"BABEŞ-BOLYAI" UNIVERSITY
FACULTY OF PSYCHOLOGY AND EDUCATIONAL SCIENCES
PSYCHOLOGY DEPARTMENT

THE DYNAMICS OF THE MENTAL REPRESENTATIONS IN THE DEDUCTIVE REASONING PROCESSES

PhD Thesis
Abstract

Thesis coordinator:
Prof. dr. MIRCEA MICLEA

PhD student:
LUCIA FAICIUC

Cluj-Napoca
October 2009

Table of contents of the PhD Thesis

INTRODUCTION **4**

TYPES OF DEDUCTIVE REASONING AND ITS DEFINITION **4**

EXISTING THEORETCAL APPROACHES AND MODELS OF THE DEDUCTIVE REASONING PROCESSES **6**

PROPOSAL OF A SCHEMA-BASED DYNAMIC MODEL OF DEDUCTIVE REASONING **9**

ARGUMENTS FOR THE CHOICE OF THE SCHEMA NOTION AS BEING CENTRAL FOR THE PROPOSED MODEL OF THE DEDUCTIVE REASONING ..... **ERROR! BOOKMARK NOT DEFINED.**

AN INTEGRATIVE DEFINITION FOR THE NOTION OF DYNAMIC COGNITIVE SCHEMA 10

A. The traditional cognitive schema notion in the cognitive psychology..... ***Error! Bookmark not defined.***

B. Limits of the traditional cognitive schema notion in the cognitive psychology..... ***Error! Bookmark not defined.***

C. Dynamic cognitive schemas and their properties..... ***Error! Bookmark not defined.***

a. Dynamic schema as a dynamic representation..... 10

b. The dynamic interpretation of the properties of a cognitive schema and new properties..... 10

c. A synthetic definition of a dynamic schema..... 11

d. Conclusion 11

DYNAMIC REASONING SCHEMAS IN DEDUCTIVE PROCESSES 12

A. General assumptions..... *12*

B. Assumed types of dynamic deductive schemas..... *12*

C. Selection of a dynamic deductive schema through actualization ..... ***Error! Bookmark not defined.***

D. Derivation of a conclusion as a pattern completion process *14*

E. The temporal course of a deductive reasoning process *14*

F. Difficulty of a deductive task ..... ***Error! Bookmark not defined.***

G. The sources of error and the prevalent wrong answers in a deductive task from a dynamic point of view ..... ***Error! Bookmark not defined.***

H. Predicted dynamic phenomena in deductive reasoning..... *14*

I. The integrated dynamic model for the deductive reasoning and its general assumptions *17*

J. A dynamic pragmatic deductive schema model for the categorical syllogisms..... *20*

a. General assumptions 21

b. Specific assumptions regarding the cognitive function of the four syllogistic figures and the semantic logical content of the correspondent syllogistic schemas..... 21

1. Cognitive functions of the syllogistic figures 21

2. The order of the cognitive importance of the syllogisms..... 22

c. A comparison between the dynamic schema-based model and mental models theory in what respects the main expected effects..... **Error! Bookmark not defined.**

1. Knowledge and content effects in mental models theory vs. dynamic schema-based model **Error! Bookmark not defined.**

2. The validity effect in the mental models theory vs. dynamic schema model... **Error! Bookmark not defined.**

3. The figure effects in the mental models theory vs. dynamic schema model.... **Error! Bookmark not defined.**

4. The task format effects in the mental models theory vs. dynamic schema model..... **Error! Bookmark not defined.**

5. The order effects in the mental models theory vs. dynamic schema model ..... **Error! Bookmark not defined.**

6. The individual differences effect in the mental models theory vs. dynamic schema model . **Error! Bookmark not defined.**

CONCLUSION 23

PARTIAL EMPIRICAL VALIDATION OF THE DYNAMIC SCHEMA-BASED MODEL ON THE SYLLOGISTIC REASONING CASE **24**

METHODOLOGICAL CONSIDERATIONS 24

STUDY 1 ..... **ERROR! BOOKMARK NOT DEFINED.**

Purpose..... ***Error! Bookmark not defined.***

Preliminary comments..... ***Error! Bookmark not defined.***

Hypotheses..... ***Error! Bookmark not defined.***

Method..... ***Error! Bookmark not defined.***

Results..... ***Error! Bookmark not defined.***

Discussion..... ***Error! Bookmark not defined.***

Conclusion ..... ***Error! Bookmark not defined.***
STUDY 2 25
Purposes *25*
Preliminary comments *26*
Hypotheses *29*
Method *30*
Results. *30*
Discussion *31*
Conclusion *32*
STUDY 3 33
Purposes *33*
Preliminary comments *33*
Hypotheses *34*
Method *35*
Results. *35*
Discussion *36*
Conclusion *38*
STUDY 4 38
Purposes *38*
Preliminary comments *39*
Hypotheses *40*
Method *41*
Results. *42*
Discussion *43*
Conclusion *44*
STUDY 5 44
Purpose *44*
Preliminary comments *44*
Hypotheses *46*
Method *46*
Results. *46*
Discussion and conclusion. *47*
STUDY 6 48
Purpose *48*
Preliminary comments *48*
Hypothesis. *49*
Method *49*
Results. *50*
Discussion and conclusion. *50*
GENERAL DISCUSSION 51
FINAL CONCLUSION **52**
REFERENCES **54**
ANNEXES **60**

INTRODUCTION

In spite of a rather intensive research, the conundrum of the deductive reasoning is far from being solved in the cognitive psychology. However, finding an answer to it is not only a parochial matter, concerning only some curious psychologists particularly interested in such a research subject, but also a matter bearing on some pragmatic issues, regarding the rational behavior of the people in their daily activities.

As Johnson-Laird and Byrne (1991) noticed, deduction is involved in many current tasks: planning, evaluation, determining the consequences of assumptions, interpreting and formulating instructions, rules and general principles, pursuing arguments and negotiations, weighing evidence and assessing data, solving problems, etc.. Therefore, their performance is dependent on the deductive ability of an individual. But such ability seems to be more like a humble and almost invisible servant, few of us and rarely being aware of its presence and activity. It is one of the reasons why its experimental study is rather difficult, which accounts also for the manifest tendency to undervalue its importance (reflected in its present negligible place as a distinct subject matter in the current formal education). But, as Venet and Markovits (2001) emphasized, the ability to reason correctly deductively "in situations where the reasoner has little or no knowledge" (p. 76) is critical for the scientific activity, because it allows predictions about the "unobservable mechanisms that can be used to understand phenomena about which there is little knowledge" (p. 76).

Two general questions have been in the focus of the empirical studies so far, puzzling the researchers. The first one is why the performance of the normal subjects confronted (especially) with formal deduction tasks is so poor and sometimes seemingly irrational, why their motivation is so low in solving them, when deduction is still one of the most important and constant component of their everyday thinking. Such discrepancy has raised doubts regarding people's rationality or their deductive competence (Johnson-Laird & Byrne, 1991). The second question concerns the appropriate methods to be used in order to improve such a defective deductive competence. The present work brings new theoretical perspectives and empirical data intended to be new pieces for solving the puzzles of those questions.

TYPES OF DEDUCTIVE REASONING AND ITS DEFINITION

Several types of deductive reasoning have been distinguished. The most general and important ones are *the propositional deductive reasoning*, with its main sort being the conditional (or hypothetico-deductive) reasoning, *categorical reasoning* (mostly identified with the so called syllogistic reasoning), and the *relational reasoning.*

The *propositional deductive reasoning* involves, in general, also, other types of so called logical connectives (or relations) than the conditional implication (for example: negation, OR, or AND) by which propositions are combined in order to produce new propositions. Through a deductive propositional reasoning, the truth value of a proposition is found based on knowing the meaning of the logical connectives (or the so

called truth conditions, i.e. when the obtained combined proposition is true depending on the truth of the component propositions) and the truth values of the remaining propositions taken into consideration. A concrete example for a conditional deductive reasoning is the following argument composed of two premises and a conclusion:

Premise 1: "If litmus paper (turnesol in Romanian) turns red, then the tested aqueous solution has an acidic pH."
Premise 2: "The litmus paper turned red."
Conclusion: "Therefore, the tested aqueous solution has an acidic pH."

Defined in a more abstract way, conditional reasoning is a kind of propositional reasoning based on the implication relation between a proposition **p** (the antecedent or the condition) and a proposition **q** (the consequent), i.e. $\mathbf{p} \rightarrow \mathbf{q}$.

In its classical form, the most important form of categorical reasoning is a syllogism, based on four types of judgments with a single quantifier ("all" or "some"), stating relations between classes of things or beings and their properties: the *universal affirmative judgment* ("All **M**s are **P**s."), generally symbolized in logics with **A**, the *universal negative judgment* ("All **A**s are **not B**s."), generally symbolized in logics with **E**, the *particular affirmative judgment* ("Some **M**s are **P**s."), generally symbolized in logics with **I**, and the *particular negative judgment* ("Some **M**s are **not P**s."), generally symbolized in logics with **O**. In such a syllogism, the three so called syllogistic terms: two *"extreme" terms*, and a *middle term* are related using the above mentioned judgments. One of the two premises states a relationship between one extreme term and the middle one. The other one states a relationship between the remaining extreme term and the middle one. In conclusion, the relationship between the two extreme terms is derived (determined) based on their relationships with the middle term stated in the two premises. An example of syllogism is:

Premise 1: "All fishes are oviparous (produce and lay eggs)"
Premise 2: "All whales are not oviparous"
Conclusion: "All whales are not fishes".

For the given example, the extreme terms are "fishes" and "whales", and the middle term is "oviparous".

Representative for the deductive *relational reasoning* is the so called "three-term series" problem.

A concrete example for such a problem would be to find out if Jane is taller than Mary, knowing that Jane is taller than Sue, and Sue is taller than Mary. The expected conclusion is that Jane is taller than Mary.

In general, in a relational reasoning, some relations between the given entities are stated in the premises, and, based on them, a conclusion is derived, stating the truth of an unknown relation between two of the entities taken into consideration. The type of the relational reasoning depends on the type of the envisioned relations (for example, spatial: "on the right", "on the left", "under" etc., temporal: "before", "after" etc., social: "to be a subordinate", "to be a father" etc.). Sometimes, when a relational reasoning involves more than one type of relation, in order to derive a conclusion it is needed to know the relation between the stated relations, i.e. second order relations[1].

[1] For example, in a reasoning in which it is stated that "object X is *at the left* of the object Y", and "object Z is *above* the object Y", in order to derive that "object X is *at the left* of object Z", it is needed to know the second order relation between the relation "at the left", and "above".

The *general definition* given by me for the deductive reasoning is as it follows:

A deductive reasoning is a thinking (conscious or unconscious) process by which the truth value of a propositional (relational) variable[2] is established (determined, derived) based on the known truth value of other propositional (relational) variables and the knowledge regarding their systematic relationships.

EXISTING THEORETCAL APPROACHES AND MODELS OF THE DEDUCTIVE REASONING PROCESSES

Numerous theoretical accounts were given by psychologists in their quest to understand the deductive thinking, which could be systematized in various ways, using multiple criteria. I am proposing the following classification scheme, partially synthesized in Table 1.

The current stage of the empirical and theoretical knowledge regarding deductive thinking obtained within the traditional framework of the cognitive psychology is suggested particularly well by the following conclusion of a recent study written by Evans (2006b):

> *"If the conscious, analytic system is at best only partially in control and in competition with not one but several implicit systems, how come everything works so well? Understanding how generally adaptive behavior can result from such an apparently chaotic cognitive architecture is one of the great challenges for cognitive science" (Evans, 2006b, p. 206).*

It reflects the impasse the deductive reasoning research has reached. Evans (2006b) himself acknowledges that, in the light of the accumulated evidence. He questions himself about the assumed properties of an integrative theory of deduction with two stated reasoning systems, and claims even that "it is far from evident at present that a coherent theory based on two systems is possible" (Evans, 2006b, p. 206). In my opinion, Evans (2006a) is heading toward a theoretical position in which there is no clear separation between an information interpretation phase and a conclusion derivation phase. Instead, it might be that derivation is obtained through interpretation. By recognizing that distributed processing is fundamental for reasoning, a step is made by Evans (2006b) in the direction of an approach of the deductive thinking from a dynamic perspective. It is a third main theoretical approach of the deductive reasoning, which only relatively recently has coagulated itself in cognitive psychology" (Evans, 2006a, p. 392), as he feels that other cognitive psychologists involved in the deductive reasoning research have doneseveral principles and has attracted attention as a possible alternative view in comparison with the traditional ones. It is centered on notions such as dynamic system[3], attractor structures[4] in its state space, interaction, coupling[5], catastrophic bifurcation[6], coordination, emergence, competition and cooperation.

---

[2] A propositional variable is a variable referring explicitly or implicitly (in the case of the formal propositional reasoning) to a kind of relation.

[3] A **dynamic system** is a system composed of one ore more *dynamic variables* (variables changing in time) that reciprocally interact in real time (the change in time of variable's value is dependent on the change in time of the other variables' values) and the so called *control parameters*, values of some external variables who control the interactions between the dynamic variables. They are included as constant values in the system of (differential or difference) equations describing the way the dynamic variables interact (in which the dynamic variables appear as unknown variables).

[4] An **attractor i**s a state or a set of states toward which a dynamic tends to evaluate in time (converge) in the absence of disturbing influences based on its intrinsic dynamics. A *fixed-point attractor* is an attractor with a single attractive state. A

Table 1: *Traditional theories for deductive processes in cognitive psychology*

<table>
<tr><td colspan="3">I. THE SYMBOLIC COMPUTATIONALIST APPROACH AND ITS MODELS</td></tr>
<tr><td colspan="2">1. Information use theories</td><td rowspan="2">2. Information interpretation theories</td></tr>
<tr><td>A. Rules theories</td><td>B. Analogical theories</td></tr>
<tr><td>Syntactic models (Braine & Rumain, 1983, in Bucciarelli & Johnson-Laird, 1999; Rips, 1994, in Bonatti, 2002)</td><td>Mental models theory (Erikson, 1974, in Miclea, 1994; Guyote & Sternbetg, 1981, in De Vega, 1994; Johnoson-Laird & Byrne, 1991; Stenning & Oberlander, 1995, Schaeken, Van Der Henst, & Schroyens., 2006)</td><td>Conversion theory (Chapman & Chapman, 1959, and Revlin & Leirer, 1978, in de Vega, 1994;) or biconditional interpretation (Wagner-Egger, 2007)</td></tr>
<tr><td>Pragmatic schemas models (Cheng & Holyoak, 1985; Cosmides, 1989)</td><td>Case based reasoning models (Vosniadou & Ortony, 1989 and Toretzky & Hinton, 1985, in Sun, 1996)</td><td>Quantifier interpretation (Roberts, Newstead & Griggs, 2001; Geurts, 2003)</td></tr>
<tr><td>Heuristic rules models: atmosphere effect (Woodworth & Sells, 1935, in de Vega, 1994; Wetherick & Gilhooly, 1990, in Roberts, Newstead, Griggs, 2001), matching bias (Evans, 1998), probabilistic theory of reasoning (Chater & Oacksford, 1999), etc.</td><td></td><td>Gricean conversational principles, relevance theory (Sperber & Wilson, 1990)</td></tr>
<tr><td colspan="3">II. INTEGRATIVE THEORIES</td></tr>
<tr><td colspan="2">A. Unifying theories</td><td>B. Dual processes theories</td></tr>
<tr><td colspan="2">Isomorphism of the mental models theory and rules theory with an algorithm using Euler circles (Stenning & Yule, 1997)</td><td rowspan="3">Analytic vs associative/heuristic processes (Evans, 1984; Sloman, 1996; Stanovitch, 1999), explicit-implicit theory (Evans, 2006), cognitive neuroscience theories (Goel & Dolan, 2001; Goel, 2003; Goel, Shuren, Sheesley & Grafman, 2004)</td></tr>
<tr><td colspan="2">Integration of the syntactic and semantic information trough a process of successive recoding of the linguistic information (Polk & Newell, 1995)</td></tr>
<tr><td colspan="2">Competence (mental models theory) and procedural theories are interrelated components of a general theory of the logical meaning (Overton & Dick, 2007)</td></tr>
</table>

The dynamic approach is supported by researchers (for example, Van Gelder, 1998) who believe that the only way to link the cerebral processes with the cognitive processes is by adopting a common theoretical framework for both of them. Since it is admitted that brain is a complex dynamic system (as it is admitted also for almost any artificial neural network), the cognitive system should be studied as a complex dynamic system too, using similar conceptual and empirical tools.

So far, there are no fully fledged dynamic theoretical models as such dedicated to the deductive reasoning. But several authors (Grim, 1993, in Vezerides & Kehagias, 2005; Shastri & Ajjanagadde, 1993; Gärdenfors, 1994; Goertzel, 1994; Kentridge, 1994; Oaksford & Malloch, 1994; Sabelli, 1995; Eliasmith, 1996; Kataoka & Kaneko, 1999, 2000; Dimitrov, 2000; Raffone and Leeuwen, 2002; Tsuda, 2001; Breakspear, 2004) have made theoretical comments and proposals regarding the manner in which a dynamic approach could

---

cyclic attractor is a sequence of attractive states characterizing the convergence toward a cyclic behavior. A *chaotic attractor* is a set of attractor states having typically a fractal structure (a special geometrical structure with a fractional geometrical dimension, presenting self-similarity at all its scales). The trajectory of a dynamic system through such an attractive region is considered to be the result of two opposing tendencies: toward convergence into a set of states and toward divergence from them. Consequently, the chaotic behavior is characterized by a high level of nonlinearity, by sensitivity to the initial conditions (two trajectories leaving from two neighboring points become divergent in a very short period of time), and a limited predictability (in the absence of disturbing influences, a dynamic system with a chaotic behavior tends to remain indefinitely in the same predictable region of states, but in each moment it is another new, unpredictable, state of that region).

[5] Two *dynamic systems are* **coupled** when at least one dynamic variable of a system is control parameter for the other one.

[6] *A* **catastrophic bifurcation** is dynamic process by which the behavior of a dynamic system is qualitatively changed by changing the value of at least one of its control parameters

be useful, in general, in the reasoning study, making reference implicitly or, sometimes, more explicitly to the deductive reasoning case, too. They could be viewed to be sketches of some future more elaborated dynamical models accounting for the deductive processes, offering guiding principles in their development. The review of the existing studies from the scientific literature dedicated to the application of a dynamic approach in the reasoning research shows that the dynamic modeling of the deductive reasoning is only in an incipient stage.

Synthesizing the above mentioned contributions, the following ideas seem to be fundamental for the present dynamic approach of the deductive reasoning:

- *Deriving a conclusion requires the stabilization of a cognitive dynamic system into a dynamic structure* after receiving the input information given in the premises.
- A stable dynamic structure could be important for a deductive reasoning for two reasons: it brings coherence to the given data and it *allows the needed reduction of the degrees of freedom when selecting the answer for a deductive task through the constraints generated by dynamic interactions*. In the same time, the stabilization into in a dynamic structure with no guaranteed constancy in time (being vulnerable to noise or fluctuating due to an intrinsic dynamic in the case of cyclic or chaotic attractors) offers *an elegant way to explain the temporal fluctuations and the context-dependency in an individual's performance when solving a deductive task* and the obvious needed flexibility in approaching it.
- In order to facilitate a dynamical modeling of the deduction, the *classical notions of symbols*, *concepts, relations, rules or cognitive schemata* that are invoked in the symbolic computationalist models of the deduction *could be dynamically interpreted to be such emergent stable dynamic structures, having a meaning partially changed*. In fact, they represent rather conceptual tools to describe the dynamic deductive processes at a higher spatio-temporal scale, without the need to assume an external executive agent charged with the task of manipulating the symbolic representations and with that of applying symbolic rules. In such a theoretical framework, even the border between semantic and syntactic processes is erased.
- *The truth values of the statements or the semantic meanings involved in a deduction might be interpreted to define continuous or discrete dynamic variables, which evolve in time through their mutual interactions until a conclusion is generated.* The dynamics of the truth variables could be coupled with the semantic dynamics defined by temporally evolving meanings (at various levels of abstraction) of the concepts involved in a deductive task, *accounting for the interaction between the so-called syntactic and a semantic levels in deriving a conclusion.*
- *Logic in a dynamic context is conceived to be of a different type than the classical static logic, having changed principles*. Therefore, *the deduction is not any more explained in the terms of the constraints stemming from the classical logical principles, but in the terms of the constraints stemming from the definition of a dynamic system and its related concepts.* They are temporal constraints generated through the interaction between dynamic variables, and the competition for actualization of a state or dynamic structure to the detriment of another state or dynamic structure.
- A *temporal code for information at the level of the transition between states or the dynamic coupling between systems* (leading to relationships of synchronization), by its intrinsic properties could be beneficial for a dynamic modeling of the deductive reasoning.

- In explaining deductive reasoning *it would be preferable to assume the existence of at least two dynamically coupled systems that are operating on a micro and, respectively, macro spatio-temporal scale, which are able to control (by providing control parameters) the dynamic behavior of the other one*. Through this physical separation, it is possible that the circular influence existing between different levels of organization in what respects their dynamics to be altered and, consequently, controlled.

Synthetically speaking, in my view, the core of a dynamic approach of the deductive reasoning could be founded on a link between the definition of a dynamic system and the definition proposed by me for the deductive reasoning. *Through a dynamic system, the variation in time of one variable is bound to the variation in time of other variables, their way of bonding being controlled by some set values of other variables*. It is this property of a dynamic system which, in my opinion, is fundamental for an understanding of the logical processes if those processes are to be modeled dynamically. As it was stated before, in the general definition proposed for the deductive reasoning, deriving a conclusion means practically to determine an unknown value for a relational variable based on the values of some other variables. Since, in our mind, reasoning processes are not instantaneously, but take place in time, it might implicitly mean that the involved values are values that are changing in time.

Therefore, taking in view the above mentioned property of a dynamic system, it would be reasonable to assume that the values determined on a certain point in time through a deductive reasoning process for the variables included in a logical conclusion (for example, truth values or meanings) are the result of the evolution in time of a subjacent dynamic system in which they are included as variables together with other relevant variables (such as those whose values occur in the stated premises).

As a consequence, it could be said that the time at which an involved dynamic variable takes a certain value has a cognitive significance (Van Gelder, 1998), directly contributing to the result of the considered cognitive process given the temporal constraints expressed by its inclusion in a dynamic system.

PROPOSAL OF A SCHEMA-BASED DYNAMIC MODEL OF DEDUCTIVE REASONING

As it could be noticed in the previous section, a major drawback of the present dynamic approach of the deductive reasoning is that, in spite of some attractive and compelling theoretical arguments on its side, it lacks a substantial link with empirical findings regarding the human deductive reasoning performance and the existing symbolic theories. My supposition is that the reason for this state of affairs is that the existing studies are either too general and unsystematic (stating some principles of such an approach), or too particular (being focused on the issue of finding an adequate architecture for a dynamic network capable of a particular deductive performance). Unlike them, my theoretical proposal of a schema-based dynamic model of the deductive reasoning *is placed at a rather intermediate level of analysis*, assumed to be more useful for designing empirical studies, or for the interpretation of their results. Its conception is rooted in several underlying ideas.

In the first place, the proposed model was *centered on the notion of cognitive schema* because I felt that it might represent a conceptual bridge between the symbolic models of the deductive reasoning and the theoretical suggestions of a dynamic approach of the deductive reasoning. Schema notion is spread over the entire domain of the theoretical endeavor with deductive reasoning, and yet, its primordial importance has not been recognized as such explicitly, remaining a background intuition. Still, other notions as rules and mental models as representational formats continue to be in the forefront of the deductive research.

An integrative definition for the notion of dynamic cognitive schema

a. Dynamic schema as a dynamic representation

In the first place, a dynamic schema has all the usual properties ascribed to a dynamic representation. The most important one is that *it corresponds to a state or a set of states from the state space of a dynamic system defined by their stability, and having a representational function by its dynamic coupling with the external represented systems*. *Stability* of a representation is a functional property, derived from the intrinsic dynamics of the underlying dynamic system. A state (or a set of states) is said to be maximally stable if it has an *attractive power*. It is reasonable to think that a cognitive schema, as an abstract representation, could be put in relation with the stable states or sets (configurations) of stable sets of a dynamic system.

b. The dynamic properties of a dynamic cognitive schema

1. *Stability of a dynamic schema*

This property lacks in a symbolic account of the schema notion.

More precisely, on the one part, stability of a schema means:

- that the *actualization of a schema is differentially resistant to noise effects*: different intensities of noise (disturbing, unspecific stimuli or changes in the control parameters) are needed in order to move away a dynamic system from a stable state correspondent to a cognitive schema to neighboring states (states from the state space having a partial resemblance to the sate of the cognitive schemata). When a system is moved from the state of a schema to a neighboring one, phenomenally it may appear as if that schema is partially actualized, with only a few of its elements.

- the *power of a schema to attract back the system into its region*, reflected in the: a) *speed of this return* and b) in *the size of the region from the state space within which such an attractive power is exerted* (how dissimilar a distant state must be from which the system still tends to evolve toward the states of that schema). In traditional terms, it would mean the number of indices (cues) needed in order to actualize a schema, if those indices are interpreted as the common part between an initial state and the final schema state.

- when it represents a stable set of states (cyclic or chaotic attractors), *a more or less regular pattern of fluctuations in time of its states, resulting phenomenally in the occurrence or the disappearance, at more or less regular time intervals, of some of its elements*.

2. *The effects of the recent past on schema actualization*

The most important change of perspective introduced by a dynamic perspective is the importance ascribed to the temporal context or to the recent past history in the evolution of the underlying dynamic system in determining the actualized schema in a certain moment of time. Recent history determines the future evolution of a dynamic system in several ways:

- if a system has been recently in a region closer to a stable state than to another one, the chances that finally the system will be stabilized in the first one are increased.
- when a schema is represented by a cyclic set of states, the determination of the value of one of its variables at a certain moment in time (when the values of the other ones are known for that moment) will also depend on the recent direction of evolution of the system within the set of stable states.
- the dynamic structure (or schema of schemas) in which a dynamic system will be stabilized when a control parameter is changed will depend on the recent values taken by that control parameter, i.e. on the direction and the continuity of the change of that control parameter.

Phenomenally, the effect of the recent past on a schema actualization leads to the expectation of ***the occurrence of order effects*** in what respects the previously actualized schemas or triggering cues for a schema.

c. A synthetic definition of a dynamic schema

Trying to give a synthetic and intuitive definition for the notion of dynamic schema, I will use the more familiar and concise term of pattern, since a pattern, as a configuration of values, is conceived to correspond to a point in a state space (Gärdenfors, 1994).

Taking into consideration the above mentioned note, the resultant definition is:

A dynamic cognitive schema is simultaneously a representational and processing structure that resides in a temporal pattern (configuration) of patterns, endowed with a degree of stability in time, placed at a higher level of abstractedness (a higher spatio-temporal scale, in which the degrees of freedom are decreased) and through which expectations are generated by dynamic processes of pattern completion involving the stabilization of a dynamic representational system into that pattern.

d. Conclusion

A dynamical point of view brings to the research focused on the cognitive schema notion a natural and coherent way to conceive its necessary and defining flexibility, or dynamism. It succeeds that by providing underlying processes of a dynamic type that do not restrict a schema dynamicity by forcing it into an unfit symbolic framework. Apart of an external dynamism (at the level of the interaction between schemas), which could be symbolically simulated in an awkward, cumbersome, manner, a dynamic approach endows a cognitive schema with an internal, essential, intrinsic dynamism that is lacking in its symbolic interpretation.

Although it has some characteristic properties as pattern of patterns, a schema is still a pattern. Therefore, its implication in the higher cognitive processes should have an important methodological consequence. It might provide a bridge through which it is reasonable to borrow research strategies (involving a dynamic theoretical underpinning) that were successful in studying the patterns at a perceptual and action control level in order to study cognitive processes at a higher level.

Dynamic reasoning schemas in deductive processes

A. General assumptions

Applied at the level of deductive reasoning, the general notion of dynamic schema needs some supplementary assumptions regarding its specific properties and regarding the reasoning process in this particular context.

a) The first general assumption is that a dynamic deductive schema is primarily a *dynamic structure of a semantic space* endowed with a characteristic dynamics. Its *actualization is presumed to be dependent on semantic features* with *logical meaning*.

b) The second general assumption is that a deductive schema is *centered on a cognitive goal,* representing a class *of argumentative experiences linked with that cognitive goal.* When a deductive task is similar with the argumentative experiences in which that deductive schema emerged, its actualization should be more likely to occur.

c) The third assumption is that during a deductive process *several kinds of dynamic schemas, at several levels of organization and with different cognitive goals, may be involved*, and that *the result of a deductive reasoning is dependent on the result of their cooperation or competition.*

B. Assumed types of dynamic deductive schemas

Using as a criterion the level of abstractness and generality of their cognitive goal, three main types of dynamic deductive schemas are assumed, as a rough approximation describing the multitude of dynamic deductive schema that it is possible to exist.

1. Deductive dynamic schemas on a basic level (elementary spatio-temporal schemas)

The following properties are ascribed to them:

- They are assumed to be *the most frequently encountered in the usual everyday thinking,* having consequently *the highest basic stability*.
- Their *cognitive goal* is mainly *directly linked with concrete actions*: a) *orientation in space and time* (deriving the relationship between points in space or time); b) *finding out the physical relationships between concrete objects* or group of objects.
- They are supposedly *emergent early in the cognitive development*.
- They are supposed to be the most stable deductive schemas.
- The most probably, they would be *correspondent predominantly to the traditional relational deductions.*
- The *dynamic neural networks* in which they are represented are placed on the *lowest level of organization*.

A *typical example of* such a schema would be one *of route finding*.

2. *Deductive reasoning dynamic schemas on an intermediate level*

The following properties are ascribed to them:

- They are centered on *more abstract pragmatic cognitive goals*, being only *indirectly linked with concrete actions* and more directly with *actions with abstract mental "objects*": concepts and their relationships, or events and their relationships, or social relationships. Their aim is to find out new relationships in such more abstract domains of action, involving representations on a higher spatio-temporal scale.
- They are *rather frequent*, since the situations in which their cognitive goals are encountered are supposedly rather frequent, although not the most frequent. Consequently, *their basic stability should be, also, at an intermediate level*.
- It is reasonable to assume that *they are placed on an intermediate level of organization of the cerebral semantic dynamic network*. At this level, *new semantic properties with logical relevance are presumed to be emergent contributing to the generation of such deductive schemas*.
- *Developmentally*, it is reasonable to assume that they are *generated later than the deductive schemas of the basic type*.

Examples of such schemas would be the *pragmatic reasoning schemas* (Cheng & Holyoak, 1985), discussed in a previous section in what respects the hypothetical reasoning (permission or obligations schemas), or some pragmatic reasoning schemas for the syllogistic reasoning (proposed and discussed in more detail in a future section). There may be also pragmatic schemas for the relational reasoning such as finding kinship relationships.

3. *Dynamic deductive reasoning schemas at the highest level*

The following properties are ascribed to them:

- They are *centered on abstract, analytical, purely cognitive or metacognitive goals*, aiming *to exhaustively identify virtual possibilities* (of interpretation, or of evolution of a given situation etc.). I named them *combinatorial schemas* because they require the identification of all the relevant potential variables involved in a given situation together with their potential values and then the identification of the allowed relationships between these values given a set of constraints. Usually, they may have as a cognitive goal finding out that a relationship is a necessary one, no matter the context and content of a deductive task.
- They are supposedly *rather infrequent in the current, day to day, life,* being encountered especially in the context of a formal education or scientific argumentation. Therefore, it is to be expected that they have, statistically speaking, *the lowest stability*. They might be needed especially for those new situations in which a substantial pragmatic experience is lacking.
- Developmentally, they are *supposedly the latest*, requiring that the people to get used with the logical "objects".
- They are *assumed to be placed at the highest level of organization of the cerebral dynamic network* underlying them. At that level, representations for extremely general and abstract categories such as variable, constant, combination, necessity, possibility, exhaustiveness, etc are presumed to emerge.

It may be the kind of schema envisioned in formal reasoning, the mental model theories or mental logic theories of the deductive reasoning.

D. Derivation of a conclusion as a pattern completion process

Derivation of a conclusion based on the winning dynamic deductive reasoning schema is suggested to be similar with the one envisioned by Haken (1995) in order to dynamically interpret pattern completion. His synergetic model was elaborated for perceptual processes, as well as for decisional ones in which the available information is incomplete or conflictual. It could be extended to the deductive reasoning in the degree that it is based on dynamic processes involving complex dynamic systems. In a similar vein, it could be said that in a deductive reasoning, premises offer incomplete information. The task of the reasoner is to complete that information based on a learned schema (pattern). But she/he will be confronted with a choice task if several schemas are compatible with the given incomplete pattern, in case this is an ambiguous one. And that choice task could proceed in the same manner as in the model of Haken (1995). In other words, ***the same dynamic phenomena occurring at a perceptual level should be apparent also at higher levels of the cognition***. ***Only that in this latter case, the task is to recognize or complete (i.e. recall) patterns of patterns.***

E. The temporal course of a deductive reasoning process

I. As the given information is coming, *subordinate dynamical patterns (corresponding, for example, to the meanings of the words) are actualized*, guiding (organizing) the receiving of the new information and the search in memory, or trough the currently available information..

II. The actualized subordinate dynamical patterns lead to the *actualization of one superordinate dynamic deductive schema (pattern) that has won the competition* with other superordinate dynamic schemas.

III. The recognition of a dynamic stable deductive schema that integrates and brings coherence to the relevant given and recalled information would allow *the occurrence of a conclusion based on a pattern completion process*. The missing part will be provided maybe by its salience in comparison with the already existing part.

IV. If there are *no available deductive actualized schemas in the given context*, then a *"no answer" will be given*, or *an answer based on memorized information* (if there is some relevant factual knowledge available) or on a *guessing strategy* will be generated.

H. Predicted dynamic phenomena in deductive reasoning

The dynamic phenomena foreseeable to occur in general in what respects the abstract patterns of patterns, have a correspondent at the level of the deductive reasoning schemas. Some of them are important in what respects their potential to lead to testable predictions. In what follows, such predicted dynamic phenomena at the level of deductive schemas are enumerated.

1) *Dynamic deductive reasoning schema should be differentially disrupted by noise* (information irrelevant for the actualization of an appropriate deductive schema, the presentation format, attention fluctuation,

distractors), in accordance with their level of stability. Consequently, the performance of the deductive reasoning will be differentially affected by the same level of noise: some deductive tasks should continue to be completed successfully almost all of the time, but for some of them, the performance will be fluctuant.

2) *The stability of a dynamic deductive schema should depend on the frequency with which the experiences that could lead to its emergence by learning are probably encountered*. It is hypothesized that *the probability of encountering such experiences should be positively related with the importance of the cognitive function* in the everyday life of that kind of cognitive situations related to a dynamic deductive schema.

3) A *dynamic deductive schema has two components of its stability*. One is given by *the level of dissimilarity of a deductive task with the experiences (cognitive situations) underlying its emergence* that still leads to its actualization. It is a stableness reflected in the breadth of its attractive domain. The greater the dissimilarity, the more stable the schema is. The other one is given by *the level of distraction (noise) needed in order to disrupt the performance* in a deductive task that is solved based on that dynamic deductive schema. The higher the level of noise, the more stable is the deductive schema.

4) In tight relationship with the previous point, it is hypothesized that for those *schemas that are more stable* (in what respects the both components of their stability), *fewer triggering cues are needed in order that they can get actualized*, leading to a successful completion of a deductive task. Consequently, *the higher the cognitive function of a type of reasoning, the more easily should be triggered its dynamic deductive schema*.

5) For *the most stable deductive schemas* (probably the ones having the highest cognitive function) should occurr a *ceiling effect*, as in pattern recognition. In other words, adding new conditions that are in general favorable to the actualization of a deductive schema (a characteristic format of presentation of a deductive task, the thematic content etc.) beyond a certain threshold should not lead anymore to a notable improvement in performance.

6) *Order effects* should occur, in the sense that the performance in a *deductive task will be affected (positively or negatively) by the completion of other preceding deductive tasks*, due to the cooperation or the competition between the deductive schemas actualized during their completion. There are possible the following two situations:

- if a deductive dynamic schema is actualized in a previous task, then the performance in a subsequent deductive task requiring the same schema should be probable improved in comparison with the situation in which there is no previous deductive task.
- if in a previous deductive task it was actualized another kind of deductive schema that is in competition with the deductive schema needed to complete the current task, then it should be statistically probable to occur detrimental effects in what respects the performance in the current task (when the needed deductive schema is not so stable).

It is foreseeable that the order effects should be not so salient for those deductive tasks with very important cognitive function (very stable corresponding dynamic schemas).

7) The performance in a deductive task requiring a deductive schema that is not so stable should be higher if it is not preceded by deductive tasks requiring extremely stable deductive schemas (with the highest cognitive function). It is *another kind of order effect* linked with the *differential probability of the transition between a stable pattern toward one that is not so stable in comparison with the reverse transition*.

8) If the information presented at first in a deductive task is able to actualize another deductive schema than the one required for the completion of the task (entering in competition with it), then it is expected a deterioration in the performance of the current task. In other words, it is *another kind of order effect*, linked with the *order of the information given in the premises*.

9) *Order effects* should occur in what respects *the order of the information presented in premises* caused by the *level of similarity between this order and the temporal pattern of the required deductive schema* in order to solve a deductive task (for exemple the order of the terms in a reasoning process based on transitivity).

10) For the deductive tasks requiring *deductive schemas that are not so stable* (having a lower importance of their cognitive function), it is expected that *their inter- and intraindividual level of performance variability to be higher in comparison with those deductive tasks requiring schemas that presumably have the highest cognitive function*.

11) A dynamic deductive schema has a) a *basic stability*, given by the importance of its cognitive function and the level of its learning, and b) a *relative stability* given by the recently actualized deductive schemas and/or the competing deductive schemas currently supported by the information given in the context of a particular task.

12) There should be a *nonlinear relation* between the *stability of a dynamic deductive schema* of a deductive task and *the performance of a deductive task requiring a similar deductive schema* that is not stable enough in comparison with the first one. The prediction is that an *intermediate level of stability* of the more stable of the two should lead to *the highest performance* in the deductive task requiring the less stable one. One reason could be the fact that if a schema is stable enough, there are higher chances to be entirely actualized, with all its distinctive features needed for its recognition, in comparison with a less stable one. A less stable one would have higher chances to be only partially actualized, with only a few of its distinctive features. Therefore, as in the perceptual recognition, a stable schema should allow an easier distinction between the situations in which its actualization is adequate and the situations in which it is not. In other words, the chances of confusion with the patterns of other schemas are lowered. Instead, when a schema is partially activated due to its low stability, the chances of confusion with similar situations requiring another, even less stable, schema should be increased. But when a schema is extremely stable, and the information to be organized and integrated is ambiguous, allowing multiple interpretations, then it should be expected that it will "enslave" it in accordance with its pattern of organization. In that way, the chances that a more adequate, but less stable, schema to impose its structure onto the data are lowered.

13) There should be a nonlinear relation between the average level of performance in deductive tasks and the average level of stability of the abstract cognitive representations. The *highest deductive performance is expected for an intermediate average level of stability of the abstract cognitive representations*, no matter their content. The general reason is a presumed trade-off between the flexibility and the stability (rigidity) needed in order to complete a task at higher level of performance, dependent on the criteria used to asses the performance. But, on the average, it is reasonable to assume that the performance will be the highest when there is equilibrium between flexibility and stability. More particularly speaking, from a dynamic point of view, there should be three reasons for the demand of an intermediate average level of stability for the patterns involved in cognitive processes:

- The excessive stability of some acquired patterns (by overlearning them) will lead to costs and to a lower performance in those tasks requiring flexibility or necessarily involving patterns with a lower stability (insufficiently learned).
- The more stable one pattern is, the less able should be to cooperate with other patterns in order to generate (on a higher level of organization), through emergence, the superordinate pattern needed in order to complete a class of tasks. Instead, it will tend to compete with them, or to subordinate or recruit them, inadvertently interpreting or organizing the new received information. But it is not preferable to have a too low stability either, because that it would mean that the resultant superordinate pattern will be also rather unstable, resulting in a lower performance.
- A too stable wrong pattern, inadvertently actualized by some early triggering cues, would block or delay the actualization of the expected pattern needed in order that a task to be correctly completed. On the other part, a pattern necessary for completing a task with a too low stability it is likely to be defeated in the competition with other patterns actualized by the already received information.

Therefore, it is to be expected a nonlinear relationship between the average level of stability of the cognitive patterns and the average level of performance in deductive tasks. My hypothesis is that, given the characteristics of the cerebral dynamic system of an individual in a particular context and her/his educational environment, there could be defined such an average level of stability of her/his cognitive representations. It would be like *an order parameter (as it is temperature for gases) describing the general dynamic state of her/his cerebral dynamic system*. It is assumed that the average level of stability of the existing cognitive patterns will define the *average width of what at a phenomenal level would seem to be an information temporal window for the integration of the received information*.

I. The integrated dynamic model for the deductive reasoning and its general assumptions

The main parts of the proposed model are represented in two diagrams in Figure 1 and Figure 2.

General assumptions of the proposed schema-based dynamic model of deductive reasoning

As it can be seen in Figure 1, there are made some suppositions that are considered to be intuitively and logically plausible.

a) From the very start, it is assumed that *deductions could have specific cognitive functions, other than the general ones of finding the truth value of a conclusion*, or to find the logical necessity of the truth value of a derived conclusion[7].

[7] Generally, with only a few exceptions (for example, Cheng & Holyoak, 1985), researchers believe that there is only one cognitive universal goal served by the deductive processes, ignoring the consequences of the fact that deductive reasoning is immersed in the daily cognitive activity of one kind or the other.

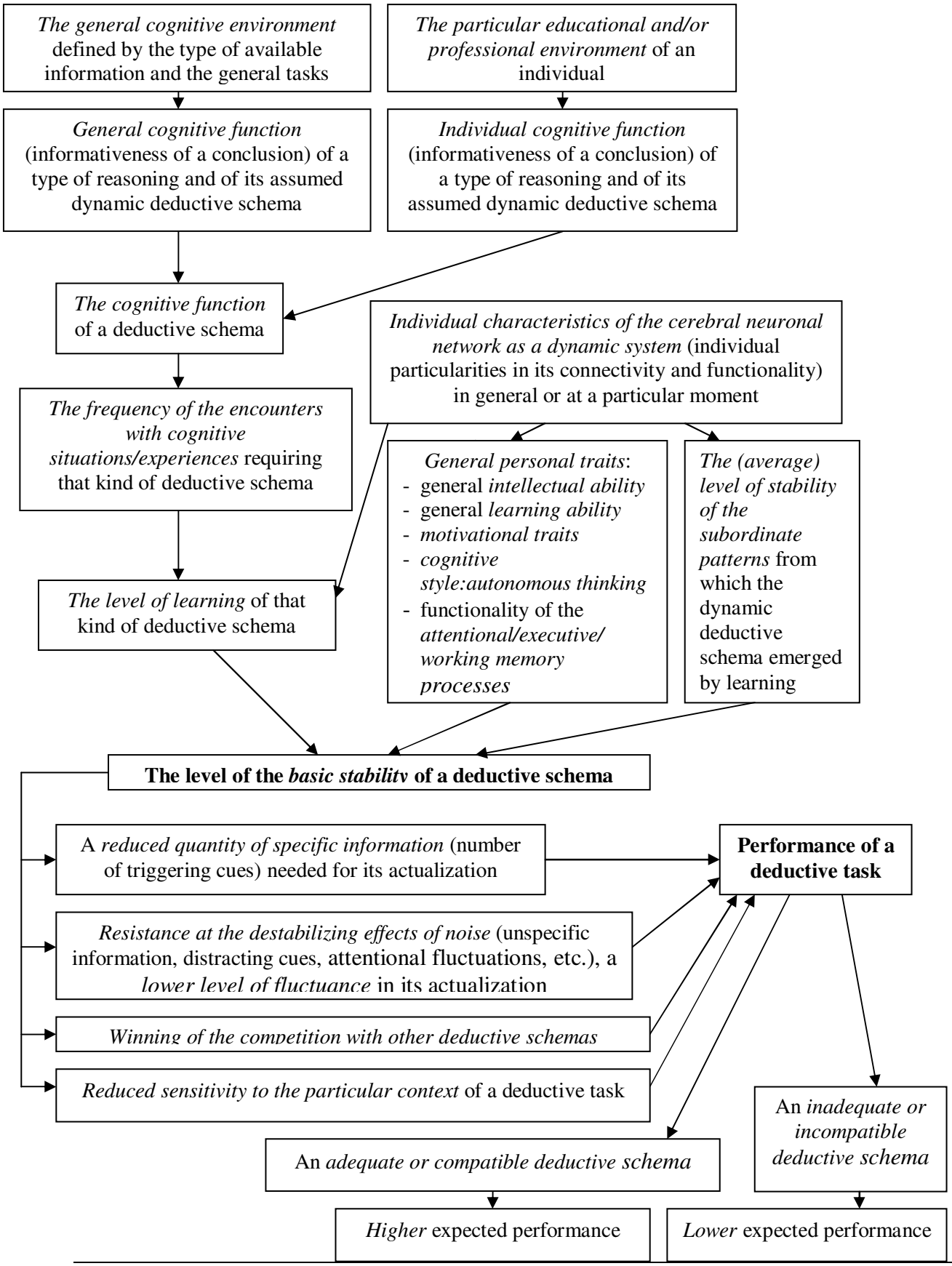

Fig. 1 *The factors determining the basic stability of a dynamic deductive schema and the consequences of its basic stability relevant in general for the performance in a deductive task*

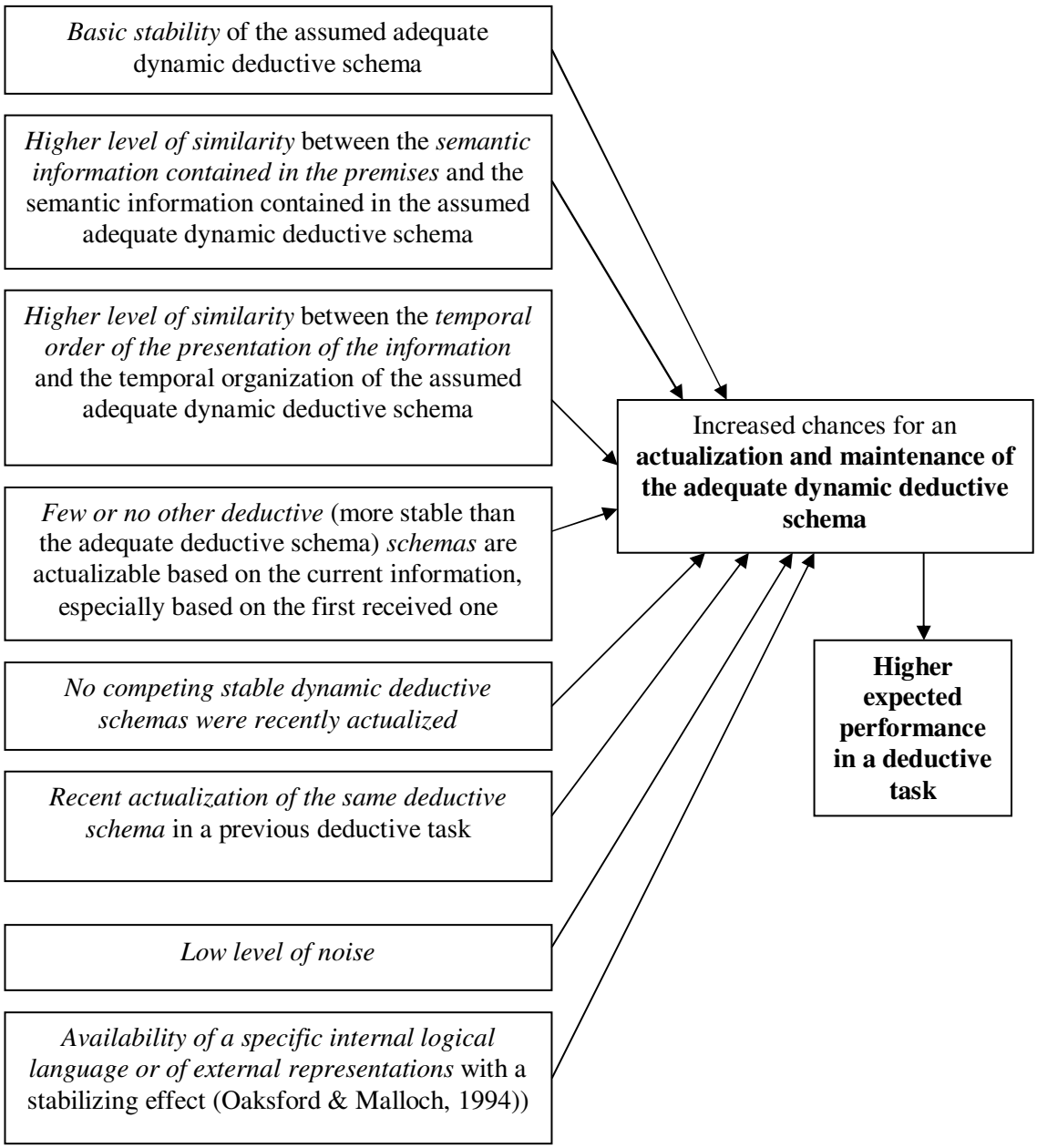

Fig 2*. The factors that are beneficial from a dynamical point of view for the successful completion of a deductive schema*

b) There is a tendency to think that people have a general logical competence and logical goals that are adapted by them to some particular circumstances and specific cognitive goals. The view supported in the proposed model is that it may be the other way around. *At the beginning, there are reasoning schemas built around specific, pragmatic, goals. Progressively, these goals become more general, more abstract, with a more salient cognitive nature.* Finally, under the influence of the formal education or the demands of a profession, people would adopt the goals stated to be important by the logicians.

c) The *cognitive goals* around which deductive schemas are built *are defined and assessed in what respects their importance by the characteristic environment of an individual*. Still, another related general criterion might be stated in what respects the importance of a cognitive goal fulfilled by a deductive task: the level of informativeness of its conclusion. The specific environment of an individual will adjust that general hierarchy.

d) It is logically plausible that *the general importance of a cognitive goal o*f a deductive task *should be reflected in the frequency with which a person encounters experiences/situations that have such a cognitive goal.*

e) It is reasonable to assume that *higher chances to encounter a class of experiences should lead to a general higher level of learning the assumed dynamic deductive schema associated with that class of experiences*.

f) The *higher level of learning of a deductive schema, the higher should be its stability*.

g) The *level of learning of a deductive schema is dependent also on some general individual traits that are widely known to influence any cognitive activity*. It is plausible that such general traits define some interactional styles with the informational environment. For example, such traits could be the autonomous thinking, as it will be investigated in the empiric part of this thesis, or other cognitive styles, as the level of cognitive complexity or the oligarchic type of thinking (Macsinga, 2001, 2007). Such traits may be also associated with some yet unspecified characteristics of the cerebral network as a dynamic system. A supposition of mine is that such a characteristic might be a general intermediate level of stability for all the representational patterns on a certain level of organization (as a state or trait individual characteristic). So, the stability of a superordinate pattern (schema) should be dependent on the stability of the patterns from which it emerged, which are placed on a lower level of organization. My fundamental presupposition is that deductive reasoning is a dynamic process sunk in the general dynamism of the entire psychological system and of its physical support, with which it is dynamically linked. When the stability of the subordinate representational patterns is excessive, the emergence of a superordinate pattern corresponding to a dynamic deductive schema should be impeded or delayed. When the stability of the subordinate representational patterns is too low, it should be relatively easy that a superordinate pattern corresponding to a dynamic deductive schema to emerge. But its stability will be extremely low, too. So it will soon vanish, as mere a transient dynamic structure.

J. A dynamic pragmatic deductive schema model for the categorical syllogisms

The empirical verification of this sketched model for the deduction in general would be a life time endeavor. That is why I have chosen to find supportive empirical results only for some of the segments of the model, for some of its predictions, by focusing the research on only one type of reasoning: categorical syllogism.

The choice of the syllogism case had several *theoretical and pragmatic reasons*:

- In comparison with the hypothetical reasoning, *there is no pragmatic schema theory formulated in its case*, and no empirical evidence in that respect, whatsoever.
- In *comparison with the relational reasoning, syllogistic reasoning has a higher level of complexity*, from many points of view. In a way, it is an integrative, paradigmatic, kind of reasoning, because it partially involves propositional (when the relations between its judgments are considered) and relational reasoning (when transitivity is used), too.
- It is a kind of reasoning that *necessarily a semantic approach* (Didilescu and Botezatu, 1976), being irreducible to a formal approach as it is the case with the propositional reasoning.

a. General assumptions

1) This model is designed ***for the case of people untrained in formal logical reasoning, having a limited experience in that respect***.

2) The *fundamental assumption* of the model is that, in their case, syllogistic tasks are completed usually (most frequently) a) at *an intermediate level of abstractedness*, b) based on several dynamic pragmatic deductive schemas, c) built around characteristic cognitive goals d) that are associated to a class of cognitive (argumentative) experiences/situations.

3) All of the *assumptions of the general dynamic schema-based model of the deductive reasoning are valid, also, in this particular case*.

b. Specific assumptions regarding the cognitive function of the four syllogistic figures and the semantic logical content of the correspondent syllogistic schemas

The *general framework has to be completed with the specification of the cognitive goals and with suggestions regarding the semantic content of the assumed dynamic deductive reasoning schemas*. I found in the work regarding the natural logics of three Romanian logicians the needed theoretical ground in order to complete such a specification, assuming that characteristic *pragmatic dynamic syllogistic deductive schemas correspond to the four syllogistic figures*.

1. Cognitive functions of the syllogistic figures

As it is known, syllogisms could be grouped in four major categories taking into consideration the position of the three syllogistic terms in the premises. If the two extreme terms of a syllogism are symbolized by **S** (for the term playing the role of the subject in conclusion), respectively **P** (for the term playing the role of the predicate in conclusion), and the middle term by **M**, then the four types of syllogisms could be schematically represented as follows:

Fig. 1:	**Fig.2:**
Premise 1: M-P	Premise 1: P-M
Premise 2: S-M	Premise 2:S-M
Conclusion: S-P	Conclusion: S-P
Fig. 3:	**Fig.4**
Premise 1: M-P	Premise 1: P-M
Premise 2: M-S	Premise 2: M-S
Conclusion: S-P	Conclusion: S-P

Given that each premise or the conclusion could be of four types (A, E, I, O), as it was specified in a previous section, then a particular syllogism could be noted by the symbols of the judgments from the premises and conclusion adding the number of its figure. For example, the syllogism named in classical logics as *Barbara*, having as premises and conclusion only universal affirmative judgments will be noted with AA1A.

In Didilescu and Botezatu's (1976) view, the study of the syllogistic reasoning is irreducible to class relations, as it is usually considered to be from formal reasons in logics, and from mimetic reasons in psychology. Instead, it necessarily involves both intensional relations (between classes and their properties), and extensional relations (between classes). They plead for a mixed syllogistic semantics, pointing out that syllogism needs in order to be properly understood, in its entire real complexity, both a class interpretation and a predicative interpretation (in terms of attributes or properties).

In a more essayistic work, Noica (1986) proposed a new classification of the judgments in six categories, based on their specific pragmatic function, and consequently he defined a specific cognitive function for each syllogistic figure.

In a shorter and integrative version, synthesizing both the suggestions made by Didilescu and Botezatu (1976) and by Noica (1986), the *cognitive goals* for the three most important syllogistic figures might be the following:

- **Figure 1**: To determine *if a group of cases of interest (i.e. a subclass) has or not in its entirety a certain property*.
- **Figure 2**: To determine *if two classes (subclasses)/categories are mutually exclusive in order to impede a falsely alleged or unwarranted subordination (inclusion) relation between them.*
- **Figure 3**: To *determine that a category is defined or not accidentally/circumstantially by a property or, in other words, that that property is not a necessary one (as it was presumably initially supposed).*

It should be noted that, in identifying the cognitive functions of the three syllogistic figures, the logical, the formal, distinction between universal and particular judgments loses its importance. Although, logically, two judgments may seem identical (are of the same type: A, I, E, or O), they might have a distinct functional utility and informativenees (informational gain), based on the meaning of their terms.

2. The order of the cognitive importance of the syllogisms

i) *The order of the cognitive importance of the valid syllogistic figures*

The three cognitive functions could be *ordered in what respects their general importance* by supposing that it is positively linked with the *informativeness (informational gain) of the allowed conclusions in each syllogistic figure*. From this point of view, their decreasing order should be figure 1>figure 2 > figure 3. It is to be noted that the difference between the figure 1 and figure 2 is not so salient, and, therefore, it might become insignificant for particular cases and contexts. Figure 2 and figure 3 syllogisms supposedly have a more salient counterargumentative significance, pointing out the exceptions, the particular cases that have been previously ignored. They are, in the same time, placed at a more abstract level because they are focused not on the description, definition at an individual level (as figure 1 syllogisms), but on the status of a relationship: if it is warranted or not (figure 2 syllogisms), or if it circumstantially or not (figure 3 syllogisms).

Synthetically speaking, it may be said that figure 3 syllogisms are less important cognitively because they determine the truth of a circumstantial relation, in comparison with the figure 1 and figure 2 syllogisms in which the truth of an absolute, context-independent relation is determined. On the other hand, figure 1 syllogisms may be somewhat more important than the figure 2 syllogisms. This statement is grounded on the assumtion that the intensional relationships between individuals and their properties are pragmatically important more frequently than the extensional relationship of subordination between classes. Moreover, through the conclusion of the figure 2 syllogisms no definite such extensional relationship is established, but only that there is not one.

ii) *The cognitive importance of the valid syllogisms within a particular syllogistic figure*

Also, within a syllogistic figure may be a hierarchy in what respects the cognitive importance of the conclusions from that figure, based on their informativeness (Chater and Oaksford, 1999). The four types of judgments would have the following partial order: A > E = I > O.

Consequently, in what regards the possibility to order all the valid syllogisms by their cognitive importance intervenes a complication, since there are two interacting factors to be considered and overlaps are therefore possible.

iii) *The reduced cognitive importance of the invalid syllogisms*.

The invalid syllogisms *do not have probably a cognitive function* in most of the circumstances. The *reasons are* the following:

- It is *cognitively and pragmatically unimportant to state that nothing could be determined for certain based on the given information*. The *exception cases* might be when a person has *counterargumentative purposes* aiming a) to fight against a false conclusion or assumption or b) to check if it is an unwarranted one. But such cases are presumably rarer and less important pragmatically than the ones involving valid syllogisms.

- The *relevant deductive processes are more abstract, being placed at a metalevel, linked with the logical status of a semantic relation*.

There may be *some typical situations, more frequently encountered, in which invalid syllogisms are more easily solved*. For example, when the two premises are particular judgments or when both are negative judgments. *Maybe these are the cases in which their level of dissimilarity with any of the valid syllogisms is extremely high, and, therefore, an inadequate assumed dynamic deductive schema for a valid syllogism is less likely to be wrongly actualized*. But even in those cases, there are persons who err, deriving a positive conclusion. A hypothetical reason for that is that they specifically interpret only the relations stated in the premises and not the meaning of the syllogistic terms, especially when more stable elementary relational dynamical schemas are actualized by the given information.

In conclusion, it is to be expected *a validity effect*: valid syllogisms are more important cognitively than the invalid ones.

Conclusion

The proposed dynamic model of the deductive processes was conceived at three levels.

1) The *general level*: Deductive processes are assumed to imply the interacting evolution in time of several dynamic variables linked with the meaning of the syllogistic concepts and judgments. Deriving a conclusion is seen as a process of completing an abstract dynamic pattern (dynamic deductive schemas) that synthesizes the experience with a class of argumentative experiences having a common cognitive goal.

2) The *intermediate level*: The general types of deductive schemas (spatio-temporal, pragmatic, or combinatorial) are specified based on the general level of abstractness of their characteristic cognitive goals. They are assumed to be emergent on different levels of organization of the subjacent dynamic structures and to

be in permanent interaction from this reason. The expected dynamic effects and phenomena are stipulated: content, order, task format effects, stabilizing and destabilizing factors.

3) The *particular level*: The elaboration of particular models for the conditional and syllogistic reasoning in the case of the reasoners without training in formal logic, by specifying the possible cognitive functions of theirs various types and the semantic content of their assumed deductive schemas.

PARTIAL EMPIRICAL VALIDATION OF THE DYNAMIC SCHEMA-BASED MODEL ON THE SYLLOGISTIC REASONING CASE

In order to check some of the predictions of the proposed general dynamic schema-based model in what respects the expected type of effects enumerated previously, I carried out a series of empirical studies. In the same time, these studies are aimed to verify some of the presumed relationships from the dynamic schema based model of deductive reasoning in the particular case of the syllogistic reasoning. Of the six studies, due to space limits, only five of them will be presented more extensively in this abstract, the experimental ones. For the first one, a correlational study, because of its complexity and length, only its mai results will be presented shortly.

Methodological considerations

1. **The main objective**

The main objective of empirical research was *the prediction of the effects of a certain task format, content, argumentative context or individual difference on the performance of a deductive task*, rather than a post facto explanation of some obtained frequencies of the correct and incorrect answers, without paying much attention to the conditions in which they were obtained. Such a methodological strategy can be encountered occasionally, in the deductive reasoning research, but without a systematic and principled grounding.

2. **Inherent difficulties in the deductive reasoning research**

- *Deductive tasks*, especially those in a formal format, are *notoriously difficult for the majority of the people* who do not have special training in logic.

- *The level of motivation in completing deductive tasks and in respecting the given instructions* is rather low.

- It is *hard to find people willing to complete such tasks voluntarily, especially when their completion takes a lot of time*. That is why a lot of studies from the deductive reasoning research have rather small samples of subjects. I had, too, an extremely limited access to subjects, particularly for testing them for time intervals longer than two hours.

3. **The general design of the present empirical research**

Given the above mentioned difficulties, I chose a general strategy with several studies with small samples of subjects, in which several hypotheses were tested, instead of a strategy with only one or two experiments with larger samples of subjects, testing a lower number of hypotheses. Furthermore, in the same time, some of the tested hypotheses were double checked in multiple studies in different experimental conditions, with the purpose to secure the consistency of the findings not by a large sample, but by their constancy in different small samples.

4. **Conclusion**

Maybe taken separately the individual studies do not provide strong enough evidences, because of the methodological difficulties occurred as a result of many pragmatic constraints. But my opinion is that together they are building a case for a dynamic schema based model for syllogisms, with results that could be extended in order to support a dynamic schema based model for deductive reasoning in general. It is to be noted, also, that it is highly improbable that it could be proved beyond any doubt, purely through experimental methods, that mental representations exists in a certain format, specifically in a dynamic one in the present case. Empirical data of this sort could be useful only to bring support and incline the balance towards one alternative over the other.

Study 2

Purposes

The *main purpose* of the study was to investigate the content, task, and order effects significant in what respects the *general hypotheses* that in syllogistic reasoning are involved dynamic processes of pattern completion based on deductive schemas with specific cognitive goals.

More precisely, the objective was to bring evidence that distinct categories of cues offered by the type of concrete content, the type of the task format, or by the temporal context (represented by the recently solved deductive tasks) lead to a significantly different syllogistic performance. Those cues were presumed to be recognition and distinction signs for the assumed available dynamic deductive schemas. The expected evidence was that the general data pattern regarding the syllogistic performance should be in accordance with the predictions made in the dynamic schema-based model of the syllogistic reasoning. In this model it is assumed a characteristic link between a particular category of cues and a hypothetic type of syllogistic schema with a typical level of cognitive importance. The expected evidence is to be interpreted taking into consideration the fact that the manipulated factors are irrelevant and neutral in what respects the syllogistic performance from the point of view of a standard version of the mental models theory. To my knowledge, there are no other explicit predictions in its theoretical framework regarding such kinds of experimental manipulations than the implicit one that they are rather unimportant. However, in what concerns the content effect, it was considered the

possibility to derive a hypothetical prediction taking in view the extensional semantics of the mental models theory.

Preliminary comments

The content effect

In the present experiment, a *comparison* is made in the first place *between* the general syllogistic performance in *an experimental condition in which the content of the syllogistic task is of a type* **A** (**concrete, centered on attributes**) *and* the one *in an experimental condition in which the content of the syllogistic task is of a type* **C** (**concrete, centered on attributes**). The comparison will be made for four distinct situations: when the task format is of a **PPC** type (traditional, with two given premises and the conclusion to be derived), administered *before* or *after* a **CPP** task, or when the task format is of a **CPP** type ("natural", with a given conclusion and the two premises to be derived), administered *before* or *after* a **PPC** task. Also, the comparison will be made on valid and invalid syllogisms. Because no clear, uncomplicated, effects are expected when that comparison is made a) on the three types of syllogistic figures, or, respectively, for the **CPP** format, on the types of conclusion judgment (A, E, I, or O), and b) on the type of syllogisms in what respects the number of mental models (one or multiple model syllogisms), the correspondent analyses will not be included in the study.

In my study, the comparison will be made *for the first time between two types of concrete, nonfactual, contents*. Those contents were chosen so that no specific, factual knowledge about the syllogistic terms or relations to be possible. They refer to fictive cases or stated relationships. However, they are considered to be partially familiar, because they call upon plausible types of concrete argumentative situations that are likely to be encountered in the everyday cognitive activity: classification of a plant, and diagnosing an illness, respectively. Therefore, the level of abstractedness and the factual knowledge as factors known to be important for the syllogistic performance were controlled by including only concrete, nonfactual information. The purpose was to show that in the concrete content of the everyday syllogistic tasks, in fact, semantic indices at an abstract level, with logical meaning, are important for the deductive process, favoring the recognition of an abstract dynamic deductive pattern. It was assumed that those indices are semantic features linked with a certain class of argumentative experiences or cognitive situations.

The standard *mental models theory* does not specifically predict that the status of attributes or as classes of the syllogistic terms would be important in building the needed mental models. But the mental models theory is an extensional one, interpreting the information from the premises by abstract tokens representing individuals of classes spatially related. Therefore, it would be reasonable to assume that a content of **C** type would be favorable for such an information codification, and this effect should be beneficial for all the syllogisms (valid or invalid, with one or more than one mental models, of different syllogistic figure). The same expectation for a beneficial effect of the **C** type content could be supported by the fact that in the **A** type content there are more words to be processed and, therefore, the supplementary load for the WM should be detrimental for the syllogistic performance.

In the *dynamic schema based model* instead, the information is assumed to be predominantly intensionally coded for the pragmatic dynamic schemas and maybe extensionally for the higher level

combinatorial schemas. Also, it is presumed that the pragmatic schemas are likely to be more stable and, therefore, to be used (by winning the dynamic competition with other existing deductive schemas) for those syllogisms having a higher assumed cognitive importance (presumably, figure 1 or 2 valid syllogisms). In order that those pragmatic schemas to be actualized and to be stable it is, too, considered to be important that the given information to offer cues in what respects the general status of the syllogistic terms, as adequate role fillers for those schemas (which supposedly include such general specifications). Moreover, that information might be helpful in eliciting the cognitive goal of an assumed pragmatic schema, besides the more traditional indices offered by the position of the middle term, the quantifiers, or negations.

But the effect of that facilitative information is expected to be dependant on the effect of other factors, particularly the basic and relative stability of a considered schema or whether such schema exists at all. If the stability of a schema is excessive, the contribution of the facilitative cues might not be perceptible at the level of the performance for those syllogisms for which that schema is adequately "recognized". Their effect would be in this case more perceptible at the level of the performance for the similar syllogisms that have less stable schemas, which could be defeated by the excessive stable one. For them, such facilitative cues may actually lead to a decreased performance. If there is no learned schema at all (probably the case of the invalid syllogisms), the effect of such facilitative cues would be only an indirect one. It should be dependant on their role in facilitating (by an excessive relative stability) or impeding confusions or "illusory recognitions" (by enhancing the relatively low stability of some schemas, making possible an optimal distinction of the appropriate triggering cues for a syllogistic schema).

Therefore, for the *valid syllogisms* (no matter the task format), for which it is more likely to exist pragmatic deductive schemas of the type specified in the proposed model, the performance in the type **A** task should be *generally higher* than the performance in the type **C** task. The prediction is made for the situation in which the tasks are administered in the first position, when no order effects could affect the content effect.

Given the presumed complex interactions between the assumed schemas of the different syllogistic figures, dependent on their contextual stability, no specific predictions are made regarding the interaction between the content effect and the figure effect (or, respectively, the type of judgment for the **CPP** task). However, it is probable that the difference between the type **A** task and the type **C** task in what respects performance to be the clearest one for the figure 1 valid syllogisms.

For the *invalid syllogisms*, since the manipulated factor is expected to have contrary effects dependent on particular conditions, no predictions are made, too.

The task and order effect

I am not aware of previous data from the scientific literature that indicate the kinds of effects expected in this experiment.

In the first place, a **CPP** task format has never been used before. Beyond the purpose of studying the content effect in its case, in the present study it was introduced in order to study order effects, too. It was

assumed that such a task, through its "ecological" value[8], would be able to facilitate the actualization of the existing stable syllogistic schemas by its power to suggest their usual cognitive goals. In that way, their presumed relative stability is raised, so that they would be more able to influence the organization of the future incoming information, from the second administered syllogistic task. Because it was expected that the task performance to be lower in the **CPP** format than in the **PPC** format[9] anyway, it was not possible to investigate that presumed order effect at the level of an improvement from a **CPP** task to a **PPC** task. Therefore, the order effect was expected rather at the level of the difference between the performance for valid syllogisms at the **A** type task in comparison with the **C** type task for the **PPC** format, when it is administered after the **CPP** format. Because of a possible ceiling effect (due to the cumulative influence of the content, task, and order effects), it was predicted that that improvement[10] might be less notable or almost negligible for the **A** type task in comparison with the one expected for the **C** type task. Correspondingly, if the difference between the performance for the valid syllogisms at the **A** task in comparison with the **C** task in the case when the **PPC** task is not preceded by the **CPP** task do occur as expected, it should disappear when the **PPC** task follows the **CPP** task.

The order effect was expected also to appear by comparing the syllogistic performance of a task with the same type of content and format when that format is administered before or after the other format. Because of an assumed ceiling effect, it might be less likely that a significant performance difference to occur *for the **A** type task* in the format **PPC** when it is administered before or after the task in **CPP** format. For the **A** type task it might be more probable that this effect to occur for the **CPP** format, since in its case the presumed syllogistic schemas are assumed to be less stable and, therefore, more sensible to destabilizing or stabilizing effects. But no specific prediction was made in that respect. It may be that a **PPC** task format to have a disruptive effect through its frame, encouraging a more "combinatorial" approach, centered on combining possibilities, than the one required by a successful completion of the **CPP** task. In the **CPP** task, the performance would be supposedly facilitated by a strategy in which the given conclusion is used as a cue for recalling learned syllogistic schema, and not by one of analyzing the possible combinations of the given judgments. *For the **C** type task*, it is likely that the possible disruptive effect of the **PPC** task format to be not so salient when the **CPP** task is administered after it. Instead, order effects are to be expected especially for the **PPC** task when it is administered after a **CPP** task, given the cognitive goal cues offered by such a task format, useful in actualizing the existing cognitive schemas.

In the theoretical framework of the mental models theory, such order effects are not expected at all, especially combined with content effects. The most important reason is the fact that solving a syllogism is primarily dependent on an ad hoc mental model built from abstract tokens that are not subsequently memorized. Speculations could be made in what respects the way the mental models theory could predict something in this respect, especially taking in view the role of the previous knowledge and learning in building initial and alternative models. But in the standard mental models theory that role is too vague, being underspecified. I see

[8] This value is presumably conferred by its similarity with the format in which syllogisms are embedded usually in the everyday argumentative flux.

[9] The reasons are that the chances of guessing the correct answer are decreased and there are many schemas that could be activated for some of the given conclusions, the missing part being bigger than in the traditional format.

[10] The improvement is considered to be a virtual one, in comparison with the situation in which the **PPC** task would have been not preceded by the **CPP** task.

no reason for which the experience with a **CPP** task would improve the performance for a subsequent **PPC** task. It may be rather the other way around, in case that specific combinations of premises with their corresponding conclusion are somehow memorized in the **PPC** format, facilitating their recollection in the **CPP** format.

Instead, as it was argued in the theoretical section of the thesis, order effects are expected in the cases of dynamic syllogistic schemas, through their power to organize new incoming stimuli and to enter in competition or cooperation with other existing syllogistic schemas supported by them. In a dynamic model, the value taken by a cognitive variable at a certain moment has cognitive significance for the state of the cognitive system in a future moment.

Concluding comments

The study was an experimental one, with a mixed 3-way factorial design. The **manipulated independent variables** were:

- the *type of content of the syllogistic task* (centered on attributes: **A** vs. on classes: **C**);
- the *type of task format* (traditional: **PPC** vs. "natural" **CPP**);
- the *order of the administration of the two types of task formats*: **PPC** then **CPP** (symbolized with **VN** or **PPCCPP**) or **CPP** then **PPC** (symbolized with **NV** or **CPPPPC**);
- the *position in the order of administration*: first vs. second

The **dependent variable** was *the level of correctness*, at the global level or for different types of syllogisms.

The *syllogistic figures, validity and the number of mental models* are additional independent variables, which were not manipulated.

Hypotheses

Main hypotheses

1) It is expected the following **content effect**: the *correctness for the **A** type task should be higher than the one for the **C** type task*, at least for the following configuration of conditions: *valid syllogisms*, **PPC** *task format, the order of administration* **VN**.

2) It is expected the following **order effect**: *no statistically significant difference* between the *correctness (total or for valid or invalid syllogisms) for the **A** type task* in comparison with the *one for the **C** type task* in the following configuration of conditions: *valid syllogisms*, **PPC** *task format, the order of administration* **NV.**

3) It is expected the following **order effect**: a *higher correctness for valid syllogisms for the* **A** *type task in the format* **CPP** *when it is administered before, not after the* **A** *type task in* **PPC** *format*.

4 It is expected the following **order effect**: a *higher correctness for valid syllogisms for the* **C** *type task in the format* **PPC** *when it is administered after, not before the* **C** *type task in* **CPP** *format*.

Presumed predictions of the mental models theory

1) *No difference* or at most, the *correctness for the **C** type task should be higher than the one for the **A** type task*, for *all the syllogisms*, in **PPC** *task format, no matter the order of administration.*

2) *No difference* or at most, the *precedence of a **PPC** format task should have a beneficial effect on a subsequent task in **CPP** format*, no matter the content of the type, not the other way around.

Method

Participants

At the study participated a total of 86 students at the Social Work Faculty (75) of the UBB and Law Faculty of the "Dimitrie Cantemir" University (11). They were in their first, second or, respectively, third year of college, having a mean age of 21 years. Of them, 66 were female students, 14 male students and 6 participants did not disclose their gender. Since of the 86 students not all managed to complete all the administered tasks (for example, they arrived later at the seminar hour or for other reasons), in the results section, for each statistical analysis, where it will be relevant, the number of participants taken into consideration will be specified.

Material

The following syllogistic tasks were used:

- A **CPP** format task, when a conclusion is given and the derivation of the premises is required, with a concrete content centered exclusively on classes (**C** type content). It had five items (see Annex 5), correspondent to the four possible types of judgments and to the "no valid conclusion" answer. The classes were fictive classes of plants.
- A **CPP** format task, when a conclusion is given and the derivation of the premises is required, with a concrete content centered exclusively on attributes (**A** type content). It had five items (see Annex 6), correspondent to the four possible types of judgments and to the "no valid conclusion" answer. The attributes were fictive symptoms of a rare disease.
- A **PPC** format task, when the premises are given and the derivation of the conclusion is required, with a concrete content centered exclusively on attributes (**A** type content). It had 24 items distributed on types and ordered as in the task used in the preceding study that had a neuter abstract symbolic content (see Annex 7). The attributes were fictive symptoms of a rare disease.
- A **PPC** format task, when the premises are given and the derivation of the conclusion is required, with a concrete content centered exclusively on classes (**C** type content). It had 24 items distributed on types and ordered as in the task used in the preceding study that had a neuter abstract symbolic content (see Annex 8). The classes were fictive classes of plants.

Each type of task was preceded by an instruction in which the argumentative situation was explained with reference to its specific concrete content and through which the modality of answer was explained. There were no trial tasks or trial syllogisms within a task.

Procedure

The syllogistic tasks were administered collectively, during the same session, at the seminar hours, without other time limit than the length of those 2 hours. The participants were allowed to give a pseudonym instead of their name in order to discourage the tendency to copy the answers from their neighbors, by securing the confidentiality of their performance.

The participants were included in the four experimental groups by a random selection, taking into consideration their arrangement in the seminar room (were selected the rows of chairs for a given experimental group). The first experimental group (**A** type task and the order **CPPPPC**) had 18 participants. The second experimental group (**A** type task and the order **PPCCPP**) had 14 participants. The third experimental group (**C** type and the order **CPPPPC**) had 16 participants. The fourth experimental group (**C** type and the order **PPCCPP**) had 19 participants.

Results

Results regarding the main hypotheses

1) Applying t-test in order to compare the ***correctness of the valid syllogisms*** *for the **A** type task with the one for the **C** type task* in the **PPC** format and the administration order **VN**, no significant difference was obtained, which is not the expected result.

Supplementary results

However, a significant difference was obtained for the **total correctness** of the ***A*** *type task,* which was higher than the total correctness of the ***C*** *type task* in the **PPC** format and the administration order **VN** (t = -2.335, df = 25, p = .031).

Also, the **correctness for the figure 1 syllogisms** of the **A** type task was significantly higher in comparison with the one for the ***C*** *type task* in the **PPC** format and the administration order **VN** (U = 37, p = .039)**.**

2) *No statistically significant difference* between the *correctness (total or for valid or invalid syllogisms) for the* ***A*** *type task* in comparison with the *one for the* ***C*** *type task* in the following configuration of conditions: *valid syllogisms*, **PPC** *task format, the order of administration* **NV** was obtained, as it was expected.

3) No significantly *higher correctness for the* ***valid syllogisms*** *of the* **A** *type task in the format* **CPP** *when it is administered before, not after the* **A** *type task in* **PPC** *format* was obtained, which is not the expected result.

Supplementary result

However, the correctness was significantly higher for the **multiple model syllogisms** for the **A** *type task in the format* **CPP** *when it is administered before, not after the* **A** *type task in* **PPC** *format* (U = 53.5, p = .009).

4) No significantly *higher correctness for* ***valid syllogisms*** *for the* **C** *type task in the format* **PPC** *when it is administered after, not before the* **C** *type task in* **CPP** *format* was obtained, which is not the expected result.

Supplementary results

However, the **total correctness** was significantly higher *for the* **C** *type task in the format* **PPC** *when it is administered after, not before the* **C** *type task in* **CPP** *format* (U = 20.5, p = .004).

Also, a significantly higher performance was obtained for the **valid figure 1 syllogisms** *of the* **C** *type task in the format* **PPC** *when it is administered after, not before the* **C** *type task in* **CPP** *format* (U = 33.5, p = .027).

Discussion

Main hypotheses

1) The expectation of the first hypothesis of a higher level of performance for the task centered on attributes (**A**) in comparison with the task centered on classes (**C**) in the **PPC** format was not obtained specifically for valid syllogisms. But it occurred for the total performance (valid and invalid syllogisms), and within valid syllogisms for the figure 1 syllogisms in particular. The obtained result could be interpreted to mean that for this sample, a content centered on attributes might have helped especially the actualization of the assumed syllogistic schemas of the figure 1 syllogisms, presumably the ones having the highest stability in these conditions, given their higher assumed cognitive importance. But the semantic cues of the intensional meaning were not so powerful in what respects the actualization of the unstable schemas of the syllogisms with lower cognitive importance. For some of the cases, especially the figure 3 valid syllogisms, these schemas may not exist at all. Moreover, for the figure 2 valid syllogisms, as it was explained in a previous section, an exclusive intensional content may not be as beneficial as it might be for the figure 1 and figure 3 valid syllogisms, being the only syllogistic figure for which the conclusion has an extensional meaning. All these three reasons offer an explanation for the fact that the expected difference did not occur separately for all the valid syllogisms. It may be that the improvement through the content effect in what respects the relative stability of the assumed schemas for valid syllogisms was at an intermediary level that should have increased the chances that the argumentative situations of the invalid syllogisms to be more easily distinguished in comparison with the argumentative situations of the valid syllogisms. So, maybe that is the reason for which the performance for the invalid syllogisms brought a contribution too to the total difference induced by the content effect. But, in their case, also, the improvement could be noticed separately, only for them.

2) When the **PPC** task was administered in the second position, after a correspondent **CPP** task having the same type of content, order effects were expected especially for the **C** type task. So, no difference was probably

to occur between the performance at the task with a content centered on attributes in comparison with the one at the task centered on classes, due to a presumed more salient improvement in the second case through an order effect. In the situation with an **A** type content, this improvement may not be so notable, given the presumed ceiling effect: adding a new stabilizing factor, which favors the recognition of an existing schema (order effect), might not have much of a supplementary contribution after another stabilizing factor. Its presence is likely to be superfluous, as it is the case also for the recognition of a human face, for example. When the minimum level of necessary elements in order to recognize it is attained, supplementary cues are superfluous. The obtained result supported this hypothesis.

3) The presumed detrimental effect of a **PPC** format task for a subsequent **CPP** task with an **A** type content (centered on attributes) was not obtained for all the valid syllogisms, as it was expected, but only for the multiple model syllogisms, the ones having the lowest presumed cognitive importance, and implicitly less stable assumed schemas. It is reasonable to assume that for them a detrimental influence should be more notable than for the syllogisms with more stable schemas, resistant to the influence of such unfavorable contexts.

4) As in the case of the content effect of the first hypothesis, the order effect expected to occur for a **C** type task as a consequence of the precedence of an assumed facilitator **CPP** task was not notable for all valid syllogisms separately, but only for those of figure 1, or for the total performance. The interpretation of this result is presumed to be a similar one.

Conclusion

Of the four main *hypotheses*, only one was entirely supported, and three of them were partially supported, in the sense that the expected performance differences did not occur specifically for all the valid syllogisms, but only particularly for the figure 1 syllogisms and for all the syllogisms. The obtained results are still in accordance with the proposed model and in contraction with the predictions of the mental models theory. The differences were explained through the particular conditions of this experiment (characteristics of the sample, type of content, the assumed level of stability of the syllogistic schemas) and taking in view the results that were close to the significance threshold.

From a global point of view, there was a *content effect*, the intensional **A** type of task tending to favor the syllogistic performance either globally or particularly for the figure 1 valid syllogisms in comparison with the correspondent performance in an extensional **C** type of task, as it was expected.

Also, there was an *order effect* combined with a *task format effect* through which the precedence of a certain task format influenced the performance for the subsequent task format. The result did not occur specifically for all the valid syllogisms as it was expected, but only for certain types of syllogisms (multiple model or figure 1 valid syllogisms), depending on the experimental condition, or for all the syllogisms (an option that was not, in fact, excluded in the hypotheses formulation). These results could be explained in the theoretical framework of the proposed model, but they are in contradiction with the hypothetical predictions of the standard mental models theory. Also, the general detrimental effect of the precedence of a **PPC** task format for the performance in an **A** type task is not accountable based on the traditional notion of priming. Such results

are more compatible with the idea of a dynamic cognitive system that is placed in its state space farther away from the region corresponding to an adequate assumed dynamic syllogistic schema.

Study 2

Purposes

The *general purpose* remains the same as the one from the previous study. All general considerations in what respects the intention to bring evidence to support the dynamic schema-based model of the syllogistic reasoning are valid in this case, too.

The *main purpose* of the present study was to investigate the *order effects* when the two types of tasks with different content **A** and, respectively, **C** are administered at the same subject in a different order. Such order effects could be interpreted to mean that some abstract mental representations actualized by an **A** type task are able to organize the syllogistic processes in the **C** type task. It was assumed that such abstract mental representations have the defining properties of a dynamic cognitive schema.

The *secondary purposes* were to find out if the results obtained in the previous study in what respects the content effects remain the same or not.

Preliminary comments

In the previous study, it was not pragmatically possible to compare the performance for the two types of tasks with different concrete content: **A** and **C** when they are administered at the same subject. The comparison is expected to be important given the fact that an order effect is anticipated. In the antecedent study the results indicated a content effect in what respects the syllogistic performance favoring the **A** type task in comparison with the **C** type task, as it was anticipated on theoretical grounds. Therefore, I presumed that the facilitative indices present in an **A** type task might extend in time their beneficial influence through a dynamic phenomenon to a subsequent different task with a content less adequate for the syllogistic performance, such the **C** type task is assumed to be. This presumption was supported also by the order effects suggested by the data from the previous study in which the **CPP** task format had such beneficial valences. Also, in the precedent study, order effects were obtained when a task format presumed to be less adequate for the syllogistic schemas actualization was administered before another task format, considered to be more adequate in that respect. Therefore, in the present study, there were expected order effects indicating a deterioration of the performance for an **A** type task when it is preceded by a **C** type task. Also, it should be expected a higher performance for the **C** type task when the **A** type task is administered before not after it. Therefore, in the hypothesis in which there occurs the expected difference between the performance for the **A** type task and for the **C** type task when they are administered in the first position, in the situation in which they are administered in the second position no such difference is likely to occur.

The expected order effects are *interpreted dynamically* based on the theoretical assumption that an actualized assumed dynamic schema is able to influence the interpretation and organization of the subsequently received information. It could enter in competition or cooperation relations with other existing schemas that could be triggered by that information.

Mental models theory does not make any specific predictions regarding the expected main order effect. As it was stated before, too, the order effects are not consistent with idea of ad hoc mental models that after a syllogistic task dissolve themselves for good. Moreover, if a beneficial effect is still to be expected as a consequence of an administration order, it would be more plausible to be one attributed to the precedence of the extensional **C** type of task over the performance for a subsequent **A** type task than the other way around. The same expectation could be supported by the fact that in the **A** type task there are more words to be processed and, therefore, the supplementary load for the WM should be detrimental for the syllogistic performance.

The preliminary general comments regarding the expected content, validity, figural or number of mental models effects from the previous studies remain valid for the present one, too.

Concluding comments

The study was an experimental one, with a mixed 2-way factorial design. The **manipulated independent variables** were:

- the *type of content of the syllogistic task* (centered on attributes: **A** vs. on classes: **C**);
- the *administration order of the two types of task*: **A** then **C** (symbolized with **AC**) or **C** then **A** (symbolized with **CA**)
- the *position in the order of administration*: first vs. second

The **dependent variable** was *the level of correctness*, at the global level or for different types of syllogisms.

The *syllogistic figures, validity and the number of mental models* are additional independent variables, which were not manipulated.

Hypotheses

Main hypotheses

1) It is expected the following **order effect**: At least *for valid syllogisms*, the *correctness is higher for the **A** type task when it is administered in the first position in comparison with the situation in which it is administered after the **C** type task.*

2) It is expected the following **order effect**: At least *for valid syllogisms*, the *correctness is higher for the **C** type task when it is administered after the **A** type task in comparison with the situation in which it is administered in the first position.*

3) It is expected the following **order effect**: At least *for valid syllogisms*, there should be no significant difference between the *correctness for the **A** type task and the one for the **C** type task* when they are administered in the second position.

Secondary hypothesis

1) It is expected the following **content effect**: the *correctness for the **A** type task should be higher than the one for the **C** type task*, at least for the following configuration of conditions: *valid syllogisms*, *administration in the first position.*

Presumed predictions of the mental models theory

1) *No order effects* or at most there should be *a beneficial effect of the precedence of the **C** type task for the subsequent **A** type task.*

2) *No difference* or at most, the *correctness for the **C** type task should be higher than the one for the **A** type task*, for *all the syllogisms*, *no matter the order of administration.*

3) *No changes in the figural and validity effects dependent on the experimental conditions.*

Method

Participants

At the study participated 43 high school students (23 girls and 20 boys) of 10^{th} and 11^{th} grade, having as their specialty mathematics and physics. The mean age was of 17 years. Only 31 of them completed all the items for the tasks administered in the first position, and only 24 of them completed all the items for the tasks administered in the second position. In the results section the number of participants involved in each comparison will be specified.

Material

The following syllogistic tasks were used:

- A **PPC** format task, when the premises are given and the derivation of the conclusion is required, with a concrete content centered exclusively on attributes (**A** type content). It had 24 items distributed on types and ordered as in task used in the first study that had a neuter abstract symbolic content (see Annex 7). The attributes were fictive symptoms of a rare disease.
- A **PPC** format task, when the premises are given and the derivation of the conclusion is required, with a concrete content centered exclusively on classes (**C** type content). It had 24 items distributed on types and ordered as in task used in the first study that had a neuter abstract symbolic content (see Annex 8). The classes were fictive classes of plants.

Each type of task was preceded by an instruction in which the argumentative situation was explained with reference to its specific concrete content and through which the modality of answer was explained. There were no trial tasks or trial syllogisms within a task.

Procedure

The syllogistic tasks were administered collectively, at the class hours, in the same session, without other time limit. The order of the syllogisms of a task was the same for all the participants, no matter the type of the syllogistic task. There were no trial task or trial syllogisms given the administration conditions (the time limited to a class hour and the content constraints). The participants were allowed to give a pseudonym instead of their name in order to discourage the tendency to copy the answers from their neighbors, by securing the confidentiality of their performance.

Participants were included in the two experimental groups by a random selection, taking into consideration their arrangement in the classroom (there were selected the rows of chairs for a given experimental group). The first experimental group (the administration order **AC**) had 16 participants for the first task, and 13 participants for the second one. The second experimental group (the administration order **CA**) had 15 participants for the first task, and 11 for the scond one.

Results

Preliminary results

No statistically significant age and gender differences existed between the experimental groups.

Comparing globally (for all the syllogisms of the both tasks) the correctness for the two experimental groups, no significant performance difference occurred between the first administered task and the second one. The comparison on types of syllogisms, using the Wilcoxon test, indicated that the only significant difference was for the correctness of the invalid syllogisms ($z = -2.083$, $p = .037$), their correctness being significantly lower at the second administered task in comparison with the first one. Analyzing to see if this significant difference occured for the both experimental groups, the results indicate that it was significant only for the group with the administration order **AC** ($z = -.2.207$, $p = .027$, $N = 13$).

Results regarding the main hypotheses

1) A significant lower performance for the valid syllogisms in the **A** type task at its administration after **C** type task in comparison with its administration before **C** type task was obtained ($U = 48$, $p = .043$, $N = 27$), as it was expected.

2) The expected difference in the correctness of the valid syllogisms at the **C** type task between the situation in which it is administered in the first position and the one in which it is administered in the second position was only close to the significance threshold ($U = 61.5$, $p = .098$). The tendency was that the correctness to be higher when the **C** type task is administered after the **A** type task, as it was expected.

3) No significant difference occurred between the *correctness for the **A** type task and the one for the **C** type task* when they are administered in the second position, as it was expected.

Supplementary result: No significant performance differences between the two experimental groups were obtained also when the comparison was made on type of syllogisms (of different validity, syllogistic figure, or number of mental models).

Results regarding the secondary hypotheses

1) Comparing with the Mann-Whitney test the correctness for the two tasks administered in the first position: **A** and **C**, a significant difference was obtained only for the valid syllogisms ($U = 70.5$, $p = .044$, $N = 31$), in the expected direction: performance for the **A** type task higher than the one for the **C** type task.

Supplementary result: The improvement for the **A** type task did not refer to particular types of valid syllogisms, because no significant differences between the two experimental groups occured in that respect.

Discussion

Preliminary notes

The possibility that the expected order effects to be accounted by learning and transfer from the previously administered task, or through a general deterioration of the performance due to tiredness was not supported by data. By comparing globally the correctness for the two experimental groups no significant difference occurred between the first administered task and the second one.

Main hypotheses

1) There occurred, as it was expected, an order effect in which the precedence of the **C** type task had a detrimental effect for the performance of the subsequent **A** type task. The result is not expected to occur in the standard mental models theory, in which, hypothetically, it should have been the other way around, given the extensional nature of the mental models. Also, the result is not accountable with the traditional notion of priming. It is considered to be more compatible with the dynamic idea that the cognitive system is placed in its state space through a **C** type task in a region that is farther away from the regions of the adequate assumed dynamic syllogistic schemas. So, their recognition when the **A** type task is administered should be affected by the precedence of the **C** type task. It might be a suggestion that different dynamic mental sets are implied by the two types of tasks. The phenomenon might be similar with the one discussed in the traditional cognitive psychology in what respects the costs involved in task switching (Walther & Fei-Fei, 2007). They are

generically explained by unclearly specified top down influences, labeled "task-set reconfiguration". Wylie, Javitt and Foxe (2003) note that the changing of a task set "relies on 'executive control' processes" and that "despite extensive efforts to detail the nature of these processes, there is little consensus as to how the brain achieves this critical function" (p. 667). They suggested a dynamic mechanism, centered on the idea of competition. Based on obtained empirical data, their view was that "preparing to switch task may not be a separate (control) process per se, but rather, the beginning of a competition between the potentially relevant tasks, a competition that is ultimately resolved during the switch trial." (Wylie et al., 2003, pp. 667). Such idea is in accordance with the notion of competition between dynamic schemas of organization of the input stimuli, as the one advanced in this thesis in what respects the interactions between dynamic deductive schemas.

2) At least for the investigated sample of participants, the facilitative effect of the precedence of an A type task, with intensional content, seems to be not as powerful as the one of the precedence of a **CPP** task format, as in the previous study, for a **C** type task. The expected order effect was only close to the significance threshold. The obtained result may be explained taking into consideration also the fact that an exclusively intensional content is not expected to have positive effects for all the syllogisms, and that an exclusively extensional content is also not expected to have detrimental effects for all the syllogisms. Moreover, in the **C** type task, the names for the fictive classes of plants could be easily interpreted as attributes also, not only as classes, resulting that the **C** type task might be not, in fact, purely extensional. Therefore, it is likely that the expected difference of performance to be not so notable.

3) No difference occurred at the second administration between the performance for the **A** type task, with intensional content, in comparison with the one for the **C** type task, with a predominantly extensional content, as it was expected, due to the combined effects of the previously two order effects. So, the performance between them at their administration in the first position might have been annihilated through the obtained order effects.

Secondary hypotheses

1) For this sample of participants, the expected difference between the task with intensional concrete content (**A** type task) and the one predominantly with extensional content (**C** type task) administrated in the first position occurred in the predicted way, specifically for the valid syllogisms. The obtained *content effect* seems to the result of a cumulative contribution for all the valid syllogisms. The difference between the results obtained in this study in comparison with the results in that respect obtained in the previous study may be due to the differences between the investigated samples. A comparison with the Mann-Whitney test of the two samples concerning the global performance and the performance for the two types of syllogisms (valid or invalid) indicated a significant performance difference, no matter the type of content of the task. So, a higher performance was obtained for this high school sample in comparison with the college students' sample for the **A** type of task at its administration in the first position ($U = 419.5$, $p = .000$, for the total correctness, $U = 491.5$, $p = .000$, for the correctness of valid syllogisms, $U = 669$, $p = .01$, for the correctness of invalid syllogisms, $U = 409.5$, $p = .000$, for one model syllogisms). The two samples were similar only in what respects the multiple model valid syllogisms in the **A** type task, where no significant difference occurred. A higher performance was obtained also for this high school sample in comparison with the college students' sample for the **C** type of task

at its administration in the first position for all types of syllogisms (U = 520, p = .000, for the total correctness, U = 760.5, p = .000, for the correctness of valid syllogisms, U = 776.5, p = .001, for the correctness of invalid syllogisms, U = 843.5, p = .002, for one model syllogisms, U = 870.5, p = .003, for multiple model syllogisms). Such results may suggest that for this sample of high school students, the basic stability of the assumed schemas for valid syllogisms might be at a higher level and the presumed schemas for figure 2 and figure 3 valid syllogisms might exist in a higher proportion. This difference may be reflected in a higher performance for all the types of syllogisms in the **C** type task, in spite of its putative extensional unfavorable content. But this high stability of the assumed schemas for valid syllogisms may be excessive for the **A** type task, so that it is possible for it to have a detrimental effect over the performance for those syllogisms with no schemas or less stable schemas. This effect might be reflected into the absence of a performance difference for the invalid syllogisms between the **A** and **C** type task at their administration in the first position. It is to be noted that only for the **A** type task, there is no difference between the two samples in what respects the multiple model syllogisms, the ones assumed to have less stable syllogistic schemas. So, it may be that an **A** type task is a facilitator factor especially for these syllogisms.

Conclusion

Two of the three *main hypotheses* regarding the order effects were supported by the data, and for third one the obtained result was only close to the significance threshold. The *secondary hypothesis* was supported by data.

The results showed a more salient content effect of the intensional type of task (**A** type task) in comparison with the previous task. Also, it indicated a detrimental effect of the precedence of an extensional task (**C** type task) for the performance in a subsequent intensional type of task (**A** type task). It may be that the interpretation of a syllogistic task as referring exclusively to relations between classes makes harder its intensional interpretation in a subsequent task, involving a dynamic competition between syllogistic schemas on different organization levels. For this sample, the intensional content did not have the same facilitative effect as the precedence of a **CPP** task format in the previous study. The obtained results are not the ones hypothetically predicted by the mental models theory.

Study 3

Purposes

The *general purpose* remains the same as in the previous studies. All general considerations in what respects the intention to bring evidence to support the dynamic schema-based model of the syllogistic reasoning are valid in this case, too.

The *main purpose* of the study was to investigate the content and order effects occurring in two types of tasks with a different abstract symbolic content (type **N**: neuter and type **L**: specifying the logical meaning of the syllogistic terms). They are important in order to support the hypothesis that in the syllogistic performance

abstract semantic indices have significance in the inferential process, not the concrete meanings as such, i.e. factual knowledge, or purely formal, syntactic indices.

Preliminary comments

The results obtained in the previous studies on a concrete content were encouraging regarding their interpretation based on the hypothesis that the semantics of the syllogisms is a mixed one. It was presumed that it includes not only an extensional component, but also a more important intensional one, defining the content of the pragmatic syllogistic schemas. The findings supported the idea that a task content centered exclusively on attributes leads to a higher global performance in comparison with a task centered exclusively on classes. Also, the result could be interpreted to mean that in the concrete content of the everyday syllogistic tasks there are semantic indices at an abstract level, with logical meaning, which are important for the syllogistic processes. But those findings may have an ambiguous interpretation in what respects the source of the obtained difference. A possible alternative explanation to be considered is that the concrete content as such of the two type of tasks was important (the classification or the diagnosing situation), not the type of linguistic and semantic cues favoring a classial or attributive interpretation. Moreover, given that with a concrete content it is hard to design syllogistic tasks with veridical situations and in accordance with the requirements of a mixed semantics[11], a comparison with a task with a concrete mixed content was not possible. Therefore, an abstract symbolic content was used instead. Only that, in comparison with the traditional abstract symbolic tasks, the general status of the syllogistic terms and of their relationship was explicitly stated using determinative abstract specifications. For example, the A type judgment in the new abstract symbolic version is: All members of the class S have the property P. The new version of the task (**L**) was compared with the traditional abstract symbolic version (**N**). That version may be considered to be neuter and ambiguous in what respects the logical semantics, but, still, it seems that it generally encourages a classial interpretation.

It was assumed that the performance for an **L** type task should be generally higher than the one for an **N** type task for valid syllogisms, for approximately the same dynamic reasons for which it was presumed that an **A** type task should lead to higher performances than a **C** type task in that respect. Also, order effects were expected when the **L** and **N** tasks are administered successively at the same subject, supported by the same theoretical dynamic argumentation as in the case of the ordered effects for the **A** and **C** tasks in the previous study.

For the current study, a specific figure effect was expected to occur due to the fact that the participants had to choose between an intensional and an extensional version of the same possible conclusion. For each syllogistic figure, only one of the two versions is predicted to occur if the mixed semantics of the syllogisms is valid for the dynamic syllogistic schemas. For the figure 1 and figure 3 valid syllogisms, the intensional version of the conclusion should be the preferred one. For the figure 2 valid syllogisms, the extensional version of the conclusion should be preferred instead. The order of the concordance between the correct chosen answer and the one predicted based on the mixed semantics should be the same with the order of the cognitive importance of the syllogistic figures. In other words, it was expected a higher concordance between the correct chosen answer and the one expected based on the assumed syllogistic mixed semantics model (i.e. if the intensional or the

[11] It is the kind of semantics proposed by Didilescu and Botezatu (1976).

extensional version of the conclusion is chosen) for the both administration orders at least for the figure 1 valid syllogisms in comparison with the figure 2 and, respectively, figure 3 valid syllogisms.

For the expected results, in this case, too, the mental models theory of reasoning does not have any specific predictions. Nowhere is it stipulated that the interpretation of the syllogistic terms as classes or attributes or of their relationship as intensional or extensional should matter for the syllogistic performance. It is to be presumed that since mental models are extensional representations, the content with an explicit intensional meaning may not be in general beneficial for the syllogistic performance. Moreover, since in the version **L** there are more words to be processed, the supplementary load for the WM should be detrimental for the syllogistic performance. The **L** type task should be harder also than the **N** type task because it has more answer options to be analyzed (9 options for the **L** type task in comparison with 5 options for the **N** type task). Also, no validity or figure effects are expected to be changed by such semantic manipulation in a very clear manner. There is no reason, too, for which there should be figure differences in what respects the chosen version of the conclusion: intensional or extensional.

Concluding comments

The study was an experimental one, with a mixed 2-way factorial design. The **manipulated independent variables** were:

- the *type of abstract content of the syllogistic task* (neuter: **N** vs. mixed logical semantics **L**);
- the *order of the administration of the two types of task*: **N** then **L** (symbolized with **NL**) or **L** then **N** (symbolized with **LN**)
- the *position in the order of administration*: first vs. second

The **dependent variable** was *the level of correctness*, at the global level or for different types of syllogisms.

The *syllogistic figures, validity and the number of mental models* are additional independent variables, which were not manipulated.

Hypotheses

Main hypotheses

1) It is expected the following **content effect**: the *correctness for the **L** type task should be higher than the one for the **N** type task*, at least for the following configuration of conditions: *valid syllogisms*, *administration in the first position.*

2) It is expected the following **order effect**: At least *for the valid syllogisms*, the *correctness should be higher for the **L** type task when it is administered in the first position in comparison with the situation in which it is administered after the **N** type task.*

3) It is expected the following **order effect**: At least *for the valid syllogisms*, the *correctness should be higher for the **N** type task when it is administered after the **L** type task in comparison with the situation in which it is administered in the first position.*

4) It is expected the following **order effect**: At least *for the valid syllogisms*, there should be no significant difference between the *correctness for the **L** type task and the one for the **N** type task* when they are administered in the second position.

5) It is expected a particular **figure effect**: There should be a *higher concordance between the correct chosen answer and the one expected based on the assumed syllogistic mixed semantics model* (i.e. if the intensional or the extensional version of the conclusion is chosen) *for the both administration orders at least for the figure 1 valid syllogisms in comparison with the figure 2 syllogisms and, respectively, figure 3 valid syllogisms.*

Presumed predictions of the mental models theory

1) *No order effect*s

2) *No difference* or at most, the *correctness for the **N** type task should be higher than the one for the **L** type task*, for *all the syllogisms*, *no matter the order of administration.*

3) It is expected no differences of *concordance between the correct chosen answer and the one expected based on the assumed syllogistic mixed semantics model* (i.e. if the intensional or the extensional version of the conclusion is chosen) between the syllogistic figures. Moreover, at most, due to the extensional nature of the mental models theory, the preferred chosen answer should be for all the cases the extensional version of the conclusion.

Method

Participants

At the study participated 51 high school students (49 girls and 2 boys) of 10^{th} and 11^{th} grade, having as their specialty mathematics and physics. The mean age was of 17 years. Of them, 50 completed all the items for the tasks administered in the first position, and only 43 of them completed all the items for the tasks administered in the second position. In the results section the number of participants involved in each comparison will be specified.

Material

The following syllogistic tasks were used:

- A **PPC** format task, when the premises are given and the derivation of the conclusion is required, with an abstract symbolic neuter content (**N** type task). It was the same with the task of 24 items from the first study (see Annex 1)
- A **PPC** format task, when the premises are given and the derivation of the conclusion is required, with an abstract symbolic content having a mixed semantics (Didilescu & Botezatu, 1976) in which the meaning of the syllogistic terms as classes or as properties was specified (**L** type task). It had 24 items distributed on types and ordered as in task used in the first study that had a neuter abstract symbolic content (see Annex 13). The number of options from which the answer could be chosen was of nine alternatives. For each type of judgment an intensional and an extensional version were provided. To the eight alternatives the answer "no valid conclusion" was added.

Each type of task was preceded by an instruction in which, this time, only a very short explanation of the task was given, assuming an implicit understanding of the task.

For the **L** task, the correctness was computed in two ways. The one used in most of the analyses did not consider the extensional or intensional version chosen for a given conclusion. The other one considered that an answer is correct only if it corresponds with the requirements of the mixed semantics.

Procedure

The syllogistic tasks were administered collectively, at the class hours, in the same session, without time limit. The order of the syllogisms was the same for all the participants, no matter the type of syllogistic task. There

were no trial task or trial syllogisms given the administration conditions (the time limited to an hour and the content constraints). The participants were allowed to give a pseudonym instead of their name in order to discourage the tendency to copy the answers from their neighbors, by securing the confidentiality of their performance.

Participants were included in the two experimental groups by a random selection, taking into consideration their arrangement in the classroom (there were selected the rows of chairs for a given experimental group). The first experimental group (the administration order **NL**) had 26 participants for the first task, and 22 for the second task. The second experimental group (the administration order **LN**) had 22 participants for the first task, and 24 for the second task.

Results

Preliminary results

No statistically significant age and gender differences existed between the experimental groups.

Comparing globally the correctness for the two experimental groups (for all the syllogisms of the both tasks), no significant difference occurred between the first administered task and the second one. The comparison on the two experimental groups (two types of administration order) and on type of syllogisms indicated the following results. Applying the Wilcoxon test, for the **NL** administration order, the only significant difference was for the correctness of the multiple model valid syllogisms ($z = -2.239$, $p = .025$). There was a higher performance for the multiple model valid syllogisms at the **L** type task in comparison with the performance for the **N** type task. For the **LN** administration order, the only significant difference was for the correctness for the figure 3 valid syllogisms ($z = -2.053$, $p = .025$). There was a higher performance for figure 3 valid syllogisms at the **L** type task in comparison with the performance for the **N** type task.

Results regarding the main hypotheses

1) A higher correctness for the **L** type task than the one for the **N** type task, for valid syllogisms, for the tasks administrated in the first position was obtained ($U = 186$, $p = .013$), as it was expected.

Supplementary results

The full analysis on the types of syllogisms and on the two types of administration order is presented in the Annex 15.

Synthesizing, the results *for the tasks administered in the first position* indicated:

- a significantly higher correctness for *invalid syllogisms* at the **N** type task in comparison with the **L** type task;
- a significantly higher correctness for *multiple model valid syllogisms* at the **L** type task in comparison with the **N** type task;
- a significantly higher correctness for *figure 1 valid syllogisms* at the **L** type task in comparison with the **N** type task;
- a significantly higher correctness for *figure 3 invalid syllogisms* at the **N** type task in comparison with the **L** type task

2) No significantly higher performance for the **L** type task when it was administered in the first position in comparison with the situation in which it was administered after the **N** type task was found. So, the expected result was not obtained.

3) A significantly higher correctness was obtained ($U = 175.5$, $p = .02$) for the **N** type task when it was administered after the **L** type task in comparison with the situation in which it was administered in the first position, as it was expected.

Supplementary results

The analysis on types of syllogisms indicated that, within the *valid syllogisms*:

- The correctness was significantly higher ($U = 186.5$, $p = .033$) for the **N** type task when it was administered after the **L** type task in comparison with the situation in which it was administered in the first position only for the *multiple model valid syllogisms*;
- For the *one model syllogisms*, the difference favoring the **N** type task at its administration in the second position was only relatively close to the significance threshold ($U = 214$, $p = .122$).
- For the *figure 1 valid syllogisms*, the correctness was significantly higher ($U = 162.5$, $p = .005$) for the **N** type task when it was administered after the **L** type task in comparison with the situation in which it was administered in the first position. For the *figure 2 valid syllogisms* there was only a slight tendency that their correctness to be higher ($U = 203.5$, $p = .077$) for the **N** type task when it was administered after the **L** type task in comparison with the situation in which it was administered in the first position;

- For *invalid syllogisms*, only a tendency that failed to reach the significance threshold was obtained (U = 201.5, p = .076) that their correctness to be higher when the **N** type task was administered before **L** type task than when it was administered after the **L** type task.

4) No significant difference between the *correctness for valid syllogisms for the **L** type task and the one for the **N** type task* when they are administered in the second position was obtained, as it was expected.

Supplementary result

A significantly higher correctness for figure 1 valid syllogisms at the **L** type task in comparison with the **N** type task was obtained (U = 171, p = .038) at their administration in the second position.

5) Applying the Wicoxon test, the following results were obtained:

- Significantly higher concordant answers were obtained for figure 1 valid syllogisms in comparison with the figure 2 valid syllogisms for the **NL** administration order (z = -2.867, p = .004), and for the **LN** administration order (z = -3.495, p = .000), as it was expected.
- Significantly higher concordant answers were obtained for figure 1 valid syllogisms in comparison with the figure 3 syllogisms for the **NL** administration order (z = -3.745, p = .000), and for the **LN** administration order (z = -3.972, p = .000), as it was expected.

Discussion

Preliminary notes

The possibility that the expected order effects to be accounted by learning and transfer from the previously administered task, or through a general deterioration of the performance due to tiredness was not supported by data. By comparing globally the correctness for the two experimental groups no significant difference occurred between the first administered task and the second one.

Main hypotheses

1) The content effect was the expected one. The result is remarkable especially taking in view the fact that for the **L** type task more words had to be processed, and more options were given for the choice of the answer. So, it should have been more difficult in comparison with an **N** type task in all four conditions. Moreover, the supplementary results showed there was a clear effect of the mixed content both on the syllogisms with the highest assumed cognitive importance (figure 1 syllogisms) and on those with lower cognitive importance (multiple model syllogisms that have the lowest performance). Instead, this time, the performance for the invalid syllogisms was lowered by the mixed content. A possible explanation might be a presumed extreme level of relative stability of the assumed schemas for the valid syllogisms in this case.

2) The fact that no order effect occurred in what respects the precedence of a **N** type task over the performance of the subsequent **L** type task may be interpreted in two ways. On the one hand, in comparison with a **C** type task, an **N** type task presumably might have a more neuter interpretation in what respects the extensionality of the syllogistic terms (the interpretation exclusively in terms of classes is not so salient). On the other hand, it may be also that the relative stability of the assumed syllogistic schemas in the case of a **L** type task is so high that any disturbing effect from the precedence of a **N** task might not be a notable one.

3) The preceding hypothetical explanation may be supported by the order effect obtained through the precedence of the **L** type task on the subsequent **N** type task. In comparison with the previous study, when an exclusively intensional task did not have a significant influence on an exclusively subsequent extensional one, a semantically mixed type of task had a significant positive influence on the performance of the subsequent neuter type of task.

4) The powerful effect of a semantically mixed type of task in comparison with a neuter one was apparent also in the content effect obtained for the first time even when the **L** type task is administrated in the second position for the figure 1 syllogisms. But for the total correctness it was no difference at the administration of the tasks in the second position, the results supporting the expected order effect.

5) The idea of a mixed semantics for the syllogistic task was supported by the results indicating a greater concordance between the chosen correct conclusion and the one expected based on this semantics, especially for the figure 1 syllogisms, the ones assumed to have the highest cognitive importance and the assumed syllogistic schemas with the highest stability.

Conclusion

Of the five main hypotheses, four were supported by data. Of the two secondary hypotheses, only one was supported by the obtained results. Still, the failure to support the two hypotheses is accountable in the proposed model, but not in the standard mental models theory. A clear content effect was obtained favoring the **L** type task, in spite of its difficulty concerning the number of words to be processed and the number of given options for an answer. This effect is also remarkable considering that it refers to the performance of two tasks with an abstract symbolic formulation. The effect of the mixed semantics was reflected also in the order effect in which the precedence of the **L** type task had a beneficial effect for the subsequent **N** type task. Support for the mixed semantics was also obtained from the figure effect occurring for the concordance between the chosen conclusion and the one predicted through this mixed semantics.

Study 4

Purpose

The *main purpose* of the study was the investigation of an order effect involving two syllogisms with the same type of content and similar premises but with a different assumed cognitive importance (valid vs. invalid) that were administered in a different order.

Preliminary comments

In the three previous studies, the order effects were investigated globally, and between syllogisms in different task formats, or with different types of semantic content. Their results supported the theoretical general hypothesis that the presumed dynamic schemas previously actualized in another syllogistic task are able to influence the performance and the syllogistic processes in a subsequent syllogistic task. It was assumed that such influences could be dynamically accounted by dynamic processes a) of cooperation, competition, recruitment, or b) of bringing the cognitive system closer or farther away in what respects the region from its state space corresponding to an adequate dynamic schema

In the present study, the order effect will be investigated more directly, with two pairs of syllogisms in a traditional task format, with abstract symbolic neuter content were chosen. Each pair contained a valid and an

invalid syllogism. The first pair contained a valid syllogism (AA1A) with an assumed cognitive significance higher than the cognitive importance of the valid syllogism from the second pair (AE2E). The invalid syllogisms were chosen in such a way that their premises were identical in what respects the type of judgments of the premises and their order, but they had a different syllogistic figure. Also, their modal incorrect answer in the previous studies had to be the conclusion for the correspondent valid syllogism. So, the valid syllogism AA1A was paired with the invalid syllogism AA2N (where N symbolizes the answer "no valid conclusion"). The valid syllogism AE2E was paired with the invalid syllogism AE3N. There were two experimental groups for which the syllogisms from the two pairs were presented in the two possible administration orders.

By presenting the syllogisms in different orders it was expected to be manipulated the presumed relative stability of their assumed dynamic schemas. But their basic stability, defined predominantly by their cognitive importance, was considered to remain the same.

In the first place, it was expected to occur an *order effect in the sense that the performance for the valid syllogism from the first pair to be higher when it is presented in the first position in the pair than when it is presented in the second one*. In the previous studies detrimental effects occurred when a syllogistic task presumed to not favor the actualization of the assumed dynamic syllogistic schemas preceded one presumed to be favorable for such an actualization. A similar phenomenon was expected here. However, in this case, it was presumed that the precedence of an invalid (or other) syllogism may move away the cognitive system from the region of its state space corresponding to an assumed adequate syllogistic schema.

In what respects the *performance for the invalid syllogism*, the direction of the influence is less predictable, since it depends on the stability of the assumed syllogistic schema of the precedent valid syllogism. As it was noted, only if that stability is at an intermediate level the performance for the invalid syllogism should be increased as an effect of the precedence of the valid syllogism. Since the assumed dynamic schema for the AA1A syllogism, in spite of its abstract symbolic content, might have a rather high stability, it was expected that for the *AA2N syllogism to occur a higher performance when it is not preceded by AA1A than when it is preceded by it*.

The influence of the preceding valid syllogism in a pair may be reflected also at the level of the prevalence of the incorrect answers for the subsequent invalid syllogisms. From that perspective, the percentage of the answer A for the AA2N syllogism should be higher when it is preceded by the AA1A syllogism than when it is not. Such result is expected to occur only if the relative stability of the assumed dynamic schema for the AA1A syllogism will be sufficiently stable in such abstract symbolic format. A similar result might be less likely to occur for the AE3N case, for the same reasons for which its performance might be less likely to be negatively influenced by the precedence of the AE2E syllogism.

The mental models theory in its standard version does not predict the expected differences. I see no reason for which building models for an AA2N syllogism should negatively influence the building of the initial model for the an AA1A syllogism.

Concluding comments

The study was an experimental one, with a mixed 2-way factorial design. The **manipulated independent variables** were:

- The *order of the valid and invalid syllogisms in a pair*

- The *type of syllogisms chosen for each pair* (valid vs. invalid, with high cognitive importance vs. with medium cognitive importance).

Hypotheses

Main hypothesis

1) It is expected an **order effect**: the *correctness for the AA1A syllogism should be higher when it is presented in the first position in its pair than in the second position.*

Tentative hypotheses

1) It is more likely the following **order effect**: the *correctness for the AA2N syllogism should be higher when it is presented in the first position in its pair than in the second position.*

2) It is more likely the following **order effect**: the *percentage of the A judgment answer for the AA2N syllogism should be higher when it is presented in the second position in its pair than in the first position.*

Method

Participants

At the study participated 30 high school students (20 girls and 10 boys) of 10^{th} grade, having as their specialty mathematics and physics. The mean age was of 16.5 years.

Material

Two versions of a task with four syllogisms formulated in an abstract symbolic neuter manner were used (see Annex 17). The two syllogisms from the first pair were AA1A (a figure 1 valid syllogism having as conclusion an A judgment), and AA2N (a figure 2 invalid syllogism, where N symbolize that the correct answer is "no valid conclusion"). The two syllogisms of the second pair were: AE2E (a figure 2 valid syllogism having as conclusion an E judgment), and AE3N (a figure 3 invalid syllogism, where N symbolize that the correct answer is "no valid conclusion"). In the first version of the task, the valid syllogism from each pair was presented in the first position of the pair (the **VN** version). In the second version of the task, the valid syllogism from each pair was presented in the second position of the pair (the **NV** version).

Each version of the task was preceded by an instruction in which only a very short explanation of the task was given, assuming an implicit understanding of the task.

Procedure

The syllogistic tasks were administered collectively, at the class hours, in the same session, without time limit. There were no trial task or trial syllogisms given the purpose of the experiment (the study of an order effect). The participants were allowed to give a pseudonym instead of their name in order to discourage the tendency to copy the answers from their neighbors, by securing the confidentiality of their performance.

Participants were included in the two experimental groups by a random selection, taking into consideration their arrangement in the classroom (there were selected the rows of chairs for a given experimental group). The first experimental group (the administration order **VN**) had 16 participants. The second experimental group (the administration order **NV**) had 14 participants.

Results

Preliminary results

By applying Mann-Whitney test, no significant differences were obtained between the two experimental groups in what respects the total correctness. There occurred a slight tendency that the correctness for the AA1A syllogism to be higher than the one for the AE2E syllogism ($z = -1.667$, $p = .096$). The correctness for the syllogism AE3N was significantly higher than the one for AA2N ($z = -2.6464$, $p = .008$).

Results for the main hypothesis

1) By applying chi-square test, a significantly lower correctness ($\chi 2(1)= 5.275$, $p = .022$) was obtained for the AA1A syllogism when it was presented in the first position in its pair than in the second position, as it was expected.

Supplementary result

No significant difference between the two experimental groups was obtained for the AE2E syllogism.

Results for the tentative hypotheses

1) It was not possible to verify this hypothesis because in the studied sample only one correct answer was given for the AA2N syllogism.

2) A chi-square test was applied for the 21 participants who answered with the A judgment at the AA2N syllogism. Only a tendency of a lower percentage ($\chi 2(1)= 3.087$, $p = .079$) of A responses was obtained for the case when the AA2N syllogism was presented in the second position in its pair than in the first position. So, the expected difference was only close to the significance threshold.

Discussion and conclusion

Main hypothesis

1) The result of this study indicate that order effects could occur also between two successive syllogisms, in the condition in which there is a significant difference in their cognitive importance (valid vs. nonvalid), and the first syllogism in a pair is not preceded by other syllogisms. There was a detrimental effect of the precedence of an invalid syllogism over the performance for a subsequent valid syllogism. The obtained effect is not accountable by a priming phenomenon. It is also not predicted by the standard mental models theory. I see no reason for which building models for the invalid syllogisms should disturb the building of the initial model for the subsequent valid syllogism. Instead, from a dynamic point of view, such a result is interpretable as a displacement of a subjacent dynamic cognitive system to a region farther away from the one corresponding to the assumed syllogistic schema for the valid syllogism. The obtained result is not explainable by a general difference in the reasoning competence between the two experimental groups, as long as no significant differences between them occurred for the global performance.

Tentative hypotheses

1) The hypothesis that the precedence of the valid syllogism should have a detrimental effect on the performance for the subsequent invalid syllogism having similar premises could not be tested, because of the extreme difficulty of the invalid syllogism.

2) Still, the possibility of such an influence was indicated by the tendency that the precedence of the valid syllogism AA1A to lead to a higher percentage of the incorrect answer **A** for the subsequent AA2N syllogism. Dynamically, this would mean the possibility that the assumed dynamic schema for the valid syllogism was inadequately recognized in the case of the two similar premises of the invalid syllogism, generating confusion. This confusion might have lead to the incorrect answer of the judgment corresponding to the correct answer for the AA1A syllogism.

Future research with other pairs of syllogisms and with larger samples of participants are needed in order to elucidate the order effects that are possible between successive syllogisms dependent on their similarity and assumed cognitive importance.

Study 5

Purpose

The purpose of the study was to investigate the relationship between an individual difference presumably indicating the average general stability of the abstract mental representations of an individual and the syllogistic performance. More precisely, the objective was to test the nonlinear relationship between the average level of stability of the subordinate representational patterns and the stability of the supraordinate assumed dynamic deductive schema predicted and theoretically argued in the theoretical section of the thesis.

Preliminary comments

In the present study, it was hypothesized that the average general stability of the abstract mental representations could be assessed by using a task of free number generation. This task was chosen for the following reasons. Numbers, through their abstract, symbolic character are similar with the symbols or general concepts of the syllogistic terms involved in a syllogistic task, as representations on lower levels of organization than a dynamic syllogistic schema. Moreover, from a pragmatic point of view, for them it is easier to apply the data analysis methods needed in order to obtain the estimated value for the relevant individual difference.

In the free number generation task conceived by me (Faiciuc, 2003), the participants had to generate a series of 400 numbers using the natural numbers from 1 to 9. Each element of the generated series was required to be the number that passes through their mind at the moment of its generation, no matter whichever is. In a series of studies I obtained data suggesting that through such a task stable individual characteristics of the dynamics of the free actualization of the mental representations could be estimated. The stability in time of such individual differences and their significant association with the performance in creativity tasks was documented in these previous studies (Faiciuc, 2008b; Faiciuc, 2003).

A first assumption was that the choice of one element of the series is influenced by the choices made for the previously generated elements.

A second assumption of mine was that the average level of influence between the chosen numbers depends on their basic stability as dynamic mental representations. The presumed reason is that the chances of a dynamical transition between a number and another one depend on the resistance at destabilization of the antecedent one, i.e. on its stability. Moreover, the chances of a destabilized system to arrive into the attractive region of the dynamic representation of another number and remain there depend also on the power of attraction of that number. Therefore, again, the transition is presumed to depend on the stability of the subsequent number. The transition is considered to be dependent also on the distance from the state space between the two attractive regions corresponding to the two considered mental representations. It should be at a relatively medium level in order that a destabilized system to move into another attractive region and remain there. If it is too small, the chances of the system to return back to the region of the first number before it gets stabilized into another one are supposedly increased. If it is too long that distance, the chances of the destabilized system to get into a neighborhood attractive region are presumably decreased. By considering all the ten given numbers, their

average level of mutual influences between them should depend on the average level of stability of their assumed dynamic representations.

The third assumption was that a rough estimation of the average level of mutual influence between the ten numbers could be the sum of the absolute values of the coefficients of interaction from the model of the series obtained by applying an autoregressive analysis.

Autoregressive analysis is a method to study autocorrelation in a temporal series and, therefore, its internal dynamics. If in a classical regression analysis the values of a variable are predicted by the weighted sum of the values of other variables, in an autoregressive analysis the value of a variable is predicted by itself, i.e. by the weighted sum of some of its previous values. The weights are the autoregression coefficients or interaction coefficients as they are also named. It was assumed that by summing the absolute values of the autoregression coefficients a rough estimation of the level of interaction between the numbers from the model could be obtained. The researcher Iarinca Luiza from Physics Institute from Cluj-Napoca helped me to obtain the autoregressive models for the series generated by the participants. With only three exceptions, a model of order 9, that is with 9 interaction coefficients, was considered to be the best fit for the remaining series. That means that the choice of a number is influenced in a significant manner by the last nine chosen numbers, and every interaction coefficient represents the level of influence of a number over the choice of the future numbers.

Concluding comments

The uncontrolled *independent variable* was the sum of the absolute values of the interaction coefficients (ICS)

The *dependent variable*: the correctness of the valid syllogisms

Hypothesis

Given all the above considerations, the general main hypothesis was that a nonlinear relationship between the correctness of the valid syllogisms and the sum of the absolute values of the interaction coefficients should occur. More precisely, the maximum syllogistic performance should be for the intermediate values of the sum of the absolute values of the interaction coefficients.

Method

Participants

At the study participated 33 college students (30 girls and 3 boys) in the first or the second year at the Social Work Faculty of UBB, who were participants also in the second study. Their mean age was of 21 years.

Material

The following syllogistic tasks were used:

- A **CPP** format task, when the conclusion is given and the derivation of the premises is required, with a concrete content centered exclusively on classes (**C** type content). It had five items (see Annex 5), correspondent to the four possible types of judgments and to the "no valid conclusion" answer. The classes were fictive classes of plants.
- A **CPP** format task, when a conclusion is given and the derivation of the premises is required, with a concrete content centered exclusively on attributes (**A** type content). It had five items (see Annex 6), correspondent to the four possible types of judgments and to the "no valid conclusion" answer. The attributes were fictive symptoms of a rare disease.
- A **PPC** format task, when the premises are given and the derivation of the conclusion is required, with a concrete content centered exclusively on attributes (**A** type content). It had 24 items distributed on types

and ordered as in task used in the study 1 that had a neuter abstract symbolic content (see Annex 7). The attributes were fictive symptoms of a rare disease.

- A **PPC** format task, when the premises are given and the derivation of the conclusion is required, with a concrete content centered exclusively on classes (**C** type content). It had 24 items distributed on types and ordered as in task used in the study 1 that had a neuter abstract symbolic content (see the Annex 8). The classes were fictive classes of plants.

Each type of task was preceded by an instruction in which the argumentative situation was explained with reference to its specific concrete content and through which the modality of answer was explained. There were no trial tasks or trial syllogisms within a task.

Also, a free number generation task (see Annex 18) was administered, requiring to the participants to generate a series of 400 numbers using the natural numbers within the interval from 1 to 9.

Procedure

The free number generation task was administered collectively, in the same session with the syllogistic tasks administered in the second study.

Results

Preliminary analysis

The participants were separated into three relatively equal groups (12, 9, and, respectively, 12) using the ICS value, at the following cut points: 0.13 and 0.44. Applying the t test in order to see if there was a significant difference between them in what respect the ICS value, the following results were obtained. A significant difference occurred between the middle group and the two extreme groups: t (29) = -8.619, p = .000, and, respectively, t (37) = -7.414, p = .000.

Nonparametric tests were used because the distribution for the valid syllogisms departed significantly from the normality.

Given the small sample, the analyses were realized by ignoring the type of content of the syllogisms and the administration order of the task formats.

Results for the main hypothesis

In the first phase, applying the Kruskal-Wallis test for the three obtained groups in order to see if there is a difference concerning the correctness for the valid syllogisms, a significant value was obtained only for the **CPP** task: $\chi 2(2)= 6.426$, p = .04.

In the second phase, a separate comparison for each possible pair of groups was carried on by applying the Mann-Whitney test. The following results were obtained:

- the correctness for the valid syllogisms was higher for those with intermediate values of the ICS than for those with lower values of the ICS (U = 22, p = .023).
- the correctness for the valid syllogisms was higher for those with intermediate values of the ICS than for those with higher values of the ICS (U = 25, p = .036).

Supplementary results

A significant difference between the three groups was obtained also for the *one model syllogisms* $\chi 2(2)= 6.529$, p = .038. By applying the Mann-Whitney test, the following results were obtained:

- the correctness for the one model valid syllogisms was higher for those with intermediate values of the ICS than for those with lower values of the ICS (U = 23.5, p = .016).
- the correctness for the one model valid syllogisms was higher for those with intermediate values of the ICS than for those with higher values of the ICS (U = 26.5, p = .037).

Discussion and conclusion

The predicted nonlinear relationship between the ICS of the numeric series generated in a free number generation task and the syllogistic performance occurred in the case of a **CPP** task, with aggregate scores, no matter the type of content. The performance was the highest for the intermediate values of the ICS, as it was expected, based on the idea that that sum might be a rough measure of the average stability of the abstract mental representations of an individual. It is a result for which the mental models theory is not able to provide

an explanation. Instead, as it was argued in the theoretical section of this thesis, from a dynamic point of view, such a result is accountable given the presumed optimal condition for the emergence of superordinate patterns (schemas) from subordinate patterns. The fact that the result could be linked with the emergence of such assumed syllogistic schemas for the valid syllogisms is indicated by the supplementary result that the expected nonlinear relationship occurred especially for the one model syllogisms. Such syllogisms are presumed to have, in fact, the highest cognitive importance and the highest chances to have stable syllogistic schemas.

The expected nonlinear relationship did not occur in the case of a **PPC** task format. One possible reason for such a result may be the assumption that in a **PPC** task, in comparison with a **CPP** task, a significantly higher proportion of the correct answers are likely to be lucky guesses. So, the presumed nonlinear relationship may be less notable because of an assumed such high error in the measurement of the syllogistic competence through a **PPC** task format. Another possible reason is the fact that in a **PPC** task format, the actualization of the assumed syllogistic schemas might be favored by the higher level of information supplied in the premises than the one supplied in the given conclusion from a **CPP** task format. So, it might be possible that in such favorable conditions less stable schemas to be actualized. Therefore, it would be harder to reveal the expected nonlinear relationship because of the influence of such less stable schemas.

More research is needed in the future, on larger samples, and on different types of syllogistic tasks, having also an abstract symbolic content, in order to investigate more thoroughly the assumed nonlinear relationship. Also, this relationship should be studied in relation with other individual differences in order that its significance to be properly understood.

General discussion

The series of six empirical studies brought indirect, compatible, evidence in favor of the proposed schema based dynamic model. In comparison, the present predominant explicative theory for the syllogistic performance, the mental models theory does not have predictions or it has generally hypothetical contrary predictions in what respects the investigated phenomena. Many of the stated hypotheses were formulated as tentative guesses, being aware that the results are by the dynamic nature of the proposed model highly dependent on particular contexts and circumstances that provide certain variation intervals for the involved variables. Those hypotheses were formulated having in mind the idea of stability of a syllogistic schema, but the level of its stability and the dynamic effects deriving from it were assumed to be dependent on contextual factors, being relative also to the stability of other involved syllogistic schemas. In my studies, unfortunately, there were no available means to measure directly such property, i.e. the stability of a dynamic schema. Therefore, it was hard to formulate clear hypotheses that would take into account all the involved factors, particularly in the situation in which no direct data were available in what respects their relative values.

In the first and the sixth studies *the association between some individual differences and the syllogistic performance* was documented for the first time in the scientific literature. *Content, task format* and *order effects* were studies in the second, third, fourth, and the fifth experiments, separately, or in combination.

For the first time in the scientific literature there were obtained results indicating *a performance difference between tasks with two concrete unfamiliar contents, or between two abstract symbolic contents*. So far, only comparisons between an abstract and a familiar concrete content were made. The findings of my studies were interpreted to mean that there might be abstract semantic features embedded in the used concrete content that should be advantageous or disadvantageous for the recognition of the abstract semantic pattern of the assumed dynamic syllogistic schemas. They support the idea that the semantic content of those assumed schemas might be mixed, involving both extensional and intensional meanings.

In what respects *the two task formats*, it was notable the fact that in a **CPP** (when the conclusion is given) format the performance might be relatively lower than the performance in a **PPC** format (when the premises are given), although no direct comparison could be made. There seems that a **CPP** format decreases the chances of lucky guesses and supplies less information for the recognition of the assumed syllogistic schemas. That is why it may provide a more accurate indication of the real syllogistic competence of a reasoner. The idea is supported by the fact that the syllogisms assumed to have the highest cognitive importance (figure 1 valid syllogisms) were the only one having a notable performance in this format.

The *order effects* for valid syllogisms, obtained for the first time in the scientific litereature, were of several types and occurred in all four experiments, although their existence depended on the particular sample of participants and the experimental conditions.

The general pattern of the results is rather complicated and complex, reflecting the involvement of numerous factors together with their suggested interaction. They seem only to scratch at the surface of the dynamic phenomena occurring during the syllogistic processes with rudimentary methods. They had a limited efficiency in comparison with the ones needed in order to reveal directly more characteristic dynamic phenomena (for example, hysteresis) than the ones suggested by a simple order effect. Standard mental models theory, which is still the predominant theory in explaining the syllogistic reasoning, offers, in my opinion, a too simplistic and rigid interpretative framework in order to account for the complex data obtained not only in this series of studies, but also in other studies from the scientific literature. The explicative power of the central variables in that theory: the number of mental models and the position of the middle term may stem from their possible status of confounded variables. But, in our studies, there are contexts in which there are syllogisms with the same number of mental models and even the same syllogistic figure but for which the performance is significant different (for example, the **L** type task, for which multiple model valid syllogisms have a higher performance than multiple model invalid syllogisms).

FINAL CONCLUSION

Synthetically speaking, the present thesis brings a contribution primarily at a theoretical level, by identifying general principles and ideas on which a dynamic approach of the deductive reasoning could be grounded, and by applying those principles on the particular cases of the conditional, and especially the syllogistic deductive reasoning. It also indicates theoretical contributions through which such a dynamic approach could be linked and could integrate concepts or the existing theories from the cognitive psychology

that are related with the deductive reasoning. In my opinion, a dynamic approach might be useful in solving also to conundrum of the deductive reasoning mentioned in the introductory part. It suggests that the deductive tasks usually used in experiments are so difficult and they are approached by participants with such low motivation despite the fact that the deductive reasoning is an important part of their cognitive activity because they might not correspond with the format and the content of their daily deductive activity. More precisely, such daily deductive activity is considered to be centered only on some specific deductive goals and it might be usually based on several pragmatic deductive schemas organized around those goals. Usually it should not involve general deductive mechanisms or the assumed combinatorial schemas, and it is less likely to require generally a proof that nothing follows from the given information. Also, the deductive processes in our usual life are not decontextualized or separated from the factual or logical knowledge, and generally their direction might be from a conclusion to be proven to the sustaining premises than the other way around.

Through the empirical studies, beyond the evidence suggesting the validity of the proposed model, new lines of experimental manipulations for the future research of the deductive reasoning are revealed. Also, new kinds of tasks (**A**, **C**, **L**, **CPP** type of tasks) were elaborated through which new aspects of the syllogistic processes could be studied.

The theoretical and the empirical results may be also useful from a pragmatic point of view.

In the first place, they could be helpful in designing training programs for developing deductive competencies. Here are some general tentative recommendations. They should be grounded on the deductive goals needed to be attained in the everyday life or in a specific domain of activity. In the syllogism case, the accent may be initially placed on the pragmatic deductive schemas for valid syllogisms. The risk of overlearning such schemas should be avoided, because then the schemas of higher level, the combinatorial ones, would emerge with difficulty and they would be presumably less stable. The development of such combinatorial schemas should be done especially by exercising with invalid deductions or rather unfamiliar deductions, with lower cognitive function, the ones used to reveal exceptions, for example. In the case of the syllogistic reasoning it may be possible that tasks with mixed semantics to be helpful in learning the required pragmatic deductive schemas. In learning deductive schemas it would be also important that the order effects to be taken into consideration. Consequently, it would be recommendable not to use syllogistic tasks presumed to have disadvantageous characteristics for the actualization of the assumed deductive schemas, especially not before learning a syllogistic task with presumed advantageous such properties.

In the second place, in what respects the measuring of the deductive competencies, the obtained results suggest that in conceiving instruments with that purpose it may be important to take into consideration what level of the assumed deductive schemas is envisioned, and which are the goals of the measurement. Furthermore, in designing such instruments, it would be important to take into consideration the content, format, and order effects documented in the present research.

The present thesis represents only the first step of a more systematic and extended possible program of research or pragmatic application of the dynamic approach from the cognitive psychology to the problematic of the deductive reasoning. It may be considered not as a competitor for the existing theoretical approaches, but rather an integrative alternative, bringing complementary perspectives over the dynamic aspects of the deductive reasoning and new interpretations of the traditional concepts.

References

Albu, M. (2002). *Instrumente pentru evaluarea autonomiei*. Lucrările simpozionului internațional "Cercetări şi aplicații în psihologie", Ediția a XV-a: "Psihologia şi aderarea europeană", Timişoara: Editura Augusta.

Albu, M. (2007). Un nou instrument pentru evaluarea autonomiei personale la adolescenți. *Anuarul Institutului de Istorie George Barit din Cluj-Napoca. Seria Humanistica"*, Tom V, pp. 99-114.

Allport, A, Styles, E., Hsieh, S. (1994). Shifting Intentional Set: Exploring the Dynamic Control of Tasks. In C. Umilta & M. Moscovitch (Eds.), *Attention and performance XV: Conscious and Nonconscious Information Processing* (pp. 421-452). Cambridge, MA: MIT Press.

Artman, L., Cahan, S., Avni-Babad, D. C. (2006). Age, Schooling and Conditional Reasoning. *Cognitive Development*, 21, pp. 131-145.

Bacon, A. M., Handley, S. J., Newstead, S. E. (2003). Individual differences in strategies for syllogistic reasoning. *Thinking and Reasoning*, 9, pp. 97–131.

Ball, L. J., Quayle, J. D. (2009). Phonological and visual distinctiveness effects in syllogistic reasoning: Implications for mental models theory. *Memory and Cognition*, 37, pp. 759-768.

Barrouillet, P., Grosset, N. (2007). Memory Retrieval and Content Effects in Conditional Reasoning: A Developmental Mental Models Account. In W. Schaeken, A. Vandierendonck, W. Schroyens, G. d'Ydenwalle (Eds.), *Mental Models Theory of Reasoning. Refinements and Extensions* (pp. 1-25), Mahwah, New Jearsy: Lawrence Erlbaum.

Becker, S., Behrman, M., Moskovitsch, M., Joordens, J. (1997). Long-Term Semantic Priming: A computational Account and Empirical Evidence. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 23, pp. 1059 – 1082.

Bonatti, L. (2002). Raisonnement predicatif, In G. Politzer (ed.), *Traité de Sciences Cognitives: Le Raisonnement* (pp. 137–182), Paris: Hermès.

Bourke, P. (1998). AutoRegression Analysis (AR). Website consulted on 3.07.2009 at the address http://local.wasp.uwa.edu.au/~pbourke/miscellaneous/ar/.

Breakspear, M. (2004). "Dynamic" Connectivity in Neural Systems Theoretical and Empirical Considerations. *Neuroinformatics*, 4, pp. 205–226.

Bucciarelli, M., Johnson-Laird, P. N. (1999). Strategies in syllogistic reasoning. *Cognitive Science*, 23, pp. 247-303.

Burgess, P., Cooper, R. (1996). The Control of Thought and Action. In D. W. Green and Others (Eds.), *Cognitive Science: an Introduction* (pp. 340-368), Oxford: Blackwell Publishers.

Cahan, S., Artman, L. (1997). Is Everyday Experience Dysfunctional for the development of conditional reasoning? *Cognitive Development*, 12, pp. 261-275.

Carver, C. S. & Scheier, M. F. (2000). On the structure of behavioural self-regulation. In M. Boekaerts; P.R. Pintrich and M. Zeidner (Eds.), *Hanbook of Self-Regulation* (pp. 42-85). Orlando, Florida: Academic Press.

Chater, N., Oaksford, M. (1999). The Probability Heuristics Model of Syllogistic Reasoning. *Cognitive Psychology*, 38, pp. 191–258.

Chemero, A. (2001). Dynamical Explanation and Mental Representation. *Trends in Cognitive Science*, 5, pp. 140-141.

Cheng, P. W., Holyoak, K. J. (1985). Pragmatic Reasoning Schemas. *Cognitive Psychology*, 17, pp. 391-416.

Cheng, P. W., Holyoak, K. J., Nisbett, R. E., Oliver, L. M. (1986). Pragmatic versus syntactic approaches to training deductive reasoning. *Cognitive Psychology*, 18, pp. 293-328.

Cooper, R. P., & Shallice, T. (2006). Hierarchical schemas and goals in the control of sequential behavior.*Psychological Review,* 113, pp. 887-916.

Cosmides, L. (1989). The logic of social exchange: Has natural selection shaped how humans reason? *Cognition*, 31, pp. 187–276.

Cummins, D.D. (1995) Naive theories and causal deduction. *Memory & Cognition*, 23, pp. 646-658.

De Neys, W. (2003). *Memory search for stored counterexamples during conditional reasoning*. Unpublished doctoral dissertation, University of Leuven, Belgium.

De Vega, M. (1994). *Introducción a la psicología cognitiva*, Madrid: Alianza Editorial.

Deci, E. L., Ryan, R. M. (1995). *Human autonomy: the basis for true self-esteem, Efficacy, Agency, and Self-esteem*. New York: Plenum.

Didilescu, I., Botezatu, P. (1976). Silogistica: teoria clasică şi interpretările moderne. Bucureşti, Edit. Didactică şi Pedagogică.

Dimitrov, V. (2000). *Strange Attractors of Meaning*. Website consulted at the http://www.zulenet.com/VladimirDimitrov/pages/SAM.html, on 09.09.2001.

Dominovski, R. L., Bourne, L. J. Jr. (1994). History of Research on Thinking and Problem Solving. In R. J. Sternberg (Ed.), *Thinking and Problem Solving* (pp. 1-33), San Diego: Academic Press.

Eiser, J. R. (1994). Toward a Dynamic Conception of Attitude Consistency and Change. In R. R. Vallacher, A. Nowak (Ed.), *Dynamical systems in social psychology* (pp. 198-218), San Diego: Academic Press.

Eliasmith, C. (1996). The third contender: A critical examination of the dynamicist theory of cognition. *Journal of Philosophical Psychology*, 9, pp. 441-463.

Elman, J. L. (1991). Distributed representations, simple recurrent networks, and grammatical structure. *Machine Learning*, 7, pp. 195-224.

Esenck, M. W., Keane, M. T. (2000). *Cognitive Psychology: a student's handbook*, New York: Taylor & Francis Inc.

Evans, J. St. B. T. (1984). Heuristic and analytic processes in reasoning. *British Journal of Psychology*, 75, pp. 451-468.

Evans, J. St. B. T. (1998). Matching bias in conditional reasoning: Do we understand it after 25 years? *Thinking and Reasoning*, 4, pp. 45-110.

Evans, J. St. B. T. (2003). In two minds: dual process accounts of reasoning. *Trends in Cognitive Science*, 7, pp. 454-459.

Evans, J. St. B. T. (2006a). The heuristic-analytic theory of reasoning: Extension and evaluation. *Psychnomic Bulletin and Review*, 13, pp. 378-395.

Evans, J. St. B. T. (2006b). *Dual system theories of cognition: Some issues*. Proceedings of the 28th Annual Meeting of the Cognitive Science Society, Vancouver, pp. 202-207.

Evans, J. St. B. T., Newstead, S.E., Byrne, R.M.J. (1993). *Human reasoning: The Psychology of deduction*. Hove, UK: Lawrence Erlbaum Associates.

Faiciuc, L. (2003). Number Generation and Creative Thinking. *Anuarul Institutului de Istorie «George Barit» Cluj-Napoca"*, tom. I, series Humanistica, pp.135-162.

Faiciuc, L. (2004). Raționamentul autonom ca o componentă a autonomiei personale, in "*Studii şi cercetări din domeniul ştiințelor socio-umane*", 12, pp.67-78.

Faiciuc, L. (2005). Orientarea motivațională către autonomie şi expresia sa grafică. *Anuarul Institutului de Istorie «George Barit» Cluj-Napoca*, tom. III, series Humanistica, pp.83-91.

Faiciuc, L. (2008a). Are there Reasons to Challenge a Symbolic Computationalist Approach in Explaining Deductive Reasoning? *Integrative Psychological and Behavioral Science*, 42, pp. 212-218.

Faiciuc, L. (2008b). Temporally Stable Individual Differences in Performing a Free Number Generation Task. *Cognitie, Creier, Comportament*, 12, pp. 327-336.

Faiciuc, L. (2008c). Abordarea dinamică a proceselor cognitive superioare. Cluj-Napoca: Argonaut.

Ferber, R. (1996). Cognitive Dynamics - Dynamic Cognition? In *Iteration Theory, Proceedings of the European Conference* (pp. 65-76), Singapore: World Scientific.

Ford, M. (1995). Two Modes of Representation and Problem Solution in Syllogistic Reasoning. *Cognition*, 54, pp. 1–71.

Freyd, J. J. (1987). Dynamic mental representations. *Psychological Review*, 94, pp. 427-438.

Freyd, J. J., Finke, R. A. (1984). Representational momentum. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10, pp. 126-132.

Gámez, E., Marrero, H. (2000). The Role of the Middle Terms Contiguity in Pragmatic Syllogistic Reasoning. *Cahiers de Psychologie Cognitive*, 19, pp. 487–512.

Gärdenfors, P. (1994). How logic emerges from the dynamics of information. In J. van Eijck, A. Visser (Eds), *Logic and Information Flow* (pp. 49-77), Cambridge, MA: MIT Press.

Geurts, B. (2003). Reasoning with Quantifiers. *Cognition*, 86, pp. 223–251.

Goel, V. (2003). Evidence for Dual Neural Pathways for Syllogistic Reasoning. *Psychologica*, 32, pp. 301–309.

Goel, V., Dolan, R. J. (2001). Functional Neuroanatomy of Three-Term Relational Reasoning. *Neuropsychologia*, 39, pp. 901–909.

Goel, V., Shuren, J., Sheesley, L., Grafman, J. (2004). Asymmetrical Involvement of Frontal Lobes in Social Reasoning, *Brain*, 127, pp. 783–790.

Goertzel, B. (1996). Chance and Consciousness. *Dynamical Psychology. An International, Interdisciplinary Journal of Complex Mental Processes*, journal in electronic format at the address http://goertzel.org/dynapsyc/dynacon.html

Goldman, A. I. (2001). Action (2). In S. Guttenplan (Ed.), *A Companion to the Philosophy of Mind* (pp. 117-121), Oxford: Blackwell Publishers.

Gutt, E. A. (2004). *Verbal communication without propositional and logical form*?, website visited on 5.05.2009, at the address: http://209.85.229.132/search?q=cache:knb-aCL_wKwJ:homepage.ntlworld.com/ernst-august.gutt/Verbal%2520communication%2520without%2520propositional%2520and%2520logical%2520form.doc+Sperber+wilson+1994+incomplete+logical&cd=2&hl=ro&ct=clnk&gl=ro

Haken, H. (1995). An Application of Synergetics. Decision Making as Pattern Recognition, *Zeitschrift für Wissenschaftsforschung*, 9/10, pp. 45-72.

Handley, S., Feeney, A. (2007). Representation, Pragmatics, and Process in Model-Based reasoning. In W. Schaeken, A. Vandierendonck, W. Schroyens, G. d'Ydenwalle (Eds.), *Mental Models Theory of Reasoning. Refinements and Extensions* (pp. 25-53), Mahwah, New Jearsy: Lawrence Erlbaum.

Hawkins, J., Pea, R. D., Glick, J., Scribner, S. (1984). Merds That Laugh Don't Like Mushrooms: Evidence for Deductive Reasoning by Preschoolers. *Developmental Psychology*, 20, 1984, pp. 584–594

Johnson-Laird, P. N., Byrne, R. M. J. (1991). *Deduction*. Hillsdale, NJ:Erlbaum

Johnson-Laird, P. N., Byrne, R. M. J. (2002). Conditionals: A theory of meaning pragmatics and inference. *Psychological Review*, 109, pp. 646–678.

Kaneko, K. (1998). Life as Complex Systems: Viewpoint from Intra-Inter Dynamics, *Complexity*, 3, pp. 53-60.

Kataoka, N., Kaneko, K. (1999). *Functional Dynamics I. Articulation Process*. Website visited at the address: http://arxiv.org/ps/adap-org/9907006.pdf, on 03.08.2005.

Kataoka, N., Kaneko, K. (2000). Functional Dynamics II. Syntactic Structure, *Physica D*, 149, pp. 147-196.

Kelso, S. J. A. (2003). Cognitive Coordination Dynamics. In W. Tschacher, J.-P. Dauwalder (Ed), *The Dynamical Systems Approach to Cognition* (pp. 45-67). New Jersey: World Scientific.

Kentridge, R. W. (1994). Critical Dynamics of Neural Networks and Spatially Localised Connections. In M. Oaksford, G. D. A. Brown (Eds.), *Neurodynamics and Psychology* (pp. 181-215), Sand Diego, CA: Academic Press.

Knauff, M., Johnson-Laird, P. N. (2002). Visual imagery can impede reasoning. *Memory and Cognition*, 30, pp. 363-371.

Kriz, J. (2001):Self-Organization of Cognitive and Interactional Processes. In: M. Matthies, H. Malchow, J. Kriz (Eds.), *Integrative Systems Approaches to Natural and Social Dynamics* (pp. 517-537), Heidelberg: Springer.

Lawson, J., Lewis, J. (2004). Representation Emerges from Coupled Behavior. In *Workshop Proceedings of the 2004 Genetic and Evolutionary Computation Conference*. June 26th -30th , 2004. Seattle, WA.

Llopis Marín, J. M. (1992). *Demandas de procesamiento en el razonamiento silogístico*, Campus Iniversitario de Almería, Instituto de Estudios Amerienses.

Macsinga, I. (2001). The Cognitive Complexity, Thinking Style and Reasoning Involved in Decision. *Cogniție, Creier, Comportament*, 5, pp. 179-193.

Macsinga, I. (2007). Raționamentul deductiv. Mecanisme cognitive şi analiză de erori. Timişoara: Editura Universității de Vest.

Markovits, H., Barrouillet, P. (2002). The development of conditional reasoning: A mental model account. *Developmental Review*, 22, pp. 5-36.

McNamara, T. P. (2005). *Semantic priming: Perspectives from memory and word recognition*. New York: Psychology Press.

Miclea, M. (1994). *Psihologie cognitivă*, Cluj-Napoca: Gloria.

Morsanyi, K, & Handley, S. J. (2008). How smart do you need to be to get it wrong? The role of cognitive capacity in the development of heuristic-based judgment. *Journal of Experimental Child Psychology,* 99, pp. 18–36.

Müller, U., Overton, W. F., Reene, K. (2001). Development of Conditional Reasoning. A Longitudinal Study. *Journal of Cognition and Development*, 2, pp. 27-49.

Newstead, S. E., Handley, S. J., Buck, E. (1999). Falsifying mental models: Testing the predictions of theories of syllogistic reasoning. *Journal of Memory & Language*, 27, pp. 344-354.

Noica, C. (1995). *Schiță pentru istoria lui Cum e cu putință ceva nou*. Bucureşti: Humanitas

Norenzayan, A., Choi, I., Peng, K. (2007). Perception and Cognition. In S. Kitayama, D. Cohen (Eds.), *Handbook of Cultural Psychology* (pp. 569-595), New York: Guilford Press.

O'Brien, D. P., Braine, M. D. S., Yang. Y. (1994). Propositional reasoning by models? Simple to refute in principle and in practice. *Psychological Review*, 101, pp. 711-724.

Oaksford, M., Malloch, M. I. (1994). Dynamic schemata: Evidence from cognitive neuropsychology. In M Oaksford, G D A Brown (Eds.), *Neurodynamics and Psychology* (pp. 83-106), London: Academic Press.

Overtone, W. F., Dick, A. S. (2007). A competence-procedural and developmental approach to logical reasoning. In M. J. Roberts (Ed.). *Integrating the Mind. Domain General versus Domain Specific Processes in Higher Cognition* (pp. 233-256), New York: Lawrence Erlbaum.

Piaget, J. (1973). Epistemologia genetică. Cluj-Napoca: Dacia.

Politzer, G. (2007). Reasoning with conditionals. *Topoi*, 26, pp. 79-95.

Polk, T. A., Newell, A. (1995). Deduction as verbal reasoning. *Psychological Review*, 102, pp. 533–566.

Popper, K. (1981). *Logica cercetării*, Editura ştiințifică, Bucureşti.

Portugali, J. (2002). The Seven Basic Propositions of SIRN (Synergetic Inter-Representation Networks). *Nonlinear Phenomena in Complex Systems*, 5, pp. 428-444.

Pronovost, S. (2006). *Of computations and dynamic systems - An overview of the dynamicistcontroversy in cognitive science*, Carleton University Cognitive Science Technical Report 2006-05. 2006. on the website visited at the: http://www.carleton.ca/iis/TechReports, on 09.04.2005.

Quinn, S., Markowits, H. (1998). Conditional reasoning, causality, and the structure of semantic memory: strength of association as a predictive factor for content effects. *Cognition*, 68, pp. 93-101.

Raffone, A., Van Leeuwen, C. (2002). Activation and coherence in memory processes: revisiting the PDP approach to retrieval. *Connection Science*, 13, pp. 349-382.

Roberts, M. J., Newstead, S. E., Griggs, R. A (2001). Quantifier Interpretation and Syllogistic Reasoning. *Thinking and Reasoning,* 7, pp. 173–204.

Rumelhart, D. E., Norman, D. A. (1982). Simulating a skilled typist: A study of skilled cognitive-motor performance. *Cognitive Science*, 6, pp. 1-36.

Sabelli, H. C. (1995). Non-Linear Dynamics as a Dialectic Logic. In *Proceedings of International Society of System Sciences*, pp. 101-112. website visited at: http://creativebios.com/Nonlinea%20Dynamics%20as%20a%20process%20logic.html, on 23.07.2000.

Saulnier, B. (2003). Au-delà du représentationnalisme symbolique. La modélisation constructiviste et morphodynamique des systèmes, et le défi de la compositionnalité. In J. Gayon (Ed), *Mémoire de DEA (Philosophie des Sciences), 1, Septembre.* Paris.

Schaeken, W., Van Der Henst, J.-B., & Schroyens, W. (2006). The mental models theory of relational reasoning: Premises' relevance, conclusions' phrasing and cognitive economy. In W. Schaeken, A. Vandierendonck, W. Schroyens, G. d'Ydewalle (Eds.), *The mental models theory of reasoning: Extensions and refinements* (pp. 129-150). Mahwah, NJ: LEA.

Schank, R. C. (1999). *Dynamic Memory Revisited*. Cambridge: Cambridge University Press.

Shallice, T. 1994. Multiple levels of control processes. In C. Umiltà & M. Moscovitch (Eds.), *Attention and performance* XV (pp. 395—420). Cambridge, MA: MIT Press.

Shastri, L., Ajjanagadde, V. (1993). From simple associations to systematic reasoning: A connectionist representation of rules, variables and dynamic bindings using temporal synchrony. *Behavioral and Brain Sciences*, 16, pp. 417-494.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, 119, pp. 3-22.

Sperber, D., Wilson, D. (1990) Spontaneous deduction and mutual knowledge. *Behavioral & Brain Sciences*, 13. pp. 179-84.

Sperber, D., Wilson, D. (1995). *Relevance: Communication and Cognition*. Oxford: Blackwell Publishers.

Stanovich, K. E. (1999). Who is Rational? Studies of Individual Differences in Reasoning. Mahway, NJ: Erlbaum.

Stanovich, K. E., West, R. F. (2000). Individual Differences in Reasoning: Implications for the Rationality Debate. *Behavioral & Brain Sciences*, 22, pp. 645–665.

Stenning, K., Oberlander, J. (1995). A cognitive theory of graphical and linguistic reasoning: Logic and implementation. *Cognitive Science*, 19, pp. 97-140.

Stenning, K., Yule, P. (1997). Image and language in Human Reasoning: A Syllogistic Illustration, *Cognitive Psychology*, 34, pp. 109–159.

Stupple, E. J. N., Ball, L. J. (2007). Figural effects in a syllogistic evaluation paradigm: An inspection-time analysis. *Experimental Psychology*, 54, 120-127.

Sun, R. (1996). Commonsense reasoning with rules, cases, and connectionist models: A paradigmatic comparison. *Fuzzy Sets and Systems*, 82, pp. 187-200.

Thelen, E. (2003). Grounded in the World: Developmental Origins of the Embodied Mind. In W. Tschacher, J.-P. Dauwalder (Eds), *The Dynamical Systems Approach to Cognition* (pp. 17-44), New Jersey: World Scientific.

Tsuda, I. (2001). Toward an interpretation of dynamic neural activity in terms of chaotic dynamical systems. *Behavioral and Brain Sciences*, 24, pp. 793–847.

van Gelder, T. (1990). Compositionality: A Connectionist Variation on a Classical Theme. *Cognitive Science*, 14, pp. 355-384.

van Gelder, T. J. (1998). The dynamical hypothesis in cognitive science. *Behavioral and Brain Sciences*, 21, pp. 615-628.

Vandierendonck, A., Dierckx, V., & De Vooght, G. (2004). Mental model construction in linear reasoning: Evidence for the construction of initial annotated models. *Quarterly Journal of Experimental Psychology*, 57A, pp. 1369-1391.

Venet, M., Markovits, H. (2001). Understanding Uncertainty with Abstract Conditional Premises. *Merrill-Palmer Quarterly*, 47, pp. 74-99.

Vezerides, K., Kehagias, Ath. (2003). *The Liar and Related Paradoxes: Fuzzy Truth Value Assignment for Collections of Self-Referential Sentences*, CS Arxiv TR cs.LO/0309046, website visited at the address: http://users.auth.gr/~kehagiat/KehPub/techreps/200309046.pdf, on 09.04.2004.

Wagner-Egger, P. (2007). Conditional reasoning and the Wason selection task: Biconditional interpretation instead of reasoning bias. *Thinking and Reasoning*, 13, pp. 484-505.

Walther, D. B. & Fei-Fei, L. (2007). Task-set switching with natural scenes: Measuring the cost of deploying top-down attention. *Journal of Vision*, 7, pp. 1-12.

Weiskopf, D. A. (2004). The place of time in cognition. *British Journal for the Philosophy of Science*, 55, pp. 87-105.

Wylie, G. R., Javitt, D. C., Foxe, J. J. (2003). Cognitive control processes during an anticipated switch of task. *European Journal of Neuroscience*, 17, pp. 667-672.

Yamamoto, T., Kuniyoshi, Y. (2002). Global Dynamics: a new concept for design of dynamical behavior. In C. G. Prince, Y. Demiris, Y. Marom, H. Kozima, C. Balkenius (Eds.), *Proceedings Second International Workshop on Epigenetic Robotics: Modeling Cognitive Development in Robotic Systems* 94 (p.177-180), Edinburgh, Scotland.

Annexes

Annex 1

În cele ce urmează sunt prezentate premisele pentru 24 de silogisme. Spre deosebire de exemplul dat mai înainte, premisele lor au o formulare mai abstractă, cei trei termeni ai silogismului fiind simbolizaţi prin înlocuirea lor cu trei litere majuscule: **S**, **M** si **P**.

Vi se cere ca pentru fiecare silogism să găsiţi o soluţie, alegând unul dintre enunţurile care sunt prezentate sub fiecare dintre ele, bifând acea literă (A, B, C, D, sau E) care se află în dreptul enunţului ales printr-o apăsare pe butonul stâng al mouse-ului în timp ce săgeata cursorului este aşezată pe pătrăţelul în care se află acea literă (adică dând un click de mouse pe acea literă).

Enunţurile care sunt prezentate sub fiecare silogism sunt:

A. Toţi **S** sunt **P**.
B. Toţi **S nu** sunt **P**.
C. Unii **S** sunt **P**.
D. Unii **S nu** sunt **P**.
E. **Nu** se poate deduce nici o concluzie necesară.

După ce aţi ales enunţul pe care îl consideraţi corect pentru un silogism, treceţi la următorul, dând un click de mouse pe spaţiul unde scrie "**Continuă**". În caz că, înainte de a trece la următorul silogism, vă daţi seama că răspunsul pe care l-aţi ales este unul greşit, puteţi să-l deselectaţi dând un click de mouse pe pătrăţelul din dreptul lui, adică pe cel pe care l-aţi selectat înainte. Apoi selectaţi un nou răspuns, pe cel pe care îl consideraţi potrivit, dând un click de mouse pe pătrăţelul din dreptul lui. După ce aţi trecut la un nou silogism nu mai puteţi să vă întoarceţi să-l corectaţi pe cel anterior.

Nu treceţi mai departe, până când nu aţi înţeles bine instrucţiunile de până acum, pentru că nu vă veţi putea întoarce să le recitiţi.

Nume şi prenume_____
Şcoala_____
Clasa_____
Sex_____
Vârsta_____
Data examinării_____

1.	Toţi **M** sunt **P**. Toţi **S** sunt **M**.	Concluzie: _____
2.	Toţi **M** sunt **P**. Toţi **S nu** sunt **M**.	Concluzie: _____
3.	Toţi **M** sunt **P**. Unii **S** sunt **M**.	Concluzie: _____
4.	Toţi **M** sunt **P**. Unii **S nu** sunt **M**.	Concluzie: _____
5.	Toţi **M nu** sunt **P**. Toţi **S** sunt **M**.	Concluzie: _____
6.	Toţi **M nu** sunt **P**. Toţi **S nu** sunt **M**.	Concluzie: _____
7.	Toţi **M nu** sunt **P**. Unii **S** sunt **M**.	Concluzie: _____
8.	Toţi **M nu** sunt **P**. Unii **S nu** sunt **M**.	Concluzie: _____
9.	Toţi **P** sunt **M**. Toţi **S** sunt **M**.	Concluzie: _____
10	Toţi **P** sunt **M**. Toţi **S nu** sunt **M**.	Concluzie: _____
11.	Toţi **P** sunt **M**. Unii **S** sunt **M**.	Concluzie: _____
12.	Toţi **P** sunt **M**. Unii **S nu** sunt **M**.	Concluzie: _____
13.	Toţi **P nu** sunt **M**. Toţi **S** sunt **M**.	Concluzie: _____

Annex 1

14. Toți **P nu** sunt **M**. Concluzie: _____
    Toți **S nu** sunt **M**.
15. Toți **P nu** sunt **M**. Concluzie: _____
    Unii **S** sunt **M**.
16. Toți **P nu** sunt **M**. Concluzie: _____
    Unii **S nu** sunt **M**.
17. Toți **M** sunt **P**. Concluzie: _____
    Toți **M** sunt **S**.
18. Toți **M** sunt **P**. Concluzie: _____
    Toți **M nu** sunt **S**.
19. Toți **M** sunt **P**. Concluzie: _____
    Unii **M** sunt **S**.
20. Toți **M** sunt **P**. Concluzie: _____
    Unii **M nu** sunt **S**.
21. Toți **M nu** sunt **P**. Concluzie: _____
    Toți **M** sunt **S**.
22. Toți **M nu** sunt **P**. Concluzie: _____
    Toți **M nu** sunt **S**.
23. Toți **M nu** sunt **P**. Concluzie: _____
    Unii **M** sunt **S**.
24. Toți **M nu** sunt **P**. Concluzie: _____
    Unii **M nu** sunt **S**.

Annex 5

Sarcină de investigare a raționamentului deductiv

În cele ce urmează vi se prezintă tipul de sarcină pe care sunteți solicitați să o rezolvați.

Se pornește de la *o propoziție* în care se enunță *o anumită relație* dintre *două tipuri fictive de plante* (inventate pentru elaborarea acestei probe): **ofideele** şi **siderinele**.

Se presupune că aceste două tipuri de plante pot avea *relații* cu *un alt tip de plantă fictivă*: **palmatele**.

Toate relațiile logic posibile între **palmate** şi **ofidee** (sau, echivalent, între **ofidee** şi **palmate**) sunt prezentate într-o listă de 8 propoziții:

1. Toate **palmatele** sunt **ofidee**.
2. Toate **palmatele nu** sunt **ofidee**.
3. Unele **palmate** sunt **ofidee**.
4. Unele **palmate nu** sunt **ofidee**.
5. Toate **ofideele** sunt **palmate**.
6. Toate **ofideele nu** sunt **palmate**.
7. Unele **ofidee** sunt **palmate**.
8. Unele **ofidee nu** sunt **palmate**.

La fel, toate relațiile logic posibile între **palmate** şi **siderine** (sau, echivalent, între **siderine** şi **palmate**) sunt prezentate într-o altă listă de 8 propoziții:

9. Toate **palmatele** sunt **siderine**.
10. Toate **palmatele nu** sunt **siderine**.
11. Unele **palmate** sunt **siderine**.
12. Unele **palmate nu** sunt **siderine**.
13. Toate **siderinele** sunt **palmate**.
14. Toate **siderinele nu** sunt **palmate**.
15. Unele **siderine** sunt **palmate**.
16. Unele **siderine nu** sunt **palmate**

Sarcina Dvs. este să găsiți
ce relație dintre **palmate** şi **siderine** şi
ce relație dintre **palmate** şi **ofidee**
trebuie să fie *simultan adevărate* pentru ca *enunțul dat* la început (care se referă la *una dintre cele 5 relații logic posibile* dintre **ofidee** şi **siderine)** să fie *adevărat în mod obligatoriu*, numai pe baze logice.

Cu alte cuvinte, este ca şi cum ați fi în situația să argumentați logic cuiva că *una dintre relațiile posibile* dintre **ofidee** şi **siderine** este adevărată, bazându-vă pe relațiile fiecăreia din cele două tipuri de plante cu cel de-al treilea tip: **palmatele**. În această situație, *ce cuplu* de propoziții ați alege (prin *selecția unui enunț* din cele din lista numerotată de la **1** la **8** şi *selecția altuia* din lista numerotată de la **9** la **16**) *ca trebuind să fie adevărate* dintre cele care descriu relațiile **palmatelor** cu **ofideele** şi cu **siderinele**?

Vă atenționăm că pentru *patru* din cele cinci enunțuri cu privire la relațiile dintre **ofidee** şi **siderine** există *mai mult de o singură soluție*!! Adică, este posibil ca pentru *oricare* dintre cele patru enunțuri să existe *mai multe cupluri de propoziții* (formate prin alegerea uneia din lista numerotată de la **1** la **8** şi a celeilalte din lista numerotată de la **9** la **16**) care, dacă ar fi adevărate, ar face ca şi acel enunț să fie adevărat în mod logic necesar.

Pentru **soluțiile alternative**, notați *perechea de enunțuri* corespunzătoare *fiecărei noi soluții* găsite de Dvs. *în cele două spații marcate cu o liniuță*, mărginite de către o pereche de paranteze (trecând *în primul spațiu*, deasupra liniuței, *numărul corespunzător enunțului ales* dintre cele numerotate de la **1** la **8** şi *în cel de-al doilea spațiu*, deasupra liniuței, *numărul enunțului ales* dintre cele numerotate de la **9** la **16**).

Vă mulțumim foarte mult pentru colaborarea la această cercetare! Fiind un studiu explorator, scopul nu este acela de a vă evalua abilitățile de gândire personale, ci de a investiga procesele raționamentului deductiv. De aceea, rezultatele obținute nu pot fi tratate ca o probă ale cărei rezultate să fie relevante în ceea ce privește măsurarea inteligenței Dvs.

Annex 5

FOAIE DE RĂSPUNS

1. Pentru *ca să demonstrez* în mod logic cuiva *adevărul enunţului*:

"Toate **ofideele** sunt cu certitudine **siderine.**"

ar trebui să ştiu că este adevărat enunţul cu numărul ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre cele numerotate de la **1** la **8**) şi *simultan este adevărat* enunţul cu numărul ___ (notaţi deasupra liniuţei numărul *corespunzător enunţului ales* dintre cele numerotate de la **9** la **16**).

Soluţii alternative

(__ , __) , (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

2. Pentru *ca să demonstrez* în mod logic cuiva *adevărul enunţului*:

"Toate **ofideele nu** sunt cu certitudine **siderine.**"

ar trebui să ştiu că este adevărat enunţul cu numărul ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre cele numerotate de la **1** la **8**) şi *simultan este adevărat* enunţul cu numărul ___ (notaţi deasupra liniuţei numărul *corespunzător enunţului ales* dintre cele numerotate de la **9** la **16**).

Soluţii alternative

(__ , __) , (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

3. Pentru *ca să demonstrez* în mod logic cuiva *adevărul enunţului*:

"*Unele* **ofidee** sunt cu certitudine **siderine.**"

ar trebui să ştiu că este adevărat enunţul cu numărul ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre cele numerotate de la **1** la **8**) şi *simultan este adevărat* enunţul cu numărul ___ (notaţi deasupra liniuţei numărul *corespunzător enunţului ales* dintre cele numerotate de la **9** la **16**).

Soluţii alternative

(__ , __) , (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

4. Pentru *ca să demonstrez* în mod logic cuiva *adevărul enunţului*:

"*Unele* **ofidee nu** sunt cu certitudine **siderine.**"

ar trebui să ştiu că este adevărat enunţul cu numărul ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre cele numerotate de la **1** la **8**) şi *simultan este adevărat* enunţul cu numărul ___ (notaţi deasupra liniuţei numărul *corespunzător enunţului ales* dintre cele numerotate de la **9** la **16**).

Soluţii alternative

(__ , __) , (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

Annex 5

5. Pentru *ca să demonstrez* în mod logic cuiva *adevărul enunţului*:

"*Nu se poate stabili nimic cu certitudine* privire la relaţia dintre **ofidee** şi **siderine.**"

ar trebui să ştiu că este adevărat enunţul cu numărul ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre cele numerotate de la **1** la **8**) şi *simultan este adevărat* enunţul cu numărul ___ (notaţi deasupra liniuţei numărul *corespunzător enunţului ales* dintre cele numerotate de la **9** la **16**).

Soluţii alternative

(__ , __) , (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

Nume şi prenume (sau pseudonim)_____
Vârsta_____
Sexul_____
Clasa_____
Şcoala_____

Annex 6

Sarcină pentru investigarea raționamentului deductiv

Sunteți solicitați să rezolvați un tip de sarcină asemănătoare celei cu care doctorii se confruntă atunci când încearcă să vadă care sunt legăturile dintre simptoame şi boli.

În cele ce urmează este vorba de cazul unui grup de medici care au studiat *relațiile* dintre o *boală* rară a ficatului: **hepatoza**, şi *semnele sale posibile la nivelul pielii*: **apariția unor pete roşii în palme**, pentru ca să ştie câtă importanță să dea acelor pete.

Relațiile logic posibile puteau fi următoarele:

A. Toți **cei bolnavi de hepatoză** au **pete roşii în palmă** din cauza bolii.
B. Unii **din cei bolnavi de hepatoză** au **pete roşii în palmă** din cauza bolii.
C. Toți **cei bolnavi de hepatoză *nu*** au **pete roşii în palmă** din cauza bolii.
D. Unii dintre **cei bolnavi de hepatoză *nu*** au **pete roşii în palmă** din cauza bolii.
E. Nu se poate spune nimic cert despre legătura dintre **hepatoză** şi **petele roşii din palmă**.

Pentru a determina care dintre cazurile de mai sus este cel adevărat, ei s-au gândit să studieze *legătura* dintre **apariția petelor roşii** şi *un alt simptom posibil* al bolilor de ficat: **nivelul bilirubinei în sânge**.

Sarcina Dvs. este să descoperiți *ce*:

- *ar trebui să ştie* medicii despre legătura dintre **hepatoză** şi **nivelul crescut al bilirubinei în sânge** şi
- ce *ar trebui să descopere* în urma investigațiilor pe care urmau să le facă privitor la relația dintre apariția **petelor roşii în palmă** şi **nivelul crescut al bilirubinei**

pentru *ca să stabilească pe cale logică* adevărul *uneia dintre cele cinci relații logic posibile* dintre **hepatoză** şi **apariția petelor roşii în palmă** (de la **A** la **E**) prezentate mai sus.

Pentru *a vă uşura găsirea şi notarea răspunsului*, puteți *alege dintre variantele* de mai jos.

Trebuiau să ştie că în ceea ce priveşte legătura dintre **hepatoză** şi **nivelul crescut al bilirubinei în sânge** este *adevărat că*:

1. Toți **cei bolnavi de hepatoză** au **un nivel crescut de bilirubină în sânge**.
2. Unii dintre **cei bolnavi de hepatoză** au **un nivel crescut de bilirubină în sânge**.
3. Toți **cei bolnavi de hepatoză *nu*** au **un nivel crescut de bilirubină în sânge**.
4. Unii dintre **cei bolnavi de hepatoză *nu*** au **un nivel crescut de bilirubină în sânge**.

5. Toți **cei cu un nivel crescut de bilirubină în sânge** sunt **bolnavi de hepatoză**.
6. Unii din **cei cu un nivel crescut de bilirubină în sânge** sunt **bolnavi de hepatoză**.
7. Toți **cei cu un nivel crescut de bilirubină în sânge *nu*** sunt **bolnavi de hepatoză**.
8. Unii din **cei cu un nivel crescut de bilirubină în sânge *nu*** sunt **bolnavi de hepatoză**.

Trebuiau să descopere în urma investigațiilor pe care urmau să le facă privitor la relația dintre apariția **petelor roşii în palmă** şi **nivelul crescut al bilirubinei în sânge** că *este adevărat că*:

9. Toți **cei cu un nivel ridicat de bilirubină în sânge** au **pete roşii în palmă**.
10. Unii dintre **cei cu un nivel ridicat bilirubină în sânge** au **pete roşii în palmă**.
11. Toți **cei cu un nivel ridicat de bilirubină în sânge *nu*** au **pete roşii în palmă**.
12. Unii dintre **cei cu un nivel ridicat bilirubină în sânge *nu*** au **pete roşii în palmă**.

13. Toți **cei care au pete roşii în palmă** au **un nivel crescut de bilirubină în sânge**.
14. Unii din **cei care au pete roşii în palmă** au **un nivel crescut de bilirubină în sânge**.
15. Toți **cei care au pete roşii în palmă *nu*** au **un nivel crescut de bilirubină în sânge**.
16. Unii din **cei care au pete roşii în palmă *nu*** au **un nivel crescut de bilirubină în sânge.**

Atenție!! Vă rugăm să întoarceți foaia pentru a citi continuarea instrucțiunilor!

Annex 6

Observaţie:

Dacă medicii ştiu sau descoperă că **doar unii** pacienţi au unul din cele două simptoame (*pete roşii în palmă* sau *nivelul crescut de bilirubină în sânge*) sau boala *hepatoză*, înseamnă că cele constatate de ei *sunt certe* pentru *cel puţin o parte* dintre pacienţii care *au putut fi investigaţi*. Este însă **posibil**, *dar nu cert*, ca ele să fie valabile *şi pentru* **toţi** *pacienţii,* adică *şi pentru cei care au putut fi investigaţi şi pentru cei care* (din diverse motive) ***nu*** *au putut fi investigaţi*.

Dacă medicii ştiu sau descoperă că **toţi** pacienţii au *cu certitudine* unul din cele două simptoame (*pete roşii în palmă* sau *nivelul crescut de bilirubină în sânge*) sau boala *hepatoză*, înseamnă că *toţi* pacienţii *au putut fi investigaţi*.

Vă avertizăm că pentru *patru* dintre relaţii dintre **hepatoză** şi **apariţia petelor roşii în palme** sunt posibile *mai multe căi logice* de a afla dacă ele sunt adevărate sau nu, adică alegând alte *perechi de variante* (*una* dintre cele numerotate de la **1** la **8**, iar *alta* dintre cele numerotate de **9** la **16**)?

Pentru **soluţiile alternative**, notaţi *perechea fiecărei noi soluţii* găsite de Dvs. *în cele două spaţii marcate cu o liniuţă*, mărginite de către o pereche de paranteze **(**trecând *în primul spaţiu*, deasupra liniuţei, *numărul corespunzător variantei alese* dintre cele numerotate de la **1** la **8** şi *în cel de-al doilea spaţiu*, deasupra liniuţei, *numărul corespunzător variantei alese* dintre cele numerotate de la **9** la **16)**.

Vă mulţumim foarte mult pentru colaborarea la această cercetare! Fiind un studiu explorator, scopul nu este acela de a vă evalua abilităţile de gândire personale, ci de a investiga procesele raţionamentului deductiv. De aceea, rezultatele obţinute nu pot fi tratate ca o probă ale cărei rezultate să fie relevante în ceea ce priveşte măsurarea inteligenţei Dvs.

FOAIE DE RĂSPUNS

1. Pentru ca medicii să determine că

"Toţi **cei bolnavi de hepatoză** au **pete roşii în palmă** din cauza bolii."

ei *trebuiau să ştie* că *e adevărat că* ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre variantele numerotate de la **1** la **8**) şi *trebuiau să descopere* că *este adevărat că* ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre variantele numerotate de la **9** la **16**).

Soluţii alternative

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),
(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

2. Pentru ca medicii să determine că

"Unii **din cei bolnavi de hepatoză** au **pete roşii în palmă** din cauza bolii."

ei *trebuiau să ştie* că *e adevărat că* ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre variantele numerotate de la **1** la **8**) şi *trebuiau să descopere* că *este adevărat că* ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre variantele numerotate de la **9** la **16**).

Soluţii alternative

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),
(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

3. Pentru ca medicii să determine că

"Toţi **cei bolnavi de hepatoză *nu*** au **pete roşii în palmă** din cauza bolii."

ei *trebuiau să ştie* că *e adevărat că* ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre variantele numerotate de la **1** la **8**) şi *trebuiau să descopere* că *este adevărat că* ___ (notaţi deasupra liniuţei *numărul corespunzător enunţului ales* dintre variantele numerotate de la **9** la **16**).

Soluţii alternative

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),
(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

Annex 6

4. Pentru ca medicii să determine că

"Unii dintre **cei bolnavi de hepatoză *nu*** au **pete roşii în palmă** din cauza bolii."

ei *trebuiau să ştie* că *e adevărat că* ___ (notați deasupra liniuței *numărul corespunzător enunțului ales* dintre variantele numerotate de la **1** la **8**) şi *trebuiau să descopere* că *este adevărat că* ___ (notați deasupra liniuței *numărul corespunzător enunțului ales* dintre variantele numerotate de la **9** la **16**).

Soluții alternative

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),
(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

5. Pentru ca medicii să determine că

"Nu se poate spune nimic cert despre legătura dintre **hepatoză** şi **petele roşii din palmă**."

ei *trebuiau să ştie* că *e adevărat că* ___ (notați deasupra liniuței *numărul corespunzător enunțului ales* dintre variantele numerotate de la **1** la **8**) şi *trebuiau să descopere* că *este adevărat că* ___ (notați deasupra liniuței *numărul corespunzător enunțului ales* dintre variantele numerotate de la **9** la **16**).

Soluții alternative

(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __),
(__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __), (__ , __)

Nume şi prenume (sau pseudonim)_____
Vârsta_____
Sexul_____
Clasa_____
Şcoala_____

Annex 7

Sarcină pentru investigarea raționamentului deductiv

În cele de mai jos vi se cere să rezolvați o sarcină de raționament deductiv, ca cele pe care doctorii le folosesc zi de zi atunci când încearcă să vadă care sunt legăturile dintre anumite simptome şi anumite boli.

Este vorba în cele ce urmează de cazul unui grup de medici care au studiat relațiile dintre o boală rară a ficatului: *hepatoza*, şi semnele sale posibile la nivelul pielii: *apariția unor pete roşii în palme* şi la nivelul compoziției sângelui: prezența în sânge a unei *concentrații ridicate dintr-o substanță numită bilirubină*. Mai precis, doreau să ştie ce relație există între *petele roşii din palmă* şi boala de ficat numită *hepatoză*, pentru ca să ştie câtă importanță să dea acelor pete în stabilirea diagnosticului. Relațiile logic posibile puteau fi următoarele:

A. Toți **cei bolnavi de hepatoză** au **pete roşii în palmă** din cauza bolii.
B. Unii din **cei bolnavi de hepatoză** au **pete roşii în palmă din cauza bolii**.
C. Toți **cei bolnavi de hepatoză *nu*** au **pete roşii în palmă** din cauza bolii.
D. Unii dintre **cei bolnavi de hepatoză *nu*** au **pete roşii în palmă** din cauza bolii.
E. Nu se poate spune nimic *cert* despre legătura dintre **hepatoză** şi **petele roşii din palmă**.

În cele de mai jos vi se dau 24 de combinații posibile între ceea ce *ei puteau şti* în ceea ce priveşte legătura dintre **hepatoză** şi **nivelul crescut al bilirubinei în sânge** şi între ceea ce ei *puteau descoperi* în urma investigațiilor pe care urmau să le facă privitor la relația dintre **apariția petelor roşii în palmă** şi **nivelul crescut al bilirubinei**. Sarcina Dvs, este să stabiliți pentru fiecare combinație posibilă la care dintre cele 5 concluzii posibile de mai sus (în ceea ce priveşte relația dintre **petele roşii din palmă** şi boala de ficat numită **hepatoză**) trebuiau să ajună pe cale logică medicii.

Observație:

- În situațiile în care medicii ştiu sau descoperă că **toți** pacienții au unul din cele două simptoame (*pete roşii în palmă* sau *nivelul crescut de bilirubină în sânge*) sau boala *hepatoză*, înseamnă că **toți** pacienții aflați la dispoziția lor, sub observație, *au putut fi investigați* de către ei.

- În situațiile în care medicii ştiu sau descoperă că **doar unii** pacienții au unul din cele două simptoame (*pete roşii în palmă* sau *nivelul crescut de bilirubină în sânge*) sau boala *hepatoză*, înseamnă că **doar o parte** dintre pacienții aflați la dispoziția lor, sub observație, *au putut fi investigați* de către ei. Prin urmare, cele constate de medici în privința lor *sunt certe* pentru *unii dintre potențialii pacienți*, adică pentru *cel puțin o parte* dintre cei investigați. Este însă **posibil** (*dar nu cert*, ca în situațiile menționate mai sus, când toți pacienții au putut fi investigați) ca ele să fie valabile *şi pentru restul pacienților*, cei care nu au putut fi investigați din diverse motive.

Vă mulțumim foarte mult pentru colaborarea la această cercetare! Fiind un studiu explorator, scopul nu este acela de a vă evalua abilitățile de gândire personale, ci de a investiga procesele raționamentului deductiv. De aceea, rezultatele obținute nu pot fi tratate ca o probă ale cărei rezultate să fie relevante în ceea ce priveşte măsurarea aptitudinilor intelectuale.

Annex 7

FOAIE DE RĂSPUNS

Nume şi prenume (sau pseudonim) _____
Şcoala_____ Clasa_____
Sex_____ Vârsta_____ Data examinării_____

1. Dacă
- *au descoperit că*: "Toţi **cei cu un nivel ridicat de bilirubină în sânge** au **pete roşii în palmă**."
- şi *ştiau că*: "Toţi **cei bolnavi de hepatoză** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

2. Dacă
- *au descoperit că*: "Toţi **cei cu un nivel ridicat de bilirubină în sânge** au **pete roşii în palmă**."
- şi *ştiau că*: "Toţi **cei bolnavi de hepatoză *nu*** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

3. Dacă
- *au descoperit că*: "Toţi **cei cu un nivel ridicat de bilirubină în sânge** au **pete roşii în palmă**."
- şi *ştiau că*: "Unii din **cei bolnavi de hepatoză** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

4. Dacă
- *au descoperit că*: "Toţi **cei cu un nivel ridicat de bilirubină în sânge** au **pete roşii în palmă**."
- şi *ştiau că*: "Unii din **cei bolnavi de hepatoză *nu*** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

5. Dacă
- *au descoperit că*: "Toţi **cei cu un nivel ridicat de bilirubină în sânge *nu*** au **pete roşii în palmă**."
- şi *ştiau că*: "Toţi **cei bolnavi de hepatoză** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

6. Dacă
- *au descoperit că*: "Toţi **cei cu un nivel ridicat de bilirubină în sânge *nu*** au **pete roşii în palmă**."
- şi *ştiau că*: "Toţi **cei bolnavi de hepatoză *nu*** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

7. Dacă
- *au descoperit că*: "Toţi **cei cu un nivel ridicat de bilirubină în sânge *nu*** au **pete roşii în palmă**."
- şi *ştiau că*: "Unii din **cei bolnavi de hepatoză** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

8. Dacă
- *au descoperit că*: "Toţi **cei cu un nivel ridicat de bilirubină în sânge *nu*** au **pete roşii în palmă**."
- şi *ştiau că*: "Unii din **cei bolnavi de hepatoză *nu*** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

9. Dacă
- *au descoperit că*: "Toţi **cei care au pete roşii în palmă** au **un nivel crescut de bilirubină în sânge**."
- şi *ştiau că*: "Toţi **cei bolnavi de hepatoză** au **un nivel crescut de bilirubină în sânge**."
atunci în mod necesar medicii trebuiau să deducă logic
concluzia _____ (notaţi *deasupra liniei litera* de la **A** la **E** corespunzătoare enunţului potrivit)

Annex 8

Sarcină pentru investigarea raționamentului deductiv

În cele ce urmează vi se prezintă tipul de sarcină pe care sunteți solicitați să o rezolvați.

Se pornește de la *două propoziții* (premise) în care sunteți informați despre *o parte* dintre *relațiile presupuse ca adevărate* dintre *trei tipuri fictive* (inventate pentru elaborarea acestei probe) *de plante*: **ofidee**, **siderine** și **palmate**. Mai precis, <u>într-una dintre propoziții</u> se *va presupune ca adevărată* o anumită *relație* dintre **palmate** și **siderine** (sau, echivalent, între **siderine** și **palmate**). <u>În cealaltă propoziție</u> *se va presupune ca adevărată* o anumită relație dintre **palmate** și **ofidee** (sau, echivalent, între **ofidee** și **palmate**).

Prin urmare, *presupunând că cele două propoziții date sunt adevărate*, <u>vi se cere</u> să deduceți logic *ce anume rezultă cu necesitate* cu privire la *relația* dintre **ofidee** și **siderine**, cea despre care nu vi s-a prezentat nici o informație.

Pentru aceasta, va trebui *să alegeți o propoziție* dintre cele cinci de mai jos, *trecând litera din dreptul său în spațiul marcat* în partea dreaptă a foii(deasupra liniei care urmează după "Concluzia logică este:").

A. Toate **ofideele** sunt **siderine**.
B. Toate **ofideele *nu*** sunt **siderine**.
C. Unele **ofidee** sunt **siderine**.
D. Unele **ofidee *nu*** sunt **siderine**.
E. **Nu** se poate deduce cu certitudine nimic precis cu privire la relația **ofideelor** cu **siderinele**.

Vă mulțumim foarte mult pentru colaborarea la această cercetare! Fiind un studiu explorator, scopul nu este acela de a vă evalua abilitățile de gândire personale, ci de a investiga procesele raționamentului deductiv. De aceea, rezultatele obținute nu pot fi tratate ca o probă ale cărei rezultate să fie relevante în ceea ce privește măsurarea inteligenței Dvs.

FOAIE DE RĂSPUNS

Nume şi prenume (sau pseudonim) _____
Şcoala_____ Clasa_____
Sex_____ Vârsta_____ Data examinării_____

1. Dacă e adevărat că:
   "Toate **palmatele** sunt **siderine**." şi că
   "Toate **ofideele** sunt **palmate**."
   Concluzia logică este: _____

2. Dacă e adevărat că:
   "Toate **palmatele** sunt **siderine**." şi că
   "Toate **ofideele nu** sunt **palmate.**"
   Concluzia logică este: _____

3. Dacă e adevărat că:
   "Toate **palmatele** sunt **siderine**." şi că
   "Unele **ofidee** sunt **palmate**"
   Concluzia logică este: _____

4. Dacă e adevărat că:
   "Toate **palmatele** sunt **siderine**." şi că
   "Unele **ofidee nu** sunt **palmate**."
   Concluzia logică este: _____

5. Dacă e adevărat că:
   "Toate **palmatele nu** sunt **siderine**." şi că
   "Toate **ofideele** sunt **palmate**."
   Concluzia logică este: _____

Annex 13

Instrucțiuni pentru proba de raționament silogistic

În cele ce urmează sunt prezentate **24 de probleme de raționament logic,** numit **raționament silogistic.**

Vi se cere să găsiți soluția pentru fiecare dintre ele, deducând **concluzia logic necesară** care decurge din *informația* prezentată în cele *două premise* (judecăți) ale unei probleme *dacă se presupune că această informație este adevărată.*

Pentru a da răspunsul, va trebui să alegeți unul dintre enunțurile de mai jos şi să notați în spațiul rezervat, în dreptul concluziei, litera corespunzătoare (**A**, **B**, **C**, **D**, **E, F, G, H** sau **I**) enunțului ales:

A. Toți membrii clasei **S** au proprietatea **P**.

B. Toți membrii clasei **S** sunt şi membrii ai clasei **P**.

C. Toți membrii clasei **S nu** au proprietatea **P**.

D. Toți membrii clasei **S nu** sunt şi membrii ai clasei **P**.

E. Unii membri ai clasei **S** au proprietatea **P**.

F. Unii membri ai clasei **S** sunt şi membri ai clasei **P**.

G. Unii membri ai clasei **S nu** au proprietatea **P**.

H. Unii membri ai clasei **S nu** sunt şi membri ai clasei **P**.

I. **Nu** se poate deduce nici o concluzie logic necesară.

Nume şi prenume_____
Şcoala _____
Clasa _____
Sex_____
Vârsta_____
Data examinării_____

1. Toți membrii clasei **M** au proprietatea **P**. Concluzie: _____
   Toți membrii clasei **S** sunt membri şi ai clasei **M**.

2. Toți membrii clasei **M** au proprietatea **P**. Concluzie: _____
   Toți membrii clasei **S nu** sunt membri şi ai clasei **M**.

3. Toți membrii clasei **M** au proprietatea **P**. Concluzie: _____
   Unii membri ai clasei **S** sunt membri şi ai clasei **M**.

4. Toți membrii clasei **M** au proprietatea **P**. Concluzie: _____
   Unii membri ai clasei **S nu** sunt membri şi ai clasei **M**.

5. Toți membrii clasei **M nu** au proprietatea **P**. Concluzie: _____
   Toți membrii clasei **S** sunt membri şi ai clasei **M**.

6. Toți membrii clasei **M nu** au proprietatea **P**. Concluzie: _____
   Toți membrii clasei **S nu** sunt membri şi ai clasei **M**.

7. Toți membrii clasei **M nu** au proprietatea **P**. Concluzie: _____
   Unii membri ai clasei **S** sunt membri şi ai clasei **M**.

8. Toți membrii clasei **M nu** au proprietatea **P**. Concluzie: _____
   Unii membri ai clasei **S nu** sunt membri şi ai clasei **M**.

9. Toți membrii clasei **P** au proprietatea **M**. Concluzie: _____
   Toți membrii clasei **S** au proprietatea **M**.

17. Toți membrii clasei **M** au proprietatea **P**. Concluzie: _____
    Toți membrii clasei **M** sunt şi membri ai clasei **S**.

Annex 15

Table 1

	Administration in the first position (N = 50)	**Administration in the second position** (N = 44)
Comparison between **N** type task and **L** type task regarding the correctness of *valid* syllogisms	U = **186** p = 013 (greater correctness for **L** type task)	-
Comparison between **N** type task and **L** type task regarding the correctness of *invalid* syllogisms	U = **204.5** p = 034 (greater correctness for **N** type task)	-
Comparison between **N** type task and **L** type task regarding the correctness of *one model* syllogisms	-	U = 169 p = 077 (greater correctness for **L** type task)
Comparison between **N** type task and **L** type task regarding the correctness of *multiple model valid* syllogisms	U = **173** p = 006 (greater correctness for **L** type task)	-
Comparison between **N** type task and **L** type task regarding the correctness of *figure 1 valid* syllogisms	U = **224** p = 043 (greater correctness for **L** type task)	U = **171** p = 038 (greater correctness for **L** type task)
Comparison between **N** type task and **L** type task regarding the correctness of *figure 1 invalid* syllogisms	-	-
Comparison between **N** type task and **L** type task regarding the correctness of *figure 2 valid* syllogisms	U = 236.5 p = 087 (greater correctness for **L** type task)	-
Comparison between **N** type task and **L** type task regarding the correctness of *figure 2 invalid* syllogisms	U = 237 p = 078 (greater correctness for **N** type task)	-
Comparison between **N** type task and **L** type task regarding the correctness of *figure 3 valid* syllogisms	U = 226.5 p = 08 (greater correctness for **L** type task)	-
Comparison between **N** type task and **L** type task regarding the correctness of *figure 3 invalid* syllogisms	U = **200.5** p = 022 (greater correctness for **N** type task)	-

Annex 17

Probă de raționament silogistic A

În cele ce urmează sunt prezentate **4 probleme de raționament logic,** numit **raționament silogistic.**

Vi se cere să găsiți soluția pentru fiecare dintre ele, deducând **concluzia logic necesară** care decurge din *informația* prezentată în cele *două premise* (judecăți) ale unei probleme *dacă se presupune că această informație este adevărată.*

Pentru a da răspunsul, va trebui să alegeți unul dintre enunțurile de mai jos şi să notați în spațiul rezervat, în dreptul concluziei, litera corespunzătoare (**A**, **B**, **C**, **D** sau **E**) enunțului ales:

A. Toți **S** sunt **P**.
B. Toți **S nu** sunt **P**.
C. Unii **S** sunt **P**.
D. Unii **S nu** sunt **P**.
E. **Nu** se poate deduce nici o concluzie logic necesară.

Vă mulțumim pentru participare!

Nume (sau pseudonim)_____
Şcoala_____
Clasa_____
Sex_____
Vârsta_____
Data examinării_____

Probleme

1. Toți **M** sunt **P**. Concluzie: _____
   Toți **S** sunt **M**.

2. Toți **P** sunt **M**. Concluzie: _____
   Toți **S** sunt **M**.

3. Toți **P** sunt **M**. Concluzie: _____
   Toți **S nu** sunt **M**.

4. Toți **M** sunt **P**. Concluzie: _____
   Toți **M nu** sunt **S**.

Annex 17

Probă de raționament silogistic B

În cele ce urmează sunt prezentate **4 probleme de raționament logic,** numit **raționament silogistic.**

Vi se cere să găsiți soluția pentru fiecare dintre ele, deducând **concluzia logic necesară** care decurge din *informația* prezentată în cele *două premise* (judecăți) ale unei probleme *dacă se presupune că această informație este adevărată.*

Pentru a da răspunsul, va trebui să alegeți unul dintre enunțurile de mai jos şi să notați în spațiul rezervat, în dreptul concluziei, litera corespunzătoare (**A**, **B**, **C**, **D** sau **E**) enunțului ales:

A. Toți **S** sunt **P**.
B. Toți **S nu** sunt **P**.
C. Unii **S** sunt **P**.
D. Unii **S nu** sunt **P**.
E. **Nu** se poate deduce nici o concluzie logic necesară.

Vă mulțumim pentru participare!

Nume (sau pseudonim)_____
Şcoala_____
Clasa_____
Sex_____
Vârsta_____
Data examinării_____

Probleme

1. Toți **P** sunt **M**. Concluzie: _____
   Toți **S** sunt **M**.

2. Toți **M** sunt **P**. Concluzie: _____
   Toți **S** sunt **M**.

3. Toți **M** sunt **P**. Concluzie: _____
   Toți **M nu** sunt **S**.

4. Toți **P** sunt **M**. Concluzie: _____
   Toți **S nu** sunt **M**.

Annex 18

Probă de generare liberă de numere

Mai jos găsiți un tabel care are 400 de căsuțe. Sunteți solicitați să îl completați scriind în fiecare căsuță *oricare dintre numerele* de la **1** la **9** *vă vine în minte în momentul completării acelei căsuțe*. Nu trebuie să țineți cont de nimic altceva decât dacă acel număr este cel pe care îl aveți în minte atunci când începeți să completați căsuța. Cu alte cuvinte, *nu are importanță cum este el (dacă este acelaşi sau nu, de exemplu) în raport cu numerele cu care ați completat căsuțele precedente*.

Începeți completarea tabelului cu prima coloană, de sus în jos, apoi continuați cu următoarele. Pentru a nu fi influențați de numerele completate anterior vă recomandăm să acoperiți progresiv cu o bucată de hârtie căsuțele deja completate.
