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Characteristics of Chess in relation to Psycho Motor Development of Children

THESIS SUMMARY

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THE IMPACT OF CHESS ON THE DEVELOPMENT OF PSYCHO MOTOR ABILITIES AND COGNITIVE SKILLS

CHAPTER 1. The topicality of the research

The popularity of chess has grown with the advancement of technology because, compared to other sports, it can be practiced in a virtual environment. The most prosperous period of chess evolution was 1970-1990, being dominated by world champions Garry Kasparov and Anatoly Karpov who became ambassadors of this game. The two played five matches, 144 games, to determine who is the world champion. The moves, the ideas and the game plans were analyzed in detail by the grand masters from that period and the annotations filled the magazines, but they appeared rarely and in limited numbers.

In addition to the competitive side, another component of chess was gaining popularity, the educational side. Between 1973-1974, a group of 92 subjects aged between 16 and 18, under the guidance of Dr. Frank (1979), were tested. The experimental group developed administrative and communicative skills and recorded improved scores in numerical problem-solving tasks. This phenomenon was recorded for each member, regardless of the level of chess acquired.

The research continued, but this time an attempt was made to observe the intellectual development of fifth graders. Dr. Adriaan de Groot used the Piaget test and, as in the case of Dr. Albert Frank, had clear results. As an adjacent consequence, practicing students have made significant progress in school tests. To justify this outcome, Dr. Adriaan de Groot summarized the project and mentioned that the environment in which chess is practiced has the characteristics of a physical education and sports lesson, but also of the theoretical classes, where the discipline is a mandatory condition.

Dr. Yee Wang Fung of Chinese University in Hong Kong tested pupils' math and science skills in 1977-1979. He registered a 15% improvement in the results and the favorable factor was the practice of chess.

Another important research was conducted in Venezuela (Gonzalez, 1989) through the "Learning to Think Project". More than 100,000 teachers were trained to teach chess and the test sample consisted of 4266 second-grade students from across the country. The conclusion, as in the case of the other three researches mentioned above, was positive: chess is an educational tool that facilitates the development of IQ in primary school students, regardless of socio-economic factors or gender.

The tests continued thanks to the work of several researchers concerned with observing the contribution of chess to the academic career. Giovanni Sala (2016a, 2016b, 2017a, 2017b, 2017c), Fernand Gobet (1996, 2006, 2008, 2011, 2014a, 2014b), but also other researchers, tried to identify how chess skills influences the didactic activities.

In addition to their work, other researchers (Gumede, 2017; Trinchero 2013, 2015) have tried to observe the influence of chess practice on mathematical performance. Trinchero conducted a research on a group of 568 primary school students. The experimental group participated in training sessions, both face to face and online. The results show a small but statistically significant increase in problem-solving skills. The result is clearer in the case of students who have worked extra.

In his research, Gumede (2017) replaced a math class with a chess class to see if solving problems on the chessboard contribute significantly to solving math problems. Similar to Gumede's study, the subjects were primary school students, and the results were the same: practicing chess helps to improve mathematical skills.

We can say that the topic is a important because the number of researches aimed at observing the influence of chess practice on the intellectual development of children has increased significantly in the last decade.

CHAPTER 2. Chess and its valences in the development of higher psychic processes

The origin of the term *thought* entered the field of psychology through philosophers. Rene Descartes equated this cognitive process with consciousness, a trait specific to humans that differentiates them from animals, saying that existence begins with reason. Thinking is the culmination of the processing and assimilation of information about both the internal and external environment. Thanks to this process, humanity has managed to evolve to its current stage and will continue to do so. Through it, is possible to move from the particular character of the elements to the general one, from the simple to the complex or from the necessary to the essential.

To understand thinking we must relate to the environment. Thus, if we discern the complexity of the phenomena that govern our existence, we can perceive the way our mind thinks. The notion of time or space has an abstract character, and man's relation to one of them seems absurd, but he managed to integrate humanity on the axis of time and also his position in the infinity of the universe.

A thinking model has a structure based on ideas with which we assimilate the empirically received information and manage to form representations of objects from the environment. The created projection is not a faithful copy of the object, we would not need all its features, so the mind registers only the fundamental characteristics. We can say that the representations formed are only an approximation of the reality in which we live, an approximation devoid of most of the details that our mind has categorized as useless. Mental models are just assumptions, generalizations, or even simple images firmly fixed in our minds that help us shape the world around us (Senge, 1990).

Thinking plays a vital role for all people in everyday life. The way we think shapes our actions and defines our daily existence. It helps us establish the goals on which we make decisions (Baron, 2000). The mind can be compared to a neural computer, which has as its operating system a large number of algorithms based on causal and probabilistic reasoning about the elements of the environment.

Instruction means implementing a wide spectrum of notions and education facilitates the implementation of a set of rules: from the basic ones to a minimum of citizen consciousness. The lack of civic behavior is astonishing in people where the education system fails (Boia, 2012). The education system requires the subordination of creativity in favor of other skills acquired in this social environment. The subjects studied in school, both theoretical and practical, develop thinking, ensuring an improvement in mental skills, but neglect creativity (Rawlinson, 1998).

To understand the whole mechanism of thinking we must identify its features:

- *Flexibility* is the prompt change of approach to a problem. During a game of chess, even those played by world champions, the changes that occur during the game can be multiple. Rarely does a top player manage to annihilate an opponent of the same caliber from start to finish. The character of the positions during a single game differs enormously, and the way of thinking used until the first critical moment will have to be abandoned and a different one will be adopted, depending on the outcome of the sequence of moves to be performed. In the Italian Defense (Muller, 2017; Pinski, 2005), the main variant, the game will be one of the maneuvers, where the strategic elements are decisive in the accumulation of small advantages, and the tactical elements are rare. At the fifth move, white may decide to sacrifice a pawn (5.d4)[1] to change the character of the position, so that strategic battle is practically eliminated and replaced with one that has a dominant tactical character. If this change is added to the fact that the opponent prefers dynamic positions, the approach of the game must undergo a sudden and categorical change. Such situations are common, and by the simple fact that a chess player plays a huge number of games, the flexibility of thinking is mandatory;
- *Fluidity* is the process by which a significant number of ideas or a high density of reasoning are analyzed and selected only those that fit, and this is done in relation to a predetermined unit of time. It is known that the game of chess stimulates the intensity of the thought process through the constant flow of information processed by the brain, which leads to the regulation of the processes of accumulation, analysis and processing of the material with which the individual comes into contact. This process is very beneficial because it increases the general level of intelligence by accumulating relevant information that people use in various daily activities (Alifirov, 2018a). The percentage of situations during a game in which the number of ideas behind the candidate moves is minimum 2 exceeds 90%, there are rare cases in which only one move maintains balance. The chess player is obliged to check, at least on a superficial level, at least two options at almost every move;
- *Originality* is given by the character of the finished product, emphasizing the element of novelty and uniqueness. This can only occur in the context of using higher cognitive

[1] The sequence of moves is: 1.e4-e5; 2.Cf3-Cc6; 3.Nc4-Nc5; 4.00-Cf6; 5.d4.

processes such as memory, attention or thinking. The game of chess is an ideal environment for their training because the player will be able to set clearer goals and select the optimal answer (Hong, 2006). The identical replay of two games is very unlikely even in the case of chess players who have played a significative amount of games, except for the draws by agreement of both players who, given the situation in the tournament, do not want to risk a possible defeat. Adapting the optimal response, discovered either during training or in previous games, to the situation on the board is a must for every player. Thinking outside the box is a training mechanism that can be acquired and any professional chess player is obliged to use it;

- The process of *elaboration* is that part of thinking in which any hypothesis can be subjected to the rules of deduction to be proved. Former world champion Robert James Fischer justifies his choice to start the games with the 1.e4 saying that this is *best by test*[2]. Any plan resulting from the interweaving of ideas must pass a test, imposed by the game development, in order to be considered good. Its quality is not altered by luck or chance, even if the opponent is wrong, and the game is undeservedly won. Thus, in the next encounter, the disadvantages of that plan will be exploited. The nature of the game is simple because the rules are clear and external variables do not exist (Vaci, 2016), but anyone who has practiced this sport can highlight its complexity by the huge number of logical reasoning that exists during a game. These simple rules manipulated by logical principles offer the chance to create or invent many as yet undiscovered game plans, but they require a huge number of hours of practice.

2.1. The taxonomy of thinking in the microcosm of chess

The basic element with which it operationalizes thinking is the *notion*. It includes features, characteristics, common or unique elements of objects and the environment. The notion has a general character and, unlike perceptions, it does not identify with the object. It is logical and applicable information about an object, action or property. The accumulation of notions implies general level of abstraction, and the main role is to categorize objects or phenomena of the environment, therefore, we can classify notions according to two criteria:

The information obtained empirically is limited, and their structure differs from one individual to another and has the role of establishing the causal relationship between

[2] https://en.chessbase.com/post/best-by-test-1-e4-bobby-fischer

phenomena and predicting an evolution. This information is the result of daily activities and therefore, the content depends on the context in which the individual is and their importance is less essential to development. If the abstract nature of notions cannot be simplified, and the essence remains misunderstood, then the way of assimilating information is done empirically (Golu, 2007).

The scientific elements are obtained from a synthesis process and include only the essential features of the environment highlighting the laws that guide it. This way of ordering the thought process is always present on the chessboard. In addition to the general rules that allow the game to take place, there are numerous laws (Larsen, 2005; Watson, 2003) that govern chess games. An example would be: *The knight on the rim is dim*[3]. Starting from the way the knight moves, we notice that there are eight squares available, four to the right and four to the left. Placed at the edge of the board, the option to move sideways can only be done in one direction, so out of the eight squares, only four are available. This general notion cannot be deduced empirically, only after a logical-deductive process it can be discovered, and such a move can lead to the loss of the game.

The notions can be *concrete*, but in this case, the reducibility to the singular is not understood, because they have an abstract character (Lupșa, 2005). Those that have a concrete character refer to the possession of features accessible to the understanding of the individual without requesting the analysis of the phenomenon. An example is the tactical procedure called the double attack, where a piece attacks two opposing pieces at the same time. The case is not unique, it does not mention the piece that performs the attack or the others that are attacked, but the form of the notion is easy to understand. Performing such a procedure does not depend on the quality of the player, and if the rule is followed, then the double attack is performed. Also, starting from the structure of the process, through a logical-deductive process, it was discovered the way in which a player can react, and his answer is also concrete. Thus, the effects of this tactical motive can be outlined in order to become easy to understand.

The second category is that of *abstract* notions. The form of such a notion is not generally valid, it only makes sense based on particular experiences. Its representation is impossible to achieve, because the relation to reality is subjective in itself and these notions are component parts of the laws of life. In the case of chess, an example may be initiative. When a series of aggressive moves force the opponent to adopt a reactive game in which his

[3] https://en.chessbase.com/post/endgame-blog-karsten-mueller-954e

plan is only to maintain the equality, then we can say that the first player has the initiative. The limits, the type of aggressive moves, the duration or the response of the opponent are all relative. The transition from abstract to concrete can only be achieved by identifying a common element that can be described, in the case of the initiative, a direct attack.

There are two types of thinking through which we can identify the use of specific processes such as generalization and concretization, which are used during chess games. Analytical thinking involves logical connections that have the role of providing a small number of possible solutions, in some cases only one, and the synthesis process is accompanied by concretization. Complementary to this, the chess player also uses creative thinking (Ebenezer, 2017) which forces the use of imagination in order to discover the subtleties of the position. Creativity is based on already accumulated experiences and knowing a large number of chess patterns turns a complicated position into an opportunity in which the number of resources is generous. The game of chess alternates between situations in which the way of thinking is used, and the transition from logical synthesis to abstraction is a necessity. Also, the ability to discover these critical moments is the difference between a good chess player and a grand master. Although complementary, in some situations, the confusion of the two types of thinking results in superficiality. The most eloquent example is found in the first part of the game, where, thanks to technology, the lines are well analyzed, and the attempts to be creative can result in a steep end of the game. Here, exclunding the lines played rarely where their analysis has not been done in depth, logical thinking is mandatory.

The child who practices chess is forced to alternate the use of logical thinking (Kislik, 2018) with the analytical one in each game they play. We can say that the chess game is a combination of the two, where transformation into an automatism is essential. Also, applying and assuming a thoughtful plan, based on logical ideas and principles, can influence self-esteem (Jianguo, 2019).

2.2. The applicability of the fundamentals of thinking in the game of chess

The way the human mind works can be understood by describing the fundamental operations that underlie it. Thus, their presentation and translation into chess is addressed individually in the following lines:

- *Analysis* is an operation of designing and decomposing an element into simple parts that can be assimilated. When analyzing a position, one tries to observe several key aspects of the game, and the cumulative results provide a verdict on the status of the position (Aagard, 2012). Among the elements checked are: the safety of the kings, the material balance, the immediate threats, the pawn structure and others. Regardless of the complexity of the position, it can be classified as equal, better for white or better for black;
- *Synthesis* deals with the mental reconstruction of a phenomenon by using elements of profound significance. This makes it easier to move information from working memory to long-term memory. Given the limited space for storing information, only those notions that are of interest to the individual will be stored. In the case of chess players, after the end of a game, the memory selects for storage only the key points, but starting from them, any professional player will be able to fully reproduce the game;
- The third operation of thinking is *comparison*. This involves finding the essential differences and similarities of some phenomena in order to adjust the information already stored. The processing itself is selective, as the material already stored is updated to compare essential elements with the newly discovered ones. After a few adjustments, the information takes a new form in order to be stored. To correct the mistakes, especially in the opening phase, the games of the grand masters played in the same variant are observed (Karpov, 1997). Plans, ideas and nuances are accessible to any player due to the fact that most top players comment and analyze their own games at press conferences after their completion. The new conclusions will be stored and the update will be used in the next game.
- *Abstraction* (Forster, 2004) has a selective character that offers the identification and highlighting of important features, omitting the others that are not of interest. In the case of a chess player, he can say that he is a player with predominantly tactical valences only because his repertoire contains aggressive, well-theorized openings. This may be true, but if in the observation of the decisive moments, from a statistical point of view, he fails to execute the tactical procedures, then we can say that the status of offensive player does not suit him. In both cases, the information, in its abstract form, must be repeatedly tested in order to be understood and processed;
- *Generalization* is a divergent operation, transforming the characteristics of a particular case into a valid axiom for a group. This process is accomplished by extending the main characteristics of an individual to a whole set. Former world champion Robert James Fischer invented and improved the English Attack so much that he could implement it in various

forms against any black setups. If we say that the Indian Attack suits every player, just because the results of the world champion were impressive, then we would be making a big mistake. In order for this system to be compatible with the repertoire of a lot of players, we should say that the level of understanding of the game is at the same level as that of Robert James Fischer, and that is false. Also, there are situations when the generalization is correct. The same world champion quoted that 1.e4 is best by test, so we can generalize by saying that any player should use it, a statistically proven statement;

- The last operation is *concretization* and this involves the application of general notions in a particular case. During games there are general rules that work as a map towards the correct move. One such statement is: When we are attacked on the flank, we counterattack in the center. The opponent's operation may not be justified by the nature of the position, and a counterattack in the center is not necessary. Most of the time, knowing the general information helps, because analogies can be made with the particular situation, and the decisions to be made can be influenced correctly. Abstraction and concretization improve the fluency of thought (Tsai, 2011).

2.3. Optimizing the thinking process through the game of chess

The role of thinking in the practice of chess is obvious, because the game is a mental struggle between two opponents and weapons are the previously assimilated notions. Their operationalization is present both in the pre-competition training sessions and during the games. Chance only occurs when impulsiveness and too much desire to win are prioritized.

Chess is the ideal environment for observing the intellectual development (Almeira, 2017; Huerta, 2012) of children. There are no stereotypes (Blanch, 2015; Stafford, 2016), age, gender, background do not influence the chess course, on the contrary, it has been shown that, statistically, girls perform better than boys (Stafford, 2018). This also extends to professional players (Blanch, 2016). There was also a consistency regarding the mistakes (Miranda, 2019) that they commit, even if the possibilities of the game are endless (Lai, 2015).

Chess players showed an improvement in both metacognitive and math problem-solving skills compared to students who did not practice chess. These results suggest that we can use chess as an effective tool of developing students' thinking (Kazemi, 2012). Several studies have shown that through chess, students are forced to use simple information previously assimilated. This repetitive exercise creates a routine beneficial not only to chess but also to everyday life. The ability to use critical thinking (e.g. criteria for determining decisions and evaluating testing alternatives) improved scores by 17.3% for students who regularly participated in chess training, compared to only 4.56% for children who participated in other forms of additional activities (Boruch, 2011). Chess also helps individuals develop problem-solving skills, improve strategic thinking (Saariluoma, 2001), self-esteem, as well as higher cognitive skills (Sigirtmac, 2016). Chess games offer the possibility of using all the fundamental operations specific to thinking to achieve a goal. Coordination of pieces can be seen as a struggle between two minds, and to win it is necessary to use previously acquired data, some even during the game, and include them in an algorithm organized according to established principles, to achieve the ultimate goal. School chess uses this sport to train cognitive and academic skills, critical to student performance, such as logical and spatial thinking, reasoning, long-term planning, assessment, decision making, memory, judgment and strategy.

The most effective side of chess in the development of thinking is the promptness of feedback. Each move of the opponent can be considered an assessment of the previous thought process and it provides enough information about his intentions and plans (Nicotera, 2014).

Research that has looked at the personality of chess players has shown higher introversion scores in chess players, as well as higher scores on unconventional, orderly and logical thinking compared to non-practitioners. Children who choose chess as a hobby are more likely to be extroverted, conscientious, and open to new experiences than those who do not play chess (Klein-Vollstädt, 2010). Also, through the specific requirements of tournaments, chess involves the development of personality (Dhou, 2018).

The statistics showed a close connection between regular chess practice and life expectancy. Thus, many chess players manage to reach the age of 80, 90 or even 100 years (for example: Yuri Averbakh), and this is due to the constant neural activity, specific to higher cognitive processes such as thinking, memorizing or distributing attention from during the game of chess, which stimulates the entire nervous system. This change generates adaptations that are felt throughout the body, as the brain creates systems for regulating physiological functions. The more complex the logical thinking process, the more neural formations are used.

Because students of this generation love to play, researchers believe that practicing a sport such as chess will improve their critical thinking and problem-solving skills (Stegariu, 2020). 1We can see a difference in the thinking of boys compared to girls. The girls prefer a style of play based on maneuvers where the aesthetic side is highlighted, while the boys have a more direct approach trying to force the opponent to make mistakes. Tactical sequences, statistically, are present in a higher percentage in boys 'games than in girls' games (Subia, 2019).

2.4. The spectrum of the influence of chess in the school curriculum of students

In school, the role of chess can be seen as a bridge from social distance, caused by age, social background or gender to inclusion in a group, later transformed into friendship. Practicing chess helps to strengthen the team spirit in the conditions in which they, together with other colleagues, represent the school in school tournaments either in the county or in the country. Also, through chess, the child comes into contact with the notion of sports fair play, because the treatment of victory must be done with elegance, and defeat with dignity. Children who are more emotional benefit from the fixed rules imposed by the laws of chess because, on the board, they can duel on an equal terms with anyone, and such a victory leads to improved self-esteem. Chess can also be a recreational activity that any child can enjoy.

The theoretical, easy-to-understand considerations that were the starting point of this research: Chess eliminates any physical or genetic advantage of time. At the beginning of the game, both players have the same resources, and the only way to win is to manage them efficiently. The game of chess offers a multitude of situations that require immediate attention and resolution. From a simple direct attack in which the opponent threatens to capture a piece, to complex strategic maneuvers that aim to create long-lasting weaknesses that will only be exploited in the endgame. Some players are so eager to move that they tend to do so without sufficient reflection and because the quality of the move is influenced by the reflection time, this can lead to an inefficient distribution (Gransmark, 2012), generating time crisis. After a mistake or rather an unresolved problem, the position becomes uncomfortable, and the feeling of regret appears immediately, especially in preschoolers and young pupils.

Chess offers immediate punishments and rewards, because any mistake leads to immediate defeat. The chances of recovering from the disadvantage, given that the hazard does not exist[4], they are insignificant, only a similar mistake can rebalance the balance. When the opponent is wrong, any chess player, regardless of age, knows that victory cannot be lost if he is careful. Thus, the punishment of mistakes, which occur in a significant number of beginners' games, educates patience and self-control. Chess creates a system of thinking (Jankovic, 2019), which used with confidence will lead to victory. There are positions, especially in the final phase, in which the steps to victory are theorized, and if they are respected, the opponent cannot resist. This algorithmic thinking occurs in any phase of the game, and neglecting it offers chances to the opponent, counter-game, which, combined with a possible tense situation in the tournament, complicates the fight.

Robert James Fischer describes the career of a professional chess player in a quote: One day you give your opponent a lesson, the next day he gives you one[5].Regardless of the level, competitiveness is increased, and a simple defeat can motivate the player to the point where he will do his best to get revenge, and this is done only if he gets better. Assuming a major defeat shapes the characters who, combined with performance, will turn into true champions.

Chess is an environment that leads to the accumulation and assimilation of new information. This can be a facilitator of cognitive development, especially since it includes a playful side. The combination of intellectual work and the playful component offers the possibility to focus attention on the task proposed by the teacher for a longer period of time. The repetition of that action triggers a series of adaptations that, over time, will improve the overall development process.

The last theoretical consideration is diversity. No game is repeated, even the strategic or tactical patterns, although identical, do not have the same shape, because the arrangement of the pieces is different, forcing a particular nuance.

There are many studies that have investigated the effect of chess on children. Many of them are qualitative and often promoted by people in the field of chess, but that does not necessarily mean that they should be ignored. Those who have witnessed the school progress of children who play chess in an organized environment over time do not need a statistical study to convince them of the benefits of this activity. A simple comparison of the grades of a practicing student with those of one who is not part of the experimental group, may reveal a major difference (Ebenezer, 2018).

[4] https://en.chessbase.com/post/chess-and-luck
[5] One day your opponent gives you a lesson, the next you give him one.

The improvement of the school grades is correlated with the child's chess level. Those who practiced only in school activities improved their math results by 5-10%, while those who participated in tournaments also saw a significant increase in both math (30-50%) and reading (10-20%). These improvements were constant in each grade, beginning with preschoolers and ending with sixth graders (Poston, 2019). One possible explanation is that chess training shares certain general characteristics with mathematics, such as: quantitative relationships (the value of chess pieces) and problem solving (tactics), which in turn can be generalized to mathematics (Sala, 2016). Another study exposes an interesting situation, namely that the increasing difficulty of uninterrupted tasks has led our participants to express more visible emotions during the experiment. From the data obtained it is clear that the expressions of emotion increase with the difficulty of the problem (Guntz, 2018). Managing emotions is a crucial factor in the proper functioning of the memory recall, without which, students have no chance to get a high grade.

2.4.1. The influence of chess on mathematics

In addition to general intelligence, chess requires a high level of spatial visualization ability. The calculation of the lines that involves visualizing with the mind's eye the potential moves and their result, was considered one of, if not, the most important factor of chess mastery. Given that no outside help is allowed, the chess player must perform these transformations without actually moving the pieces.

Chess players have a detailed and concrete picture of the actions and transformations that take place on the chessboard during a game à l'aveugle[6]. Even the best players said that the representations are abstract, without a three-dimensional visualization of the pieces (Bilalic, 2006).

Although chess should not replace one of the existing subjects in the school curriculum, it can be an additional beneficial activity, especially for regular students (Liptrap, 1998). Ortiz (2019) (table 1) created a table of studies aimed at chess in which the data necessary to understand the contribution of this sport to improving the academic career of students are presented.

Table 1. The role of chess in the process of learning mathematics (Ortiz, 2019)

[6] Blind chess that involves playing the game without moving the pieces.

Author	The country	Nr. participant	Purpose of the study
Fernandez-Amigo et al.	Spain	N = 141 experimental group (79 boys, 62 girls)	The usefulness of chess materials in teaching mathematics
Achig	Ecuador	N = 35 experimental group (20 boys, 15 girls)	The impact of chess on logical-mathematical reasoning
Guerrero et al.	Mexico	N = 32	Discovering the effects of practicing chess on mathematical operations in fifth grade students
Gumede and Rosholm	Denmark	N = 264	Characteristics of the impact of chess in mathematics during the first and third grade students
Sala et al.	Italy	N = 309 experimental group (169 boys, 140 girls) N = 251 control group (116 boys, 135 girls)	Investigating the potential of online chess lessons on problem-solving skills in 2nd, 4th and 5th grade students
Rosholm et al.	Denmark	N = 323 experimental group N = 159 control group	Analyzing the effects of replacing a math class with a chess class in 1st and 3rd grade students

This is just some of the research that has established a correlation between chess and mathematics. In addition to the above, Barrett, Bart, Gobet, Kakoma and Kazemi conducted similar studies, and the results are oriented in the same direction. The replacement of a traditional math lesson per week with a chess lesson did not negatively affect the mathematics results of the students from the experimental group, on the contrary, we can say that they improved them. In essence, the experimental group spent less time studying the math curriculum (30 days of teaching) compared to the control group and yet it was not passed in any of the eight math tests (Barrett, 2011).

Students in the experimental group scored significantly higher on post-test scores on math and metacognitive skills than members of the control group. A main finding of the research is that the study and practice of chess significantly improves students' mathematical skills and metacognitive abilities (Bart, 2014).

During the games, the player must understand the position, recognize the strategic or tactical pattern, evaluate the position, find the candidate moves and that in a relatively short time. This set of cognitive skills required for the game of chess are transferable in the process of learning mathematics or other areas in which understanding, inductive thinking, problem analysis and assessment of a complex phenomenon are required. (Bart, 2014).

Children who participate in chess training show significant improvements in math skills. This statement is also true for those with a low IQ (Kakoma, 2016).

2.4.2. The influence of chess on reading

The connection between mathematics and chess is obvious, but several researchers have made a correlation between practicing chess and reading (table 2).

The description of the process of reading a text is similar to that of a chess game. Students need to use new knowledge and information about the position through a complex process called choosing the candidate move, and this is similar to selecting an important sentence (idea) from a text. The cognitive processes used are similar, and in both cases students participate in activities in which the decision must be made rationally and assumed.

An explanation for the influence of the reading process can also be the rigorous selection made by competitive chess. The top chess players have in common an above average intellectual level (Grabner, 2014), and this selection is made naturally starting with the level of amateurs. Being a group of students with high intelligence automatically and the academic results are better, but even so, the design of the research varied.

Table 2. Correlation between chess practice and reading (Ortiz, 2019)

Author	The country	Nr. participant	Purpose of the study
Margulies et al.	DOOR	N = 1118 Participants N = 22 Groups	Studying the reading process before and after practicing chess
Liptrap et al.	DOOR	N = 571 Participants N = 504 Non-participants	Determining the degree of student involvement in a chess club
Duccette	DOOR	N = 151	Analyzing the effects of a chess program on behavior, math, and reading
Dapica-Tejada	Spain	N = 60 Participants 30 (21 boys, 9 girls) experimental group 30 (20 boys, 10 girls) control group	Highlighting the improvement of the process of reading and understanding the text in students who practiced chess

Another researcher who emphasized the role of chess in the process of reading and understanding a text is Sala (2016), who stated that chess requires superior decision-making skills and cognitive processes (such as accumulating and selecting relevant information from a problem) similar to those used in math and reading.

CHAPTER 3. Psycho motor abilities and their role in the development of cognitive abilities

Psycho motor abilities are a complex process by which the education and development of motor functions are performed simultaneously with the psychic ones, resulting in the dynamic integration of the individual in the environment (Abalașei, 2011). It is not limited to motor activity, but includes the entire scheme of adaptation of the individual to the requirements of life, observing and analyzing the manifestations of perceptual functions coordinated by the intellect in response to the stimulation of stimuli.

The importance of studying psycho motor abilities is especially vital in the prevention, recovery or education of many types of disabilities in the early stages of life and beyond (Berdilă, 2019). Basic psycho motor abilities are constantly evolving, being strongly influenced by the contribution of education, physical and intellectual development and daily habits. Aptitude can be considered a form of reaction of the individual to a stimulus based on his mental and neuropsychological states (Abalașei, 2011). Given that the individual is a member of a society, his skills will be assessed according to the rules imposed by it. We cannot say that a man is not aptly endowed, but that they are less developed, and their measurement is made by analyzing his performance in the context of imposed tests. Taking a first grader as a model, we can see that his ability to throw a handball ball is different from that of his classmates, due to the genetic content and the uneven development of the children, but it exists. Motor ability is the reaction of a preexisting aptitude in an established setting. It can be quantified and is the subject of a direct assessment, being a form of manifestation of skills.

In the preschool phase, the child discovers the world using motor acts as the main tools. One can notice a lack of coordination between intellectual and motor skills, so the motor act becomes as a reflex to various stimuli, later entering under the tutelage of the psyche. With the transition to school life, we are witnessing an acceleration of the development of intellectual functions, and in this phase we can see a detachment of the intellectual component because most of the motor activity is automated.

3.1. Education of perceptions and representations

The development of cognitive functions in children is closely related to the evolution of sensory-motor structures because they are the foundation for the use of fundamental operations of thinking. We can say that intelligence arises from action, based on the transformations of perception of objects and phenomena in the environment. Therefore, it is necessary to observe and analyze the evolution of perceptions in order to understand the general development of children. Perception is the figurative character of the environment, the way in which an individual receives the sensory information and the motor activity has the role of outlining, through his operations, the real shape of the environment.

Michotte (Piaget, 1968) conducted an experiment in which the influence of perceptions on thinking was highlighted. A group of children watched a sequence in which a square named A follows a straight path to a square B motionless. Three different cases were presented, based on the evolution of the first. In the first case, A remains motionless after the moment of contact, thus creating a perception of the launch of square B as a consequence of the collision. In the second, square B moves, but only after a sequence of time in which it remains inert so that its motion acquires an independent character. In the latter situation, both squares become mobile, but B's speed is higher, giving the impression of a training relationship and triggering after touching. Following this experiment, it was stated that motor skills provide a lot of information necessary to learn the process of cause and effect through which the child is involuntarily forced to use the operations of thinking.

If in the preschool phase, the child fails to acquire precise spatial-temporal cues, once the school activity begins, we witness an accelerated development from this point of view. The child will research in detail the objects and figures with which he comes in contact, eliminates illusions. When he listens to fantasy stories he gets bored easily, and those about the supernatural acquire a mystical connotation difficult to discern, thus developing a strong sense of anticipation. Perceptual activities manage to clearly outline the real world, but can lead to conceptual errors that will persist as they grow. Two boxes of different sizes, but with the same weight, carried at different times will provide different feedback, just because of the anticipatory spirit of the child.

The child develops the ability to accurately differentiate objects and phenomena by overcoming the syncretism of perceptions resulting in the enrichment of practical knowledge necessary for daily activities (Stanciu, 2014). Under the tutelage of learning, both intellectual and motor, the representations are more and more varied, achieving a detachment from the phenomenon itself that gives the child the opportunity to generate new images.

Visual perceptions are influenced by the evolution of the written-reading process. There was an increase in general visual sensitivity of up to 60% compared to preschoolers, and the differential one by 45% (Cretu, 2005). Even in the first year of school, children can identify the symmetries and asymmetries in the images whose meaning was perceived. The difference between handwriting and printing is a daily exercise that develops orientation in strongly delimited spaces, forming automated schemes. There is an increase in reading speed, which is due, in addition to intellectual development, to the anticipatory spirit of the succession of syllables and the improvement of the eye muscles. The need to follow the line with the finger will disappear when the child manages to develop his vocabulary to the stage where he can express his opinion argued, even if in a simplistic form.

Thanks to the writing exercise, the tactile perceptions are improved, especially at the level of the hands, and the auditory ones are trained to read. There is a differentiation of the tone of speech which leads to the singing of specific songs respecting the musical rules. Perceptual sensory abilities are made more efficient, and the apogee is reached towards the end of the primary cycle. This is due to the activities imposed by school practice such as: reading, writing, drawing, singing, developing fine motor skills, and prompt interpretation (Briceag, 2017).

Representation is an involuntarily triggered mental process that cannot be controlled, having as a finality the shaping of reality from the perceptual message (Abalașei, 2011). The properties of objects are made in the form of images that are integrated into a set guided by similarities.

To better understand this term, a comparison with another previously presented, is necessary. They are similar in content, but differ in the way they are formed. If in the case of perceptions no previous experience is required, the representations condition a previous action influencing the individual.

The representations present the following particularities (Abalașei, 2011):

- They have a figurative character, they appear in the absence of the object, the phenomenon;
- They are not stable, they are constantly changing based on new experiences that generate new perspectives;

- They can be modified by language, therefore the school, by its predominantly scientific character, plays an essential role in triggering an efficient mechanism for producing representations;
- They are weak, any vague updating of an object can trigger a new representation;
- Because they represent a stored accumulation of information, the efficiency of updating them is given by the item with attached emotional impact;
- They have the form of a panoramic image, as a whole, they often have an abstract character;
- Facilitates the transition to the notion, the object necessary for the functioning of the operations of thought;

In addition to the features mentioned above, they have the following uses:

- It helps to move general information from long-term memory to working memory to serve specific tasks that in turn will change the size of already formed representations;
- Representations, due to the general nature of the information, are the basis of the imagination. This is closely related to the number and quality of stored representations;
- Helps to expand vocabulary due to the analogies that can be created;
- They are essential to generalization, a fundamental operation of thinking that serves to solving specific problems.

Primary school students form their representations according to the activities imposed by the new social environment. These are much richer because the source of origin ensures the optimal conditions for the formation of clear representations, given the predominantly scientific context.

The formation of representations is done simultaneously with the intellectual evolution, and the degree of generality knows an ascending slope. This operation of thinking is reversible, and the more the student manages to understand, sort and order complex representations, the easier it will be to assimilate new ones. The main new categories are those acquired during math and communication classes, being the graphic and phonetic ones (Crețu, 2005).

The schoolboy knows a large number of representations, but most have attributed wrong or incomplete meanings giving a confusing character (Sion, 2003). Most representations are often used as follows: the child develops an ability to break down into parts to use in solving certain given tasks. After fulfilling them, new components are made with which he will be operate, developing a thought process. From the individuality of the representations it is passed to groups of representations increasing the degree of generality. There is also a dynamism of their usefulness due to the transition to a higher level of intelligence specific to school. It is very important that the teacher or parent pay serious attention to modeling misrepresentations.

Taponier performed an experiment (Piaget, 1968) to observe the difference in clarity between the representations of a group of preschoolers and those of a group of primary school students. He lined up 12 red chips, face to face with another 12 blue chips to show that they were in equal numbers. After the blue chips were spaced apart, the kindergarten children stated that they were not in equal numbers, while the schoolchildren kept their opinion. From this experiment we can conclude that the representations are only a system of symbols that reveal the level of operative or preoperative comprehension of the students. They do not have a final product of their own and are used by the fundamental operations of thought.

3.2. Education of body schema

The body schema is the three-dimensional image of one's own person perceived in several poses: when the individual is moving, when he relates to other objects belonging to the environment and the relationship of body parts with the whole body.

This allows an objective assessment of the relationship between the individual and the components of the environment. From here we can observe two ways of perceiving one's own body: the spatial image, where the spatial dimensions delimit exactly the shape of the body and the affective image, as a result of the experiences obtained from the relationship with the elements of the environment.

According to (Abalașei, 2011) the body schema has the following components:

- The visual component through which the integration of body segments in the spatial dimensions of the environment is achieved;
- The cognitive component helps to control the segments and the whole body in performing various daily or specific activities;
- The Gnostic component clarifies the role and anatomical possibilities of the individual;
- The vestibular component helps to maintain balance, by being aware of body position, in dynamic activities;
- The sensory component has the role of integrating the body into the environment through a series of optimal reactions to sensory stimuli;

At the beginning of the primary cycle, the child will make major changes in the body schema due to the particularities of the new social environment. There is a transition from the narcissistic period to that of knowledge. This period is defined by a decrease in syncretism, because the operations of thinking are used differently, and the assignment of meaning to phenomena becomes a priority.

Attempting to classify objects by distinguishing similarities will lead to highlighting the qualities that are verified by freshly lived experiences. This mechanism of thinking will be applied, in the first phase involuntarily, and will later be done voluntarily, on the capabilities of one's own body.

The thirst for knowledge will also affect the relationship with the parents, but due to the pattern of changes, they are in a state of balance regarding instinctual conflicts (Sion, 2003). The perception of oneself often does not correspond to that of the teacher or colleagues, which leads to an involuntary re-evaluation of the information already assimilated. There is a defense mechanism in the context of a school failure that leads to a mismatch between the results obtained at school and the expectations of parents, which, in the worst form, turns into a lie (Briceag, 2017). Affective reactions become more reserved, with voluntary control being observed through simulation and hiding of key elements.

The interaction of the individual with the environment or with its constituent elements is a continuous process whose main purpose is the formation of the body schema. The representation of the body schema undergoes changes, sometimes regressive, depending on the sensory information received (Assaiante, 2013). Maravita (2003) considers that, from a neurosensory approach, the body schema is based almost entirely on the information received visually. They produce internal representations (Haggard, 2005) that have the role of generating a response at the brain level, which means that there is a close link between intellectual capacity and the level of the body schema.

In order to be able to understand the body, the brain needs an efficient and accurate integration of the information received so that the representations become coherent (Liu, 2017). The assignment of meaning is done only when the individual is aware of how the elements of the environment influence the evolution of their body. Therefore, the need to develop a thought process is essential during early schooling. The child is forced to live in several social environments that have different characteristics, and the transition is sudden and irreversible, for example, from kindergarten to school. The preschool period is shaped by fantastic elements that influence the child's perception of both the environment and himself. Cognitive limitations restrict the possibilities of testing, which means that, the external impact on how the body pattern evolves is open and constant.

Liu (2017) proposes the example of a prism to explain the role of cognitive processes in the formation of the body schema, where the proportions, color and shape of objects differ from the real ones. In children, given that their motor experience is limited, the body pattern takes the form of what they know, not what they see. If we examine a child's drawings, we can see that the essence is related to their mental development (Maley, 2009) and as they grow, the drawings become intelligible due to the fact that they are able to introduce fine details (Thomas, 1990) that they did not know before.

According to Raimo (2021a), at the end of the primary cycle, students manage to outline structural representations similar to those of the adult. This upward trend continues until the age of 60, when self-perception regresses (Raimo, 2021b). It should be noted that, by the age of 10, the elements of the face were better defined than the others (Auclair, 2014), and a possible explanation would be that the main stimuli used to accumulate environmental information are at the level of the head. According to Kagerer (2014), the general dynamic coordination in children shows a variability inversely proportional to age. The seven-year-old and the ten-year-old will be able to frame the elements of the face in a circle that represents the face of the individual, but the difference is made in terms of positioning and proportions.

The perception of one's own body is essential in daily activities and contributes to the development of self-awareness (Maravita, 2003). The location of body segments, even in children, is done involuntarily, so we can talk about their control in relation to spatiality. The complexity of the process described and its transformation into automatism gives us clues as to how the body's pattern evolves. In the case of the child who practices chess, due to the clearly defined hierarchies (Elo, 1978), any result generates a response at the cerebral level. If we take into account the chess progress, then we can speak of a repetition of favorable results against a category of players. This process leads to a substantial change in the body pattern, especially in the way the child perceives his own image in relation to the competition. Medina (2010) and Schowebel (2005) talk about these changes and confirm the existence of a constantly evolving body schema. There are a growing number of internal systems that help us shape our own three-dimensional images according to the environments in which we live.

In conclusion, this stage of life, from the perspective of the formation of the body schema, is one of accumulation without offering a finished product, only during adolescence the first forms of the body schema are outlined. The child enters a world of knowledge both externally, by exploring the environment, and an inner one, by observing and analyzing his own body.

3.3. Education of laterality

Laterality justifies the functional inequality of a pair of analogous organs (hands, eyes, feet), and the main factor is the selection of the dominant cerebral hemisphere. This relationship of superiority does not exclude a relationship of complementarity between body segments during an action (Albu, 1999). From an anatomical point of view, the brain has a clear symmetry, but it is highlighted by an executive asymmetry that has a role in the configuration of the body schema, but also in the development of perceptual-motor behaviors.

The location of the main commands is done in the opposite hemisphere, therefore, right-handers process information in the left hemisphere, and in the case of left-handers, in the right. The theoretical names for the two categories are: dexterality and senestrality (Radu, 2003). It should be noted that this aspect is relative, because, in addition to those cases in which the individual has a completely dominant hemisphere, there are situations of poorly defined laterality, also called ambidexterity. A less pleasant situation that can affect the psycho motor development of the child is found in children who are forced to change their laterality through education. There is also inhomogeneous laterality in which the individual uses the right eye and hand, but at the level of the legs, he uses the left.

3.4. Education of spatial-temporal orientation

Space and time are the landmarks to which we relate any activity carried out, either by the objects in the environment or by our own person. These two elements define the structure of the environment within which people operate in this way. A poor perception of these two landmarks can lead to inefficiency of actions.

The spatial relationships already known to the school have a general character: close, next to, above, etc., but they become clear when the units of measurement learned at school are included. In the first phase, the estimation will be deficient by addition, and towards the end of the primary cycle, students will underestimate the distances and sizes (Șchiopu, 1997). The space can be seen from an emotional perspective, but also as a territoriality. The organization of the personal space will be guided by intimacy, and in this small circle family members and close friends will be allowed. This space is psychological in nature, and the context in which the student participates in an activity will change its metric dimension. The territory in which the student carries out his activity has several characteristics: shape, size, possibility of extension and personal relationships.

Through geography, they discover a new side of space, immensity. From here, in the case of those with a high intellectual level, the need for proportionality for the establishment of maps can be deduced. Substantial changes are also taking place in the perception of time. Due to its relative nature, due to the lack of interest in its awareness, it becomes consistent through the timing process imposed by the disposition of school activities. The student will discover the specific units of measurement, and his activities will be related to them.

Spatial-temporal orientation is a psycho motor behavior that is closely related to the development of the body schema (Lopez, 2012). It is easy to understand the role of children in the maturation process. Integration into the environment, which is essential for the formation of the body pattern, is not possible without a good definition of spatial and temporal landmarks, and this process takes shape only during puberty. To give a clarifying example, we can observe team sports, for example, football or handball, where until the age of 13-14, the emphasis is not on collective tactics, but on individual technique.

In conclusion, this basic psycho motor behavior knows significant improvements during the primary school period due to the required activities. Even so, owning one is still beyond the reach of the average person.

CHAPTER 4. Preliminary study – The effects of chess practice on the multilateral development of small social actors

4.1. Research premises

Before setting the hypothesis we analyzed the evolution of chess practice in school and most studies that have this independent variable. We noticed an evolutionary trend of research towards multidisciplinary areas, and the most interesting approaches were those of Garcia (2019), Golf (2015), Hanggi (2014) and Villafaina (2018) which presented the effects of chess practice beyond the cognitive processes already analyzed. Also, in an attempt to improve the training methods for children who try to become professionals, we have identified many similarities between individual sports, such as tennis, karate or judo and chess. The only different element is physical activity, but its effects on the body are also found during chess competitions.

The processes of growth and development do not follow a valid general pattern that applies to each child so we can talk about stages and limits of normalcy, but the genetic element, the social environment, education or entourage are factors that can influence them decisively. In addition to the educational activities included in the school curriculum, students benefit from a non-formal education that has the role of complementing and influencing multilateral development.

The premises described above have provided a new perspective that required special attention, thus observing the effects of practicing chess on certain psycho motor abilities, essential in the process of integrating the child into the environment, is the foundation of this preliminary study.

4.2. Objectives and hypothesis of the preliminary study

4.2.1. Objectives of the preliminary study

The main objective of the preliminary study is to quantify the contribution brought by the practice of chess to the multilateral development of students. The secondary objectives are:

- verification of the test battery and its completion in order to carry out the main study;

- choosing the group of subjects.

4.2.2. Preliminary study hypothesis

The main hypothesis:

1. The practice of chess contributes to the psycho motor development and influences the intellectual component of primary school students.

1.1. Studying and practicing chess contributes to the psycho motor development of primary school children.

1.2. Studying and practicing chess influences the intellectual component of primary school children.

2. The effects of chess practice depend on the gender of the students.

4.3. Research variables

Preliminary research had as an independent variable (table 3) chess practice under special conditions imposed by the pandemic caused by the SARS-VOC2 virus.

Table 3. Preliminary study variables

Independent variable	Dependent variables	Influenced abilities	Test method
Chess	Psycho motor abilities	Body schema	Goodenough
		Laterality	Harris
	Cognitive abilities	Logical thinking	Absurd Phrases
		Analytical thinking	Similarities
		IQ	Raven Progressive Matrices
Gender	Psycho motor abilities	Body schema	Goodenough
		Laterality	Harris
	Cognitive abilities	Logical thinking	Absurd Phrases
		Analytical thinking	Similarities
		IQ	Raven Progressive Matrices

Dependent variables were the psycho motor abilities and the cognitive abilities, more precisely: body schema and laterality, respectively logical thinking, analytical thinking and IQ.

The testing methods of the dependent variables are:

Psycho motor abilities:

Body schema - Goodenough Test;

Laterality - Harris Test.

Cognitive skills:

Logical Thinking - Absurd Phrase Test;

Analytical Thinking - Similarities Test;

IQ - Raven Progressive Matrices.

4.4. Research subjects

To carry out the research, 67 students were selected (figure 1.) from the primary cycle enrolled at the "Bogdan Petriceicu Hașdeu" School, no. 22, Iași. Their age is between 9 and 11 years, and this variation is given by the time they were enrolled in school.

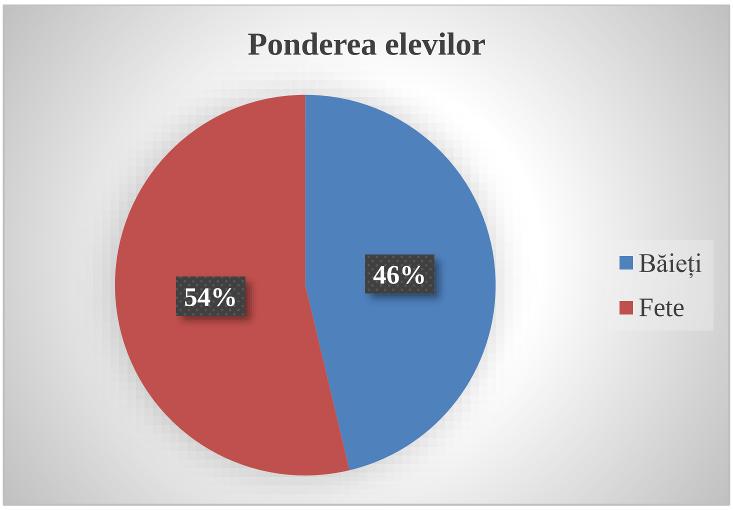

Figure 1. Distribution of subjects - preliminary study

4.5. Test battery

The tests used were divided into two categories, the first two measured the level of development of psycho motor abilities and the last three of cognitive abilities, such as logical and analytical thinking and IQ.

The first category, that of psycho motor tests, consists of the following tests:

1. Goodenough test - body schema;
2. Harris test - laterality.

The following tests were used to test intellectual abilities:

1. Absurd Phrases test - logical thinking;

2. Similarities test - analytical thinking;
3. Raven Progressive Matrices - IQ.

4.6. Lesson schedule

The program of lessons was organized according to the structure of the school year 2020-2021, and they took place in the form of an optional part of the school curriculum (CDS[7]). The activity was coordinated by the author and the whole class participated in the activities, regardless of whether some of them were registered at the local chess clubs. Due to the pandemic situation, according to the national decision, all the lessons were conducted online so there were some changes that affected the teaching quality, but also some different elements that were not used during face-to-face activities. The chess lesson, planned for face-to-face activity, is divided into three distinct stages: individual study, group study, and thematic or verification games. The temporal distribution is made according to the following proportion: 40%, 20% and 40%. Depending on the difficulty of the new content that had to be taught, the time allocated to the group study will equal the individual time. The necessary materials include a chess set, a notebook and a demonstration board. The individual study involves solving some positions, diagrams, in which the objective is a clear one and previously presented.

The most important moment in the chess lesson is the presentation of the new material on the demonstration board. The difficulty of this process is given by several factors, including: the way of teaching, the disturbing elements that catch the children's attention, the child's level of understanding, the temporal location of the class during the school day, the teacher's competence, etc. Also, the element of novelty enriches the baggage of knowledge, and the progress is conditioned to a large extent by this aspect. Depending on the content, the proper conduct of the individual study depends on the effectiveness of the collective presentation. The thematic games propose a form of manifestation in adversity of the theoretical part presented in the previous lesson sequence. The dynamics and adversity of the game forces the simulation, using similar conditions (time, the level of the opponent), during training. The best way to consolidate the notions is to play games outside the school program.

[7]Curriculum at the school's decision

4.7. Presentation and interpretation of data

4.7.1. Data presentation

In table 4. the statistical data recorded is displayed and it have been grouped in such a way that the comparison between the initial and final values is visible. It is also noted that with the statistical progress there was a homogenization of the group in four of the five tests. This is due to the lower value of the standard deviation in the case of final tests.

Table 4. Statistical data - preliminary study

Sample	Group	N	Mediate	Standard deviation	Average standard error
Goodenough	Initial	67	29.76	6.30	.77
	Final		33.45	5.98	.73
Harris	Initial		1.93	.91	.11
	Final		1.87	.92	.11
Absurd phrases	Initial		14.21	2.05	.25
	Final		16.09	1.14	.14
Similarities	Initial		16.00	4.29	.52
	Final		18.69	3.58	.44
Raven	Initial		39.78	8.22	1.00
	Final		42.76	7.18	.88

4.7.2. Interpretation of data

4.7.2.1. Main hypothesis 1

To determine if the differences between the results of the two tests were statistically significant, we applied the Paired Samples t-test (Table 5.7.), And the value of p is less than 0.05 on all tests except the Harris. We can say that the students have made a general progress in the case of cognitive abilties, but the psycho motor results require more attention.

In the Goodenough test, a substantial increase in the collective average can be observed, and this is validated by the test standard. The final collective result increased by about four units and a progress represents the transition from one age category to another. Due to this, the average of the group exceeded the value of 30 units, so the classification according to the test standard is at the border between 10 and 11 years.

Table 5. Paired Samples t- test Preliminary Study

Sample	N	Initial average	Final average	Correlation/ Sig.	p
Goodenough	67	29.76	33.45	**0.693** / 0.000	**0.000**
Harris		1.93	1.87	0.604 / 0.000	0.550
Absurd phrases		14.21	16.09	0.557 / 0.000	**0.000**
Similarities		16.00	18.69	0.158 / 0.202	**0.000**
Raven		39.78	42.76	**0.769** / 0.000	**0.000**

In the pre-school period, ambidexterity is a normal feature, as motor activities are often used as a means of knowing the environment. Due to the fact that an overwhelming percentage of children learn the ability to write using the right hand, dexterity is perceived as an index of normalcy. Although they seem to be in opposition, senestriality involves the same thing, the establishment of a dominant emisphere for the whole body. Disorders, also called dyslaterality, severely affect the child's development, and among the most dangerous effects are: manual hyperexcitability, hemianopsia (visual field limitation), graphic delay, mirror writing, tics, feelings of inferiority, lack of dexterity, anxiety, irascibility, guilt etc (Radu, 2003). The final collective values do not differ significantly from the initial ones, so the results require an in-depth analysis to find an explanation for the inconsistency with the literature.

In the case of the Absurd phrases, we notice an improvement in the results. The usefulness of this test is given by the fact that, in the preschool period, children outline their environment based largely on similarities, thus deducing the imitative nature of the child. First day of school involves a shift from imitative to logic-based actions. Solving the test requires the successive use of fundamental operations of thinking such as analysis, comparison and synthesis. This intellectual ability is often used in the game of chess, but socio-cultural factors should not be neglected, as some answers may be the effect of learning or experience required. The test combats this aspect through items that require logical thinking, to the detriment of general culture. Final testing raises a first question about the validity and effectiveness of the test because the collective average (16.09) is less than one unit away from the maximum (17). There are two possible, diametrically opposed, explanations that justify this result: Either the intellectual level of the students is so high that the task of the test is easy, or the correctness of the answers remained imprinted in the memory after the initial one.

The Similarities test maintains the evolution recorded in the previous test, so we can mention that the students registered a progress in the tests of cognitive abilities. It is significant because this period coincides with an intellectual maturation so the results validate the qualitative evolution of the students.

The final value (18.69) is more than two units higher than the initial one (16) so they solved an extra task out of the 13. Even if the difference does not seem substantial, compared to the small number of items and the way of scoring, it is a statistically significant.

A simple linear regression was calculated to predict the level of psycho motor abilities of students based on their IQ. Preliminary analysis has been done to ensure that there is no breach of the assumption of normality and linearity, so a significant and insignificant regression equation has been obtained, and in the case of the Raven-Harris relationship, the results are interesting, but with a high margin of error.

At the relationship between intellect and body schema, we discovered a significant regression equation: $F(1, 65) = 12.875$, with $R2 = 0.17$ and $p < 0.05$.

Table 6. Raven Goodenough regression statistics

Pearson	R2	R2 adjusted	Standard error	N	p	The intersection with Oy
0.41	0.17	0.15	5.50	67	**0.000**	18.97

According to the data obtained, the connection between the two tests can be interpreted as follows: for each unit in the Raven test, the student will make a progress of 0.34 units in the Goodenough test. The predictive value of the Goodenough test can be defined by the equation: Goodenough = 18.97 + 0.34 * Raven coefficient.

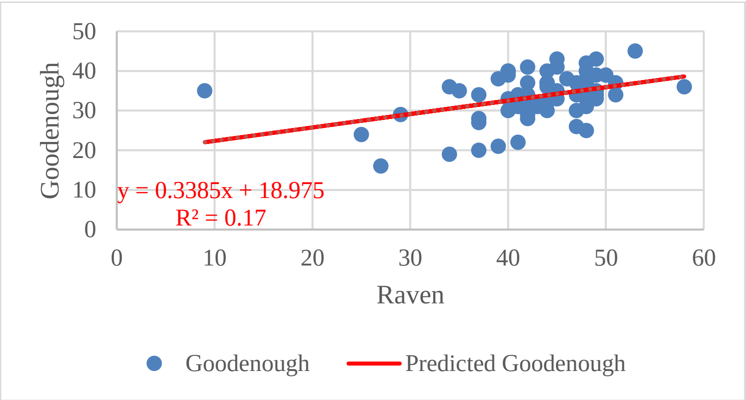

Figure 2. Raven Goodenough linear regression

The regression line has an upward trend, so we can say that the correlation between the results of the two tests has been validated. In the case of Harris test, the data is not statistically significant, but accepting the increased margin of error, we have an interesting result. The regression equation is: $F (1, 67) = 0.442$ with $R2 = 0.01$ and $p > 0.05$.

Table 7. Raven Harris regression statistics

Pearson	R2	R2 adjusted	Standard error	N	p	The intersection with Oy
0.08	0.01	-0.01	0.92	67	**0.508**	1.42

According to the data obtained, for each unit in the Raven test, we record an increase of 0.01 in the Harris test. The predictive value of the Harris test can be defined by the equation: Harris = 1.42 + 0.01 * Raven coefficient.

Even if the results are not statistically significant, at the level of the student body there is a tendency to increase the values towards dexterity weakly outlined at the same time as those recorded in the Raven test. Thus we can state, according to figure 3, that students who have not fixed the dominant cerebral hemisphere have a higher level of intelligence than others.

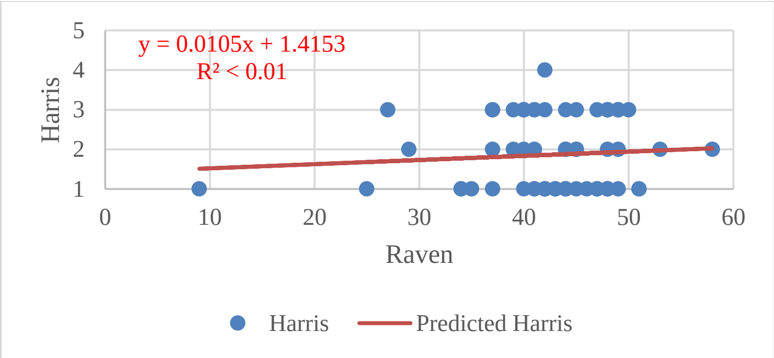

Figure 3. Raven Harris linear regression

4.8.2.2. Main hypothesis 2

In order to determine whether the differences between the results recorded according to the gender, regarding the effects of learning the game of chess, are statistically significant, the Independent Samples t-test was applied.

Table 8. Statistical differences by gender - preliminary study

Sample	Testing	N	Average - boys	Average - girls	t	p
Goodenough	Initial	31B 36F	26.81	32.31	3,875	**0.000**
	Final		31.39	35.22	2,667	**0.010**
Harris	Initial		2.03	1.83	-0.891	0.376
	Final		1.77	1.94	0.753	0.454
Absurd phrases	Initial		14.03	14.36	0.647	0.520
	Final		15.84	16.31	1,660	0.103
Similarities	Initial		15.65	16.31	0.619	0.538
	Final		17.97	19.31	2,070	**0.042**
Raven	Initial		36.84	42.31	2,743	**0.009**
	Final		40.77	44.47	2,740	**0.009**

The value of p is less than 0.05 in the Goodenough (body schema), Raven (IQ) and Final Similarities tests. The girls outperformed the boys at 2 of the most important tests, Goodenough and Raven which highlights the gap between them.

Conclusions of the preliminary study

According to the results, we were able to observe the limits of the influence of practicing chess on primary school students. We used a battery of tests consisting of five tests, two psycho motor (Goodenough and Harris) and three designed to test cognitive abilities (Absurd Phrases, Similarities and Raven). With the exception of laterality, in all conducts, the final value was statistically improved.

In the case of the Absurd phrases, the final collective average is less than one unit away from the maximum of the test, so the veracity of the data can be challenged. A test battery check is required in other circumstances, either in a group of younger subjects or at a longer distance between tests, for example: preparatory class - 4th grade. Conclusions should be treated with caution and limited to research subjects. Generalization is not recommended.

The results recorded in the Similarities Test, although showing a statistically significant progress, do not follow a normal distribution, except for the C.C.I. student who did not understand the task at the initial test, most obtained final values that do not correlate with the initial ones. As with the Absurd Phrases test, the results cannot be generalized, and the conclusions are limited to this group of subjects. Given the above conclusions, these tests will not be used in the main study.

We found a uniform evolution in two of the five tests, more precisely in the Raven and Goodenough test, so they will be included in the main study. Intelligence and body schema are important milestones in children's multilateral development and the validation of the battery of tests highlighted this.

Another essential conclusion of the research was that by studying chess, in special conditions caused by the SARS-COV2 pandemic situation, the dominant cerebral hemisphere was not fixed, on the contrary, we identified a large number of students who have nonhomogeneous laterality. This is an alarm signal because its non-fixation is correlated, in some cases, with serious emotional problems so, in the main study, laterality will be a topic of interest.

We noticed that intelligence is a predictor of the level of the body schema in a percentage of 17%, and if we take into account all the elements and phenomena in the environment that directly influence the individual's perception of himself, then we can say that by developing intelligence we improve the level of the body schema.

The design of the research, by its form, requires that chess classes to be carried out for a minimum of 9 months (one school year), but it is recommended to extend it during an educational cycle. Also, the tests battery used is suitable for the evaluation of students aged between 9 and 11 years, or transposed during the school period, grades III-IV.

CHAPTER 5. Main study - The impact of moving chess on the psycho motor development of primary school children

5.1. Research premises

The benefits of chess lessons are many, but the element that has not been exposed in other studies and helps the student to a great extent is that this sport is the ideal environment for unconditional display of knowledge regardless of age, gender, background or other external factors. The rules of the game are few, clear and strict, and their handling is impossible. Chess develops analytical thinking (Boruch, 2011), improves attention (Velea, 2019), enhances creativity (Sigirtmac, 2016), raises the level of body schema and spatial orientation (Bilalic, 2006), has a therapeutic role, prevents dementia (Crespo, 2019) and improves the behavior of children suffering from ADHD syndrome (Eldaou, 2015).

The period of primary school, also called the end of childhood, is the most significant in terms of acquiring information and skills. During this period, the development of the thinking filter begins, so it is recommended to expand the number of activities that the pupil carries out. The child who practices chess is forced to alternate the use of logical and analytical thinking in each game they play.

5.2. Objectives and hypothesis of the main study

5.2.1. The objectives of the main study

The main objective of the study is to highlight the effects of chess practice, with methods and means in the field of physical education and sports, on the multilateral development of primary school students.

Secondary objectives:

- Design and implementation of a program for the game of chess, using means of physical education and sports for the first year of study (regardless of the level of training: primary, secondary and high school);
- Identify gender differences in primary school students who practice chess.

5.2.2. Main study hypothesis

The main hypothesis:

1. Practicing *chess in motion* contributes to the development of psycho motor abilities and optimizes the intellectual education of primary school pupils.

    1.1. We estimate that the game of chess influences psycho motor development (body schema, laterality and spatial orientation).

    1.2. The intellectual education of primary school children is optimized through the game of chess.

2. The gender of primary school children influences the learning outcomes of the game of chess.

3. The sociocultural environment influences the impact of chess practice on the multilateral development of students (psycho motor abilities and cognitive skills).

5.3. Main study variables

The main study addresses three different perspectives (Table 9), namely:

1. The influence of practicing dynamic chess on psycho motor and intellectual abilities.
2. Presentation of differences according to the gender of the subjects.
3. Presentation of the differences depending on the environment of the children's origin.

Table 9. Main study variables

Independent variable	Dependent variables	Influenced behaviors	Test method	Statistics
Dynamic Chess	Psycho motor abilities	Body schema	Goodenough test	Paired samples t-test, Cohen's d, Pearson correlation, linear regression.
		Laterality	Harris test	
		Spatial orientation	Bender-Santucci test	
	Cognitive abilities	IQ	Raven Progressive Matrices	
Gender	Male / Female	Body schema	Goodenough test	Paired samples t-test, Independent samples t-test, Pearson correlation.
		Laterality	Harris test	
		Spatial orientation	Bender-Santucci test	
		IQ	Raven Progressive Matrices	
Environment	Rural / Urban	Body schema	Goodenough test	Independent samples t-test, Pearson correlation.
		Laterality	Harris test	
		IQ	Raven Progressive Matrices	

The battery of tests has been improved, and due to the fact that in the main study the chess lessons were carried out with methods and means of physical education and sports, a new test was introduced: the Bender-Santucci test.

The statistical elements used are:

- Independent samples t-test - differences between groups (girls - boys);
- Paired samples t-test - differences between tests (initial - final);
- Cohen's d - measures the size of differences;
- Pearson correlation - indicates the degree of correlation between tests;
- Linear regression - highlights whether intelligence is a predictor of psycho motor abilities.

5.4. Subjects of the main study

65 students from the third grade were selected for the research. No selection criteria were imposed, so the composition of three classes, III A and III B from the "Dimitrie Sturdza" Gymnasium School from Popești and III A from the "Ioanid Romanescu" Gymnasium School from Românești, Iași County, formed the group of subjects. Their age is between 9 and 11 years, and this variation is given by the time they were enrolled in school. According to Figure 4, we notice that the number of female subjects (31) is close to that of male subjects (34), so the comparisons by gender is justified from the perspective of proportionality.

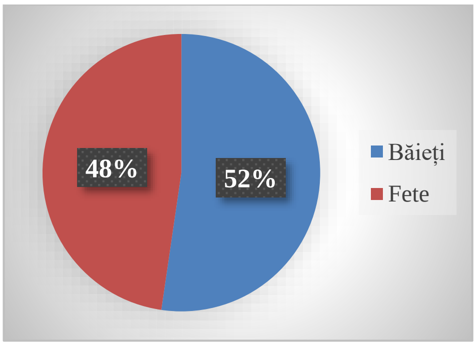

Figure 4. Distribution of subjects - main study

The students were initially tested at the beginning of the second semester in the third grade, and the final testing took place at the end of the first semester in the fourth grade. I opted for this period because the difference between the two tests is 12 months (calendar year) and not just 9 months (school year). After the initial test, they went through the chess program for the first year of study – dynamic chess and at the end of the first semester of the school year 2021-2022, they took the final test.

5.5. Tests battery

The battery of tests follows the order of psycho motor and intellectual abilities that are the foundation of this research.

The category of psycho motor tests consists of:

1. Goodenough test - body schema;
2. Harris test - laterality;
3. Bender-Santucci test - spatial orientation.

Testing intellectual abilities was achieved through the Raven Progressive Matrices.

5.6. Chess intervention plan

It is assumed that traditional methods of teaching chess are not sufficiently motivating for students who are familiar with the use of technology (Gliga, 2013) so a new methodology is needed. Given that motor activities are seen as a method of relaxation and not as an essential component of life (Szabo, 2016), the implementation of a chess program for the first year of study with means of physical education and sports meets the social needs to combat sedentarism among students. Everyday life demands in an overwhelming proportion the functions of the nervous system (Suciu, 2007) and the technological evolution neglects motor activities. Even if chess improves patience and self-control (Gumede, 2015), it must be borne in mind that, in the current form of teaching, it does not involve physical effort. The transposition of the teaching activity on the sports field preserves the scientifically proven benefits (Achig, 2015; Dapica-Tejada, 2016; Duccette, 2009; Guerrero, 2015; Sala, 2016a, 2017c), but at the same time influences the multilateral development of students. Another argument that motivates this adaptation is the fact that the physical training implemented in the daily life of chess players has led to improved results (Alifirov, 2018c).

The Ministry of National Education, by the Ministerial Order number 3249 of 31.03.2014, approved the School Programs for the optional subject Chess Education, year I and year II of study (http://frsah.ro/wp-content/uploads/2019/02/OMEN-Sah1.pdf) which are part of the national curriculum offer. This decision facilitates the introduction of chess in school, but retains the form of teaching that does not involve physical effort. Given the fact that the material is intended for beginners, we propose an adapted form with means of physical education and sports that meets the needs of students. I mention that the proposed material can be used only in the primary cycle, while the program approved by the Ministry of National Education has no age restrictions. The predominantly playful nature of the activities triggers the curiosity of primary school students, but can be perceived as boring by those in middle school or high school. In the case of the latter, I recommend using the program approved by the ministry.

The main differences between the two documents are the location of the time and the physical effort. If at the content level, we meet the same goal, the introduction to the game of chess, the means and teaching methods differ. *Dynamic chess* involves adapted exercises that are performed on the field of physical education of the school. The demonstration board is used to imprint the notions freshly taught.

5.7. Data presentation and data interpretation

5.7.1. Data presentation

In table 10, descriptive statistics of the results are presented. Their grouping was done in order to provide a clear overview where a first comparison can be made, initial - final. We note that in the case of psycho motor tests, the final value of the standard deviation decreased at two out of three tests, which indicates a distribution of results closer to the collective average. In the Raven test we saw an increase in the standard deviation, and this is justified by the fact that 24 students obtained a result with at least five units higher in the final test.

Table 10. Statistical data - main study

Test	Period	N	Mean	Standard deviation	Average standard error
Goodenough	Initial	65	28.35	5.58	0.69
	Final		32.02	4.88	0.61
Harris	Initial		2.22	1.02	0.13
	Final		1.78	1.17	0.14
Bender-Santucci	Initial		27	5.85	0.73
	Final		32.18	4.95	0.61
Raven	Initial		25.34	8.6	1.07
	Final		29.2	10.49	1.3

5.7.2. Interpretation of results

5.7.2.1. Main hypothesis 1

The verification of the differences between the two tests, initial and final, was performed by applying a paired samples t-test presented in table 6.5. We can see that in the case of the four tests the value of p is less than 0.05 which indicates that the final result is significantly higher than the initial one.

Table 11. Statistical differences between tests

Test	N	Initial average	Final average	Correlation/ Sig.	p	Cohen's d
Goodenough	65	28.35	32.02	0.234 / 0.060	**0.000**	0.7
Harris		2.22	1.78	**0.747** / 0.000	**0.000**	-
Bender-Santucci		27	32.18	**0.619** / 0.000	**0.000**	0.96
Raven		25.34	29.2	**0.758** / 0.000	**0.000**	0.4

We also calculated the Cohen's d to observe the probability of superiority so that in the case of Goodenough test 75.8% of the final results are higher than the overall average from the initial test, and if we randomly pick a student, then there is a probability of 69% so that it has a better final score. We did not calculate the Cohen's d in the Harris test, because the test is qualitative and not quantitative and the numerical transposition of the results does not provide a ranking of students. In the Bender-Santucci test, the superiority of the final test is undeniable: 83.1% of the final results are above the initial collective average, and in the case of a random selection, there is a 75.1% probability that the child will have a better final result. In the case of Raven, there is a 61.1% chance for a randomly selected student to have a higher final result than the initial one. 65.5% of the final results are higher than the average value of the initial ones.

We note that the four tests provide a different level of correlation between the test results. Goodenough testing involves a deviation from the rule where the correlation level is low (0.234) and the significance exceeds 0.05 (0.06). The result obtained is caused by the fact that 8 students had a remarkable final value, over 12 units, the equivalent of three categories in the test standard. Except for them, progress, though less exciting, has been constant. In the Harris test we found a strong correlation (0.747) with a significance less than

0.05 (0.000), a result that indicates a collective fixation of the dominant cerebral hemisphere. These data validate the effectiveness of chess practice on the psycho motor development of children. In the case of the Bender-Santucci test, the correlation is moderate (0.619), and the significance is also less than 0.05 (0.000). The recorded value is relevant because it is close to the upper limit. In the case of the Raven test, there is a strong correlation (0.758) with a significance less than 0.05 (0.000), and this indicates that progress is due to a collective improvement of students.

According to Table 12, we recorded a moderate correlation (0.47) between the results of the Raven and Goodenough tests. The percentage (22%) with which the level of intelligence predicts the evolution of the body schema is satisfactory because, even if this value does not seem substantial, we must keep in mind that the evolution of it is a continuous process, influenced by many factors, including external, family and socio-economic environment, entourage, education or genetic inheritance. To validate the regression equation, we added in table 12 the value of p which is less than 0.05 and the intersection with the Oy axis differs from 0 (25.63).

Table 12. Regression statistics - Raven - Goodenough

Pearson	R2	R2 adjusted	Standard error	N	p	The intersection with Oy
0.47	0.22	0.20	4.34	65	**0.000**	25.63

In figure 5 we can see that the regression line is far from the point of intersection of the two axes.

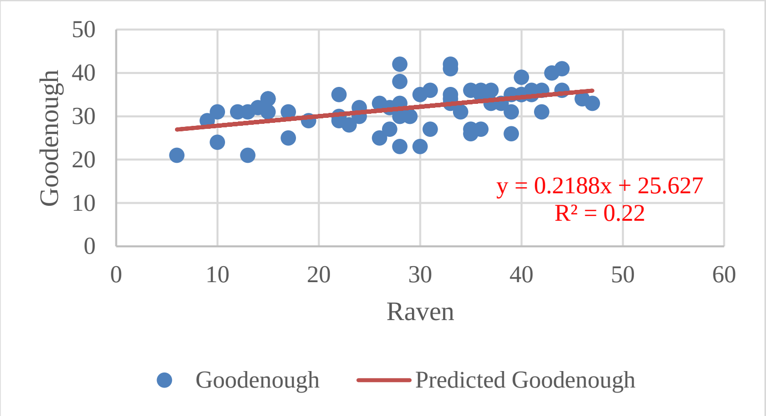

Figure 5. Raven - Goodenough linear regression

We also reject the null hypothesis because the value of p is less than 0.05 so we can say that the linear regression found is statistically valid. According to the obtained results, the regression equation has the following form: y = 0.2188x + 25.627 thus, if we introduce the value of 35 Raven units, corresponding to the intelligence category *above the average level*, we obtain a goodenough coefficient of 33.285 which falls between 10 and 11 years (grades IV-V).

In table 13 the statistical data of the Raven-Harris regression are exposed, and the most important value is that of p (0.461) > 0.05 so we can say that the regression equation is statistically insignificant. Compared to the preliminary study, the current group of subjects made statistical progress that can be translated into a fixation of the dominant cerebral hemisphere. The level of intelligence is a predictor of laterality only in a proportion of 1%. The low value of the correlation coefficient has a positive interpretation, namely, the normality in the Harris test (pronounced dexterity) received the numerical correspondent 1, the lower end on the scale 1-5 so the improvement of intelligence level involving a unit increase will correlate with close values of 5.

Table 13. Regression statistics - Raven - Harris

Pearson	R2	R2 adjusted	Standard error	N	p	The intersection with Oy
0.09	0.008	-0.007	1.17	65	**0.461**	1,482

Due to the fact that most students with nonhomogeneous laterality performed well on the Raven test, the regression line indicates a trajectory from pronounced dexterity to weakly outlined dexterity.

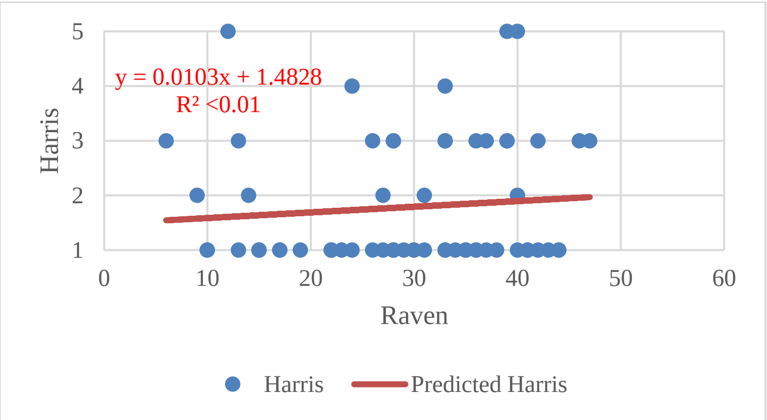

Figure 6. Raven - Harris linear regression

The apparent conclusion must be treated with reluctance due to the fact that those with a pronounced senestriality are poorly represented in this group. Figure 6 shows us a future direction of research, namely, the formation of a group of subjects, with equally distributed laterality, who will study chess and observe its impact on psycho motor abilities.

We observe a Pearson coefficient of 0.42 which means that there is a moderate correlation between the results of the two tests. R^2 shows the percentage with which intelligence predicts the evolution of spatial orientation so, according to table 14, we notice that in proportion of 17% the IQ coefficient influences the development of spatial orientation ability.

Table 14. Regression statistics - Raven - Bender-Santucci

Pearson	R^2	R^2 adjusted	Standard error	N	p	The intersection with Oy
0.41	0.17	0.16	4.5	65	**0.000**	26.50

Also, to validate the regression equation, the value of p (0.000) must be less than 0.05, and the intersection with the Oy axis must differ from 0 (26.48). In figure 7 we can see that the regression line is far from the point of intersection of the two axes, so the null hypothesis that assumes that there is no linear relationship between spatial orientation and intelligence, being valid only if its value p exceeds 0.05, is rejected.

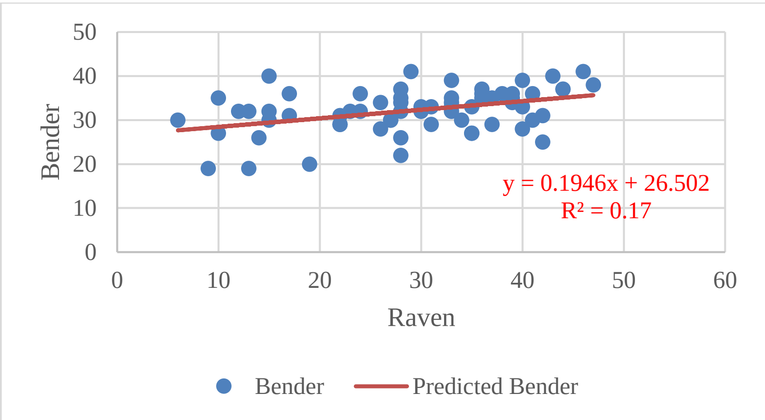

Figure 7. Raven - Bender-Santucci linear regression

In the case of the main study, we state that there is a linear relationship between the two tested behaviors. From these data, we can conclude that the linear regression found is statistically valid.

According to the obtained results, the regression equation has the following form: y = 0.1946x + 26.502 thus, if we enter the value of 35 Raven units, corresponding to the category*above average intelligence,*we obtain a Bender-Santucci coefficient of 33.31 which falls between 11 and 12 years (grades V-VI). As we can see in Figure 7, the regression line between the level of intelligence and that of spatial orientation is ascending. In conclusion, through chess training we managed to improve the IQ so that the level of spatial orientation increased significantly.

5.7.2.2. Main hypothesis 2 - Results ordered by gender

An important aspect of the research was to observe the evolution according to gender, and to highlight possible fluctuations we used paired samples t-test (initial - final) and independent samples t-test (girls - boys).

A first perspective was the observation of the differences between the two tests depending on the gender of the students. In the case of boys, a statistically significant progress was made in all four tests (0.004, 0.007, 0.000, 0.013), and this validates the numerical difference between the two averages. According to Table 15, we notice that in the Harris, Bender-Santucci and Raven tests there is a strong correlation (0.756, 0.721, 0.696) between the initial and final values. Thus, we can say that collective progress is justified by the fact that most students have improved their final score. The Goodenough sample presents a different perspective where the correlation is low (0.136) and the significance (0.443) exceeds the value of 0.05. The significant difference between the two tests is due to excellent individual results.

We also calculated the Cohen's d (Table 15) To observe the probability of superiority so, in the Goodenough test we have a probability of 62.2% that a final value is higher than the initial collective average, and the chance as a chosen student random to have a higher final result than the initial one is 58.7%. In the case of Bender-Santucci testing, the probability of superiority is clearer. Thus, 70.2% of the final results are higher than the initial collective average, and the chance to choose a student who registered a final value higher than the initial one is 64.6%. In the case of Raven testing, there is a 57.8% chance that a randomly selected student will have a higher final result than the initial one, and 61% of the final results will be higher than the average value of the initial ones.

Table 15. Statistical differences between tests - male subjects

Tests	N	Initial average	Final average	Correlation/ Sig.	p	Cohen's d
Goodenough	34	26.79	30.56	0.136 / 0.554	**0.007**	0.31
Harris		2.21	1.79	**0.756** / 0.000	**0.004**	-
Bender-Santucci		25.68	30.71	**0.721** / 0.000	**0.000**	0.53
Raven		23.12	26.56	**0.696** / 0.000	**0.013**	0.28

We also applied paired samples t-test in the case of female subjects to check if the numerical differences between the initial and the final results are statistically significant. According to Table 16, we notice that in all four samples the value of p (0.004, 0.001, 0.000, 0.000) is less than 0.05.

Table 16. Statistical differences between tests - female subjects

Sample	N	Initial average	Final average	Correlation/ Meaning	p	Cohen's d
Goodenough	31	30.06	33.61	0.262 / 0.155	**0.001**	0.39
Harris		2.23	1.77	**0.737** /0.000	**0.004**	-
Bender-Santucci		28.45	33.81	0.439 / 0.013	**0.000**	0.44
Raven		27.77	32.10	**0.791**/0,000	**0.000**	0.27

Given that the final averages are about four units higher than the initial ones, a difference that forces the promotion to an upper category, is another confirmation of the collective progress.

The Harris and Raven tests showed a strong correlation (0.737, 0.791) between the initial and final results, but this was not a general rule. In the Bender-Santucci test we observe a moderate correlation (0.445) and the significance threshold (0.012) is lower than 0.05, but in the case of the Goodenough test the correlation is low (0.196) with a significance threshold (0.291) higher than the standard of 0.05. As in the case of boys, collective progress is due to excellent individual results. The Cohen's d, in the case of girls, shows values relatively similar to those recorded by boys. In the Goodenough test, 65.2% of the final results are higher than the initial collective average, and if we randomly choose a final value, we obtain a percentage of 60. 9% to be higher than the initial one. We note that in the Bender-Santucci test we recorded a 67% probability that a final result will exceed the initial collective average, and if we randomly choose a final value, we have a 62.2% chance that it will be higher than the initial one. In the Raven test there is a 57.6% probability that a final result will be higher than the initial one, and 60.6% of the final results are higher than the initial average.

We applied independent t-test samples to validate the numerical differences between the initial and final results grouped by gender. According to Table 17, we can see that in the Goodenough, Raven tests and the final test at Bender-Santucci, the girls definitely outperformed the boys. The level of intelligence and that of the body schema are clearly higher due to the early maturation of the girls.

Table 17. Statistical differences by gender - main study

Test	Period	N	Mean boys	Mean girls	t	p	Cohen's d
Goodenough	Initial	34B 31F	26.79	30.06	-2,483	**0.016**	0.27
	Final		30.56	33.61	-2,680	**0.010**	0.34
Harris	Initial		2.21	2.23	-0,768	0.938	-
	Final		1.79	1.77	0.680	0.946	-
Bender-Santucci	Initial		25.68	28.45	-1,957	0.055	0.28
	Final		30.71	33.81	-2,629	**0.011**	0.25
Raven	Initial		23.12	27.77	-2,244	**0.028**	0.39
	Final		26.56	32.10	-2.195	**0.032**	0.35

In the case of the Bender-Santucci and Goodenough tests, the Cohen's d has about the same value (0.28, 0.27), so 61% of the girls 'results are higher than the boys' average, and if we compare two randomly selected results, we get a favorable ratio for girls in a proportion of 57.8%. In the Raven test, 65.2% of the girls 'results are higher than the boys' collective average, and if we choose a girl and a boy at random, there is a 60.9% chance that her value will be higher than the boy's.

In the case of the final test at the Goodenough test, 63.7% of the girls' results are higher than the collective average of the boys, and if we choose a girl and a boy at random, there is a 59.8% chance that the value obtained by the girl will be higher. The situation is the same for the Raven test, because the Cohen's d is approximately equal (0.35, 0.34). In the Bender-Santucci test, the superiority of the girls decreased slightly. Thus, 59.9% of girls' results are higher than the average of boys, and if we choose a girl and a boy at random, in 57% of cases, the girl's value is higher.

5.7.2.3. Main hypothesis 3 - Results ordered according to sociocultural environment

Following the two studies, we noticed a number of common traits between the two ways of teaching chess, but also some distinct elements that are of interest. The common tests that were performed in both cases are presented in table 18. The only statistical difference was the Raven test, where $p < 0.05$ indicates that students in urban areas have a higher IQ.

Table 18. Statistical differences according to sociocultural environment

Test	Period	N	Preliminary	Main	p
Goodenough	Initial	67 Preliminary 65 Main	29.76	28.35	0.176
	Final		33.45	32.02	0.133
Harris	Initial		1.93	2.22	0.088
	Final		1.87	1.78	0.659
Raven	Initial		39.78	25.34	**0.000**
	Final		42.76	29.2	**0.000**

It should be noted that both groups of subjects have made considerable progress between the two tests so that the influence of chess practice, regardless of the form of teaching, is clear. In the case of laterality, we did not obtain a statistical difference between groups, because the students from the rural area obtained a higher initial value. We can observe the progress by comparing the final results where the students who practiced dynamic chess are closer to the pronounced dexterity.

Conclusions of the main study

Following the preliminary research, we came to a series of conclusions that represent a starting point for future studies on the effects of practicing chess. The test battery consisted of four tests, three psycho motor (Goodenough, Harris and Bender-Santucci) and one for the intellect (Raven Progressive Matrices). This 3 to 1 weighting is justified by the fact that the focus of the research was on observing psycho motor abilities and not on cognitive abilities. Also, the Absurd Phrases and Similarities that were used in the preliminary research were excluded for objective reasons because the validity of the data can be challenged.

The results recorded in the Goodenough test, which have the role of quantifying the level of the body schema, indicate that by practicing dynamic chess the students scored significantly better final scores. We found an upward regression line, and the IQ is a 22% predictor of the body schema level. This behavior develops from the first moments of life and is in a perpetual change until the age of 65, when the perception of self deteriorates. The conclusions are similar to those found in the preliminary research so we can say that both forms of teaching chess positively impact the body schema of students.

In the case of laterality, we used the Harris test to highlight the dominant cerebral hemisphere. After comparing the results, we noticed that the final results indicate a weakly outlined approach to dexterity, and this evolution represents a significant progress, because most students had an nonhomogeneous laterality in the initial testing. The regression equation is not statistically significant so we cannot say whether the level of intelligence is a predictor of laterality.

The measurement of spatial orientation was performed using the Bender-Santucci test, and the final results are significantly better than the initial ones. We recorded an increase of 5.18 units and the transition to an older age group is only 4 units, so at the end of the main study the level of spatial orientation falls into the first category of the test standard. The regression line is ascending, and the IQ is a 17% predictor of spatial orientation. Similar to the state of the body schema, the value can be considered substantial due to the fact that there are several factors that influence this psycho motor ability.

The Raven Progressive Matrices is one of the most popular non-verbal tests used to measure IQ. The intellectual classification of the students shows a significant improvement thus, if at the initial test the mean was in the category of *medium level intelligence (poor)*, at the final one they passed to the next one, *medium level intelligence (good)*. As with preliminary research, practicing chess has improved students' cognitive abilities. Therefore, we can say that the study of chess, both in the classical version and with the methods and means of physical education and sports, improves the IQ of young students (primary school).

After sorting all the results, we noticed an obvious pattern, the boys recorded inferior results to the girls in all quantitative tests. Both initial and final tests show a gender gap that can be justified by the fact that the maturation process of girls is triggered earlier than that of boys. The ability to maintain attention and focus on a given task is more developed at girls. The biggest gap was registered when testing the IQ, where the difference was of two categories. It should be noted that the progress was similar to the Goodenough and Bender-Santucci tests, but in the Raven test, the girls did extremely well. Progress is collective, but the boys scored awflul at the initial tests.

Also, the sociocultural environment and the form of chess teaching revealed two important aspects that can be the foundation of future research, namely:

1. The IQ of students is substantially higher in the case of those in urban areas:

- initial test: 39.78 (above average intelligence) - 25.34 (medium intelligence (poor));
- final test: 42.76 (higher intelligence) - 29.2 (medium intelligence (good)).

2. The practice of chess with methods and means of physical education and sports influences lateralization.

- students who studied chess in the classical version obtained the following results: 1.93 (initial) - 1.87 (final), which indicates a stagnation;
- students who studied dynamic chess made statistically significant progress: 2.22 (initial) - 1.78 (final). Most students have a pronounced dexterity, even if the weight of inhomogeneous laterality in the initial test is substantial.

Selective bibliography

A. Books, textbooks and encyclopedias:

1. Abalașei, B. (2011). *Psihomotricitate și reeducare psihomotrică*, Ed. Universității, Iași.
2. Albu A., Albu C. (1999). *Psihomotricitatea*, Ed. Spiru Haret, Iași.
3. Baron, J. (2000). *Thinking and Deciding*, Ed. Cambridge University Press, New York.
4. Briceag, S. (2017). *Psihologia vîrstelor,* Ed. USARB, Bălți.
5. Crețu, T. (2005). *Psihologia copilului*, Ed. Credis, București.
6. Golu, M. (2007). *Fundamentele Psihologiei*, Ed. România de Mâine, București.
7. Karpov, A. (1997). *My 300 best games*, Ed. Russian Chess House, Moscow.
8. Kasparov, G. (2008). *How life Imitates Chess*, Ed. Arrow Books, London.
9. Kislik, E. (2018). *Applying Logic in Chess*, Ed. Gambit Publications, London.
10. Larsen, B.H. (2005). *Foundations of Chess Strategy*, Ed. Gambit Publications, London.
11. Lupșa, E., Bratu, V. (2005). *Psihologie- Manual pentru clasa a X-a*, Ed. Corvin, Deva.
12. Miclea, M. (1999). *Psihologie Cognitivă*, Ed. Polirom, Iași.
13. Piaget, J., Inhelder, B. (1968). *Psihologia copilului*, Ed. Presses Universitaires de France, Paris.
14. Pinski, J. (2005). *Italian Game and Evans Gambit*, Ed. Gloucester Publishers, London.
15. Radu, D.I., Ulici, Gh. (2003). *Evaluarea și educarea psihomotricității copiilor cu dificultăți psihomotorii de integrare*, Ed. Humanitas, București.
16. Rawlinson, G. (1998). *Gândire creativă și brainstorming*, Ed. Codecs, București.
17. Sion, G. (2003). *Psihologia Vârstelor*, Ed. România de Mâine, București.
18. Stanciu, C., Cotruș, A. (2014). *Stadialitatea dezvoltării umane*.

B. Scientific articles:

1. Alifirov, A.I., Mikhaylova, I.V., Makhov, A.S. (2017). Sport-specific diet contribution to mental hygiene of chess player. *Theory and Practice of Physical Culture*, (4), 30-30..
2. Alifirov, A. I., Mikhaylova, I.V. (2018). Physical education of highly qualified chess players. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 9(4), 1725-1730.

3. Almeira, N., Schaigorodsky, A., Perotti, J., Billoni, O. (2017). Structure constrained by metadata in networks of chess players. *Scientific Reports*. 7. 10.1038/s41598-017-15428-z.

4. Auclair, L., Jambaqué, I. (2014). Lexical-semantic body knowledge in 5- to 11-year-old children: How spatial body representation influences body semantics. *Child Neuropsychol*. 21, 451–464. doi:10.1080/09297049.2014.912623.

5. Barrett, D., Fish, W. (2011). Our move: Using chess to improve math achievement for students who receive special education services. *Int. J. Spec. Educ*. 26.

6. Bart, W.M. (2014). On the effect of chess training on scholastic achievement. *Frontiers in Psychology*. http://doi.org/10.3389/fpsyg.2014.00762

7. Berdilă, A., Talaghir, L.G., Iconomescu, T.M., Rus, C.M. (2019). Values and Interferences of Psychomotricity in Education-a Study of the Domain-Specific Literature. *Romanian Journal for Multidimensional Education*, 11.

8. Bilalic, M., McLeod, P., Gobet, F. (2007). Does chess need intelligence? — A study with young chess players. *Intelligence*. 35. 457-470. 10.1016/j.intell.2006.09.05.

9. Campitelli, G. et al. (2007). Brain localization of memory chunks in chess players. *The International journal of neuroscience*. 117. 1641-59. 10.1080/00207450601041955.

10. Chang, Y.H., (Alicia), Lane, D. (2016). There Is Time for Calculation in Speed Chess, and Calculation Accuracy Increases with Expertise. *The American Journal of Psychology*. 129. 1. 10.5406/amerjpsyc.129.1.0001.

11. Charness, N. et al. (2005). The role of deliberate practice in chess. *Applied Cognitive Psychology*. 19. 151-165. 10.1002/Acp.1106.

12. Crespo, M. et al. (2019). Chess Practice as a Protective Factor in Dementia. *International Journal of Environmental Research and Public Health*. 16. 2116. 10.3390/ijerph16122116.

13. Dapica-Tejada, R. (2016). Influencia del Ajedrez en la Comprensión Lectora y los Movimientos Sacádicos en Niños Madrid. *España: universidad Internacional de la Rioja*.

14. Ducette J. (2009). An Evaluation of the Chess Challenge Program of ASAP/After school Activities Partnerships. *Philadelphia, PA: after School Activities Parnerships*; p. 1-13.

15. Ebenezer, J., Manoharan, S., Easvaradoss, V., Chandran, D. (2017). A Study on the Impact of Chess Training on Creativity of Indian School Children. *In CogSci*.

16. Fattahi, F. et al. (2016). Auditory memory function in expert chess players. *Medical journal of the Islamic Republic of Iran*. 29. 275.

17. Ferguson, R. (1983). Developing Critical and Creative Thinking through Chess.

18. Ferguson, R. (1988). Development of Reasoning and Memory through Chess.

19. Forrest, W. (2005). Chess Development in Aberdeen's Primary Schools: a study of literacy and social capital.

20. Förster, J., Friedman, R. S., Liberman, N. (2004). Temporal construal effects on abstract and concrete thinking: consequences for insight and creative cognition. *Journal of personality and social psychology*, 87(2), 177.

21. Frank, A., D'Hondt, W. (1979). Aptitudes and learning of the game of chess in Zaire. *Psychopathologie Africaine*, 15, 81-98.

22. Gallotta, M.C., Emerenziani, G.P., Franciosi, E., Meucci, M., Guidetti, L., Baldari, C. (2015). Acute physical activity and delayed attention in primary school students. *Scandinavian journal of medicine & science in sports*, 25(3), e331-e338.

23. Gliga, F., Flesner, P.I. (2014). Cognitive Benefits of Chess Training in Novice Children. *Procedia - Social and Behavioral Sciences*. 116. 10.1016/j.sbspro.2014.01.328.

24. Gobet, F., Simon, H. (1996). Templates in Chess Memory: A Mechanism for Recalling Several Boards. *Cognitive psychology*. 31. 1-40. 10.1006/cogp.1996.0011.

25. Gobet, F., Campitelli, G. (2006). Educational benefits of chess instruction: A critical review. *In T. Redman (Ed.), Chess and Education: Selected essays from the Koltanowski conference (pp 124-143). Dallas: Chess Program at the University of Texas at Dallas (PDF) Educational benefits of chess instruction: A critical review.*

26. Gobet, F., Campitelli, G. (2008). The role of practice in chess: A longitudinal study. *Learning and Individual Differences*. 18. 446-458. 10.1016/j.lindif.2007.11.006.

27. Gobet, F., Campitelli, G. (2011). Deliberate Practice: Necessary But Not Sufficient. *Current Directions in Psychological Science*. 20. 280-285. 10.1177/0963721411421922.

28. Gobet, F., Ereku, M. (2014a). Checkmate to Deliberate Practice: The Case of Magnus Carlsen. *Frontiers in psychology*. 5. 878. 10.3389/fpsyg.2014.00878.

29. Gonzalez, R. (1989). Ministering intelligence: a Venezuelan experience in the promotion of cognitive abilities. *International Journal of Mental Health*, 18(3), 5-18.

30. Grabner, R. (2014). The role of intelligence for performance in the prototypical expertise domain of chess. *Intelligence*. 45. 26–33. 10.1016/j.intell.2013.07.023.

31. Gumede, K., Rosholm, M., Mikkelsen, M. (2017). Your move: The effect of chess on mathematics test scores. *PLoS ONE*. 12. 10.1371/journal.pone.0177257.

32. Hänggi, J., Birrer, K., Siegel, A., Jäncke, L. (2014). The architecture of the chess player's brain. *Neuropsychologia*. 62. 10.1016/j.neuropsychologia.2014.07.019.

33. Hong, S., Bart, W. (2006). Cognitive effects of chess instruction on students at risk for academic failure. *Int. J. Spec. Educ*. 22. 938-939.

34. Jaarsveld, S., Lachmann, T., Hamel, R., Leeuwen, C.V. (2010). Solving and Creating Raven Progressive Matrices: Reasoning in Well- and Ill-Defined Problem Spaces. *Creativity Research Journal* 22, 304–319.. doi:10.1080/10400419.2010.503541.

35. Kezia, J. (2016). Chess training improves cognition in children. *GSTF Journal of Psychology* (JPsych), 2(2).

36. Klein-Vollstädt, S., Grimm, O., Kirsch, P., Bilalic, M. (2010). Personality of Elite Male and Female Chess Players and its Relation to Chess Skill. *Learning and Individual Differences*. 20. 517-521. 10.1016/j.lindif.2010.04.005.

37. Krawczyk, D. et al. (2011). Brain organization of perception in chess experts. *Neuroscience letters*. 499. 64-9. 10.1016/j.neulet.2011.05.033.

38. Lai, M. (2015). Giraffe: Using deep reinforcement learning to play chess. *arXiv preprint arXiv:1509.01549.*

39. Lopez, C., Schreyer, H.M., Preuss, N., Mast, F.W. (2012). Vestibular stimulation modifies the body schema. *Neuropsychologia*, 50(8), 1830-1837.

40. Maley, C.Y. (2009). Children's Human Figure Drawings: An Investigation Using the Goodenough-Harris Drawing Test and the Rasch Model for Measurement. *Ph.D. Thesis, James Cook University, Townsville, Australia.*

41. Maravita, A., Spence, C., Driver, J. (2003). Multisensory integration and the body schema: Close to hand and within reach. *Curr. Biol.*, 13, R531–R539.

42. Margulies, S. (1992). The effect of chess on reading scores: District nine chess program second year report. *The American Chess Foundation, New York*.

43. Tsai, C. I., Thomas, M. (2011). When does feeling of fluency matter? How abstract and concrete thinking influence fluency effects. *Psychological Science*, 22(3), 348-354.

44. Van der Maas, H., Wagenmakers, E.J. (2005). A psychometric analysis of chess expertise. *The American journal of psychology*. 118. 29-60.

45. Velea, T., Cojocaru, V. (2018). The effect of playing chess on focused attention. *The European Proceedings of Social & Behavioural Sciences*, 685-690.

46. Wessel, T., Aciego, R. (2017). Neuropsychological impact of chess on executive functions and attention of adolescents: A quasi-experimental pilot study.