, tremors, dizziness, lump in the throat. These physiological symptoms, which are closely related to the emotional factor, are consequences of each other and should therefore be classified into one factor. Behind the anxiety, negative statements can be assumed. whose subfactors are: attitudes, attributions, and beliefs. The Cognitive Symptoms factor is not subdivided into other sub-factors, all content related to mathematical thinking is displayed here, no group breakdown is required. Attempts were made to formulate the statements in such a way as to cover the content as much as possible. Twenty items were generated for both factors, based on MARS, MAS, and ATMI questionnaires. They also paid attention to make the statements easy for the age group of the students to understand.

Thus, in terms of age, during the development of the test, special attention was paid to the fact that the youngest age group to be measured, i.e. the upper secondary school, could be measured, as according to some literature data, mathematical anxiety can appear at the age of 9–11 (Nótin et al., 2012).

There is no upper age limit for the use of the questionnaire, as the content of mathematical anxiety does not change, but rather intensifies with age (Svraka, 2016).

Introducing the Math Anxiety Test (Annex 1.)

The questionnaire is the Math Anxiety Test (Matematikai Szorongást Mérő Teszt /MSzMT/), which consists of a total of 40 items. The questionnaire contains statements on which the student has to decide how characteristic they are. To judge each item, a 7-point Likert scale was developed for better differentiation. The values of the scale are as follows:

1: not typical of me at all
7: completely characteristic of me

The factors and contents of the questionnaire are presented below. The individual factors are fundamentally separate, but due to the complexity of the structural factors of mathematical anxiety, it is not possible to completely separate the individual symptoms.

1. Emotional and physiological symptoms (20 items)

Items related to emotions and physiological symptoms that occur during math tasks have been included in this factor. Statements include, on the one hand, the learner's emotions in a specific task situation and in general in mathematics. For example, a statement about a specific task situation: "If I have to solve math problems, I will be very anxious". A more general emotion about math, for example, is, "I'm often irritable and restless from math". Physical-physiological symptoms are, on the one hand, symptoms that appear in a math task situation, such as "While solving math tasks, I feel like I have a lump in my throat". On the other hand, those symptoms also appear in the statements when students think about math, such as "My stomach twitches when I think about math". Most of the items contain negative symptoms as these indicate the presence of mathematical anxiety. The more characteristic the student considers the statement to be, the bigger his or her mathematical anxiety is.

Items in the factor: 4, 6, 8, 10, 13, 15, 17, 19, 21, 25, 27, 29, 31, 33, 37, 39, 40
Reverse items: 1, 23, 35

2. Cognitive Symptoms- Attitudes, Attributes and Beliefs (20 items)

There are three sub-factors within the cognitive factor:

a) Attitudes
b) Attributions
c) Opinions

a) The items belonging to the Attitude sub-factor include attitudes related to the subject of mathematics and dealing with mathematics. Attitudes represent a kind feeling towards a particular attitude object that also plays an important role in mathematical anxiety. If a student has negative attitudes towards math, he or she may develop anxiety about math."

The higher a student's score is on negative attitudes, the more he or she indicates the presence of math anxiety.

Items belonging to the attitude subfactor: 11, 18, 30
Reverse items: 7, 38

b) The sub-factor Attributes refers to the factors to which a person attributes a good achievement in mathematics or a poor performance. As we have seen earlier, girls and students in Eastern countries often tend to attribute their mathematical success to external factors, such as luck, while boys tend to attribute good results to their good abilities. If a student believes that success in math does not depend on him/her, math anxiety may appear, which could increase the chances of failure. Attributions often include gender stereotypes, such as "Boys tend to be better at math than girls". Other items included in the questionnaire are related to math performance ("Sometimes I don't get a good grade in math because I have a hard time understanding the subject") and learning math ("I often have a hard time learning math").

Items belonging to the sub-factor attributes: 5, 12, 14, 16, 24, 32, 34
Reverse items: 3, 20

c) The sub-factor Opinions includes those thoughts and opinions that largely determine the attitude towards mathematics. If a student is negative about math in a way that is stressful, difficult, or even unnecessary for him or her to deal with the subject, he or she may develop a negative attitude that can affect math anxiety and performance. The formulated items refer to: The usefulness and importance of mathematical knowledge, e.g. „Right now, the knowledge of math is completely unnecessary in my life" Application of mathematics e.g. „I am not able to do mathematics in practice" Subsequent use of mathematics e.g. „I won't need math at all later"

Items belonging to the sub-factor opinions: 2, 9, 22, 26
Reverse items: 28, 36

Among the 40 closed questions, there are six negative wordings to reduce deformation. These were already reversed during encoding and entered into the computer at the time of data recording with the corrected value (Nótin et al., 2015).

The first analysis performed was the reliability test, which shows whether the applied psychological tests and the pedagogical test reliably measure the given sample. The Math Anxiety Test (Matematikai Szorongásmérő Teszt / MSzMT/) has a high internal consistency of both factors: Cronbach-alpha a = 0.838 for emotional-physiological symptoms, and α = 0.717 for cognitive symptoms. The DPV measure also reliably shows cognitive abilities in our given sample, the value of Cronbach- alpha is α = 0.826 (Svraka, 2016).

Study population – Sample presentation, frequency indicators

Our sample consisted of a total of 999 upper secondary school students in Hungary, ranging in age from 10.67 to 15.08. Of which 483 boys, which 48.3% of our sample, and 516 girls, who make up 51.6% of our sample.

Our sample can be considered homogeneous as there is no significant difference in terms of gender and grade.

We examined a total of 253 students (25.3%) in the 5th grade, 249 students (24.9%) in the 6th grade, 253 students (25.3%) in the 7th grade, 244 students (24.4%) in the 8th grade.

The distribution of the sexes by grade is as follows:

123 (12.3%) boys and 130 (13%) girls participated in the study in the 5th grade, 120 (12%) boys and 129 (12.9%) girls in the 6th grade, 124 (12.4%) boys and 129 (12.9%) girls in the 7th grade, 116 (11.6%) boys and 128 (12.8%) girls in the 8th grade. (Table 1.)

Table 1
The distribution of students in the sample by grade and sex

	5th grade		6th grade		7th grade		8th grade		Total	
Gender	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Boy	123	12.3	120	12.0	124	12.4	116	11.6	483	48.3
Girl	130	13.00	129	19.0	129	12.9	128	12.8	516	51.7
Total	253	25.3	249	24.9	253	25.3	244	24.4	999	100

In Hungary, knowledge is evaluated with grades. Excellent (5) rating means the best result, insufficient (1) means the worst result.

The end-of-the-year grades of the students shows the following distribution. (Table. 2.)

Table 2
The distribution of students' grades at the end of the year

	5th grade		6th grade		7th grade		8th grade		Total	
Mark	N	%	N	%	N	%	N	%	N	%
1	2	0.2	5	0.5	5	0.5	3	0.3	15	1.5
2	30	3.0	29	2.9	41	4.1	24	2.4	124	12.4
3	66	6.6	81	8.1	76	7.6	90	9.0	313	31.3
4	104	10.4	84	8.4	94	9.4	75	7.5	357	35.7
5	51	5.1	50	5.0	37	3.7	52	5.2	190	19.0

A total of 15 students (1.5%) got insufficient grade, 124 students (12.4%) got sufficient grade, 313 students (31.3%) got medium grade, 357 students (35.7%) got good grade, 190 students (19.0%) got significant / excellent grade.

We have compiled a set of tasks from a diagnostic test bank to measure current knowledge in order to measure the answer to the question of the extent to which mathematical anxiety affects mathematical performance. Children had completed the knowledge meter before they did the anxiety meter test.

Results

The result is given as a percentage. The average of the knowledge measured on the sample is 73%, which shows a grade of 3.58 in the grade. The average grade of the girls is 3.66, while that of the boys is 3.53.

The basis for the acquisition of knowledge is the appropriate level of cognitive abilities. To measure this, we used the criteria-based measurement procedure of the Pedagogical Examination of Dyscalculia (Diszkalkulia Pedagógiai Vizsgálata /DPV/).

Mathematical learning problems, learning difficulty, and learning disorder divided the sample into three major bands by deliberate professional decision and measurement process.

There are 580 (58.1%) students with minor problems, 405 (40.5%) students with learning difficulties, and 14 (1.4%) students with predictable learning disabilities.

The cognitive criteria recorded during the test showed the following percentages: orientation problems were predicted in 28.4%, memory problems in 31.7%, attention problems in 30.7%, and motivational problems in 34.3%.

Broken down by gender, 277 boys have no problems with mathematics, 198 boys have moderate difficulty, and 8 boys are presumed to have learning disabilities. 144 boys have a lack of orientation, 152 boys have a memory impairment, 151 boys have an attention deficit and 180 have a lack of motivation.

In the case of girls, 303 of them have no problems with mathematics, 207 girls have moderate difficulty, 6 girls have a presumed learning disability, 140 girls have a lack of orientation, 165 have a memory impairment, 156 have a lack of attention and 163 girls have a lack of motivation.

The highest score available on the Math Anxiety Test is 280 points on the two main factors and sub-factors. The test has no standard value, it can always be interpreted by the results of the given group. It is highly criteria-oriented and takes into account the atmosphere of the group, external influences, circumstances, methods, standards of teaching mathematics, the role of the educator, and factors that may all influence the development and persistence of anxiety. However, it can be seen that the lowest score of the sample is 44, while the highest is 246, the average score of the sample is around 131.6126, which is considered to be average compared to the maximum available. Mathematical anxiety is typically moderately present in our sample, but there are also students with exceptionally high levels of anxiety, they are among the girls.

Conclusion

Mathemathical anxiety is an emotional reaction that inhibits the performance of mathematical operations and thus may reduce cognitive performance.

Problems in the field of computation are most easily observed in mathematics lessons or computational situations.

Dysfunction of numerical abilities can manifest itself in the symbolic interpretation of numbers, difficulties in learning and applying arithmetic facts, barriers in understanding and using positional notation, or in the memorization of operational methods.

Affective factors often aggravate the situation, anxiety may generalize.

Since numbers can appear in any number of classes during the lessons from the beginning of the upper grade, the shortcomings in this area become particularly obvious. Therefore, we conducted our research among upper secondary students in Hungary.

Eight schools undertook the survey, with 999 parents agreeing to the study. Our goal is to set up a cognitive ability profile with a specific emphasis on mathematical skills. In parallel, we also examined the appearing affective factors. Our test tools were measured in a preliminary study that attempts to nuance the relationship between cognitive ability, mathematical performance, and mathematical anxiety with a myriad of factors and subfactors.

The results clearly highlight that mathematical anxiety is moderate in our sample, with higher values in girls.

Nevertheless, girls are also more effective in terms of abilities and performance. It is clear from this, that anxiety does not necessarily occur with a lower ability profile and lower performance. In our study, only frequency data are presented, and a number of interesting correlations can be deduced from the results, which will provide additional useful information for professionals, educators, and parents to address the problem effectively.

References

Atkinson and Hilgard's (2014). *Introduction to Psychology*. Cengage Learning EMEA.

Baddeley, A. D. (2012). Working Memory: Theories, Models, and Controversies. *Annual Review of Psychology, 6,* 1-29. https://doi.org/10.1146/annurev-psych-120710-100422

Caviola, S., Carey, E., Mammarella, I. C. & Szűcs, D. (2017). Stress, Time Pressure, Strategy Selection and Math Anxiety in Mathematics: A Review of the Literature. *Frontiers in Psychology, 8*, 1488. https://doi.org/10.3389/fpsyg.2017.01488

Chan, W. W. L., Au, T. K. & Tang, J. (2013). Developmental dyscalculia and low numeracy in Chinese children. *Research in Developmental Disabilities, 34*(5), 1612–1622. https://doi.org/10.1016/j.ridd.2013.01.030

Cole, M. & Cole, R. S. (2001). *Fejlődéslélektan*. Osiris Kiadó.

Csépe, V., Győri, M. & Ragó, A. (2007). Nyelv, tudat, gondolkodás. In Csépe, V., Győri, M. & Ragó, A. (Eds..), *Általános pszichológia 3. kötet.* Osiris Kiadó.

Csíkos, Cs. & Szitányi, J. (2020). Teachers' pedagogical content knowledge in teaching word problem solving strategies. *ZDM Mathematics Education 52*, 165–178. https://doi.org/10.1007/s11858-019-01115-y

Dékány J., Polgárdi, V., Láz, Cs. (2020). *Matematikatanulási problémák hatékony és preventív mérése. A Diszkalkulia Pedagógiai Vizsgálata és Előszűrő Eljárása 1-4. (DPV; E-DPV).* Logopédiai Kiadó.

Eysenck, M. W. & Calvo, M. G. (1992). Anxiety and Performance: The Processing Efficiency Theory. *Cognition and Emotion, 6,* 409–434. https://doi.org/10.1080/02699939208409696

Geary, D. C. (1995). Reflections of evolution and culture in children's cognition: Implications for mathematical development and instruction. *American Psychologist, 50*, 24–37. https://doi.org/10.1037//0003-066x.50.1.24

Jármi, É. (2012). Számolási képességek fejlődése óvodás- és kisiskolás korban. P*szichológia, 32*(4), 317−339. https://doi.org/10.1556/Pszicho.32.2012.4.2

Kopp, M. & Skrabski, Á. (2003). *Alkalmazott magatartástudomány. A megbirkózás egyéni és társadalmi stratégiái*. Corvinus Kiadó.

Krajcsi, A. (2010). A numerikus képességek zavarai és diagnózisuk. *Gyógypedagógiai Szemle, 38*(2), 1–21.

Marin, M. F., Lord, C., Andrews, J., Juster, R. P., Sindi, S., Arsenault-Lapierre, G., Fiocco, A. J. & Lupien, S. J. (2011). Chronic stress, cognitive functioning and mental health. *Neurobiology of Learning and Memory, 96*(4), 583–595. https://doi.org/10.1016/j.nlm.2011.02.016

Meggyesné, H. T. & Nagyné, H. A. (2013). *A tanulásban akadályozottak pedagógiájának komplex megközelítése*. „Mentor(h)áló 2.0 Program" TÁMOP-4.1.2.B.2-13/1-2013-0008 projekt). http://www.jgypk.hu/mentorhalo/tananyag/A_tanulasban_akadalyozottak/51_a_kognitv_kpessgek_rendszere.html. (03.09.2020)

Myers, T., Carey, E. & Szűcs, D. (2017). Cognitive and neural correlates of mathematical giftedness in adults and children: A Review. *Frontiers in Psychology, 8,* 1646. https://doi.org/10.3389/fpsyg.2017.01646

Nótin, Á., Páskuné, Kiss J. & Kurucz, Gy. (2012). A matematikai szorongás személyen belüli tényezőinek vizsgálata középiskolás tanulóknál. *Magyar Pedagógia, 112*(4), 221–241.

Nótin, Á., Páskuné Kiss, J. & Kurucz, Gy. (2015). A tantárgyi szorongás kérdőív bemutatása. *Alkalmazott pszichológia, 15*(4), 109–131. https://doi.org/10.17627/ALKPSZICH.2015.4.109

Piros, V. &Séra, L. (2017). Az iskolai tanulásra való készenlét és a tanulási zavarok. In N. Kollár, K. & Szabó, É. (Eds.), *Pedagógusok pszichológiai kézikönyve I. kötet* (pp. 501–524). Osiris Kiadó.

Polgárdi, V., Csabáné, L. & Judit, D. (2018). Alapismeretek a Diszkalkulia Pedagógiai Vizsgálatáról. *Gyermeknevelés Tudományos Folyóirat, 6*(1), 24–54. https://doi.org/10.31074/gyn201812454

Prado, J. (2018). The interplay between learning arithmetic and learning to read: insights from developmental cognitive neuroscience. In Henik, A. (Ed.), *Heterogeneity of Function in Numerical Cognition* (pp. 27–49). Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-811529-9.00002-9

Sandi, C. (2013). Stress and Cognition. *Cognitive Science, 4*(3), 245–261. https://doi.org/10.1002/wcs.1222

Séra, L. (2017). Percepció és figyelem. In N. Kollár, K. & Szabó, É. (Eds.), *Pedagógusok pszichológiai kézikönyve I. kötet* (pp. 347–386). Osiris Kiadó.

Svraka, B. (2016). *A matematikai tudás és a szorongás kapcsolatának vizsgálata.* Szakdolgozat. Szegedi Tudományegyetem Bölcsészettudományi Kar.

Szűcs, D. & Mammarella, I. C. (2020). *Educational Practice Series 31. Math Anxiety.* International Academy of Education (IAE).

Szűcs, D., Devine, A., Soltesz, F., Nobes, A. & Gabriel, F. (2014). Cognitive components of a mathematical processing network in 9-year-old children. *Developmental Science, 17*(4), 506–524. https://doi.org/10.1111/desc.12144

Trezise, K., & Reeve, R. A. (2017). The Impact of Anxiety and Working Memory on Algebraic Reasoning. In *Understanding Emotions in Mathematical Thinking and Learning* (pp. 133–158). Academic Press. https://doi.org/10.1016/B978-0-12-802218-4.00005-4

Zsolnai, A. & Kasik, L. (2012). Megküzdési stratégiák 8, 10 és 12 éves tanulók körében. *Iskolakultúra, 22*(4), 3–1.

Annex 1

Math Anxiety Test (Matematikai Szorongásmérő Teszt /MSzMT/)
Circle the correct number.

1: Not characteristic of me at all
7: Totally characteristic of me

Q_1 I'm always calm in math class	1	2	3	4	5	6	7
Q_2 I am not able to apply math in practice	1	2	3	4	5	6	7
Q_3 Since the tasks that need to be solved in the dissertation are not too difficult, I usually achieve good results	1	2	3	4	5	6	7
Q_4 Sometimes I get so confused about solving math problems that I am almost unable to pay attention to my problem.	1	2	3	4	5	6	7
Q_5 I think I'm moving slower from math than I should be	1	2	3	4	5	6	7
Q_6 I think I'm moving slower from math than I should be	1	2	3	4	5	6	7
Q_7 I love math	1	2	3	4	5	6	7
Q_8 I never feel like I can properly learn the actual math material	1	2	3	4	5	6	7
Q_9 I won't need math at all later	1	2	3	4	5	6	7
Q_10 If solving math problems doesn't go easy, I may start to shake and sweat	1	2	3	4	5	6	7
Q_11 It doesn't matter to me that I have good results from math	1	2	3	4	5	6	7
Q_12 I think boys are usually better at math than girls	1	2	3	4	5	6	7
Q_13 If I have to solve math problems, I will be very nervous	1	2	3	4	5	6	7
Q_ 14 I tend to get worse results from math because sometimes there are more difficult tasks in the test than I did at home or in class.	1	2	3	4	5	6	7
Q_ 15 When I have to solve math problems, I am unable to think with a clear head and come up with a solution.	1	2	3	4	5	6	7
Q_16 Most subjects go relatively well, but math isn't so much	1	2	3	4	5	6	7
Q_17 I remember almost nothing of what we learn in math class, and that makes me feel bad	1	2	3	4	5	6	7

Q_ 18 Math is the most disgusting subject of all of me	1	2	3	4	5	6	7
Q_19 When I have to do math, I often feel uncomfortable	1	2	3	4	5	6	7
Q_20 I get good results from math because I usually understand the material	1	2	3	4	5	6	7
Q_21 I'm afraid it turns out in class that I have a hard time doing math and I lag behind others	1	2	3	4	5	6	7
Q_22 Right now, my knowledge of math is completely superfluous in my life	1	2	3	4	5	6	7
Q_23 It is completely relaxing and a pleasure to do math tasks	1	2	3	4	5	6	7
Q_24 I'm never sure I solve math problems well	1	2	3	4	5	6	7
Q_25 While solving math problems, I feel like I have a dumpling in my throat	1	2	3	4	5	6	7
Q_26 I often have to ask for help with math problems because I can't solve them alone	1	2	3	4	5	6	7
Q_27 I am often afraid of getting a bad mark for my math test	1	2	3	4	5	6	7
Q_28 I use my math after school	1	2	3	4	5	6	7
Q_29 Solving math problems is often frightening	1	2	3	4	5	6	7
Q_30 I wouldn't be happy for him if I had to do more math than that	1	2	3	4	5	6	7
Q_31 When I do math, I feel a violent heartbeat, which is uncomfortable for me	1	2	3	4	5	6	7
Q_32 Many times I have a hard time learning math	1	2	3	4	5	6	7
Q_33 My stomach twitches when I think of math	1	2	3	4	5	6	7
Q_34 Sometimes I don't get a good mark from math because I have a hard time understanding the material	1	2	3	4	5	6	7
Q_35 I feel very enthusiastic when I do math	1	2	3	4	5	6	7
Q_36 Math skills can help me manage my affairs well later, e.g. the money	1	2	3	4	5	6	7
Q_37 I worry a lot about solving math problems well	1	2	3	4	5	6	7
Q_38 I love everything related to math	1	2	3	4	5	6	7
Q_39 I usually understand math, but I'm afraid it will get harder later	1	2	3	4	5	6	7
Q_40 I am unsure when I need to solve math problems	1	2	3	4	5	6	7