LINGUISTIC RELATIVITY AND PLACE VALUE CONCEPT: THE CASE OF ARABIC

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Abstract This study examined the effect of language on acquiring the concept of place value. The sample for the study consisted of 211 Arabic-speaking children aged between 6;6 years and 7;8 years. Children were interviewed individually and asked to represent written two-digit numbers using base-10 blocks. A new approach for testing the linguistic relativity hypothesis was used, explicit grouping language approach. Following a screening task, participants were randomly divided into 4 groups: control, 20-cube, prompt and explicit grouping language. The results of the study revealed that language played an important role in the acquisition of the place value concept. On the other hand, the results support the argument that instructions given with the task alter children's performance on the task.

Introduction The superiority of Asian children in mathematical performance has directed researchers' attention to studying the role of language in learning mathematics. The number-naming systems in the Chinese-based languages are highly regular. Spoken numbers in Asian languages correspond exactly to their written form: 16 is spoken as "ten six" and 35 as "three-ten five." In contrast, most European systems of number words are considerably irregular through 100.

So, one potential advantage of the Chinese-based number-naming system is that it is easy to acquire because a learner can follow a pattern instead of memorizing many numbers individually as in English for example. Miura (1987) stated "Asian languages that have their roots in ancient Chinese (among them, Chinese, Japanese, and Korean) are organized so that numerical names are congruent with the traditional Base 10 numeration system" (p. 79). Researchers argued that by making apparent the values of each power of ten, and their strict correspondence between spoken and written numbers, Asian number-naming systems facilitate children's understanding of base structure, place value, and associated arithmetical computations (Fuson & Kwon, 1991, 1992; Miura, 1987; Miura , Okamoto, Kim, Chang, Steere, & Fayol, 1994). Arabic number-naming system is similar to that of English. Unlike in Chinese-based languages and like in English, numbers 11 and 12 in Arabic seem to be arbitrary. While 1 and 2 are spoken as wahed (one) and ithnan (two), 11 and 12 are spoken as ahada-ashar, and ithna-ashar respectively. Similarly, the number of tens is not made explicit in the decades (Ishroon (20), Thalathoon (30), arba'oon (40), khamsoon (50),…, tess'oon (90)). Except ishroon (20) in which ithnan(2) is not there at all, all other decades are made by adding "oon" (equivalent to "ty" in English) to the single digit numbers after making some adjustment on them (thalath instead of thalathah (3), arba instead of arba'ah (4), khams instead of kamsah(5), … tess'a instead of tess'ah (9)) (See table 1).

Table 1: Number names across languages

Arabic numeral	English	Arabic	Japanese
1	One	Wahed	Ichi
2	Two	Ithnan	Ni
3	Three	Thalathah	San
4	Four	Arba'ah	Shi
5	Five	khamsah	go
6	Six	Settah	roku
7	Seven	Sab'ah	sichi
8	Eight	Thamaniyah	hachi
9	Nine	Tess'ah	ku
10	Ten	Asharah	Juu
11	Eleven	Ahada-ashar	Juu-ichi
12	Twelve	Ithna-ashar	Juu-ni
20	Twenty	Eshroon	Ni-juu

30	Thirty	Thalathoon	San-juu
21	Twenty one	Wahad-wa-eshroon	Ni-juu-ichi
100	One hundered	Me'ah	hjaku
1000	One thousand	Alf	sen

Selected Studies

Miller and Stigler (1987) conducted a study on Taiwanese and American children aged 4 to 6 years. They asked the children to count up to the highest value possible. The study revealed that Taiwanese children were more accurate in their counting than Americans, and counted to larger numbers. Also, two more points were reported in that study. First, the children from both nationalities tended to stop counting when they approached a decade boundary (e.g 29), suggesting that this might have prevented children from continuing to count. Second, skipping a number in the sequence was the most frequent error made by American children. This error might be explained by the need of English speakers to learn more number names, rather than applying a rule for generating them (Towse & Saxton, 1998).

Miura and others (Miura, 1987; Miura, Kim, Chang, & Okamoto, 1988; Miura & Okamoto, 1989; Miura, Okamoto, Kim, Steere, & Fayol, 1993; and Miura et al., 1994) have conducted a series of studies to explore the influence of language and mathematical cognition. The main focus of these studies was the influence of language on acquiring the concept of place value.

Miura, Kim, Chang, & Okamoto (1988) compared the cognitive representation of number of children from the United States, China, Japan, and Korea. The study aimed at determining if there might be variations in those representations as a result of numerical language characteristics that differentiate Asian and non-Asian language groups. It was found that Asian children preferred to use a construction of tens and ones to represent two-digit numbers. On the other hand, American children preferred to use a collection of units. Moreover, it was found that more Asian children than American children were able to construct numbers in two different ways, which suggested "greater flexibility of mental number manipulation" (Miura et al. , 1988, p. 1445).

These findings were supported by another study that examined the argument that differences in mathematics performance between American and Japanese students may be explained at least partially by variations in cognitive representation of number resulting from differences in numerical language characteristics (i.e. Miura, & Okamoto, 1989). In that study both cognitive representation of number and place value understanding were studied. Japanese children outperformed American children in both the ability to construct correct representations of numbers using base-10 blocks and understanding the concept of place value (Miura, & Okamoto, 1989).

Similar results were also reported in Miura et al. (1993) and Miura et al. (1994). The consistency of results throughout this series of studies encouraged Miura to argue that "variability in mathematics performance may be due to differences in cognitive representation of number that is affected by numerical language characteristics that differentiate Asian and non-Asian language groups" (Miura et al., 194, p. 402).

Towse and Saxton (1997) argued that the number-matching task used in previous studies was not sufficient to test the relationship between language and cognition. They explained that there was no direct demonstration of the association between language and cognition. In their study, they exposed two groups of English speaking children to two different experimental conditions. One group was presented with unit cubes and blocks of 10 cubes "standard condition". The other group was presented by blocks of "20-cubes" (two blocks of ten attached together) in addition to what was presented to the first group. Their rationale was that the presence of the 20-cubes would explicitly cue the use of multi-unit block for representing numbers in the twenties such as "24" giving the children the advantage enjoyed by Asian children (24 in Asian languages is read as 2-ten four).

Besides, they included teen numbers in both conditions because teen numbers "do not give a language-based cue to a block response". Thus, if children in the 20-cube group used twenties blocks for numbers in the twenties, but ones on the teen numbers, this would provide evidence for the importance of language structure on mathematical representations. This study revealed that the 20-cube group significantly used more block strategies than did the standard condition group. Another important finding was that children in the 20-cubes group who used block strategies did so with both teen numbers and numbers in the twenties (Towse, & Saxton, 1997). Also, Towse and Saxton (1997) criticized the procedures of the previous studies and argued that children can be strongly influenced by the instructions provided at the outset. They explained that Miura et al.'s (1994) gave children two examples, in which only 2 and 7 were chosen, both of which require ones cubes only, which may have cued some children to follow the experimenter's demonstration and use only ones cubes.

To test this possibility, Towse, & Saxton (1997) designed another experiment that involved 6- and 7- year-old English-speaking children and created two experimental conditions. In one condition the example given to children involved a single-digit number "2". In the other condition, children were given two examples a single-digit number "2" and a two-digit number "14". Only, standard base-10 blocks were used (i.e. ones and tens). Their study revealed that children given two examples were significantly more likely to use blocks of ten in representing two-digit numbers than was the case with standard instruction involving only single-digit numbers.

In this study, I examine the linguistic relativity hypothesis with Arabic speaking children. In addition to the approach followed by Towse and Saxton (1997), a more direct approach to language is used. In this approach, the aspect of Chinese-based language number-naming systems, making the number of tens explicit in the decade names, is borrowed. So, instead of asking children to represent "thalathah –wa- ishroon" (23) using base-10 blocks, they are asked to represent " thalathah –wa- asharatan" (three and 2 tens). If children who did not represent numbers appropriately using standard language could do so with explicit grouping language, this would give a direct evidence to the influence of linguistic relativity.

Method

Subjects: The subjects of this experiment were 211 school children aged between 6;6 years and 7;8 years (M= 84.6, SD= 5.02), from two randomly assigned public schools in Al-Ain City, United Arab Emirates.

Procedure: The researcher interviewed children individually in a quiet small room in their school. The experiment went through 2 stages.

Stage 1: Screening stage

The child was familiarized with the ones and tens of base-10 blocks (i.e. the small cube represents one, and the long piece represents 10), then asked to read two 2-digit numbers (the numbers were printed on cards) and represent them using base-10 blocks. First children were asked to represent the number 23 and second the number 15, while they had at their disposal a large set of individual cubes (ones) and longs (10s). Children's responses were classified into 3 categories: ones (if the child chose to represent the number by only ones), blocks (if the child chose to represent the number by the appropriate number of tens and ones)and mixed (if the child chose to represent the number 23 by one ten and 13 ones). Blocks and mixed strategists were thanked and returned to their classes. Ones strategists continued to stage 2.

Stage 2: Experiment stage

When a child was classified as a ones strategist, she was assigned to one of 4 groups: control group (n=24), 20-cube group (n=23), prompt group (n=23), and explicit grouping language group (n=23). The process of assigning participant to the different groups followed a fixed pattern: the first ones strategist goes to the control group, the second to the 20-cube group, the third to the prompt group, and the fourth to the explicit grouping language group.

Control group: the child was asked to represent the numbers 24 and 16. Children's responses were classified in the same way as in stage 1.

20-cube group: new pieces of Base-10 blocks were added, the 20-cube blocks that were made by gluing two 10-cube blocks together. The researcher directed child's attention to the new piece, and then asked her to represent the two 2-digit numbers 24, and 16 respectively. Children's responses were classified as in stage 1 except that the "blocks" category in this stage meant that the child used the 20-cube and 4 ones for representing 24, and used one ten and 6 ones for representing 16.

Prompt group: The researcher provided examples of representing 2-digit numbers using base-10 blocks, one example on the teens numbers (not 16), and another on a number between 21 and 29 but not 24. Then the child was asked to represent the numbers 24 and 16. Children's responses were classified in the same way as in stage 1.

Explicit grouping language group (EGL): This time, the researcher presented children with a rabbit toy which he called "Arnoob" (little rabbit). The child was first asked to read a number printed on a card (24) and then told that Arnoob reads numbers in a different way, 21 as "wahed –wa- asharatan" (one and two tens), 22 as "ithnan -wa- asharatan" (two and two tens), 23 as "thalathah –wa- asharatan" (three and two tens). Then the child was asked to read the number 24 in Arnoob's way, and represent it with base-10 blocks. If the child represented the number by only ones, the interview was ended. If the child represented the number correctly, she was asked to read a different number (her way not Arnoob's way) printed on a card (34) and represent it with base-10 blocks. Children's responses were classified in the same way as in stage 1.

Results and Discussion

In stage 1, there were 105 block strategists, 93 ones strategists, 4 mixed strategists, and 9 children could not read the printed numbers. So, 93 children continued to stages 2. The results for stage 2 are shown in table 2. Nine of the 11 block strategists in EGL group, used blocks to represent 34 when they read the number their way. One of the 2 participants who used the 20-cube block to represent 24, used one ten and 6 ones to represent 16.

Group	N	Blocks	Ones
Control	24	1	23
20-cube	23	2	21
Prompt	23	9	14
EGL	23	11	12
Total	93	25	68

Chi square tests were used to test the differences among the groups. There was no significant difference between control group and 20-cube group (chi square = .403, $p > .05$). Significant differences were found between prompt group and control group(chi squarer = 8.57, $p < .05$), and between EGL group and control group (chi square = 11.77, $p < .05$). No significant difference was found between prompt group and EGL (chi square = .354, $p > .05$). For EGL group, a paired sample t-test was used to test the tendency of block strategists (those who used blocks to represent multi-digit numbers when reading it in Arnoob's way) to do the same when reading the numbers in a regular way. A score of "1" was given to using blocks and a score of "0" for using ones. The test revealed no significant difference between the two methods. This suggested that generally participants who use blocks as a result of EGL will do the same with the regular language.

These results are similar to those of Towse and Saxton (1997) in one way and different in another. While the instruction given to children had an important effect on children's responses (prompt group), the 20-cube blocks seemed to have very little effect. This might be due to the difference between Arabic and English in terms of the order of tens and ones. While in English 25 is said as twenty-five, it is said in Arabic as five and twenty. Therefore, when Arabic speaking children represent 25 using blocks, they start with the ones (this is true when writing numbers also). So children who are originally ones strategists might forget the presence of the 20-cube blocks while being busy collecting ones to represent 5, and continue to collect ones for representing 20.

In Towse and Saxton (1997), significantly, more children used the 20-cube blocks in representing numbers in the twenties, but the researchers did not consider that as a support for the linguistic relativity hypothesis. Their argument was that the same children used bocks of ten to represent teen numbers, which indicated that it was not the language that affected children's responses; the presence of new kind of blocks was (Towse and Saxton, 1997). This argument, however, seems not to hold in the light of the present results. If the presence of new pieces had encouraged children to use multiple blocks to represent numbers, the participants of this study would have done so.

These results give support to the linguistic relativity hypothesis and place a question mark on the use of 20-cube blocks with Arabic speaking children. When the number of tens was made explicit in the number name, children tended to represent numbers by appropriate number of tens and ones. It is so interesting that most of children, who represented numbers correctly using the explicit grouping language, did so even when they used the regular language. This indicates that the explicit grouping language influenced children's thinking about numbers. Children knew that 25 had the same value whether read regularly or as five and 2 tens. But the second way clued the way of representing the number and this was transferred to the regular language.

Again, the transfer of knowledge in this study challenges the explanation of Towse and Saxton (1997) regarding the results of the 20-cube condition. They asked children to represent 6 two-digit numbers, three of them in the teens and 3 in the twenties. The numbers were presented randomly with a 50% chance of getting a number in the twenties first. So, those who got a number in the twenties first, might have used the 20-cube blocks because of the correspondence between the number name and the block, directing their attention to a new way of representing numbers, which was transferred to the teen numbers.

Generally, language seems to affect the acquisition of the concept of place-value. However, as suggested by the results of the prompt group, instruction could remedy disadvantages placed by language.

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