RE-EXAMINING THE LANGUAGE SUPPORTS FOR CHILDREN'S MATHEMATICAL UNDERSTANDING: A COMPARATIVE STUDY BETWEEN FRENCH AND VIETNAMESE LANGUAGE.

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The aim of present study was to re-examine the influence of language characteristics on mathematical understanding and performance. Third grade French-speaking Belgian and Vietnamese students participated on the study. In Vietnamese language, the number-name system has particular characteristics, which indicate explicitly the zero's position (e.g, 2004 is said "two thousand zero hundred remainder four"). Language had an impact only on the number-name related task and did not affect the tasks involving manipulation of symbols. The relative influence of language, the use of tasks in comparatives studies and the different numerical experiences of children are discussed.

Keywords: language supports, cross-national comparisons, syntactic zero, transcoding, relativity language

INTRODUCTION

Even though the Arabic number and its mathematical structure are used worldwide, Arabic code (e.g., 45) cannot be used by itself. It is required to be transcoded in a language to be used, to attribute a meaning to those symbols, which are called a verbal-number (e.g., forty five). Therefore, even if the code is used worldwide, this unavoidable transcoding process is going to induce significant differences on its treatment by each individual, depending on their language and cultural context.

Previous cross-national studies showed that due to a more transparent verbal name system, the differences of performances and errors in the verbal-Arabic transcoding task were found (Seron & Fayol, 1994; Lochy, Delazer, Domahs, Zoppoth, & Seron, 2004; Nguyen & Gregoire, 2012). The more efficient way of naming numbers in Asian languages is also an important explanation for the differences favoring Asian children in previous studies between Asian and Western children in certain mathematics skills such as abstract counting (Miller, Smith, Zhu & Zhang, 1995; Miller & Stigler, 1987), mentally addition (Geary, Bow-Thomas, Fan & Siegler, 1993; Geary et al., 1996), understanding of the canonical base-10 system and place value understanding (Miura, Okamoto,Kim, Steere & Fayol, 1993). The effect of language differences has also supported the Chinese children to surpass their English and American counterparts in embedded-ten cardinal understanding (Ho & Fuson,

1998) and in the acquisition and use of ordinal numbers corresponding to their ordinal names (Miller, Major, Shu & Zhang, 2000).

Like other verbal systems of numbers in East Asia, the Vietnamese language possesses a transparent name-number system, in particular the name-number for the teens. The numbers designation from eleven to nineteen is done with an addition relationship (e.g., eleven is pronounced “ten one”). However, Vietnamese has peculiarities when the digit in the tens or hundreds position is a zero. This is not found in other Asian languages like Chinese, Korean or Japanese. Vietnamese uses the word "zero" as a lexical primitive in the number construction. For example, the Arabic number 3024 is named “three thousand zero hundred two ten four”. This zero is not masked in its verbal form like in others languages. There is however an exception when the zero is in the tens place where it is replaced by the word "remainder". For example, the Arabic number 309 is named "three hundred remainder nine". We can understand the word "remainder" as the rest of the division of 309 by 100. Therefore, for the Arabic number 2009, it is said in Vietnamese "two thousand zero hundred remainder nine".

Depending on its position in a number, two types of zero were distinguished (Granà, Lochy, Girellid, Seron, & Semenza, 2003). The first type is the lexical zero, as in numbers “520”, which is semantically represented. The second type is the syntactic zero as in numbers “508” or “7014”, which is a production of syntax. The syntactic zero is inserted into the number by application of a rule to indicate a missing value in a position.

Due to the particular properties of Vietnamese, the syntactic zero may be easier to manipulate in Vietnamese than in other languages. In our previous study (Nguyen & Grégoire, 2012) we examined the impact of language differences related to the syntactic zero on a verbal-Arabic transcoding task in Vietnamese and French. Results from this study showed the advancement of Vietnamese children in comparison with Belgian children (French-speaking Community). Notice that the mathematical program in Vietnam is more developed on the large numbers topic than in Belgium. However, our task comprised many large numbers so the difference between two countries may be highly due to variation between the two countries mathematical programs.

Previous studies emphasized the role of languages in the understanding of mathematics and in the performance of mathematics tasks but notice here that there is also a limitation of this influence. Nunes (1992) had demonstrated that the developed number name system can restructure mental activity and not involve other basic abilities such as memory and logical reasoning. Results from Miller and Stigler’s (1987) work showed that even if Chinese children were better than US children in abstract counting, there is no difference between the two groups in counting objects. In addition, the difference between children in cross-cultural studies really appears in tasks directly related to language. The Chinese children were more advanced than U.S children in abstract counting but they did not differ in object counting and

problem solving, which is more symbol related (Miller, Smith, Zhu & Zhang, 1995). The limitation of language influence on the cognitive representation of number is also remarked in the cross-cultural study of Saxton and Towse (1998). In this study the researchers suggested that the difference between performances of English-speaking and Japanese-speaking children was mainly due to the task instructions.

From the perspective of limitation concerns of language influence on mathematical understanding and performance, Vietnamese children may not differ with others in the case of a task indirectly involving a name-number. To better understand the influence of language, tasks specifically related to the syntactic zero were built, not only verbal-Arabic transcoding task as in the previous study. Four tasks assessed the competence in comparison, understanding of positional digit in the number, verbal-Arabic number transcoding and analog-numerical-representation into Arabic code transcoding were administered in the present study. In the analog-Arabic transcoding task, the children are asked to produce the Arabic number from a number represented with cubes (e.g., a big cube represents a hundred and a small cube represents ten etc.). Therefore, the children in both countries have the same input code and the support from transparent denomination of the syntactic zero is here masked for Vietnamese children. Having the analog-Arabic transcoding task at the same time with verbal-Arabic transcoding task allowed us to determine more specific effects of language on the interpretation and performance of children. The tasks in the present study comprised only four digits numbers to avoid the variation of the mathematical programs between the two countries, Vietnam and Belgium (French-speaking Community).

We investigated whether the numerical language characteristic involving a zero has also an effect on the tasks involving the manipulation of symbols. Children at grade 3 from two countries, Vietnam and Belgium (French-speaking Community) performed four tasks: understanding of digit value (Comparison), understanding of positional digit in the number (Digit Identification), verbal- Arabic number transcoding and analog- Arabic number transcoding. It was expected that in this examination of transcoding from verbal into Arabic number, Vietnamese children should have higher performances than Belgian children because of the Vietnamese linguistics support. But this support would disappear on other task such as comparison, number digit identification or analog- Arabic number transcoding.

METHOD

Two groups of children participated to this research. In Belgium, we assessed 56 children of Grade 3 (26 girls and 40 boys; mean age 106 months). In Vietnam, we assessed 92 children of Grade 3 (51 girls and 41 boys; mean age 105 months). The children were randomly selected. The study took place in the second half of the school year.

Four Paper-and-pencil tasks were constructed with twenty four items for each task. The test was performed collectively in the classroom. Children worked individually

without time pressure. The average time to achieve each task was between five and fifteen minutes.

The Comparison task consisted of 24 pairs of natural numbers. Half of the items included two digits equal to zero (e.g. 4500 vs.4050) and the other half consisted of items with one digit equal to zero (e.g.6302 vs.6032). Both numbers of each pair had the same digits and the same thousand. They only varied in the position of the digits, which had the form $\overline{a0bc}$ vs. $\overline{ab0c}$ or $\overline{ab0c}$ vs. $\overline{abc0}$.

The Verbal-Arabic Transcoding task was for participants to write the natural numbers from a verbal form into an Arabic number. There were two categories. The Syntactic Zero Verbal Transcoding category was used for numbers containing a syntactic zero (e.g.36**0**4). Numbers without zero, such as 2146, were used in the Non Syntactic Zero Verbal Transcoding category.

The Digit Identification task included none to two digits of zero (e.g. 2146; 3064 and 2006). Children were asked to circle the digit indicating the tens and the hundreds. There are two categories. The category Zero Digit Identification comprised the numbers with the digit needed to be circled equal to zero (e.g. "Circle the digit indicating the tens in the number 4205"). The category Non Zero Digit Identification comprised the numbers with the digit needed to be circled different from zero (e.g. the number 3264).

In the Analog- Arabic number Transcoding task, children were asked to produce the Arabic number from a number represented with cubes (e.g., a big cube represents a thousand and a small square represents a unit etc.). The same 24 items of the Verbal-Arabic Transcoding task were used for the Analog-Arabic Transcoding task. Notice that item order was changed in the two tasks. The Syntactic Zero Analog Transcoding category was used for numbers containing a syntactic zero (e.g.3604). Numbers without zero, such as 2146, were used in the Non Syntactic Zero Analog Transcoding category.

RESULTS

Overall

Two-way repeated measures analysis of variance (ANOVA) were conducted on the correct response rates with the Category (Comparison, Transcoding Verbal-Arabic, Digit Identification and Transcoding Analog-Arabic) as the within subjects factor and the Country (Belgium and Vietnam) as the between subjects factor. The main effect of Country was significant, $F(1,156)=7.15$, $p=0.008$, partial $\eta=0.44$, which means that the scores of Belgians children were higher than those of Vietnam. The main effect of Category was also significant, $F(3,468) = 21.01$, $p<0.001$, partial $\eta=0.119$ implies that performances differed across tasks. The interaction between Category and Country was also significant, $F(3,468) = 6.85$, $p<0.001$, partial $\eta=0.042$ which means that the achievement across category differed according to the country. To understand this difference more precisely, we made four one-way ANOVA with « Country » as a between-subject variable, separately for each category.

On the category Comparison and Transcoding Analog-Arabic, there are significant differences between Belgians and Vietnamese children, $F(1,156)=9.78$, $p=0.02$ and $F(1,156)=18.8$, $p<0.001$ respectively for task Comparison and Transcoding Analog-Arabic. The scores of Belgian children were higher than Vietnamese in these tasks. Only on the category Transcoding Verbal-Arabic, however, the score of Vietnamese children was slightly higher than the Belgian but there was no significant difference between them ($p>0.05$). Also, on the task Digit Identification, children in the two countries did not differ ($p>0.05$). The findings are consistent with our hypothesis that the influence of different mathematical languages changed according to the task which was associated with language in different ways.

Table 1: Mean rates and standard deviations of correct responses (in percent) in each category by country

	Belgium		Vietnam	
Category	M	SD	M	SD
Comparison	97.0	8.6	89.2	18.9
Digit Identification	77.9	29.8	71.5	41.8
Transcoding Verbal-Arabic	84.5	26.6	90.4	18.6
Transcoding Analog-Arabic	84.9	26.7	65.1	29.5

The impact of zero in the task identification of digit

To investigate the impact of zero in the task Identification Digit, the correct response rates in two categories named Zero Identification Digit and Non Zero Identification Digit were compared. Two-way repeated ANOVA was conducted with the Zero Identification (Zero Digit Identification and Non Zero Digit Identification) as a within-subjects factor and the Country (Belgium and Vietnam) as a between subjects factor. The main effect of Country was not significant, $p<0.05$. The main effect of Zero in the Identification Digit task was significant, $F(1,156) = 18.9$, $p<0.001$, which means the children had more difficulties in identifying the digit of number when this digit was equal to zero. The interaction between Zero Identification and Country was also significant, $F(1,156) = 9.25$, $p<0.05$, which means that the effect of zero differed according to the country.

To understand this interaction more precisely, two-way repeated ANOVA were conducted, separately for each country. The effect of Zero in digit identification was emphasized more for Belgian children than for Vietnamese. In fact, this effect was significant for Belgian children, $F(1,65) = 15.3$, $p<0.001$, meaning that the presence of a syntactic zero leads to lower scores for Belgian children, but it was not significant for Vietnamese children, $F(1,91) = 1.64$, $p>0.05$.

Table 2: Mean rates and standard deviations of correct responses (in percent) in category Identification Digit

	Belgium		Vietnam	
Category	M	SD	M	SD
Zero Digit Identification	69.7	40.5	70.0	43.6
Non Zero Digit Identification	86.1	26.6	72.9	42.7

The impact of zero on the task Transcoding verbal-Arabic

Table 3: Mean rates of correct responses (in percent) depending on the type of zero in category Transcoding

	Belgium		Vietnam	
Category	Syntactic Zero	Non Syntactic Zero	Syntactic Zero	Non Syntactic Zero
Verbal-Arabic	85.3	82.0	89.2	93.8
Analog-Arabic	83.2	89.9	57.4	88.2

Two-way repeated ANOVA were conducted with the Category (Syntactic Zero Transcoding Verbal and Non Syntactic Zero Transcoding Verbal) as a within-subjects factor and the Country (Belgium and Vietnam) as a between subjects factor. The main effect of Country was not significant, $F(1,156)=5.3$, $p>0.05$, partial $\eta=0.033$. The main effect of Category in the task Transcoding Verbal-Arabic did not differ significantly $F(1,156)=0.25$, $p>0.05$, partial $\eta=0.002$. But the interaction between Category and Country was significant, $F(1,156)=7.4$, $p<0.05$, partial $\eta=0.045$, which means that the effect of syntactic zero differed according to the country.

To understand the impact of the syntactic zero more precisely, two-way repeated ANOVA were conducted, separately for each country. The results confirmed that the impact of syntactic zero was not significant for Belgian groups, $F(1,65)=2.41$,$p>0.05$, partial $\eta=0.036$ but it was significant for Vietnamese, $F(1,91)= 5.7$, $p<0.05$, partial $\eta=0.059$ which means the Verbal-Arabic transcoding with a number containing a syntactic zero is more difficult than without a syntactic zero.

The impact of zero on the task Transcoding Analog-Arabic

Two-way repeated ANOVA were conducted with the Category (Syntactic Zero and Non Syntactic Zero) as a within-subjects factor and the Country (Belgium and

Vietnam) as a between subjects factor. The main effect of Country differed significantly, $F(1,156)=13.06$, $p<0.001$, partial $\eta=0.077$, which showed that the performances of Belgian children were higher than Vietnamese. The main effect of Category in the task Transcoding Analog -Arabic differed significantly $F(1,156)= 44.77$, $p <0.001$, partial $\eta=0.223$, indicating that the category Syntactic Zero Transcoding Analog provided less correct responses than the category Non Syntactic Zero. The interaction between Category and Country was also significant, $F(1,156) = 18.65$, $p<0.001$, partial $\eta=0.107$.

To understand the impact of the syntactic zero more precisely, two-way repeated ANOVA were conducted, separately for each country. The results confirmed the impact of the syntactic zero was significant for both countries, $F(1, 65) =4.86$, $p<0.05$, partial $n = 0.07$ and $F(1,91)= 53.38$, $p<0.001$, partial $\eta= 0.37$ respectively for Belgian and Vietnamese samples. The impact of the syntactic zero was more highlighted with Vietnamese children than with Belgian.

DISCUSSION

In the current study, the superior performances of Vietnamese children in a verbal-Arabic number transcoding task than Belgian children, even when this task comprised only numbers of 4 digits, was consistent as reported by our previous study (Nguyen & Grégoire, 2012) related to an effective number-name system of Vietnamese language compared to the French. In addition, regarding the results of Vietnamese children in the Digit Identification task, we observed a large variation between them (M=71.5, SD=41.8) and the performances across the Zero Digit Identification and Non Zero Digit Identification were similar. If the Vietnamese children had low performances in this task, they failed to grasp the basics of positional number system. For Belgians, on one hand the impact of zero was significant on the Digit Identification task and on the other hand the variation between children was smaller than Vietnamese. In addition, performances of Belgian children were also higher in other tasks involving the Arabic number production such as analog-Arabic number Transcoding. This suggests that Belgian children's difficulty with this task is slightly due to a general failure of mastery of positional number and rather more to a specific misunderstanding of zero. Even if Belgian children surpassed Vietnamese in this task, they were more affected by the impact of zero than Vietnamese. Vietnamese children may be able to better detect the role of zero, occupied by a position in the number. It can be explained by the support of a greater transparency in Vietnamese number denomination, where the zero's position is explicit. This result also confirmed the previous studies concerning supports of language characteristics on mathematical performances.

The relativity linguistic hypothesis was well examined by many studies of Muira and colleagues. Looking at the impact of languages closely, Saxton and Towse (1998) replicated a study of Muira with some subtle changes in task instructions. Results suggested that the impact of languages on the cognitive representation of a number

was less direct than previously suggested and that the numerical experience played an important role. Recall that in our previous study (Nguyen & Grégoire, 2012), in the verbal-Arabic number transcoding task with numbers from 3 to 6 digits, Vietnamese children at grade 3 was more advanced than Belgians, particularly with large numbers such as 5 and 6 digits. This difference corresponds to the Vietnamese experience of large numbers in school and daily life. Even if only 4 digits numbers were used in this study to avoid the dissimilarity of experience between the two samples, Vietnamese children performances were always higher than their counterparts. However, in the Analog-Arabic number Transcoding task, a large gap between Vietnamese and Belgians was observed, which means Belgians surpassed Vietnamese children. One explanation is due to the manipulation experience with analog-representation numbers of Belgian children. In fact, in Vietnam, this number code is rarely used in textbooks and also for mathematical activities in school. These results showed the limitation of language influences on the less related name-number tasks and emphasised the numerical experience in cross-national performance differences.

It can be questioned what kind of task can measure the impact of languages on mathematical understanding and performances. As Saxton and Twose (1998) had pointed out, the task used by Muira and al. (1994) to attest the support of languages didn't measure this impact directly. In fact, the matching numbers task to evaluate the place-value understanding in this study rather involved analog code (the cubes used to represent units and tens) which connect indirectly with language (Dehaene, 1992). Results from work of Miller and al. (1995) also supported the perspective of language influence limitation regarding these kinds of tasks. Chinese children were better than U.S children in abstract counting but they did not differ in object counting or mathematical problem solving, which revolved more on the relation and manipulation of symbols. Therefore, choosing tasks in order to measure correctly the impact of language in cross-national studies must be done carefully.

The results supported our hypothesis. On one hand, support of language characteristics was also demonstrated with the superior performances of Vietnamese children in verbal-number transcoding task. On the other hand, this support was not direct and showed its limitation when the introduced task was less related with the number-name. In the task related to Arabic numbers and semantic representations (analog code) of numbers, the effect of language did not appear. Other factors like mathematical experience and differences in approach to mathematics teaching might be a plausible explanation for the differences between the two countries, which favoured Belgian children. The utilisation of varied tasks was useful to underscore the strong effect of different competences related with numerical language. In particular, it also showed how the performances of children in each country changed due to the relation with number-name on the corresponding tasks. It provided a fuller view about the mathematical understanding and performances in cross-cultural studies. It will be worth, in further researches, to re-examine the appropriateness of

tasks which were used in previous studies that concern testing the influence of language on mathematical performances.

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