INVOLVEMENT OF LANGUAGE IN THE DEVELOPMENT OF NUMERICAL REPRESENTIATION AR PRESCHOOL CHILDREN

Cristina ŢÎMPĂU*

Abstract

In recent years, one of the questions that developmental psychology has tried to answer is related to the origin and how our cognitive system development. A significant impact on trying to find an answer to this question have been research conducted on numerical skills of children, and as a consequence of this interest, the development of phylogenetic and ontogenetic perspective numeracy skills, has become studied one of research topics most intensively.

Based on the failure of the model approach in the context of "object files" at the preschoolers numerical skills, motivation of this paper refers to the attempt to provide a numerical approach to basic skills correspondence, ordering or numeracy in the context of transition from numerical representations to verbal and preverbal role that language plays in supporting performance, while taking account of how children numerical concepts and changes implemented strategies they use at different ages. If until now it is clear that language development is a mediating factor in the reorganization of numerical knowledge is needed in-depth approach of how procedural skills affect solving numerical tasks and the extent to which models originally developed to describe numerical skills of children under one year of preschool children can be applied in the context of language development.

Keywords: *numerical skills,numerical representations, numerical concepts and changes, language development.*

1. Introduction

In recent years, one of the questions that developmental psychology has tried to answer is related to the origin and how our cognitive system development. A significant impact on trying to find an answer to this question have been research conducted on numerical skills of children, and as a consequence of this interest, the development of phylogenetic and ontogenetic perspective numeracy skills, has become one of research topics most extensively studied (for summaries, see Carey, 1998; Wynn, 1998; Gallistel & Gelman, 2000; Geary, 2000; Feigenson, Dehaene & Spelke, 2004).

Recently, the development of experimental models such expectations violation (violation of expectation) revealed the existence of numerical skills even in children under 1 year (Wynn, 1992; Simon, Hesp & Rochat, 1995; Uller et al., 1999; Feigenson, Carey & Spelke, 2002). Although innate or acquired origin is still debated numerical representations (Simon, 1997; Carey, 1998; Gallistel & Gelman, 2000), the literature is remarkable consensus phylogenetic continuity in the development of numerical skills. The methods of cognitive neuroscience have revealed the behavior in a number of primate species (Brannon & Terrace, 2000; Sulkowski & Hauser, 2001; Nieder & Miller, 2004), birds (Emmerton, Lohmann & Niemann, 1997; Emmerton 1998 ; Xia et al., 2001) or rodents (Dalrymple-Alford & Breukelaar, 1998; Leon & Gallistel, 1998), which are considered antecedents of nonverbal numeracy skills.

These studies in humans and infrahuman have led to two models. First, the object model files, which holds that each element of a set of distinct representations are created, stored independently in working memory (WM) (Trick & Pylyshyn, 1994; Simon, 1997; Leslie et al., 1998; Uller et al., 1999). On the other hand, the model battery (accumulator model) proposes a mechanism that allows the representation of an amount in proportion to the number of elements quantified (Xu & Spelke, 2000; Chiang & Wynn, 2000; Xu, Spelke & Goddard, 2005). Conclusion The studies validating these models was that these models suggest descriptions of similar phenomena, but rather distinct. The object files requires a precise numerical representation, which however is limited to 3-4 elements (in tasks such as "1 + 1" or "2 vs. 3"), while the battery model produces inaccurate representations but claim discrimination larger sets of objects (in tasks such as "8 vs. 16"). Furthermore, studies of cultural anthropology (Gelman & Gallistel, 2004; Gordon, 2004; Pica et al, 2004) and the bilingual subjects (Spelke & Tsvirkin, 2001), suggests that at least accurate mathematical calculations are dependent on acquiring mathematical symbols and their verbal referents, while inaccurate calculations are independent of language. A possible interpretation of these results is that the language support numeracy skills, but once they are acquired, the language no longer has a central role in the activation of knowledge. The theoretical perspective that supports this idea is known as the weak hypothesis of language (language weak hypothesis), but which was insufficiently tested by experimental studies on preschool children. Except Houde (1997), who adapted for children 2-3 years of experimental model

* PhD Candidate at the Faculty of Psychology and Educational Sciences, University of Bucharest (e-mail: **cristinatimpau89@gmail.com**; **cristina.timpau@drd.unibuc.ro**).

Wynn (1992), no other research in this age group didn't seek validation of the model object files in these tasks, the more since the claims that its content is accurate numerical representations, with language acquisition, partially dependent on it (Simon, 1997; Gallistel & Gelman, 2000).

A second aspect related object model files found in studies in humans and infrahuman was sensitivity to continue properties (continuous properties) such as density, size or length that seem to interfere with the numerical size (Scholl & Pylyshyn, 1999; Uller et al., 1999; Feigenson, Carey & Spelke, 2002). Numerical representations to the interference susceptibility was explained by the absence of sufficiently developed capacities inhibition in children under 7 years (Temple & Posner, 1998) and were found both in correspondence tasks (Houde, 1997) and in the ordering (Mix & Clearfield, 1999; Brannon & Van de Walle, 2001). The main limitation of these studies is that the use of methodologically designs pretest-posttest type that can highlight the learning rather than actual skills of preschoolers. A positive aspect, however, is conferred by trying to establish a link between numeracy and performance in the two types of tasks. The results so far support the hypothesis poor language and numeracy development suggests that support performance, but between the two variables cannot establish a causal relationship. Continuing the relationship numeracy-language approach to a deeper level of analysis, particular attention was paid gestures function in implementing the concept of cardinal value (Alibi & DiRusso, 1999; Graham, 1999), but so far the model proposed by Alibi & DiRusso (1999) has not yet replied.

If until now it is clear that language development is a mediating factor in the reorganization of numerical knowledge is needed in-depth approach of how procedural skills affect solving numerical tasks and the extent to which models originally developed to describe numerical skills of children under one year of preschool children can be applied in the context of language development.

Based on the failure of the model approach in the context of object files preschoolers numerical skills, motivation of this paper refers to the attempt to provide a numerical approach to basic skills correspondence, ordering or numeracy in the context of transition from numerical representations to verbal and preverbal role that language plays in supporting performance, while taking account of how children numerical concepts and changes implemented strategies they use at different ages.

The purpose of this paper is to highlight how language mediates access to accurate numerical representations, especially given that this relationship was poorly investigated. First, from the model object files propose adaptation based on the experimental model of expectations violations carried out by Houde (1997), testing assumptions related to the successive transformations of this model is subjected to a sequence in which the multiple objects.

Further, it will investigate the second assumption of the model object files interference exerted on continuous variables on performance in tasks of correspondence and ordering. Also, it will track the extent to which these skills are supported by numerical numeracy capabilities. Finally, we intend to test the proposed model assumptions & DiRusso Alibi (1999) on the role of gestures in numeracy and replication procedure proposed by the two authors.

The overall objective of the three experiments suggested further relates to the implications of object files and the models proposed by Alibi & DiRusso (1999) on numerical representations in children preschool or the impact that has on the acquisition Limaj numerical representations. Next, we detail the reasoning underlying the three proposed experiments

2. The role of language in the number representation systems

A number of surveys conducted by Amazonian tribes whose language lacks words to denote numbers, have brought the issue of the role of language in the development of numerical concepts (Gelman & Gallistel, 2004; Gordon, 2004; Pica et al., 2004). The question this study sought to answer is whether the use of certain mathematical concepts is impossible due to lack of lexical reviewers. These studies have considered three types of hypotheses about the relationship language - numerical skills. The first is "strong hypothesis of language '(strong language hypothesis) proposed by Benjamin Lee Whorf, that language determines the nature and content of cognition. The main criticism of this relation deterministic concerns on the one hand that eliminates the possibility of any kind of reasoning, and hence the numerical animals or children whose language is not sufficiently developed, and on the other hand offers no explanation on how exposure to a particular language could generate concepts and representations that support it. The second hypothesis considers irrelevant language (language irrelevant hypothesis) to develop mathematical concepts as people, animals also possess innate nonverbal numerical skills, selected along evolution and allow processing without symbols numbers (Dehaene, 2001; Feigenson, Carey & Spelke, 2002). A third category of theories based on the assumption poor language, nonverbal numerical representations acknowledging irrelevance hypothesis postulates language, but believes that the development of numeracy skills undergo a profound transformation once children acquire language for the numerical symbols (Simon, 1997; Carey, 1998; Dehaene et al., 1999).

Analyzing the three theoretical orientations in terms of empirical studies of cultural anthropology offered by comparing the performance of Amazonian tribes with those of Europeans, were derived two conclusions: 1) approximate numerical representations are identical to those of the Amazonian tribesmen people from cultures possessing a number system, which provides evidence of the assumption that this power is acquired independently of language (language irrelevance hypothesis); 2) Unlike approximation, exact numerical representations are affected by lack numerals, which supports the hypothesis that language plays an important role in the emergence of representations accurate population (weak hypothesis language). Otherwise we said, we can distinguish two basic systems for representing numbers: one for the accurate representation and one for repezentări approximate whose main features have been detailed above (for summaries, see Carey, 1998; Wynn, 1998; Gallistel & Gelman, 2000; Feigenson, Dehaene & Spelke, 2004). As shown the two systems are activated by different stimuli in different experimental tasks ("2 <3" accurate depictions and "8 <16" for accurate representations), plus operate independently and are limited to representing numbers natural (Gallistel & Gelman, 2000; Feigenson, Dehaene & Spelke, 2004; Fias & Verguts, 2004).

Recently, a number of neuroimaging and neuropsychological studies have revealed the cerebral substrate of the two numerical systems. Approximate representation system is best characterized and is associated with activation of the inferior parietal cortex (ICC) intraparietal sulcus and (SIP) (Dehaene, 2001; Dehaene et al., 1999; Feigenson, Dehaene & Spelke, 2004). These studies are confirmed by neuroimaging studies in subjects with lesions of cortical areas involved in language, which still retains relatively intact numerical representations (Varley et al., 2005). This would suggest that the degree of specialization of these cortical areas is quite pronounced at least in adults, and thus determine their relative independence of other neural circuits (Dehaene, 2001).

In addition to studies of fMRI (functional magnetic resonance imaging) and injuries (Varley et al., 2005), electrophysiology studies conducted on monkeys showed preferential activation of the emergence of numerical stimuli of neurons in the prefrontal cortex, the ICC and SIP (Nieder & Miller, 2004). Unlike the system of representation, the exact representation is ill-defined. Except for a few neuroimaging studies that have shown the involvement of extrastriate cortex, the data are still inconclusive due turn, prevents the representation of objects is essential to the process of perception and prevents the development of control tasks required in fMRI, the target system must be inactive.

For the two systems of representation of the number two explanatory models were formulated: the battery for the system object model representations approximate and exact representations model files. Next we intend to present experimental evidence adduced in support of the two approaches, from studies in humans or infrahuman.

3. The research and results

In the experiment, investigate numerical skills development focused on highlighting the resilience to interference in verbal output tasks for sets of small objects. The specific objectives were:

1) to test model predictions object files that the number is not relevant stimuli when non-numeric variables interfere in its acquisition of explicit knowledge about verbal numeral system; Unlike previous studies performed on infants will assess verbal output in numerical tasks skillful correspondence and ordering;

2) construction of correspondence and ordering tasks, the application of the two concepts to be evaluated in terms of interference number / length

3) highlighting changes with age in the strategies and how they allow resistance to interference number / length;

4) highlighting the relationship between performance on tasks of correspondence or ordering, and the ability to provide answers cardinal.

The experiment was designed to highlight the extent to which the relevant number is a dimension pre-school children conditions that interfere with the perceptual dimensions such as the length of the row of objects. To test this prediction model was chosen task object files of correspondence and ordering two sets of objects. Based on data demonstrating the failure of children 3 years of correspondence tasks (Houde, 1997) and the success of the same age group in tasks ordinal (Brannon & Van de Walle, 2001), it was inferred that probably reduce interference number / length tasks correlation occurs at a higher age. Thus, interference number / length will affect greater performance than children 3 years of the 5 years due to reduced ability to inhibit irrelevant perceptual schemas, and will affect a greater burden than the correlation of ordering.

The experiment aims to test the following hypotheses:

1) the number of correct choices of subjects for 5 years is influenced by age and type of task;

2) the number of correct choices for ordinal skills is significantly higher than for the mapping;

3) the number of correct choices is significantly higher than the age of 5 years to 3 years.

Also for pregnancy How many? a task assessing numeracy ability to respond cardinal, following predictions were made in order correlations:

1) ability to provide answers cardinal is a predictor for success in the task of ordering;

2) the ability to provide answers cardinal is a predictor of performance in the task of mapping.

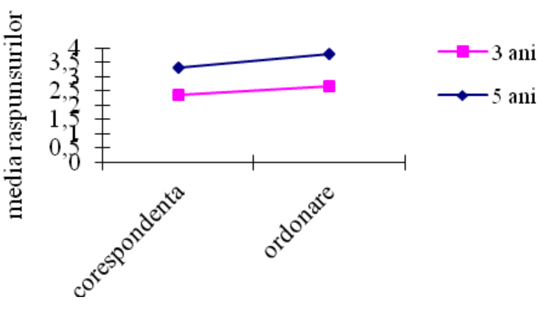
Investigation revealed indices of central tendency obtaining differences both between the ages of 3 and 5 and between the two tasks, correspondence and ordering. Thus, the burden of ordering 3 years M = 2.68 (SD = 99) is greater than the correlation of the load F = 2.36 (SD = 1.22), while at the age of 5 years is distinguished same pattern of results, the performance of the task of ordering M = 3.80 (SD = 40) are superior to task correspondence M = 3.32 (SD = 74).

Distributions of the age of 3 are symmetrical, but its proximity distributions environments maximum 4 to 5 years old za share index was calculated skew (each distribution is under 30 subjects). For ordering load distribution z = 1.32, where z <2.68 ns, while the task of correspondence z = 3.45, where z> 2.68, which means a negative asymmetric distribution.

In order to establish the relationship between the type of task and verbal numerical skills measured by How many numeracy task, the Pearson correlation coefficient was calculated to yield significant correlations between correlation and numeracy average r = 0.42, p <.01, respectively between ordering and numeracy, r = 0.47, p <.01. Removal of subjects who failed to provide even a correct answer in numeracy task (sample 8 children 5 years), amended such correlation coefficients, r = 0.47, p <.05 for correspondence relationship, numeracy and r = 0.31, p <.05 for relationship-numeracy ordering.

To verify the hypothesis, we chose repeated measures ANOVA because they fulfilled all criteria stated in the previous experiment, including the value Mauchly's W test, statistically insignificant. We have shown the following results: for the interaction effect F (1, 24) = 28, p> .10, ns, a significant effect of age variable F (1, 24) = 26.60, p <.001, and and a significant effect of task type variable F (1, 24) = 6.90, p <.01 (Fig. 4), which confirms the assumptions made for the main effects of age variable.

Fig.1 Media correct answers are higher than age 5 to 3 years, but significantly higher than in the task of sorting mail



Based on the significant effects of the two variables, comparisons were performed Bonferroni post-hoc type. Results showed a significant effect of age, children 5 years with 3 years of superior performance, Bonferroni t = 5.14, p <.001, while ordering task performance are significantly better than those in the correspondence Boferroni t = 2.63, p <.01.

Statistical analyzes also revealed in terms of age, that between the ages of 3 to 4 years, no significant differences between the means of the two groups in charge of correspondence t (24) = 1.24, p> .10, ns (M = 2.68, SD = 1,18 to 4 years), but significant differences in pregnancy ordering t (24) = 3.46, p <.001 (M = 3.36, SD = 0.63 4 years).

4. Conclusion

In a first analysis of data necessary following conclusions: 1) for both types of tasks is highlighted standard deviations higher in group 3 years, this high variability in performance indicating heterogeneity of responses at this age, and 2) reducing this variability in 5 years old, it becomes apparent convergence towards systematic response patterns. In addition, the strong negative asymmetry in pregnancy ordering supports the assumption that with numerical skills development, access to knowledge facilitates performance even in tasks where there is perceptual interference.

These conclusions are reinforced by inferential statistics, confirming on the one hand improve the ability to cope with non-numeric interference with age, and on the other hand maintaining a dichotomy between the performance of the task of ordering, which are superior to task correlation.

For the first observation, a possible explanation is offered even object model files, which claims that the number is not an obvious characteristic especially when there are perceptual correlate of type string length interfering with the latter, and the experimental data confirms the results of Huntley -Fenner & Cannon (2000) and Van de Walle & Brannon (2002) and the Clearfield & Mix (1999), Feigenson, Carey & Spelke (2002) on children under one year. Unlike the results of Huntley-Fenner & Cannon (2000) and Van de Walle & Brannon (2002), correlations between ordering and numeracy remain significant even after excluding cases of children who have not even given a correct answer, but the average value of the correlation coefficient, might suggest that susceptibility to interference under ordinal relations number / length is only partially dependent on the ability to deliver a cardinal. By contrast, if the load correlation, the correlation coefficient while remaining average is higher under exclusion of subjects who did not meet the minimum criteria of at least one correct answer in numeracy task. This would indicate, at least for this task relevance numeracy skills for performance.

These data are the first source of explanation of the differences in performance between the two tasks. A second source is the type of strategies that children use to solve the task, ie the extent to which they rely on a numerical strategy. Unlike previous studies that only have inferred the possibility of using different strategies (Sophianos, 1997; Brannon & Van de Walle, 2001), in the present study were followed children's answers on how they solved the task or prosecution gestures and mimic accompanying their answers.

Their responses were classified into two categories: 1) answers that reflect the use of digital strategies, and 2) answers that reflect the use of a non-numerical strategies. The first category of answers that were part of the child demonstrate the ability to use explanations like "3 is greater than 2" or more index string with Mickey, saying "there are more" (for the task of ordering) or "are all 3" and "are as many Mickey" (for load correlation). Also, children who were unable to provide metacognition observed nonverbal behavior, gestures or vocalizations or delivery in a low voice of numerals. This category of respondents were part especially children 5 years in some cases even recorded spontaneous reactions to explain the answer.

In the second category of responses were included explanations like "here are the pairs Mickey" (task correlation) or "here is a matchless Mickey", which reflect the use of the strategy set by the experimenter. In addition, children were considered pointing gestures using a strategy similar to that presented by the experimenter. The inclusion of responses in one of two categories based strategy type detected by comparing with the ability to respond correctly in numeracy task. We assumed that children who have not given an explanation for their answer nor proved numeracy skills, perhaps never implemented such a strategy. Accordingly, strategies have been quantified at least one REPLIES correctly. With the exception of three children of 3 years which gave wrong answers to all tests, both in charge of ordering and in the correspondence, all children have managed at least one correct answer.

If most answers correct to 3 years non-numerical strategy reflects a 82% (36 of 44 responses) at age 4 strategies numerical percentage increase from 18% to 46% at 4 years of age (23 responses from 50) and at 78% at 5 years (39 of 50) (Fig. 2). In addition, constant numerical strategies are adopted more frequently than the tasks of mail ordering, 14% vs. 23% (3 and 5 Responses) of 3 years (Fig. 3), 48% vs. 60% (12 and 15 replies) to 4 years (Fig. 4) and 64% vs. 92% (16 and 23 response) at 5 years.

Fig 2. Percentage of numerical and non-numerical strategies used compared to the three ages.

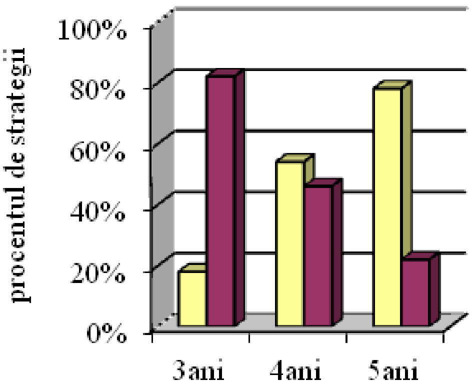


Fig.3. Percentage of non-numerical strategy is superior to 3 years of numerical correlation in both tasks and ordering.

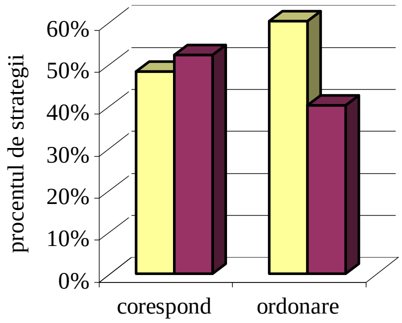
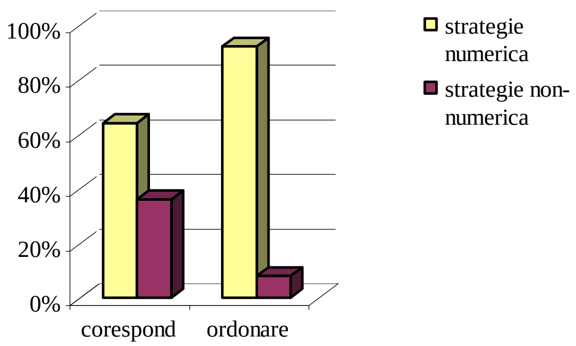


Fig.4. The percentage of non-numerical strategy is prevalent in charge of correspondence, but the numbers are prevalent in charge of ordering the age of 4 years.



Together these results lead to the conclusion that performance in these tasks is the first result numeracy skills, but the most relevant aspect is given the ability to implement this knowledge as a strategy for solving the tasks of correspondence and ordering (Sophianos, 1997 Brannon & Van de Walle, 2001). Once the numerical strategies are applied by default and the ability to solve tasks of interference increases. It is therefore obvious that the age of 4 years knowledge of numeracy begin to be implemented as a strategy and consequently improves performance in these tasks. Unlike children 4 years, 3 years that the knowledge about verbal numeral system, fail to transfer in solving non-numerical worded, these results are strengthened by previous research (Houde, 1997; Huntley- Fenner & Cannon, 2000), but not by Brannon & Van de Walle (2001). Possible differences between the data presented above and those obtained by the two authors, could be even opted for the method in this experiment. Thus, unlike the study by Van de Walle & Brannon (2001), who investigated the interference resistance to surface / number of children 2-3 years in terms of a learning phase, this experiment aimed to evaluate the knowledge that children have already and how they are able to use them in practical situations.

In conclusion, with language development, children are able to transfer this knowledge to the tasks of correspondence and ordering while the number is not an obvious stimulus. The numerical implementation of a strategy to support resilience inteferenţa number / length, which thus can be countered. Based on the importance of knowledge for verbal numeration system performance tasks and interference due to obvious changes seem to occur around the age of 4 years in terms of implementing this knowledge, we aimed to investigate the model proposed by Alibi & DiRusso (1999) strategies that children of this age they use numeracy.

The purpose of this research was to investigate how numerical representation in the context of language acquisition in preschool children, and the relationship between the number and type of the strategic skills implemented.

The experiment indicated that children's performances are influenced by changes continue properties, namely the interference number / length. These results confirms the predictions of the model object files, as well as previous research (Houde, 1997; Huntley-Fenner & Cannon, 2000; Brannon & Van de Walle, 2001). Furthermore, the performance is influenced by the type of load. Ordering seems to be easier for children than correspondence, probably for two reasons: first, the wording of ordering task in terms of "gain" is working scheme that facilitates identification of the correct answer even in interference (Sophianos, 1997), and Second, the task of the correlation, which requires the identification of equivalence relations is more difficult to apply. The latter involved a comparison interitemi strategies that would require more sophisticated numerical knowledge, but is not yet sufficiently clear whether such a strategy could be applied to tasks of ordering. Another aspect is given by the relationship between the two tasks and numeracy skills, although not fully confirms previous results (Brannon & Van de Walle, 2001), they suggest a correlation between the average performance experiments and numeracy tasks, indicating that between numerical knowledge and skills children there is a deterministic relationship.

However, the relevance of knowledge about numeracy strategies is evident that children utlizează. With 5 years of age, subjects explanations focuses mainly on numerical relationships (eg "there are more, because 4 is greater than 3" for ordering, "here are 3 and here are all" for correspondence) and less than those that involve the application load in the way that was done by the experimenter.

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