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COGNITIVE MECHANISMS IN THE ASSIMILATION OF THE MOTHER TONGUE

- Abstract of the doctoral thesis -

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Cluj-Napoca
2011

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KEY WORDS: vocabulary development, academic performance in the Romanian language in the primary grades, short-term memory, working memory, inhibition, attention shifting, updating in the working memory, processing speed, fluid intelligence, reading comprehension disabilities

The importance and topicality of the theme

Considering the school failure as the result of a double maladjustment: the individual's maladjustment to school activities and the maladjustment of the school to the internal factors of the individual (Kulcsar, 1978 apud Jurcău and Niculescu, 2002), and arguing that it takes more than an overall assessment of the small pupil regarding the school results, we propose in this paper to identify whether certain cognitive factors explain the differences between children in a specific aspect of the Romanian language as a mother tongue, namely the understanding of written language and vocabulary development.

The cognitive factors of the language processing from the perspective of the cognitive neuropsychology (The information processing model)

Table no. 3.1. Cognitive mechanisms related with acquiring the mother tongue (Milton, 2008)

Reading Decoding	Reading Comprehension	Written Language
- Phonological - Processing - Short-Term Memory -Visual Processing - Sequential Processing - Working Memory - Long-Term Memory	- Working Memory - Long-Term Memory - Executive Processing - Fluid Reasoning	- Working Memory - Executive Processing - Processing Speed - Planning

Short-term memory

Closely related to the working memory approach, the short-term memory can be addressed as a separate system (in the split model) or as a state of activation of a unified retrieval system (Miclea, 2003) in integrated models.

In the split model, the verbal component of the complex memory tasks is stored in a separate system of the short term memory, called the phonological loop (Baddeley and Loggie, 1999).

The phonological memory skills in children are associated with their vocabulary so the children who perform better on PWM tasks tend to have a better developed receptive and expressive vocabulary (Adams and Gathercole, 1995, 2000, Gathercole and Adams, 1993, 1994, Gathercole, Hiych, Service and Martin, 1997).

Working memory

Since 1974, a more elaborate theory of the short-term memory has developed, being under empirical validation (Milton, 2008). Baddley and Hitch (1974) developed the idea of working memory (WM) in terms of short-term memory (STM) (Milton, 2008). ML has been defined as a "*system for temporary maintenance and information handling during the execution of a range of cognitive tasks such as comprehension, learning and thinking*".

The first version of the multi-component model consisted of three aspects of the WM: the phonological loop, the visual spatial draft and a central executive component, which controls the other two sub-systems considered as being subordinated. Baddley's model is hierarchical, with the central executive system as a dominant factor that controls all the subcomponents. The central executive as part of the tripartite model was originally presented as identical with the SAS component (Supervision Attention System) of Shall's model of attention (1988). Considered initially as a function of the executive unit, the data provided by recent studies divided this function. The executive functions identified and included in the model are: the focused attention, the split attention and the ability to shift attention (Miyake and Shah, 1999).

The interactions or the resource barters between information storage and processing are the central feature of an alternative tradition of working memory research, namely what is often called the "unitary" or "integrated" model of the working memory (Miyake and Shah, 1999).

In terms of working memory capacity, a synthesis of the theoretical and empirical approaches in the field (Balazsi, 2007) allows the identification of two major types of models: models explaining the performance of working memory based on specific factors, depending on the stimulus used - The model of efficiency of processing (Daneman and Carpenter, 1980) and The model of specific resource (Just and Carpenter, 1992); and models that explain the working memory performance on the basis of some general mechanisms that affect the processing regardless of stimulus used - The effectiveness of the change task (Towse and Hitch, 1995), The effectiveness of inhibition processes (Hasher and Zacks, 1988), The general resources model (Engle, Cantor and Carullo, 1992), The controlled attention model (Conway and Engle, 1994).

The relationship between working memory and difficulties in reading comprehension in primary grades

In the early 1960s a large number of studies have shown that poor performance on tests of short-term memory is one of the most common characteristics of children with reading disabilities (Jeffries and Everatt, 2004). *Participation of the executive working memory is required, particularly when*

phonological processing during reading has not yet become automatic. The general opinion is that readers with a reading disability frequently have an insufficient capacity for working memory resources (a phonological processing deficit, a phonological short-term memory deficit, a language processing deficit or a processing speed deficit) (De Jong, 1998, Savage et al. , 2007).

Studies of development and validation on the Romanian population of the *Verbal Ability Test for Primary Grades*

The description of the *Verbal Ability Test for Primary Grades*

The development of the test is based on a need for measurement and prediction of the verbal ability of children in primary school cycle, following the structure pattern of the tests assessing the verbal abilities of the Battery of Psychological Tests of Cognitive Abilities (BTPAC) but it is aimed to be used in people older than 12. Verbal ability is measured by two tests: the vocabulary test and the syntax test.

The Vocabulary test is designed as a Scale of synonims. For a better content validity, the items were chosen after thorough assessment of the curricula reference objectives, of the textbooks for primary grades, which were the milestones for the types of exercises used and for the words known by pupils, as follows: *The ABC* (*Handbook for the Ist grade*) by Marcela Penes, *Romanian Language and Literature (Textbook for the IInd grade*) by Tudora Pițilă and Cleopatra Mihaiescu, *Romanian Language and Literature (Textbook for the IIIrd grade*) by Tudora Pițilă and Cleopatra Mihaiescu, and *Romanian Language (Textbook for the IVth grade)* by Marcela Penes and Vasile Molan, as well as *The Romanian Language Dictionary for grades I-IV*, *The Dictionary of Antonyms* and *The Dictionary of Synonyms*.

The Syntax test is made up of an assessment scale for the agreement accomplishment, using tasks in which the requirement is to fill in with the proper phrase, respectively to identify the wrong phrase, and another scale that assesses the syntactic comprehension through thematic roles analysis. The construction of the items of the scale, we started from the grammar knowledge presumed to be acquired by the end of the IInd grade. The words and phrases used belong to the basic vocabulary and many of them are found in the Romanian language and literature textbooks for primary grades.

Among the total number of the items, only those that have obtained an index of difficulty in the range [0.30 - 0.70] were selected. Some items had to be reworded; others were suggested again because there weren't enough items with a good index of difficulty.

The instructions of administration as presented by the examiner are:

For the Vocabulary Scale: "This test measures your vocabulary knowledge. You will be presented one word, followed by four answers, of which only one is correct. Your task is to choose the version with the same meaning to the underlined word. Circle on the answer sheet, at the *Vocabulary* column, the letter

of the chosen variant."The examiner will ask the people tested to follow the example in the worksheet, which will be read aloud:

EXAMPLE: **lazy**

a) sleepy

b) quiet

c) nifty

d) slow

For *Syntax A* *(The Scale of filling in sentences with the correct statement or phrase)*: "You will be presented some incomplete statements. Your task is to select from the three types of response the one that fits the best, so that the statement to be meaningful. Circle on the answer sheet at the *Syntax A* column your answer."

EXAMPLE: Ina buys apples . . . . . pears.
a) even
b) and
c) nor

For *Syntax B* *(The wrong expression identification scale)*: "You will be presented some statements, each of them with 3 underlined phrases. One of these phrases is wrong. Your task is to find the wrong phrase. Circle on the answer sheet at the *Syntax B* column the letter corresponding to the wrong phrase."

EXAMPLE: My father buy an interesting fairytale book for my birthday.
a) b) c)

For *Syntax C* *(The Scale of syntactic comprehension / reformulation)*: "You will be presented some underlined phrases, and 3 reformulated variants of each of them. Choose between the 3 variants of answer the one that keeps the significance of the underlined phrase. Circle on the answer sheet at the *Syntax C* column the letter corresponding to the chosen variant.

EXAMPLE: Aura and Nicu are carrying Maria's bag.

a) Aura's bag is carried by Maria and Nicu.

b) Maria's bag is carried by Nicu and Aura.

c) Maria and Aura are carrying Nicu's bag.

Values of the coefficients of difficulty and discrimination of the *Verbal Ability Test for Primary Grades*

The final form of the test was administered to a number of 112 participants chosen by simple random selection, students of grades II, III and IV at the „Nicolae Bălcescu", „Onisifor Ghibu" and „Iosif Vulcan" Schools in Oradea. The values of the coefficients of difficulty and discrimination of the test are presented below.

Table no. 5.12. The indexes of difficulty for the items of the Vocabulary Scale

Item number	1	2	3	4	5	6	7	8	9	10	11	12
N	112	112	112	112	112	112	112	112	112	112	112	112
p	,70	,70	,61	,63	,57	,34	,55	,55	,51	,30	,34	,30

N = number of subjects who answered the item

p = the coefficient of difficulty

We may notice that all the items of the final form of the scale have the coefficients of difficulty ranged between [0,30; 0,70].

Table no. 5.16. The indexes of discrimination for the items of the Vocabulary Scale

Item number	1	2	3	4	5	6	7	8	9	10	11	12
D	25,7	31,2	45,7	39,4	58,6	45,5	43,5	24,9	38	30,4	48,8	26,6

Our results indicate that items 1, 8 and 12 showed good discrimination indexes while the remaining items are excellent in terms of discrimination ability.

Table no. 5.17 The indexes of difficulty for the items of the.: The Scale of Completing sentences with the correct statement or phrase, The wrong expression identification scale and Sintactic Comprehension Scale

Item number	1	2	3	4	5	6	7	8	9	10
N	112	112	112	112	112	112	112	112	112	112
p - The Scale of Completing sentences with the correct statement or phrase	,71	,59	,44	,70	,50	,51	,52	,43	,30	,48
p - The wrong expression identification scale	,64	,70	,66	,42	,49	,57	,62	,53	,40	,43
p – Sintactic Comprehension Scale	,70	,55	,57	,71	,48	,68	,58	,53	,50	,41

N = number of subjects who answered the item

p = the coefficient of difficulty

Table no. 5.23. The indexes of discrimination for the items of the Syntax Scale

Item number	1	2	3	4	5	6	7	8	9	10
D - Syntax A	27,1	54,7	53,8	49	69,6	41,4	31,9	6,2	37,6	41,4
D - Syntax B	41,9	44,7	48,1	45,3	41,4	24,7	39,6	25,4	25,0	42,4
D - Syntax C	41,9	53,8	47,6	31,4	32,9	51,4	51	53,8	27,6	28,6
N	112	112	112	112	112	112	112	112	112	112

Since the Syntax A Scale (*The Scale of Completing sentences with the correct statement or phrase*) and Syntax B (*The wrong expression identification scale*) were designed to assess the same thing, namely the ability of grammatical expression, but using differently formulated items, in the analysis of the psychometric qualities of the test we considered the total score of the two scales and we

used the name of Grammar Expression Scale.

The fidelity of the *Verbal Ability Test for Primary Grades*

The test shows a good fidelity at the Vocabulary and the Syntax Tests, in the case of the latter for the overall score as well as for the scores at the two components/scales: The Grammar Expression Scale and The Syntax Comprehension Scale.

Table no.5.24. α – Cronbach`s values

Scale	N itemi	N	α - Cronbach
Vocabulary Scale	15	134	.84
Syntax Scale	30	134	.76
Sintactic Comprehension Scale	10	134	.71

The stability of the results was determined after 7 weeks in april-may 2009.

Table no.5.25. Test – retest reability

Scale	N	r
Vocabulary Scale	73	.64**
Syntax Scale	73	.69**
Sintactic Comprehension Scale	73	.52**

Note: ** $p < .001$

The content, construct and criterion validity of the *Verbal Ability Test for Primary Grades*

The content validity is based on the fact that the items of the vocabulary test were made of words taken from the textbooks for grades II, III and IV, so the items are within the scope of the test content. The set of items was tested in three different studies on three different samples. We calculated the index of difficulty and the discrimination index for each item and we selected only the items with a difficulty index in the range [0.30; 0.70], and items with a discrimination index higher than 0.25.

The construct validity is the extent to which it can be argued that the test measures a specific feature or a variable. One way to test the construct validity is the correlation analysis of the Vocabulary Scale and the Syntax Scale and the age of the subjects. The positive correlation between the Vocabulary Scale and the age of the subjects, as well as The Syntax Scale and the age of the subjects is mentioned also in other reference tests (The BTPAC Handbook, 2003).

The averages obtained at each of the three scales gradually increase with age and the Bravais-Pearson correlation coefficient indicates the existence of a positive correlation between the results of the Vocabulary Scale, the Grammar Expression Scale and the Syntactic Comprehension Scale on the one hand and age of subjects on the other hand.

In order to determine the convergent validity of the Vocabulary Scale, a total of 188 children

responded to the Vocabulary Scale of the Wechsler Intelligence Scale for Children IV - R (IV WISC-R) and Raven Progressive Matrices, which is the established measure of the eductive ability (which loads the same factor and correlates with the reproductive ability measured on vocabulary scales). The tests are under the license of RTS Cluj, they are validated and standardized on Romanian population and were administered with permission of use for research purposes.

To highlight the discriminative validity, two tests were applied in order to measure the inhibition ability of the subjects, namely the Stroop colors and the Stroop words tests of the Battery of Psychological Tests of Cognitive Abilities (BTPAC), for which the agreement was also obtained for research use.

The values of the Bravais - Pearson coefficients is evidence both for the convergent validity, because the scores at the Vocabulary Scale strongly and significantly correlate with the scores of an established scale in the field and standardized on the Romanian population, namely the Vocabulary Scale of the WISC, and also with the scores of the Color Raven Progressive Matrices, also standardized on the Romanian population; and for the discriminative validity because Stroop colors and Stroop words evaluate the cognitive inhibition ability by negative primer, capacity of resilience to interference and the correlation of the scores of these tests with the scores of the Vocabulary Test is invalid.

To determine the convergent validity of the Grammar Expression Scale and the Syntactic Comprehension Scale, a total of 192 children completed the Reading Comprehension Assessment Test (TECC) (Mih, 2004), built and standardized on the Romanian population, while for the discriminative validity, the correlation with Stroop colors and Stroop words was examined.

The construct validity of the Grammar Expression Scale and the Syntactic Comprehension Scale is supported by the highly significant correlation with the Reading Comprehension Assessment Test, to determine the convergent validity and the lack of correlation with Stroop colors and Stroop words, administered to determine the discriminative validity.

The criterion validity

The criterion, in the case of ***Verbal Ability Test for Primary Grades***, is the marks obtained at Romanian Language and Literature by the students participating in the research study. We may speak of the existence of a concurrent criterion validity as the time between the administration of the test and the verification of the criterion was rather short, about a month. We took into account the overall average verbal ability as a general predictor for academic success (Mommers, M. J., 1987; Jurcau, E. and Jurcau, N., 1989).

The correlation between the test scores and the criterion scores is a highly significant positive correlation, so it can be considered that the test has a very good criterion validity.

Factors involved in the vocabulary development in children of primary classes

Objectives:

- Identify the social and cognitive predictors of vocabulary development in primary school children
- Develop a predictive model of vocabulary development through the split model of working memory when the influence of the age is statistically controlled

Hypothesis 1: The social and cognitive factors are predictors of the level of vocabulary acquisition Linear regression; predictive purposes.

Hypothesis 2: The individual cognitive factors explain the differences in vocabulary acquisition levels when the influence of age is eliminated

Multi-linear regression.

Method: hierarchical; explanatory purpose.

Participants

A number of 112 children, students of the ”Nicolae Bălcescu” School in Oradea participated in the study. In terms of age, the sample includes 68 children in grade II and 44 children in grade IV. I checked the gender distribution and found that there was no significant difference between the two age groups, which might lead to an effect misunderstood as being the difference of grades (Balazsi, Kirshner, Călbează and Dobrean, 2009), the value being $\chi^2 = 5.14$ (df=2), p= .76.

Materials

The instruments used in the study are: the demographic questionnaire, which contains references on the child’s ethnicity, the mother's educational level/training, the existence of brothers and leisure activities; the Vocabulary Scale developed and standardized for this research; the Color Raven Progressive Matrices Test to assess the fluid intelligence; the Non-words Test to assess the phonological short-term memory; the Numbers in descending order Memory Test to assess the working memory; tests to assess the executive function: The Flexibility of Categorization to assess the ability of attention shifting; the Barrage test for assessing the concentrated attention ability; the Encoding B test to assess the speed of information processing and the Stroop colors test to assess the ability of inhibition by resistance to proactive interference.

Results and interpretation

The first objective of the research aims to identify the social and cognitive predictors of the vocabulary development in primary school children. I performed a simple regression analysis. In order to

check the homogeneity of the scores in the two age categories (grade II and grade IV), I compared the statistical results of the study variables. Since the K-S coefficients are statistically insignificant, the distributions are symmetrical and we used parametric methods. The results are presented in Table 6. 2.

The results show that the groups are not homogeneous for all the variables measured, therefore, naturally, the age variable will be included in the regression equation and controlled when the regression models will be statistically verified. I wanted to check whether all cognitive and non-cognitive variables selected are significant predictors for the development of the vocabulary and I used a simple regression analysis. The results are shown in Table 6. 3.

Table no. 6.3. The results of regression analisys for Vocabulary Scale scores

Model	**R**	**R square**	**Standard error**	***β***
Age	0,41	0,21	3,70	**t = 5,60 (p=0.00)**
Mother`s school level	0,08	0,00	4,18	t = 0,89 (p=0.37)
The presence of brothers	0,00	0,00	4,20	t = 0,02 (p=0.98)
concerns for the after school time	0,02	0,00	4,20	t = 0,22 (p=0.82)
Fluid intelligence	0,34	0,12	3,94	**t = 3,90 (p=0.00)**
Working memory	0,36	0,12	3,91	**t = 4,10 (p=0.00)**
Short term memory	0,24	0,05	4,07	**t = 2,61 (p=0.01)**
flexibility of categorisation	0,44	0,18	3,76	**t = 5,19 (p=0.00)**
focused attention	0,28	0,07	4,03	**t = 3,06 (p=0.00)**
resistance to proactive interference	0,03	0,00	4,20	t = 0,40 (p=0.68)
Processing speed	0,27	0,06	4,04	**t = 3,02 (p=0.00)**

As shown in Table 6. 3, not all the variables are important for the vocabulary development. There were identified as significant predictors only the age and cognitive factors such as the fluid intelligence, the short-term memory, the working memory, the flexibility of the categorization, focused/concentrated attention and processing speed). Non-cognitive factors (mother's education level, presence of siblings, concerns for leisure) and the inhibition ability cognitive factor as measured by the resistance to proactive interference are not significant predictors to explain the differences between children in terms of vocabulary acquisition.

The second purpose of the research aims at constructing a hierarchical regression model with an explanatory role in the relationship between the cognitive factors and the level of vocabulary development in children.

For the students of grades II and IV, taken together, several hierarchical regression models will be tested according to which the level of the vocabulary acquisition is significantly influenced when the age variable is controlled.

We built more hierarchical regression models in which we wanted to highlight whether the

cognitive factors, divided into three blocks (fluid intelligence – the first block, short term memory - the second block and working memory, focused attention, flexibility of categorization and speed processing – the third block) would indicate a significant participation in the prediction of criterion scores (The Vocabulary Scale). We grouped the factors based on empirical evidence that considers the fluid intelligence (or eductive ability) as a component of *g-factor* involved in all the tests that measure academic ability (Spearman, 1927 as cited in Raven, Raven and Court, 2003) - for step 2; based on the split model of working memory (Baddley 1986) according to which the short-term memory has a specific role in vocabulary acquisition (Gathercole and Baddeley, 1990) - it was introduced in step 3 and the factors identified with the executive functions and working memory were introduced in step 4.

Table no. 6.7. The results of regression analisys for Vocabulary Scale scores when the predictors was age and cognitive factors

	Models	**R square**	**R square adjusted**	**Beta**	**B**	**SE b**
Step1	**Age**	.22	.21**	**.47****	4.02	.71
Step 2	Age **Fluid intelligence**	.37	.36**	.50 **.39****	4.33 .27	.64 .05
Step 3	Age Fluid intelligence STM	.37	.36	.50 .39** .00	4.30 .27 .01	.72 .05 .12
Step 4	Age Fluid intelligence STM WM **Focused attention** **Flexibility of categorisation** Processing speed	.45	.41**	.38** .32** -.02 .01 **.24**** **.22**** -.05	3.25 .22 -.03 .03 .20 .03 -.01	.90 .05 .12 .17 .07 .01 .02

Table no. 6.8. The results of regression analisys for Vocabulary Scale scores when the predictors was age and cognitive factors – statistical changes

Model	**Change R square**	**F change**	**df1**	**df2**	**Sig. F change**
1	,22	31,38	1	110	,00
2	,15	**27,24**	1	109	,00
3	,00	,00	1	108	,92
4	,07	**3,55**	4	104	,00

The results support only partially the study hypothesis. As expected, the age explained a significant proportion of the variance in vocabulary acquisition, namely 21%.

Introducing the fluid intelligence factor in the model affects positively the vocabulary acquisition (adjusted R square = .36, $p < .01$). This factor explains the 36% of the variance of the vocabulary level, in addition to the variance explained by age. F change is statistically significant, which means that adding the fluid intelligence factor into the equation significantly improves this model. The Beta coefficient

shows that when the fluid intelligence test score increases by one standard deviation, the level of the vocabulary increases with .47 standard deviations.

In the third step, adding the short-term memory variable in the model doesn't bring any significant improvement of the model, no further explanation from the previous model. However, adding in the last step the cognitive factors such as working memory and associated functions, significantly improves the model (F change = 3. 55, p <;. 01), and this addition to the model explains 41% of the variance of the vocabulary level in addition to the variance explained by the age difference and fluid intelligence. However, of the cognitive factors included in the final step of the analysis, only focused attention and flexibility of categorization explain the variance in Vocabulary Scale scores.

We may conclude that some of the variables tested in hierarchical regression equation, when age differences are controlled, explain the individual differences in the level of vocabulary acquisition.

Discussions

We wanted to check in the first part of the study to what extent the social factors, on the one hand, and cognitive factors on the other hand can be considered as having a role in the vocabulary development. Contrary to our expectations, the mother's education level, the presence of siblings or the leisure concerns (solitary or involving interaction with other people) do not constitute significant predictors of vocabulary development. We considered only the mother's level of training because the studies cited by other authors (Balazsi et al., 2009) support a stronger involvement of mothers in the child's education. However, in our study, the mother's education level doesn't have a significant importance in predicting the level of vocabulary. The explanation could be that children are usually up in the afternoon at school doing their homework, that most of the remaining free time is occupied with other activities (sports and various English classes, ballet, tennis etc.) and because the status role of the women today is increasingly overloaded so little time is left for effective interaction with the child. The absence of a significant percentage of the "presence or absence of siblings" variable can also be explained by the same mechanisms as those above, namely the availability of the nowadays children having a sometimes more overloaded program than the adults. The explanation for the fact that leisure concerns is not a significant predictor of vocabulary acquisition would be that the vocabulary was assessed through a written test and the expressive language was not assessed. On the other hand, children generally do not involve in just one activity (playing a computer game or playing in the park with their friends) and then it is more difficult to control the influence of other concerns.

Among the individual cognitive factors identified as significant predictors, we mention the fluid intelligence, the short-term memory, the working memory, the flexibility of categorization, concentrated/focused attention and processing speed. The cognitive factor named inhibition capacity,

measured by resistance to proactive interference, is not the predictor of vocabulary acquisition; perhaps because the test by its nature does not require this ability, the words for which you have to choose the synonyms do not have a priming role for the items that follow. Probably it would have been better selected a test that measures the inhibition ability of resistance to distracting influence.

In this first part of the survey in which we also tested a predictive model of vocabulary acquisition through hierarchical regression analysis, the results only partially support the study hypothesis. As expected, age explained a significant proportion of the variance in vocabulary acquisition, 21%. When introducing the fluid intelligence factor into the model, the vocabulary acquisition was positively affected, this factor explaining 36% of the variance in the vocabulary level, *in addition* to the variance explained by age, confirming the hypothesis Spearman launched on the existence of a common factor to which any aptitude test appeals, to a greater or less extent and which would consist of two parts – the eductive ability and the reproductive ability (Raven, Raven and Court, 2003). The eductive ability is identified as being the fluid intelligence and it is the ability to discern the meaning of confusion, to generate new concepts and required for the children to find the implicit meaning of the language rules.

In the third step, adding the short-term memory variable to the model does not bring any significant improvement to the model, or further explanation to the previous model. This lack of improvement could be explained in terms of structure of cognitive functions in vocabulary acquisition and specificity (or non-specificity) of the selected test and in the light of the results obtained in the second part of the study on the direction of the causality relationship between the language performance and short-term memory performance. However, adding in the last step of the cognitive factors named working memory and associated functions improves significantly, explaining 41% of the variance of the vocabulary level *in addition* to the variance explained by age difference and fluid intelligence. However, of the cognitive factors included in the final step of the analysis, only focused attention and flexibility of categorization explains the variance of the scores in the Vocabulary Scale. These results can be explained by the specificity of the task and the way the children are asked to answer, and they may be considered predictors not of the vocabulary development in general but the level of success in a task similar to school tasks for assessing the level of the vocabulary knowledge.

The structure of working memory and the predictive valences of the working memory components in the reading comprehension of children in primary grades

Objectives

- check the degree of ”purity” of tasks used to assess the executive functions, which, even established in the field, are very susceptible to interference of measurement error and difficult to select because of the many controversies that still exist in this area in terms of their definition

- investigate the organization of working memory in children of primary school to identify the mechanisms that define its capacity
- analyze the ecological and predictive valences of the executive functions mediating the relationship of the working memory with the reading comprehension ability
- identify the most powerful predictor of reading comprehension in the relationship of the latter with the working memory.

Participants

Although we started from a number of 205 participants, because the testing was done in several stages, some participants were absent from some parts of the testing. After eliminating the missing data, the final number of subjects included in the study is of 160 children aged 8 years and 2 months to 11 years and 4 months. The three age groups were balanced in terms of number of participants (53 participants in grade II, 51 in grade III and 56 in grade IV) and in terms of gender distribution (80 girls and 80 boys). All the study participants had normal or corrected to normal sight and as a native language – the Romanian language.

Results and interpretation

The main objective of the study is to identify the unitary or fractional structure of the working memory in children of primary grades. But the main problem is the impurity of the tasks, because even the executive functions themselves can not be totally separated as they are very complex and interconnected in terms of operation/functioning. To select the samples meant to be included in the testing of the two alternative models proposed, we conducted an exploratory factor analysis (EFA) especially to check if the selected instruments load the factors as we assumed previously.

KMO coefficient (0.79) and Bartlett's test ($\chi 2 = 365.75$, df = 105, $p<0.00$) indicate that the factor analysis is justified and that the sample is appropriate. The method of extracting factors was "*the main component analysis"* and for turning the factors we used the *Varimax with Kaizer Normalization* procedure.

Factor extras	**Eigenvector inițial**			**Suma pătratelor saturației după extragere**		
	Total	*% al variației*	*% cumulat*	*Total*	*% al variației*	*% cumulat*
1.	3,71	24,76	24,76	3,71	16,03	16,03
2.	1,31	8,76	33,53	1.31	14,98	31,01
3.	1,24	8,26	41,80	1,24	10,42	41,43
4.	1,07	7,19	48,99	1,07	7,55	48,98

Table no.7.2. Explained variance by the tasks used for executive functions

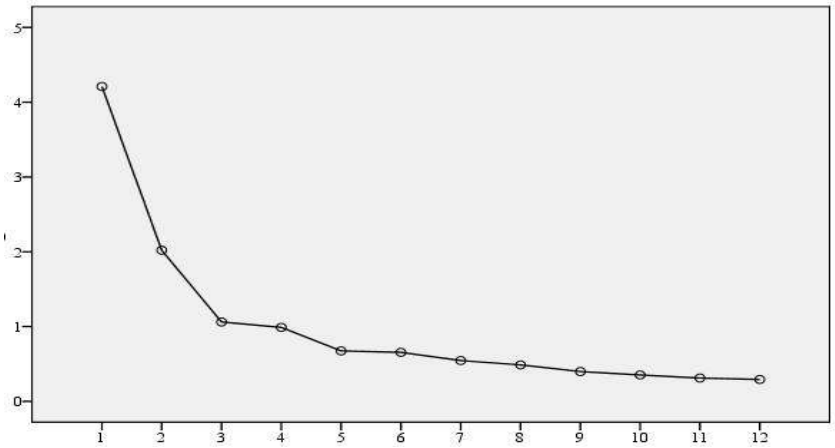


Figure 7.1. Scree-plot figure for EFA of tasks used in working memory investigation for the primary school age children

The factor analysis allowed the identification of *four* factors which explained 48.99% of the total variance (table 7. 2). The screen-plot figure (Figure 7. 1) confirms the solution with four factors.

Thus, factor 1 that explains 16, 03% of the total variance is a factor fed mainly by tests investigating short-term memory (memorization of non-words and of numbers in ascending order) and working memory (memorizing numbers in descending order). We may refer to this factor as being the short-term memory factor.

Factors 2, 3 and 4, which explain 14, 98% of the variance, 10, 42%, respectively 7, 55% of the variance, are factors that load the tests assessing the executive functions. The executive functions investigated correlate so strongly and they depend so much each on the functioning of the other that they can hardly be separated. This explains why factor 3 is loaded by trials assessing the inhibition as well as tasks assessing the update function. Factor 2 consists of trials meant to assess the ability to shift attention, while factor 4 is the factor related to information processing speed. Contrary to first impressions, namely that the way of the distribution of trials designed to assess working memory capacity (for each of the first three factors) indicates a unitary structure of the working memory, the fact that the first factor is loaded mainly with tests assessing the short-term memory leads us to the idea that the structure of the working memory in children of primary school could be organized as a split model.

The main objective in this study was to check how appropriate the tests used are for the results obtained by completing them to lead us to test the most appropriate model of working memory organization in primary school children. *The analysis of the trial distribution on factors does not justify the removal of either from the model with one exception: the Rey Verbal test*. The trial is loaded distinctly on the second factor, unlike the other two measurements for short-term memory, namely the memorization of non-words and memorization of numbers in ascending order. This could signal a problem with using this evidence, namely that it does not strictly measure the capacity of the short-term memory. Since the classical task is to update the words in the order in which they are recalled and not in

the order they were read by the examiner (which allows a lot of processing on the content for the reorganization of the material), the trial isn't any more a measure of the short-term memory capacity, as defined in the field, for which we decided not to introduce it in the models proposed for exploring the organization of the working memory structure.

The second objective concerns the organization of the functioning of working memory: unified or divided/split. We performed a confirmatory factor analysis (CFA) in which we tested two competing models of the organization of working memory. All the trials mentioned in the exploratory factor analysis were initially introduced in the models, except for Rey Verbal Test, but because Stroop colors and "Plus-Minus" task had a very small load in both models, we decided to exclude them from the final models.

In the first model (the unitary model), we postulate that all the trials (the functions measured by them) will be loaded onto a general factor, the expression of a unitary model of working memory structure.

Further, it is noted that each latent subject has a significant load on the general factor; the indicators for each track are presented in Table 7. 5. Each track is significant as $p < 0.05$.

Table 7.5. The saturation of the components of the common factor corresponding to the structure of a unitary model of the working memory (based on CFA)

			Coef. Regresie b	**Coef. Regresie ß**	**std.error**	**critical reporting**	**p**
Coding task	<---	Working memory	1,197	,504	,246	4,873	***
Number-letter task	<---	Working memory	18,656	,269	6,630	2,814	,005
flexibility categorisation	<---	Working memory	,517	,566	,097	5,309	***
Letter updating	<---	Working memory	1,000	,661			
Image updating	<---	Working memory	,238	,212	,106	2,247	,025
Stroop-words	<---	Working memory	-,505	-,387	,129	-3,919	***
Proba "Baraj"	<---	Working memory	2,400	,512	,486	4,937	***
Non-words memory	<---	Working memory	,258	,440	,059	4,375	***
Figures memory in the same order	<---	Working memory	,170	,450	,038	4,456	***

In the second model proposed (the split model), we suggested the existence of two factors that form the structure of working memory in primary school children, i.e. a factor being the short-term memory capacity and the other the central executive. Since none of the two models presented cannot be rejected (that is perfectly normal in terms of duration and intensity of controversy in the field), we compared the indicators of parsimony of the models (parsimony-adjusted measures) (Sava, 2004) in Table 7. 8.

Table 7. 8. The values of the main comparison indicators of simplicity of the tested models

	PNFI	**PCFI**	**AIC**	**CAIC**
Unitary model	0,557	0,634	89,296	162,64
Split model	0,552	0,626	86,810	164,23

Given that three of the four indicators are lower for the split model compared to the unitary model, we believe that the split organized structure of the working memory, in which the central executive is separated in some extent from the short-term memory is present at primary school children.

The last two goals of the present study aim to demonstrate the predictive values of the working memory components in reading comprehension in primary grades.

In the first step of processing, the subjects for which there were missing data and also the outliers in the relationship between working memory and reading comprehension were excluded from the study. Outliers have been identified on the basis of influence statistics by the Beta Standardized DF coefficient. We have removed any value that exceeded the 0.16 and this has affected 6.2% of the sample.

The second step was to normalize the distributions, a process done differently depending on the distribution shape (Sava, p. 85). We checked the distribution shape considering Kolmogorov - Smirnov (K-S) indicator. This wasn't statistically significant for the trials that measure short-term memory, shifting capacity, processing speed and reading comprehension. For other trials, K-S indicator was significant and the shape of distribution was asymmetrical. We analyzed the distribution form by checking the histograms. For tests that measure working memory and inhibition ability, the distribution was skewed to the right and the normalization procedure was radical extraction and for the tests measuring the ability to update the form of distribution was skewed to the left, the procedure used being the radical extraction of the reflected number. We checked the K-S indicators after normalization and they notice that they had become statistically insignificant.

The third step was applying the hierarchical regression to demonstrate the mediation effect. The three ways were checked for each of the four mediators in part and one can see in Table 7.9 that all the correlations between the variables involved are statistically significant. We assumed in the analysis that there is a mediation effect in the relationship between working memory and reading comprehension, an effect achieved by the two components of the validated model (short-term memory and the two executive functions – the ability of shifting attention and the ability of updating information) on the one hand and the speed of information processing on the other hand. Controlling every possible mediator, it is noted that all the part correlation coefficients for path C is reduced (e.g. the strength of the correlation between working memory and reading comprehension decreases from 0.41 to 0.27 when the updating ability is controlled). There is a mediating effect for all the variables studied.

Updating the memorized information means changing the memory content to adjust to the new input beyond merely maintaining the information that is significant for the task. This change requires the ability to reduce the level of activation of previous information that has become irrelevant or less relevant when a new information input come, in order to avoid the interferences that would otherwise affect the accuracy and updating ability (Morris and Jones, 1990 apud Caretti, Cornoldi, De Beni, 2004). The failure of this process can lead to the misinterpretation of the text content (Blanc and Tapiero, 2001; de Vega, 1995; Johnson and Seifert, 1998).

Although the working memory seems crucial in reading comprehension (Daneman and Merikle, 1996; Oakhill, Cain and Bryant, 2003) and the link between them is mediated by the updating function as shown by the previous study (Tables 7.9 and 7.10) and by the results obtained by other researchers (Gernsbacher, Varner and Faust, 1990), there are only few studies that directly examine the relationship between updating, reading comprehension and working memory.

Because the test used allows to compute two dimensions (the ability to update using the number of correct answers) and at the same time the ability to reduce the level of activation of irrelevant and less relevant information, but which should be under-activated or reactivated according to the new information input (the ability to suppress the number of errors committed in the update process), we aimed to analyze in depth this relationship of mediation conducted by the ability of updating between the working memory and reading comprehension in primary school children.

I assumed that the readers with poor comprehension ability update fewer correct words not because they have a weak short-term memory, but because they are less able to under-activate the irrelevant items related to the required task and these items, through proactive interference, overload the working memory capacity, making the processing difficult to handle.

We have two objectives:

a) find a clearer proof of the relationship between the updating of the working memory and the reading comprehension skills

b) analyzing the role of the control mechanism used to suppress information.

Hypothesis 1: The ability to suppress the level of activation of irrelevant or possible irrelevant information may explain the differences between children in terms of reading comprehension ability

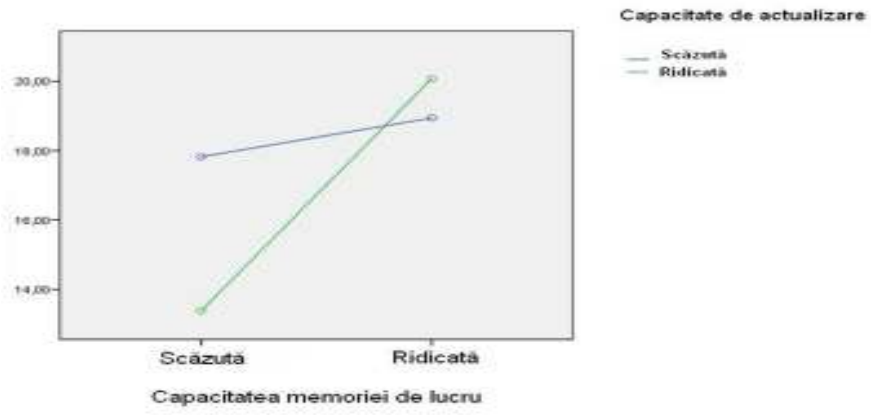
Hypothesis 2: Working memory capacity explains the differences between children in terms of reading comprehension ability

Hypothesis 3: There is an interaction effect between the suppressive ability and the working memory capacity that explains the differences in reading comprehension in primary school children

Intergroup bifactorial design, 2x2; method: analysis of variance

The ability of reading comprehension is different depending on the level of development of the working memory capacity, being more developed in children with high working memory capacity.

No statistically significant differences related to the suppressive capacity were obtained, but this does not mean that this mechanism does not affect the relationship between the updating ability of the memory and the reading comprehension, but only that no direct relationship can be evidenced by calculating the differences between averages.



There is a strong effect of interaction between the working memory and the ability to reduce the level of information activation. The analysis of the graphic of interaction (Figure No. 7.4) suggests that the influence of the working memory on the ability of reading comprehension is different at different levels of the ability of reducing the level of activation of irrelevant information. The influence of the working memory capacity is greater when the suppressive capacity is low.

The suppression capacity measured with the Image Update test is represented by the composite score of the intrusion errors for the items that should be inhibited as soon as they enter the attention focus because they are not relevant to the task and the intrusion errors for the items that must be maintained for a while at a lower level of activation and then under-activated or inhibited because they are not relevant to the task. We called the first category *immediate errors* and the second – *delayed errors*.

Hypothesis 4: There is a statistically significant correlation between the number of immediate and delayed errors on the one hand and the reading comprehension on the other hand.

Hypothesis 5: The capacity of inhibition (suppression) of the information that is irrelevant for the task and which needs to be under-activated immediately explains the differences between children with high performance and low-performing ones in terms of reading comprehension

Hypothesis 6: The capacity of inhibition (suppression) of the information that is irrelevant for the task and which need to be under-activated later explains the differences between skilled and less skilled readers.

We examined whether the activation level determined by the period in which the irrelevant item

has to be maintained explains the differences between skilled and less skilled readers. The influence of the activation level was measured by the number of errors made by both the skilled and less skilled readers. We divided the children into two contrast groups depending on the reading test outcome (we excluded from the analysis the children with average outcome, in the range $m \pm 2\sigma$) and we calculated the difference between the frequencies of delayed errors and of the immediate errors separately for the two contrast groups.

Table 7.14. Chi-square coefficients for the two levels of activation of irrelevant information in explaining the differences between the high and the low ability of reading comprehension

		Delay intrusions	**Immediat intrusions**
Reading comprehension	r	-,271(**)	-,404(**)
	N	57	57

We note that there are significant differences in the comprehension ability of the participants only in the frequency of the immediate errors and the differences are insignificant for the delayed errors. In other words, when the irrelevant information is more active because it is maintained in the attention focus, the skilled readers react like the less skilled ones. The results show that the only aspect that explains the difference in reading performance is the ability of the skilled readers to inhibit effectively the irrelevant immediate information (immediate intrusion), unlike the less skilled readers who lack this mechanism.

Since it was assumed that the more active the items, the greater the likelihood of erroneous inclusion of the set of items to be updated (De Beni et al., 1998; Oberauer, 2001; Osaka et al., 2002), this hypothesis wasn't confirmed, suggesting that not the proactive interference but the ability to inhibit the distracters determines the ability to update the working memory in relation with the reading comprehension.

Discussion

Two models of the structure of working memory were analyzed: the unitary model and the split model. Two of the tests assessing the executive functions, namely Stroop colors - to assess the ability to withstand interference by negative priming and the "Plus-Minus" test for evaluating the capacity of shifting attention, had a very small load in both models, so we decided to exclude them from the models. None of the two models under consideration can be rejected, but the model with the best of the four indicators presented is the split model. We assumed that there is a split organizational structure of the working memory at primary school children, the central executive being separated to some extent of the short-term memory.

Of course, although there is a consensus regarding the involvement of working memory in discourse comprehension (reading comprehension), *this consensus begins to disappear when analyzing the relationship in terms of the underlying mechanisms that define the capacity of the working memory* (Miyake and Shah, 1999).

Starting from the idea that the mere correlation between the performance at working memory tasks and reading performance tasks does not necessarily imply a causal relationship, in the second part of the study we wanted to highlight the mechanisms that mediate this association and also the most powerful mediator which could explain the differences in the reading comprehension ability in primary school children. The regression analysis for the purpose of demonstrating the mediation effect states that all the executive functions, except the ability of inhibition, were identified as predictors in the relationship between the working memory and reading comprehension.

The strongest mediator identified was the updating ability defined as the ability to reduce the level of activation of previous information that has become irrelevant or less relevant for new input information, to avoid interference that would otherwise affect the accuracy and updating ability (Morris and Jones, 1990 apud Caretti, Cornoldi, De Beni, 2004).

We further analyzed in depth this effect of mediation. In a first step, we checked if the reading comprehension is different depending on the level of the development of working memory capacity, if the reading comprehension is different depending on the updating ability of the memory and if there is an interaction effect between the working memory and the ability to reduce the level of the activation of the information. The results confirmed the first and last assumption. No statistically significant differences were obtained due to the suppressive capacity, but this doesn't mean that this mechanism does not affect the relationship between memory update and the reading comprehension, but only that no direct relationship can be evidenced by calculating the differences between averages.

The effect of interaction between working memory and the ability to reduce the level of activation of information shows that, at different levels of the capacity to reduce the level of activation of irrelevant information, the influence of the capacity of the working memory is different, being as greater as the suppression capacity is lower.

We also checked whether the level of activation due to the period during which the irrelevant item has to be maintained active is the fact which explains the differences between skilled and less skilled readers. The influence of the activation level was measured by the number of errors made by both the skilled and less skilled readers. The differences were significant only in terms of frequency of immediate errors and insignificant in terms of delayed errors. This suggests that not the proactive interference, but the distracter inhibition capacity is the one that determines the ability to update the working memory in relation with reading comprehension.

Final conclusions and discussions

We started this study from the assumption that school failure is the result of a double maladjustment: the individual's to school activities and the maladjustment of the school to the individual's internal factors (Kulcsar, 1978 apud Jurcau and Niculescu, 2002) and we wanted to identify the cognitive factors which explain the differences between children in a specific aspect of the Romanian language as mother tongue, namely written language comprehension and vocabulary development.

For the purpose of this research, we have developed a series of tests to assess both verbal ability and some cognitive mechanisms. The ***Verbal Ability Test for Primary Grades*** was assigned a whole chapter of data concerning the preparation and validation, because the level of achievement of the mother tongue is assessed exactly by the scales of the test: vocabulary, grammar expression and syntactic comprehension.

To assess the cognitive mechanisms identified in this paper with the cognitive functions represented by short-term memory, working memory, processing speed, ability of inhibition, updating and shifting, I obtained the agreement as stipulated in the copyright law or created experimental tasks where I didn't have the proper instruments. Such experimental tasks were: *The "Number-Letter" task* to assess attention shifting and *Figures Update Task* to assess updating. These tasks were created using the StimScope experimental software. Some paper-pencil versions of the tasks were also created, such as *The Reading Span Test*, to assess working memory, the *Plus-Minus Test* to assess attention shifting or *The Updating Images* for measuring updating.

More than 20 tests were used, most of them individually, at more than 250 primary school children. Although, as other researchers recognize, a problem in the field addressed in the paper (the field of executive functioning) binds to the "impurity" of the tasks assessing the executive functions and another problem I encountered in this study links to the "compliance" of small participants in a research of such a great span due to the number of tests used, we are allowed to conclude some of the research results, extrapolating them to the entire educational field.

The first study of the research refers to the factors involved in vocabulary development in primary school children, it only highlights the cognitive predictors involved in vocabulary acquisition, namely the fluid intelligence, the working memory, the focused attention and the speed of information processing, the social ones having no particular contribution.

The second study tests two competing models of working memory, revealing the superiority of the split model, shows the strongest predictors of performance in reading comprehension in primary school children in terms of organization of the working memory and examines in detail the underlying mechanisms of the mediation relationship between the strongest mediator and the working memory in

reading comprehension in young pupils/students. The strongest mediator was found to be the ability of memory updating. The study of the updating processes in children may be the most important from a theoretical and also practical point of view. From the theoretical point of view, it seems that the relationship between working memory and reading comprehension is more important in children than in adults because the latter relies more on their general knowledge. So the analysis of the children's performance could provide clearer results on the nature of the mechanisms underlying this relationship. In addition, because the difficulties in reading comprehension are more evident in the early school years and may affect the overall school trajectory, the children's selection based on the criteria adopted to diagnose learning disorders may also suggest approaches in developing educational programs. I assumed that the students with reading disorders have a low performance in updating. I also assumed that the items kept longer in memory (delayed intrusion) are more prone to intrusion in updating than the items removed immediately (immediate intrusion) and that this disorder could be linked to reading ability. The results show that the only aspect that explains the differences in reading performance is the skilled readers' ability to inhibit effectively the immediate irrelevant information (immediate intrusion), unlike the less skilled readers, who have deficiencies in this mechanism.

For the assessment of the learning disabilities, knowing the relationship between specific academic skills and specific functions of working memory is a valuable piece of information that can guide the assessment, the interpretation of the results and the diagnosis of the learning disorders. Children with different specific learning disabilities show unique types of working memory deficits. Thus, a profile of an individual's working memory, at least to a certain extent, can help to distinguish between specific learning disabilities.

Given the well established relationship between the reduced working memory capacity and the school failure, a measure of working memory would be the appropriate complement at the early school evaluation. Working memory assessments can identify those children who are at risk to obtain low achievements/outcomes in the future. With a focus on early intervention, including a summary measure of phonological short-term memory and verbal working memory, the early identification of children at risk of school failure and learning disabilities can be improved.

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