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PARTICULARITIES OF REASONING IN PRIMARY SCHOOL CHILDREN. THE EFFECTIVENESS OF A TRAINING PROGRAMME

SUMMARY

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Table of contents

KEYWORDS: inductive reasoning, similarity/differentiation of attributes and relations, deductive reasoning, syllogism, inductive reasoning training, cognitive development, primary school age

INTRODUCTION

Reasoning is considered, the hard "core" of thought. Thinking occupies a central place in the human psychic system, having this privilege because it has the role to lead, guide and harness all other processes and mental functions. Due to reasoning, we obtain new knowledge, based on the knowledge already stored. Thus, we can say that reasoning has the facilitator role in obtaining new information, as in contemporary society we are bombarded by a large amount of data.

Researchers and practitioners accept that reasoning involves: chain of judgments, obtaining of new information by combining existing ones. What are the qualities and skills that a person must have in order to have a good reasoning? Nickerson (2004) enumerates the following qualities: intelligence, general information about human cognition, specific information in the domain, self-knowledge, knowledge of thought instruments, the ability to analyze and evaluate arguments, good judgment, the ability to estimate, sensitivity to missing information, the ability to treat uncertainty effectively, the ability to have alternative perspectives, counterfactual reasoning ability, the ability to solve problems, reflexivity, curiosity, a strong desire to support true beliefs. The absence of one of the above mentioned qualities increases the possibility of diminishing the quality of reasoning in varying degrees.

Reasoning is a distinct field within psychology, generally, and within cognitive sciences in particular. In traditional approaches, reasoning seems to be the top of cognitive hierarchy, which has a physiological processing at its basis (sensation, perception, memory). Although such a model has not long dominated cognitive sciences, it remains current in educational sciences (it is at the basis of Bloom's taxonomy of educational objectives). This paper lies within the concerns focused on reasoning and on the relationships between this and the various dimensions of personality, the age group being primary schooling.

The first chapter is devoted to conceptual boundaries within the psychology of reasoning. We shall make a classification of types of reasoning, then, in the second part we will focus on neuro-physiological bases of reasoning and on the relationship of reasoning with other cognitive skills.

Since the research considers deductive and inductive reasoning, we considered appropriate the analysis of these two types of reasoning in the following theoretical chapters. In the second chapter, we discussed traditional and modern theories of inductive reasoning, a particular attention being paid to computational models of induction. In the second part, we insisted on the evolution of inductive reasoning in terms of research results.

The third chapter highlights the issue of deductive reasoning. We will try to discuss the theory of mental models versus the theory of mental logics, since these have long dominated the psychology of deductive reasoning.

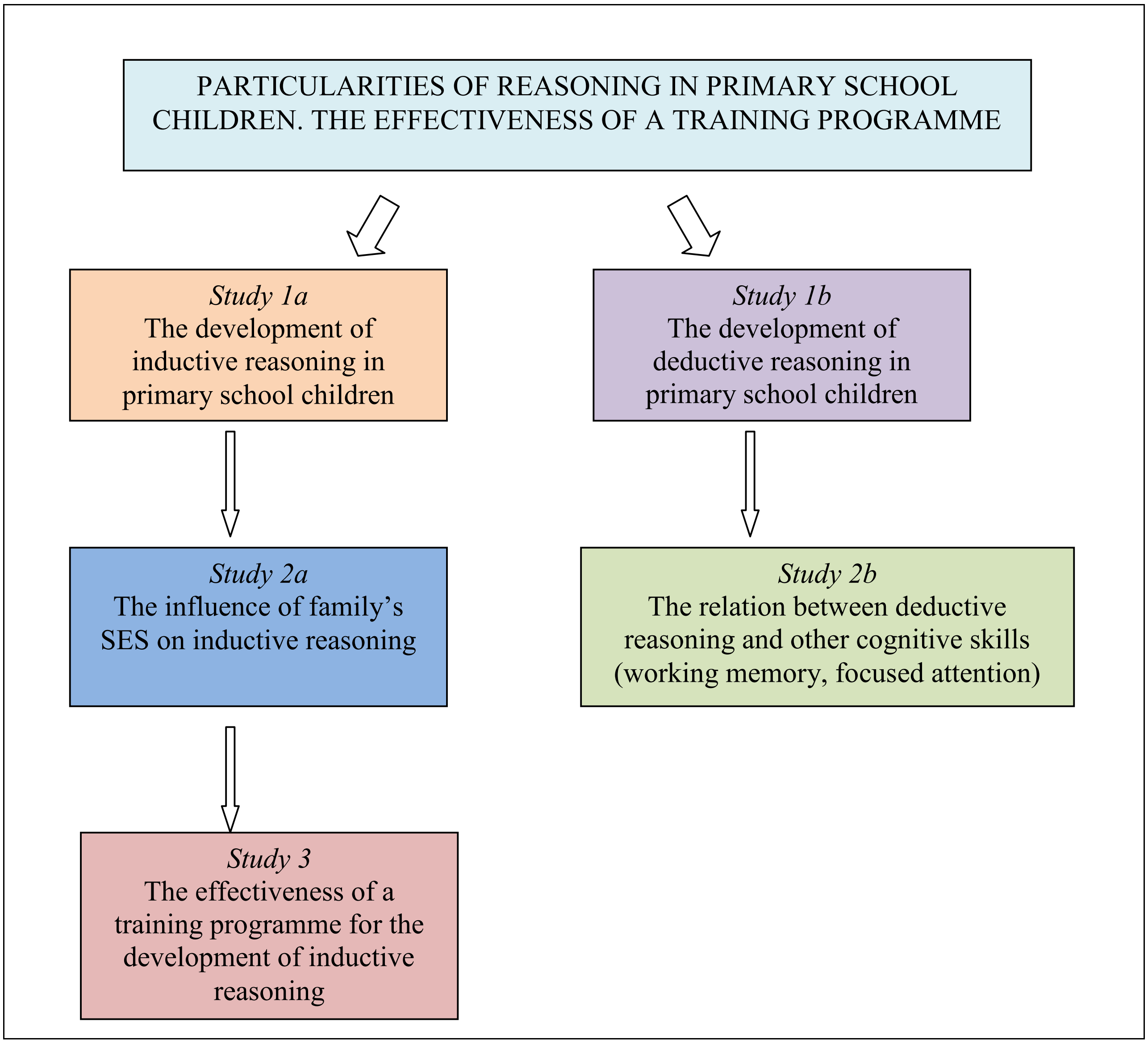
The fourth chapter includes 3 studies aimed at validating the research instruments on Romanian population. In the first study, we adapted Test of Inductive Reasoning. The second study aims to adapt Primary Test of Nonverbal Intelligence - PTONI – for children aged 3 -9.11 years. The third study proposes to adapt on school population the subtests Design Memory and Number/Letter within the battery Wide Range of Assessment of Memory and Learning.

The next three chapters are dedicated to personal contributions, established on the basis of experimental investigations, which attempt to clarify the issue of inductive and deductive reasoning during primary school. Chapter 5 approaches the two types of reasoning from the perspective of development, aiming to highlight the differences in reasoning in primary schoolchildren. The sixth chapter aims to highlight the factors involved in reasoning, two studies being included here. In the first study, we attempt to clarify to what extent parents' socioeconomic status affects cognitive abilities, namely the ability of inductive reasoning. In the second study, we focused on the relationship between reasoning and other cognitive skills (working memory and focused attention). The seventh chapter proposes to highlight the effectiveness of a training program of inductive reasoning. Based on existing theories in reference literature, we built 120 inductive reasoning tasks, implemented in some classes of young school children, in Oradea city. In order to verify the effectiveness of this program, we shall use intergroup comparisons (experimental group, control group and placebo group) and intra-group comparisons (pre-test, post-test and follow-up).

The last chapter is devoted to final considerations on the contributions of the research and on some directions for future investigations on the topic of interest.

Thus, reasoning is the mediator that leaves the mark on everything that we think and perform. This happens because our thoughts and actions involve drawing conclusions. When we learn, analyze, judge, evaluate, apply, discover, imagine, we reach conclusions based on existing information, therefore, reasoning enters the stage.

The schematic general structure of the research is presented bellow.



CHAPTER I
REASONING IN THE ARCHITECTURE OF THE HUMAN COGNITIVE SYSTEM

Popescu-Neveanu (1978, apud Roman, 2006) defines judgment as "a fundamental logical form consisting of a chain of judgments by means of which new knowledge are derived from given knowledge. The transition from given knowledge to new ones does not take place directly, but through a third judgment".

The reference literature describes two main types of reasoning: inductive reasoning and deductive reasoning. Klauer (1989, apud Koning, Hamers, Sijtsma & Vermeer, 2002) defined inductive reasoning as a systematic and analytical comparison of objects, which tends to the discovery of rules in apparent chaos and of irregularities in apparent order. Deductive reasoning involves a series of calculations governed by rules of deduction, so that, in some premises, it necessarily derives a logical conclusion.

The issue of the existence of one or two types of reasoning has also been studied at neurological level. A series of experiments of brain scan were conducted. Osherson et al. (1998, apud Smith et al., 2005) used PET to obtain images of the brain, while these were performing tasks involving inductive or deductive reasoning. A number of brain areas were active during deductive reasoning, but not during inductive reasoning and a number of areas showed the opposite pattern. These results indicate that the two types of reasoning are mediated by different mechanisms (Smith et al., 2005). While solving deductive reasoning tasks, areas in the right hemisphere were activated, some of them being situated near the rear face of the brain. During inductive reasoning, the main activated areas are located in the left hemisphere, in a region of the frontal cortex.

The conclusions drawn from studies conducted in order to highlight the neuro-physiological bases of reasoning refer to the following (Goel, 2005):

- involvement of prefrontal cortex in logical reasoning is selective and asymmetric;
- its involvement is higher in reasoning based on familiar contexts, which have content;
- the left prefrontal cortex is necessary and often sufficient for reasoning;
- the right prefrontal cortex is sometimes necessary, but not sufficient for reasoning.

Reasoning needs to be studied also through its relation with other cognitive abilities (intelligence, working memory, attention etc).

Understanding the relation between cognitive abilities and education is important in today's society. It can be said that this relationship is one of mutual causality: cognitive skills are predictors of academic achievement, and a better education fosters the development of cognitive skills. If we analyse from the perspective of mutual relationship, we find a number of studies that support this idea (cognitive abilities appear as internal factor of learning activity, and these, in turn, can be modelled by education). Cognitive development occurs as an important element of education, therefore, it can provide significant milestones in the educational process. Thus, cognitive structures and educational content cannot be separated. Cognitive development and school learning must be integrated into educational practices. A teacher notices the changes that occur in cognitive development, changes that children present during lessons. A child continues an argument under the guidance of the teacher; he can explain the respective argument. Knowledge of cognitive development provides teachers a support to organize activities in accordance with these.

CHAPTER II

THE DEVELOPMENT OF INDUCTIVE REASONING

Studies on inductive reasoning are classified into two categories. The first group includes studies describing the effect of similarity between premises categories and conclusion, but only for a single property or for a homogeneous set of properties. The second group includes studies that present some differences in inductive reasoning that are based on different properties, especially those that people prefer to generalize (Heit & Rubinstein, 1994).

In early childhood, analogical reasoning is limited by the perception of similarity and by a default reaction when confronted with a problem. Problems of relational similarity are more difficult. Many researchers agree with Piaget in this regard. In relational similarity problems, children have to identify the conceptual relation between two items and then to use the information in order to solve the task. At this level, analogical reasoning is a complex cognitive process, involving the ability to perceive conceptual relationships and to retain this information.

This aspect requires working memory. Goswami (1991, 1992, apud Taylor, 2005) has shown that at four years of age, children are capable of analogies as long as the areas are familiar.

Researches on analogical reasoning have identified factors that restrict the child's ability to solve analogies. Singer-Freeman (2005, apud Abdellatif, Cummings, Maddux, 2008) enumerated three elements that may limit analogical reasoning in childhood:

• An inability to perform relational inferences, which require the child to make the connection between A and B and to apply it to C and D; if they do not indicate the relationship between A and B, they will not apply the relationship to the second term of analogy.

• The absence of relational knowledge, which requires children to have information on super-ordination relationships on which the solution of analogy depends.

• Lack of clarity of task that allows the child to understand the objective of the task.

CHAPTER III

THE DEVELOPMENT OF DEDUCTIV REASONING

In the study of deductive reasoning, two paradigms have appeared: mental logics and mental models. According to *mental logics*, deductive reasoning consists in applying the rules of mental inference, premises and conclusions of argument. The sequence of applied rules forms a mental derivation or evidence of the conclusions in premises where such implicit evidence are analogous to the explicit evidence of elementary logic (Johnson-Laird, 1999).

Deductive reasoning depends on understanding the meaning of the premises and the use of sense and general information to build a set of *mental models* related to what the premises describe (Johnson-Laird, Girotto & Legrenzi, 2004). A mental model is a representation of a possibility. Its structure and content capture what is common in the case of different modalities. Hence, a central component of reasoning is generating possibilities.

Most studies aiming at developmental perspective have considered deductive reasoning as a basis for the evaluation of performance at tests of reasoning (Markovits, 2004). Some studies have shown that at 6 and 7 years of age, children can make logical inferences fairly consistently both in the affirmation of consequent and in the denial of antecedent, starting from verbal premises (Markovits, 2000; Markovits et al., 1998, apud Markovits, 2004). Other studies have shown that at 7 years, children can give logical correct answers when they are supported by concrete material (Kuhn, 1977) or when additional information appears, contradicting a bi-conditional interpretation and learning to produce uncertain answers.

The theory of mental model (Johnson-Laird et al., 1986) assumes that deductive reasoning goes through three main stages:

Stage I – the ones who reason imagine a typical situation in which the premises are true. It is important that this theory does not have a subjective character.

Stage II – the ones who reason will explore the built models in order to determine if they will reach conclusions. The fact that people reach valid informative conclusions has important implications for psychology; any theory which assumes that there is internalized logic is not sufficient to explain human deductive competence.

Stage III - to ensure the validity of the conclusion, the ones who reason should consider whether there is another model of premises that lack support.

CHAPTER IV

VALIDATION STUDIES OF ASSESSMENT INSTRUMENTS

This chapter is intended to adapt the used research instruments on school population, analyzing their psychometric qualities (reliability, validity). These instruments are: Test for Inductive Reasoning (TIR), Primary Test of Nonverbal Intelligence (PTONI) and subtests Design Memory and Numbers/Letters within the battery WRAML 2 (WIDE RANGE ASSESSMENT OF MEMORY AND LEARNING – SECOND EDITION).

In what concerns TIR, we selected 332 primary school children, mean chronological age was 9.04 ($\sigma = 1.21$), to whom we applied this test, whose authors are Koning, Sijtsma & Hamers (2003). Inductive reasoning was operationalized based on tasks requiring comparison. Tasks that require finding similarities or differences of object attributes are called *generalization and discrimination* tasks. Tasks that require simultaneous induction of similarities and differences are called tasks of *cross-classification*. Tasks that require finding similarities and differences in the relations among objects are called *seriation*, respectively *perturbed seriation* and *system formation*. Klauer (1989, apud Koning, Sijtsma & Hamers, 2003) operationalized the comparison process in tasks with concrete objects used in everyday life and in tasks with geometric patterns. By combining these two types of content with the six kinds of tasks, 12 types of items result, which were included in the Test for Inductive Reasoning (TIR). The obtained results allow us to state that TIR test has adequate psychometric qualities for the population it was applied to.

The second analyzed research instrument is PTONI (Primary Test of Nonverbal Intelligence). The authors of the test, Ehrler and McGhee (2008) used in its construction, the theory of Cattell-Horn-Carroll concerning intelligence. Among the objectives PTONI wants to achieve, we mention three. The first objective aims the estimation of *the ability of general reasoning* among young children, especially in the case of those for whom other intelligence tests are either inappropriate or are influenced by biases (linguistic diversity, physical and cultural limitations). The second objective focuses on the *anticipation of future outcomes* for these children. The third objective serves as a *research instrument for measuring intelligence*. We included in the study 234 primary school children, selected from two schools in Bihor county (a school from urban area and one from rural area), the average age is 8.35 and the standard deviation is 0.70. The results obtained on the school population in our country show that this instrument is useful in the evaluation of primary school pupils. According to these, PTONI is a good predictor of academic performance. Thus, a school psychologist can predict, after the application of PTONI, the direction of a child's academic development. Research has shown the involvement degree of cognitive abilities in school learning activities. Intelligence and educational areas are so related that it is almost impossible to understand the mechanisms of intelligence, without discussing its relation with education. A further step will be to extend the application sample of this test, including preschool children; we also intend to explore other psychometric qualities as recommended by the authors (interrater reliability, construct validity).

Next, we focused attention on two subtests Design memory and Numbers/Letters within WRAML 2 battery (Adams & Sheslow, 2003). In order to achieve the objectives, we included 215 primary school pupils, participants from School No. 11 Oradea. Their mean chronological age is 9.64 and the standard deviation is 0.95. We adapted these subtests for their use in further research, for the study of the relationship between these two skills assessed by the adapted sub-tests and deductive reasoning. The analysis of results enables their consideration as useful research instruments. Thus, MD and NL have adequate psychometric qualities. The internal consistency indices we obtained converge to the same values obtained by the authors of the battery, for young school children. Then, we noticed a good predictive validity, meaning that the two subtests are good predictors of academic performance.

CHAPTER V

REASONING DURING PRIMARY SCHOOL – A DEVELOPMENTAL APPROACH

STUDY I: THE DEVELOPMENT OF INDUCTIVE REASONING DURING PRIMARY SCHOOL

The objective of this study aims to review the development of inductive reasoning during primary school. The identification of the stages of reasoning development is a central task of research in developmental psychology. Relating to the "relational perspective" presented in Piaget's theory of development, the emergence of knowledge is explained by building complex relations increasing between meanings (Piaget, 1968, apud Muller, Overton & Sokol, 1999). Children's reasoning differs from one age to another. Children of a certain age seem to reason in a characteristic way in different contexts.

We formulate the following hypothesis in this study:

We assume that there are significant differences in the ability of inductive reasoning based on chronological age.

The study is of comparative type (quasi-experimental), the independent variable is of classificatory type, with its modalities: grade I, grade II, grade III and grade IV. The dependent variable is represented by inductive reasoning, operationalized by the scores obtained at TIR and PTONI.

In this study, we included young school children, 559 school children, selected from School No. 11, Oradea, “Iosif Vulcan” Pedagogical high-school Oradea and School no. 08 Batăr, Bihor County. The average age is 8.68 and the standard deviation is 0.95.

In order to achieve the proposed objectives, we used the following instruments: TIR test and PTONI test, which were described in detail in the previous chapter.

TIR test was applied to the pupils of School 08 No. 11, and PTONI test was applied to pupils of “Iosif Vulcan” Pedagogical high-school Oradea and to those of School no. 08 Batăr, Bihor County.

The hypothesis aimed at verifying the existence of significant differences at the level of inductive reasoning in primary school pupils. The hypothesis is supported by the obtained results. Thus, inductive reasoning evolves during primary school. We obtained significant differences within the measured dimensions between pupils in grade I and pupils in other grades. From psycho-pedagogical perspective, in class I, we discuss about fundamental acquisitions (reading, writing, calculating). The child is cognitively solicited in a greater extent, compared to the previous period. These solicitations will facilitate cognitive development.

At the beginning of primary school, cognitive functioning is characterized by organization and logics only if pupils operate at concrete level. Establishing similarities has two components: generalization and seriation. Generalization involves the correct establishment of horizontal and vertical relationships between classes. Seriation is an important skill for children's performance in mathematics. At items assessing generalization, the subject must identify a common attribute, attribute that is not based on perceptual similarity, but on functional similarity. We notice the significant improvement of this skill in pupils in grades III, IV respectively. However, perceptual similarity provides information about how objects actually are in reality. Cognitive development, implicitly of generalization, favours the transition from perceptual, situational attributes to abstract, verbal-conceptual attributes. Conceptual structures are rooted in perceptual structures, as, perceptual similarity does not decrease with chronological age, but, on the contrary, it becomes more complex, paving the way for functional similarity. For example, what common attribute have eyes, mouth and ears got? There is no question of perceptual similarity, but of functional similarity; they are elements of the human face.

The obtained results allow us to state that, during grades III and IV, pupils turn to the formal operations stage. In the case of seriation, of identifying relations between objects, pupils must find points of connection between the elements in the perceptive field, based on the gained knowledge, in order to create connection strings. At the level of the two dimensions, generalization and seriation, different patterns are recorded in the case of post-hoc tests. In the case of generalization there are no significant differences between pupils in grade I and grade II, whereas in the case of seriation, there are differences. Seriation concerns perceptual aspects, generalization takes into account functional aspects. Pupils of grades I and II do not differ significantly in terms of generalization. At this age classifications based on concrete attributes are dominant. Perceptual description plays an important role in the recognition and identification of objects, while functional similarity serves to inductive generalization. Generalization is closely related with ability of classification, which gives meaning to experience because it reduces the complexity of environment by sorting objects into categories. It is important not only for the previously mentioned aspect, but also because most cognitive activities involve the ability to group objects, events according to their class.

Seriation becomes difficult when there are differences between stimuli regarding properties, other than those based on which seriation is done. In addition to the properties of the stimuli, the number of series stimuli can also affect pupils' performance at this task. A large number of stimuli cause a decrease in performance, especially at young ages. In our study, seriation is based only on images of real objects or figures, based on perceptual features. Seriation is simple because we considered only one feature. Seriation does not involve increased complexity because we respected the characteristics of cognitive development of primary school children. TIR items for seriation are not so complex because pupils must recognize the appropriate element that completes the series. Pupils can achieve seriations of 10 objects spontaneously, without error and without necessarily depending on the perceptual configuration of the series (Siegler, 2001). For pupils to obtain good performance in seriation, it is necessary for them to have the prerequisite skills: differentiation of specific properties of objects and recognition of differences in the relations between objects. In the seriation process, four basic components are involved: discovery of relations, discovery of periodicity, completion of pattern description, extrapolation (Kotovsky & Simon, 1973). The series is analyzed in order to formulate an assumption regarding the relation between elements. It is verified whether the relation is repeated at regular intervals. Flexibility is a factor that facilitates seriation.

In the stage of concrete operations, children can consider two dimensions when they have to solve a problem. In the case of cross-classification and construction of system, it is necessary to use both the ability of establishing similarities and the ability of establishing differences. For the simultaneous processing of two dimensions or properties, inferential processes must be activated (Shayer, Demetriou & Pervez, 1988). Decentration enables pupils in grades III and IV to operate two dimensions simultaneously. In solving items from system formation, an important role belongs to the process of rule generation. A larger number of rules will attract a higher number of errors. Pupils in grades III and IV can use a larger set of rules for filling matrices, as compared to those in grades I and II. We must also take into account the ease of detecting elements governed by the same rule.

STUDY II: THE DEVELOPMENT OF DEDUCTIVE REASONING DURING PRIMARY SCHOOL

The objective of this study is to analyze syllogistic reasoning during a stage of development (primary school age). **The hypothesis** that we shall test in this study is the following:

We assume that there are significant differences concerning the ability of syllogistic reasoning according to chronological age.

The study is comparative (quasi-experimental), the independent variable is of classificatory the type and the dependent variable is represented by the scores obtained in syllogistic reasoning tasks.

In this study, we included 215 primary school children, selected at School No.11, Oradea. The average age is 9.647 and the standard deviation is 0.955.

To achieve the objectives, we used a set of 16 syllogisms (Appendix 2). These syllogisms were grouped into four categories: universally affirmative, universally negative, particularly affirmative and particularly negative. Each category includes four syllogisms. Each syllogism consists of two premises and a conclusion. The conclusion is formulated as a question. Pupils must answer that question. At each of these syllogisms, children had the possibility of choosing one option from the following: yes, no or unsure. If they chose correctly, they were given one point. We realized a total for each of the four categories and a total for all syllogisms. In addition to this list, we used a list of counterfactual syllogisms, two in each category (Appendix 3).

The quantitative analysis of results allows a partial confirmation of the hypothesis. Intergroup comparisons concerning syllogistic reasoning have not revealed any significant differences between classes, as the value $F(2,212)$ corresponds to a higher threshold than the critical threshold of 0.05. Counterfactual syllogistic reasoning differs significantly at the level of the three grades (II, III, IV respectively). We obtained appropriate values of f coefficient, indicator of effect size. The responses of pupils in III and IV grades are more consistent, so, between them, there were no significant differences. At this age, pupils are able to process simultaneously more dimensions. For the scores obtained at counterfactual syllogisms, the differences are highly significant, we have $F(2, 120) = 38.833$ with a threshold of 0.000. F coefficient has a value of 0.647, indicating a high effect size, statistical power is 1.000. Thus the relation between the attended grade and counterfactual syllogisms is strong, 64% of the performance variance at counterfactual syllogisms is explained by chronological age. The obtained results allow the idea that they have a good practical value. Post-hoc Games-Howell tests show that statistically significant differences are recorded between pupils in grade II and grade III (-3.290, $p = 0.00$) and respectively grade II and grade IV (-3.797, $p = 0.00$). The differences are not statistically significant between pupils in grade III and grade IV (-0.498, $p = 0.580$).

The situation is different in the case of intra-group comparisons. For pupils in grade II, we obtained $F(3, 252) = 38.670$ significant. Therefore, there are significant differences in the pupils in grade II according to the type of syllogism used, meaning that in the affirmative ones, the performances are better, in comparison to negative ones. For pupils in grade III, Greenhouse-Geisser correction $F(2.48, 181.16) = 37.950$ is statistically significant. Similar results are obtained in the case of pupils in grade IV. $F(3,165) = 11.914$ is statistically significant, there are significant differences concerning the four types of syllogisms, at the fourth-grade level.

Overall, analyzing the results, the positive form of syllogisms attracts better results compared to the negative one. Pupils manipulate more easily positive premises than negative ones. In everyday life, we operate more frequently with affirmations than with negations. We conclude that the negative form involves deep processing, pupils being forced to look for valid counterexamples in order to solve syllogisms correctly.

When and how is developed the ability of solving syllogisms? The question remains open as researchers have come to different conclusions in the course of research. At one pole, there are those who claim that the ability to solve syllogisms develops since early childhood; at the other pole, there are those who deny this aspect. The difficulties faced by children are due to the presence of preoperational thinking and absence of operational thinking. Syllogistic reasoning, when demands concrete operations, is not dependent on formal operations and thus, it can be expected that it is influenced by verbal factors. The results of Kunn’s studies (1977) are consistent with the idea that the logical operations needed to solve syllogisms are acquired during secondary school.

CHAPTER VI
THE FACTORS INVOLVED IN THE EVOLUTION OF REASONING IN PRIMARY SCHOOL PUPILS

STUDY I: THE INFLUENCE OF FAMILY'S SOCIO-ECONOMIC STATUS ON REASONING

The study aims to reveal the influence of the child's family's socioeconomic status on some cognitive abilities, especially the ability of inductive reasoning.

We postulated the following hypothesis:

We assume that the socioeconomic status of parents (educational level) influences significantly their cognitive abilities.

This study is a comparative (quasi-experimental) one, the independent variable is of the classificatory type, its modalities being: a_1 – university studies and a_2 – high-school graduates. Cognitive skills were operationalized by scores obtained at TIR and PTONI.

In this study, we included 559 primary school children, selected from School no. 11, Oradea, „Iosif Vulcan" National College, Oradea and Batăr School, Bihor county. The average age is 8.68 years and the standard deviation is 0.95. We applied TIR and PTONI, instruments that have been described above.

The results confirm the formulated hypothesis. We chose to analyze only this element of SES, since research confirms that the educational level of parents is the most „popular indicator of social class" (Liberator et al., 1988, apud Bornstein & Bradley, 2003).

In what concerns inductive reasoning, the mean of scores of pupils from families with university studies is higher than the mean of pupils from families with high-school diploma. The standard deviation is lower for the results obtained from the first sample, the data having a lower scattering around the average. The comparison of the means of the two samples emphasizes highly significant differences at the level of inductive reasoning, $t(277.961) = 4.886$ has a lower threshold than the critical threshold of 0.05. ω^2 coefficient has a value of 0.064, thus, the effect size is medium, the obtained results have good practical value.

Regarding the comparison of the results obtained at PTONI, for all three dependent variables measured (concrete items scores, abstract items scores, total score PTONI), the rank means is higher for pupils whose parents have university studies. The values of Mann-Whitney test for these variables have lower significance thresholds than 0.05, thus, the education level of parents has a significant influence on children's reasoning ability.

The relation between social factors (poverty, minority status, educational level of parents) and family involvement in education has been extensively studied. Parents with low levels of formal education are less involved in school activities (Dauber & Epstein, 1993, apud Wade, 2004). Economically disadvantaged pupils will obtain lower school performance because their parents value less education.

Educationally disadvantaged parents will not create a learning environment at home which supports the children's cognitive development and academic success, will offer less incentives and resources which act in the child's zone of proximal development. Parents with higher education levels will value education and will have high expectations from their child. The child's involvement in school activities will also be enhanced and a proper partnership will be maintained with the school. School performance, especially in mathematics, of pupils from families with high SES can be attributed, at least partially, to differences in the early operation of mathematical problems in books, educational toys and educational TV programs (McNeil, Fuhs, Keultes & Gibson, 2011).

The educational level of the parents has an effect on the way they structure their home environment and on how they interact with their own children in order to ensure academic success. Finders & Lewis (1994, apud Georgiou, 2007) presented a number of elements that function as barriers to parental involvement in education (parents' difficulty to get permission from work to participate in school activities, cultural differences between them and teachers, psychological barriers due to personal school failure).

Educational policies should be oriented towards improving the cognitive abilities of children from economically disadvantaged families, by implementing educational programmes that facilitate their development. The educational programmes aimed at cognitive development should be designed so as to reduce differences between pupils from families with university studies and those from families with high-school studies, concerning cognitive skills.

STUDY II: THE RELATION BETWEEN DEDUCTIVE REASONING AND OTHER COGNITIVE SKILLS

The objective of this study is to analyze the relation among four forms of syllogistic reasoning and working memory, respectively attention.

The hypothesis that we tested in this study is the following:

We assume that, working memory, respectively attention represent predictors for performance on syllogistic reasoning tasks.

In this study, we included 215 primary school children, selected at School No.11, Oradea. The average age is 9.647 and the standard deviation is 0.955.

To achieve the proposed objectives, we used a set of 16 syllogisms and the subtests Memory design (MD) and Numbers/letters (NL).

The hypothesis formulated at the beginning of this study, according to which working memory and attention represent predictors of syllogistic reasoning, was partially confirmed. The analysis of R^2ajust. values leads us to the conclusion that syllogistic reasoning is explained in 16% percent by working memory. Thus, there is a direct relation between predictor and criterion. If we increase the working memory level with a standard deviation, the level of syllogisms will increase by 0.405 standard deviations. Working memory has greater explanatory power than attention, in the case of syllogisms. Things change in the case of counterfactual syllogisms, these being explained in proportion of 11.5% by attention. In the case of pupils in grade IV, 11.1% of the syllogism variance is explained by working memory. We can notice an increase with 0.356 of standard deviations in syllogism performance when working memory increases with one standard deviation. Attention explains 7% of the variance in performance on syllogistic reasoning.

Taking into account the obtained results, we tend to believe that working memory explains better syllogistic reasoning, whereas attention explains better counterfactual syllogistic reasoning. Of course, when one has to solve a counterfactual problem, attention is more intensely required, because the pupil must operate with information that contravenes reality. Negative forms of syllogisms are better explained by working memory, requiring the activation of large amounts of information in the process of solving them.

Working memory can limit the complexity of new structural representation (Halford, Wilson & Phillips, 1998). Working memory can cause difficulties in comparing multiple models.

Therefore, it does not explain counterfactual syllogisms as well as attention. During reaching conclusions to counterfactual reasoning, a deeper processing is required. Therefore, errors can occur more frequently when we resort to working memory.

The correlation between working memory and syllogistic reasoning is insignificant in the study conducted by Johnson-Laird, Oakhill & Bull (1986, apud Barrouillet & Lecas, 1999). The explanation of these authors resides in the fact that children's syllogistic reasoning is based on other processes than the construction and manipulation of mental models.

CHAPTER VII
THE EFFECTIVENESS OF A TRAINING PROGRAMME FOR THE DEVELOPMENT OF INDUCTIVE REASONING

Research on thought, in general, and on the effects of training programmes that influence children's performance at problems of induction, in particular, are relevant theoretically and practically, and therefore they require special attention (Tomic, 1994).

The objective of this study is to analyze the extent to which a training programme can contribute to the improvement of relating skills in an inductive manner, in the case of primary school pupils.

We assume that *the proposed intervention programme significantly improves inductive reasoning skills in primary school pupils*. Design of research is mixed (pretest-posttest-follow-up, with control group and placebo group).

The training programme was attended by 118 primary school children, selected from School no. 11, Oradea, grade II, mean chronological age is 8.5 years (σ = .36). Three groups were formed: experimental group, control group and placebo group. In the experimental group 44 pupils (24 girls and 20 boys) were included, the control group consisted of 33 pupils (17 girls and 16 boys) and in the placebo group we included 41 pupils (25 girls and 16 boys).

In the pretest phase, we applied Test for Inductive Reasoning to the three groups of pupils, in January, last the school year. The test was applied before the start of the intervention programme, at the completion of the programme and at an interval of 3 months after the programme.

Intervention, both for the experimental group and for the placebo group was carried out over a period of 10 weeks; two activities per week were conducted. The activities focused on the development of inductive reasoning skills. Lessons were held by the researcher.

The experimental group received a set of activities, spread over a period of 10 weeks. The topic addressed within the training programme focuses on the components of inductive reasoning: determining similarities, differences and similarities/differences. Thus, we used as a starting point the training programme proposed by a group of researchers from the University of Leiden (Els de Koning), Utrecht (Jo H.M. Hamers and Adri Vermeer), Tilburg (Klaas Sijtsma). The placebo group received a training programme based on Edward de Bono's theory (2008), Thinking Hats.

After analyzing the results, we can say that the training programme, designed based on the theory of Koning and his collaborators, contributed to the development of inductive reasoning ability, which is operationalized through three dimensions: establishing similarities, establishing differences and establishing similarities/differences. There were significant differences between the experimental and control group, respectively placebo group, in the posttest phase. In the follow-up phase, we noticed the stability of results for the three groups included in this study; the means of scores is higher in the experimental group, compared to the control and placebo group.

Mauchly test for generalization dimension is significant statistically (Mauchly's $W_{experimental} = 0.514$, $p<0.05$, Mauchly's $W_{control} = 0.541$, $p<0.05$, Mauchly's $W_{placebo} = 0.711$, $p<0.05$); the condition of sphericity is not fulfilled and we used Greenhouse-Geisser correction of F (Sava, 2004). Greenhouse-Geisser correction indicates the value $F(1.34, 57.85) = 76.82$, $p<0.01$, for the experimental group, $F(1.37, 43.85) = 3.52$, $p> 0.05$, for the control group, $F(1.55, 62.06) = 13.26$, $p> 0.05$, for the placebo group. The effect size for the experimental group at generalization dimension calculated by eta-squared coefficient (part η^2 – 0.64) is high (Hopkins, 2000, apud Popa, 2008).

For the experimental group, we proceed to the analysis of repeated, standardized contrasts, in the case of generalization dimension. In order to highlight the contrast between pretest and posttest, we obtained a coefficient partial eta squared 0.672, statistical power 1.00. For the second contrast, between posttest and follow-up, the coefficient is 0.102, statistical power of 0.579.

Greenhouse-Geisser correction for perturbed seriation dimension indicates value $F (1.08, 46.53) = 54.38$, $p < 0.01$, for the experimental group, and $F (1.16, 46.69) = 3.27$, $p > 0.05$ for the placebo group. For the control group, $F (2,64) = 3.02$ has the threshold $p > 0.05$. For the experimental group, eta-squared coefficient has a value of 0.55, which means a high size of large effect.

For cross classification, Greenhouse-Geisser correction indicates the value $F (1.31, 56.67) = 67.54$, $p < 0.01$, for the experimental group, $F (1.64, 52.60) = 1.90$, $p > 0.05$, for the control group, $F (1.37, 54.81) = 0.53$, $p > 0.05$, for the placebo group. Over 60% (medium to high effect size) of the variance of scores in the experimental group are due to factor.

Analyzing the difference of means between pretest and posttest for each of the six dimensions of inductive reasoning, we can highlight the following aspects: the best development was recorded by generalization, followed by seriation, perturbed seriation, cross-classification, discrimination and system formation. These results are not in accordance with the studies carried out by Molnar, in which the author obtained the best development at system formation, followed by generalization, seriation, discrimination, perturbed seriation, cross-classification. Our results support the idea that, at this age, children are not easily oriented towards two characteristics.

Unlike the present study, Koning and his collaborators have used verbal material in their training programme, in addition to visual material. In the pretest phase, the means of scores at Vocabulary test and Comprehensive listening test did not differ significantly between the control group and the experimental group. ANCOVA analysis shows significant differences between experimental conditions and control conditions in posttest and follow-up stages. Effect size in the follow-up stage is 0.48. In the case of our study, the effect size for the experimental group for all six dimensions exceeds the value 0.50. It would be necessary to focus our attention in a future study on the use of some verbal tasks in the training programme, as combining the two modalities would certainly ensure a greater effectiveness of education.

Another difference between our study and other studies focused on training programmes of inductive reasoning refers to the inclusion of a placebo group in our study. We designed the scientific approach in such a manner in order to highlight the positive effects of the training programme. Even if the placebo group received a different type of cognitive strategy (Thinking Hats method), which is mostly verbal, our programme is especially designed for primary school children, as it was conceived by reference to the particularities of cognitive development specific to this age group, with a focus on nonverbal tasks.

CONCLUSIONS

In the context of contemporary society, reasoning is a means by which children acquire knowledge; it is an essential skill that mediates cognitive skills. In our view, reasoning is a constructive process, which involves, besides the identification of the problem, the generation of appropriate solutions. The experiences lived by the child do not repeat exactly, finding solutions depending on the power of the mind to create links between past and present situations. This ability requires manipulation of information, analysis of components and synthesis of existing information in order to obtain new solutions to raised problems.

In this paper, the approach of reasoning was done from a psychological perspective, knowing the fact that it lies on the border between psychology and logics. This paper is part of the concerns regarding the implications of the ability to obtain new information by combining existing ones on the level of educational psychology.

The strategies of learning used in schools can facilitate understanding; the use of a wide variety of problems represents means for developing cognitive skills. Taking into consideration that the strategies of learning in grade II are predominantly inductive, we believe that the proposed training program is a starting point for the development of inductive reasoning in primary school pupils.

Reasoning is an important element in the architecture of the human cognitive system. For this architecture to be completed, it is necessary for all elements to operate and interact efficiently. This skill involves the extraction of conclusions; every human action has as a consequence the formulation of conclusions based on existing information.

In theory, this study addresses the issue of reasoning, of ontogenetic perspectives on reasoning and a number of theories related to reasoning. We summarize below the main contributions within the three theoretical chapters:

- Tackling the issue of reasoning, regarded as an important skill of the human cognitive system, specifying its neuro-physiological substrate; in this context, we also are interested in the relation of reasoning with other cognitive skills, the description of BIS model (Berlin

Intelligence Structure Model) being significant, reasoning appears as an operational component of intelligence; as we studied reasoning at an early school age, we considered it appropriate to present the implications that it has on learning activity;

- Presentation of international research directions regarding inductive and deductive reasoning, through specialized studies; the paper is based on a traditional and a modern vision of reasoning, the key element being the theory of a group of researchers from the Netherlands (Els de Koning, Jo H.M. Hamers, Adri Vermeer şi Klaas Sijtsma).

In order to achieve these, we tried to cover, integrate, associate explanatory models for each of the presented concepts separately in an overview, outlining a comprehensive picture of the processes with their implications in learning activities.

The theoretical part presents a synthesis of the main theories of the two types of reasoning (inductive reasoning and deductive reasoning), theories addressed from a traditional and a modern perspective. We also considered the neuro-physiological bases of reasoning and its relation to other cognitive abilities (intelligence, working memory, language).

The objectives of this study are presented below:

- The adaptation on the Romanian population of the used research instruments, specifying their psychometric qualities
- The analysis of the two types of reasoning (inductive and deductive) in primary school pupils
- The depiction of the influence of some factors on reasoning; first, we studied the impact of parents' educational level on the development of children's reasoning; then, in an integrative manner, we analyzed the relation of deductive reasoning with working memory, respectively attention
- Highlighting the effects of a training program designed to improve inductive reasoning of primary school children.

We consider that the undertaken methodological approach facilitated the proposed objectives.

The research also makes contributions to the *methodological level*. We realized the adaptation on Romanian population of some evaluation tests of reasoning ability: Test for Inductive Reasoning and Primary Test of Nonverbal Intelligence for children between 3 and 9.11 years. These instruments also present psychometric qualities (reliability and validity) and the sample for Romanian population. In order to capture the relation of reasoning with other cognitive abilities (working memory and attention), we also adapted two scales to the assessment of these skills: Design Memory and Number/Letter within the battery Wide Range Assessment of Memory and Learning - second edition (WRAML - 2nd).

In the first study, we conducted a developmental approach of inductive and deductive reasoning, during primary school. Understanding the development of reasoning during a stage of development will facilitate the choice of appropriate learning strategies (inductive or deductive). Since the first grade is the period of fundamental acquisitions (writing, reading, calculating), the development of inductive reasoning is necessary in this period. According to theories supported in the theoretical part, inductive reasoning involves establishing similarities, differences and similarities and differences simultaneously. Compared with pupils in first grade, pupils in grade IV obtained higher scores at inductive reasoning tasks. Thus, the development of reasoning requires time, being in close connection with the child's cognitive development. Inductive reasoning becomes more productive in pupils in grade IV, taking into account not only the exterior features of objects-images, but also essential, inner ones (belonging to a particular category). Regarding syllogistic reasoning, we used in building tasks corresponding concrete verbal material.

Our results are consistent with those of Kuhn’s studies, primary school pupils being able to respond logically when we use verbal material with support in everyday reality. It can be said, however, that pupils in grade IV solve counterfactual syllogisms in a “more logical” manner than pupils in grade I. These (pupils in grade IV) are closer to the stage of formal operations. Comparisons emphasize that the affirmative form of syllogisms attracts better results than the negative one. Whether we support the theory of mental models or of mental logics, one aspect is certain: solving syllogisms depends on the material with which we operate. Mental models are cognitive structures that correspond to real or imaginary states. In the case of concrete premises, the differences registered among children can be explained by the limited capacity of working memory. A child builds the models of premises, basing on a relatively low number of information used in the correct solving of inferences. The theory of mental logics argues that the evidence of early competence reflects the existence of basic deductive schemata, which are logical. Development is achieved through experience and involves the further acquisition of complex schemes. (Markovits, 2004).

In the second study, we aimed at highlighting some factors with direct action on reasoning. We have demonstrated that the parents' socio-economic status, respectively their educational level has a significant influence on the development of cognitive abilities in children. Children from families with higher educational level have higher inductive reasoning skills than the others. The practical value of this study resides in that parents with low SES may be involved in educational programs for children's cognitive development. We have also discussed in this context the changing attitudes of parents towards education. Parents can be considered as mediators in the learning process. If children will be offered the opportunity to engage in favourable/constructive interactions, their cognitive potential will certainly develop. Parents' expectation towards children's school performance influence structure of family and educational environment. Family-school partnership represents an important factor that affects the child's development. We support the idea of cognitive modifiability, as at a young school age, there is an increased receptivity for the acquisition of new information and skills. In the second segment of this research, we studied the relation of reasoning with other cognitive abilities (working memory and attention). The activation of relevant information is made during the reasoning process. A sustained effort is required in order to keep all the premises in working memory, the limited amount of resources available for finding information in working memory. Reasoning should reflect the way in which information is structured in memory.

On a *pragmatic level*, the paper provides a developmental program of inductive reasoning. The study included three groups: experimental, control and placebo in order to ensure a rigorous control of research. It showed long-time stability of the obtained results, the comparisons between post-test and follow-up being relevant. The study could represent a starting point for future programs of developing inductive reasoning among primary school pupils. Also, this program can represent a basis for other future studies in what concerns the specific of reasoning in primary school pupils, of course with the extension of research to a larger number of subjects. It provides primary school teachers with possibilities of valuing the proposed activities in order to ensure the optimal cognitive development of young school children.

Along with the above mentioned contributions, we consider appropriate to mention the *limits* of this research. First, because the program implementation was done at the level of the entire school micro-group, we took into account in a lower extent the individual differences among pupils in terms of personal characteristics. In what concerns the socioeconomic status of parents, we considered that the parents’ income is not relevant enough in the current context of Romanian society, therefore, this criterion was not an independent variable. The most common criterion encountered in studies is the parents' educational level because it tends to be the most stable.

Because the research theme allows opening a path, *future research directions* may deepen the issue regarding the following aspects:

- The study of other factors directly related to reasoning (verbal memory, understanding), taking into consideration that the studies support the need for a complete understanding of relations within premises
- Longitudinal study on inductive and deductive reasoning, during a stage of development (primary school age)
- Comparative study concerning reasoning of pupils with learning difficulties and of those with normal development
- The study of the direct influence of the types of reasoning on learning activities during primary school
- Development of a measurement instrument of deductive reasoning, respectively its adaptation on the population for whom it is intended (grades III and IV)
- The application of the training program of inductive reasoning to some pupils from disadvantaged backgrounds
- Establishment of a group of primary school teachers in order to get familiarized with the training program and to apply it.

The support of pupils by teachers in order to develop cognitive skills in general, and especially reasoning, should be a primary objective of education. In the future, it would be necessary to include a discipline, “cognitive education” at primary school level, taking into consideration the results of our research. This discipline should be included in the school program for pupils, within the curriculum designed by the school. Emphasis transfers from the informative character of the educational process to its formative character.

Highlighting the existence of significant relations of reasoning will draw attention to the consideration of these issues in the design and development of the instructive-educational process, if we aim at pursuing a harmonious development of pupils: "All teachers need to focus their attention from the product of reasoning (correct or incorrect answer) to the reasoning process (how the answer was found) with the purpose of the pupils' metacognitive development... The focus on the development of inductive reasoning should become possible in order to define a line of thought in the direction of improving the design of teaching and training students during primary school for them to become critical and competent school learners" (Koning, Hamers, Sijstma & Vermeer, 2002, p. 28).

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