DEVELOPMENT OF THE CARDINALITY PRINCIPLE IN MACEDONIAN PRESCHOOL CHILDREN

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Cardinality principle refers to the fact that the last number tag used in counting determines the cardinality of a set. Macedonian kindergarten children were tested with the give-a-number task for understanding of this principle. It was found that Macedonian children, unlike their western counterparts, pass through an additional stage, 5-knowers, before they master the cardinality principle. Also, the age at which they pass through the individual stages is somewhat higher than the age of children coming from western samples. Possible explanations are offered and discussed.

Key words: counting, counting principles, cardinality principle

INTRODUCTION

When children start school they have already discovered some simple addition and subtraction strategies. In these strategies counting plays a crucial role. For example, in order to do addition children may use the counting all strategy where they will count both addends by establishing the numerosity of both sets (both addends). When they advance a little more they realize that they do not have to count the first addend and use the counting on from the first strategy. Finally, a child will master the commutative principle and will start counting on from the larger addend. Similarly, in order to do subtraction a child initially uses the counting down strategy. Subtraction and addition are closely related to counting. In its essence, counting is adding one item at a time, and counting backwards is subtracting one item at a time.
When do children start to count and when do they come to understand counting as adults do, that is: as a procedure which serves to determine the cardinality of a set? Is it evidence that a preschooler knows to count if he recites the counting list or he needs to have understanding what counting serves for before we can say that a child has learned to count? This paper is going to look at these questions. First, two views of children’s counting will be presented. Then, research on the development of the cardinality principle will be reviewed. Finally, results of the research examining the development of cardinality principle in Macedonian context will be presented.

Two views of children’s counting

It seems that children master verbal counting in the first few years of life. The pronoun verbal is used here to distinguish verbal counting from the process of non-verbal counting (enumeration) in infants, discussed elsewhere (Nikoloska, 2008).

Although most researchers (Wynn, 1990; Le Corre, Van de Walle, Brannon & Carey, 2006) seem to agree that in the verbal counting domain the procedural knowledge (skill) develops before the conceptual knowledge (the underlying principles that govern the counting), the issue is debated (Siegler & Rittle-Johnson, 1998). On one side there are the proponents of the principles first view, also called the continuity hypothesis, according to which the child’s learning how to count is guided by innate counting principles (Gelman & Gallistel, 1978; Gelman & Meck, 1983), implying that the conceptual knowledge is present before procedural knowledge. On the other side there are those who advocate the principles-after view (Wynn, 1990), or discontinuity hypothesis, which states that children first learn the procedure of counting, and only after that they understand the concept of counting.

Gelman and Gallistel (1978), proponents of the principles-first view, proposed three innate principles that guide counting. The one to one correspondence principle states that each counting entity is tagged only once with the corresponding number tag. The stable order principle states that the same ordered array of number tags is always used. The cardinal principle states that the last number tag used when counting determines the cardinality of a set. In order for the counting to be correct all principles have to be satisfied. As evidence that children understand the principles, Gelman and Gallistel pointed that children always count the objects with the same counting sequence, although sometimes it may be an idiosyncratic list (ex. 1, 2, 5, 8 instead of 1, 2, 3, 4 ), implying that they understand the stable order principle. Also, when asked how many objects are there, children tend to repeat the last number in the counting list, therefore implying that they know the cardinal principle (Gelman & Meck, 1983). Hence, according to the principles-first view, the conceptual knowledge (the principles) of counting is present before the procedural.

The principles-after view states that children first learn to count and only after this they come to understand the underlying principles. The proponents of this view argue that children’s counting initially is meaningless recitation of the number list, a
fun activity without purpose. Therefore, children first learn the procedure (the activity) of counting and later they understand the underlying principles and purpose of counting. As an argument that goes in favor of their theory they often state that children learn by imitating others to give the last number word used in a counting to the question “how many”, without having any notion that counting establishes the cardinality of a set (Wynn, 1990).

Because children seem to develop the understanding of the cardinality principle slowest, most of the debate is concentrated around the acquisition of this principle.

**The development of the cardinality principle**

The cardinality principle refers to the fact that the last number tag used in counting determines the cardinality of a set. Therefore if children are asked to count several items and immediately afterwards asked how many items there were, children who have grasped the cardinality principle should repeat the last number they used while counting.

Several tasks have been devised in order to prove that children have (or do not have) understanding of the cardinality principle.

One simple way to test understanding of this principle is to ask children how many items there are. Wynn (1990) asked two and three year old children to count an array of objects and immediately after counting asked how many objects there were. Only children at around three and a half years gave the last number word used in a count, implying that only they understood the cardinality principle. The young children could count correctly adhering to the one to one correspondence principle but after counting could not determine the numerosity of the set they have just counted. Instead they started counting again or just gave a random number, therefore not demonstrating understanding of the cardinality principle.

Wynn’s (1990) findings, however are not proof that the younger children lack understanding of the cardinality principle because they may simply love to count, or take the experimenter’s question to mean that they have counted incorrectly. Likewise it does not mean that children who give cardinal number understand the cardinality principle, because they may simply apply a “last word rule”. Therefore, it seems more appropriate if another task is used to probe children’s understanding of counting.

Gelman and Meck (1983) used an error detection task, where a puppet counts either adhering to the principles or not, and children are asked to say whether the puppet counted all right or not. The rationale is that even children who are having difficulties in counting could succeed on the error detection task and demonstrate understanding of the principles. Also, it is reasoned that if these children are able to say that non-conventional but correct counting procedure (for example, starting to count from the middle of a row) was all right, and conventional but incorrect
counting such as double counting or skipping an item or saying the wrong cardinal was not all right, than they have grasped the principles (Gelman & Meck, 1983). Gelman and Meck (1983) found that children as young as 3 years understand the principles that guide the counting procedure and that the set size to which they apply the principles is greater than their counting range. Other studies (Wynn, 1990) have demonstrated that children acquire the principles at around three and a half years of age. Therefore Gelman and Meck’s findings that 3 years old understand the cardinal principle is not proof that the principles guide the acquisition of the procedure, because the children in their sample may have acquired the principles earlier than the average age and still have gone through a phase where they just recite the number sequence without understanding the principles. The finding that children are able to generalize their knowledge to numbers that fall outside of their counting range implies only that children know that counting works the same for all numbers, but it makes no implications for whether children first learn the procedure of counting or first have the principles.

One step further towards solving the debate of principles vs. procedure first was taken by Sophian (1988). She used an error detection task in order to investigate the question whether children are affected or unaffected by the set size when judging counting made by others. Her findings show that children aged 3 and 4 did not perform well when they had to compare two sets, which means children at this age have not completely grasped the concept of counting. This finding seems to agree with the principles-after theory, because children knew the procedures before they had mastered the concept of counting and understood when counting could be applied and for what purposes.

Other research seems to confirm these findings. Wynn (1990) used give-a-number-task to probe preschoolers’ understanding of counting. She asked the children to give a particular number of toys (give-a-number task), and looked whether they counted to give the number asked for. The reasoning is that this is a true task which measures understanding of the cardinal principle, because children will have to count in order to determine the number asked for. If they did count it would mean that they understand the cardinality principle – with the help of counting they can determine the number asked for. Some of the children did count (counters), but some only grabbed a random number of toys (grabbers). Le Corre et al. (2006) refer to grabbers as subset knowers, because they know the meaning of only a subset of number words in their counting range. Subset knowers are further differentiated as one-, two-, three-, and four-knowers according to their performance on the give-a-number task. One knowers knew the meaning of the word “one” only and they could give one toy when asked for one, but when asked for other number they just gave a random number of toys. Similarly, two knowers knew the meaning one “one” and “two” and they could give these numbers correctly, but not the numbers beyond two. Also, those who knew the meaning of a number from the subset of their counting range (for example, 2) never gave that number (2) of items when asked for another number. Wynn’s (1990) results suggest that the cardinal principle is understood when children start using counting to make sets. Her results
were replicated by Le Corre et al. (2006). Both their findings go in favor of the principles-after theory because in both cases children who were grabbers could count correctly, but they could not produce the number asked for, therefore not demonstrating understanding of the cardinal principle that counting determines the numerosness of a set.

Several arguments can be used against Wynn’s (1990) findings. It has been suggested that grabbing a random number of toys does not necessarily need to be explained by lack of understanding of the cardinal principle. Children may simply feel overconfident that they will grab the right number of toys or they might grab because they are over-impulsive (Freeman, Antonucci & Lewis, 2000). The give-a-number task has also been criticized for being too difficult for children because they have to remember the target number while using counting to gather the number of items asked for (Le Corre et al, 2006), which means that this task asks too much from a child’s memory. The critique, however has no firm basis because it cannot explain why grabbers would feel over confident when they need to give a number of items for which they do not know the meaning of, but they do not feel over confident and give the right number when asked for a number they know the meaning of (ie. number 2 for 3-knowers). The memory argument is also weak because in tasks which are less memory demanding children’s performance is the same. Therefore, these arguments do no weaken the principles-after theory.

One way to overcome the memory critique is to use a less memory demanding task. Less memory-demanding task is the point-to-x task. Wynn (1992) used the point-to-x task, which consists of presenting two cards with different number of objects and asking the child to point to the card with a particular number. She compared the performance on this task and the give-a-number task and found within child consistency. The strong within child consistency on the point-to-x and give-a-number task, again go in favor of the principles after theory because children did not show cardinal principle understanding on the easier, less memory demanding task.

All the above mentioned tasks were explicitly focused on cardinal values. Gelman (1993, as cited in Le Corre et al 2006) thought that children might do better if cardinal value is not explicitly mentioned. She proposed the “what is on this card” task. In this task a card with a given number of objects is presented and the child is asked “what is on this card” without any suggestions that he needs to count. Gelman found that this task is more sensitive than other tasks because even 2;6 (y;m) old children succeed and showed understanding of the cardinal principle almost a year before it is believed that children understand the cardinal principle (Wynn, 1990).

However, the success of the younger children could be due to them already being cardinal principle knowers. The mean age for cardinal principle knowers in Wynn’s (1990) study was 3;6 but some of the children reached the cardinal stage at the age of 2;11 (Le Corre et al., 2006). If that is so, than it will not mean that the what is on this card task is more sensitive and that 2;6 olds in general understand the cardinal principle (principles first view), but it will mean that Gelman’s findings reflect just differences in the sample, where most of the children at the age of 2;6 are
already cardinal principle knowers, and they have gone through the phases of subset knowers.

To see whether the what is on this card task is really more sensitive than the give-a-number task and children as young as 2;6 know the principles, Le Corre et al. (2006) replicated both Wynn’ (1990) and Gelman’ (1993, as cited in Le Corre et al., 2006) studies, looking for whether the success on the what is on this card task was a function of the performance on the give-a-number task or of the child’s age. They found strong within child consistency. Those who were cardinal principle knowers were classified as such on both tasks. Those who were subset-knowers were classified as subset knowers on both tasks. Only, the what is on this card task proved to be a little easier to demonstrate more understanding because some of the subset knowers advanced one level on the what is on this card task, and few of the three and four subset knowers on the give a number task were classified as CP knowers on the what is on this card task. However, in general there was strong consistency in the performance. This study confirmed once again that procedure precedes the principles when discussing counting.

**Problem**

The reviewed studies showed that no matter what task was used, children understood the cardinal principle around the age of 3;6 and only after they have been through the phases of subset knowers. In other words, the studies support the principles after theory.

Considering all presented studies it appears that children first learn how to count and only later they grasp the principles that guide the counting. No matter how easy the task children younger than about the age of 3;6 are presented with, they fail to demonstrate understanding of the cardinal principle, and without understanding this principle they have not mastered the concept of counting.

The aim of this study is to examine the cardinality principle in Macedonian context.

All children presented in these studies are children coming from western countries, tested in western kindergartens, where the daily activities are presumably different from those in Macedonian kindergartens. The curriculum in those counties is oriented towards preparing children for school, counting is frequently practiced and school starts at an earlier age. In Macedonia, preschool children are not engaged in preparatory activities for school until they come to attend their last year in kindergarten, at around age 5 or 6. In western countries, children’s activities are highly structured and academically oriented, but in the Macedonian kindergartens a child’s day generally passes in free-play, watching cartoons, drawing, physical exercising, learning foreign language or dancing. Around 30 minutes each day children spend learning about various topics, but counting as such is rarely practiced. Children usually have to create equivalent sets on the basis of one to one correspondence when they learn the numbers 1-5, which is at the age of
Development of the cardinality principle in Macedonian preschool children

approximately 4 years. Therefore, Macedonian children might be at a slight disadvantage regarding their western counterparts in the development of the cardinality principle. Counting is early developing mathematical skill, but nevertheless scaffolding plays an important role, thus it was reasoned that children from western societies who start school from an early age, and who have more academic kindergarten curricula might be at a slight advantage over the age at which they master the cardinality principle. The present research was conducted to see if there would, indeed, appear any differences in understanding of the cardinality principle between western and Macedonian children.

In this study children attending Macedonian kindergartens were tested for understanding of the cardinality principle. The cardinality principle was examined using the *give-a-number* task. It was decided in favor of this task because this is the one most widely used in the literature, so any discrepancies between the age at which children are at a certain stage could be registered using the same task. It is expected that children pass through the same phases of 1-, 2-, 3- and 4- knowers before they become cardinality principle knowers, so we expected to observe children at each of these phases.

**Participants**

In this study participated 68 kindergarten children. The mean age for the final sample was 4;4 (years; months) (the range was 3;9 – 5;2). Out of those 37 children were cardinality principle knowers (mean age 4;6 (years; months) range 3;10-5;2), while 31 were subset knowers (mean age 4;3 range 3;9-5;1). The sample consisted of 26 boys and 42 girls (15 boys and 22 girls in the cardinality principle knower group and 11 boys 20 girls in the subset knower group). Information about the socioeconomic status was not gathered, but presumably children were coming from middle class families. All children were native speakers of Macedonian and all children were attending state kindergartens.

**Procedure**

Children were tested in a separate room in their kindergartens. Each child was tested in individual session by a female experimenter. Children from 4 separate kindergartens participated. The kindergarten principle gave permission to test the children.

Children were told that they would play a counting and number games with the experimenter and were asked to join her in a separate room. Upon arrival the child was given 10 yellow blocks arranged in a straight line approximately 1 cm apart and was asked to count them. The purpose of this task was to see whether the child could count to 10 and whether they used the standard counting sequence or
not. If they did not manage to count to 10 they were given the counting task again at the end of the session to see whether they knew the counting sequence to 10 but failed to demonstrate that knowledge. Only 4 children did not count up to 10 on either occasion. All children used the standard counting sequence, up to the numbers they counted reliably.

After this they were given the “give-a-number” task. In this task children were asked to give 1 item, then 3 and further questioning depended on the answer of the child. If children were unsuccessful at a given number, they were asked for N-1. For example if a child could give one when asked for one, but not three when asked for three, next he would be asked for 2. If he managed to give 2 he would be asked for 3 again. If he managed to give 3 he would be asked for 4, and if not he would be asked for 2 again. If he could give 2, he would be asked for three again and if he could not give three the questioning would stop there and his or hers knower level would be noted, (in this case 2). (If he could give three successfully he would be asked for 4, and if he could not give 4 he would be asked for 3, etc.). Each child was asked until he had 2 successes at a given number and 2 failures at a subsequent number (in this case 3). All children who managed to give 6 items were also asked for 8 items. This was done for two reasons. The experimenter wanted to make sure that the child did not accidentally grab 6 items when asked for six (although in almost all cases the children counted the items), and (2) to test the claim that children who learn the meaning of 5 and 6 become cardinality principle knowers and learn the meaning of all the words within their counting range. So, children who gave 6 when asked for six were supposed to give 8 items when asked for 8 items (provided that they could count as high as 8). Fifteen yellow cubes were put in a pile in front of the children and a lion toy was introduced. The lion was put approximately 20 cm away from the pile and the children were asked to give 1 cube to the lion. They were told “Could you give 1 cube to the lion? Take one cube and put it in front of it”2. After they complied with the request they were asked a follow up question “is that N”? This procedure was repeated for the other numbers asked for. If children responded “no” to the follow up question, the initial request was repeated in the following way: “But the lion wanted N items. Could you put N items in front of it?” Children were given neutral feedback, for example, after the follow up question children would answer “yes” and no matter whether the number of cubes they had given was the number asked for the experimenter would say “Okay, now let’s put those back, and could you give N cubes to the lion. Take N cubes and put them in front of the lion”. If after the request a child asked the experimenter “how much is N” or “is this N” the experimenter replied “just guess how much N is”.

Scoring for this task was carried out in the following way: Children who had two successes at a given number and two failures (that is to say, they gave some other number when asked for N) at a subsequent number were classified according to the highest number that they could give (for example, 2 successes at 3 and 2

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2 The exact wording in Macedonian was “Možeš da mu dadeš edna kocka na lavot? Zemi edna kocka i stavija pred nego.”
failures at 4 means that the child was classified as 3 knower). Children who could give 6 items were classified as cardinality principle knowers (regardless of whether they could give 8 or not).

**RESULTS**

Almost all children, other than 7, could successfully count to 10. The seven children who could not were all subset knowers. Two of these children could count up to 6 and they were 2 knowers. Two of the children were one-knowers and could count up to 5 and 7. The other one was 5-knower and he could count to 8. Two of the children recited a different counting sequence on each of the two occasions (for example, once 5 6 7 9 10 5 7 9 10 0, and once 6 5 8 9 5 9 10 8 6). Both of them were one knowers.

The number of children observed at each level is reported in table 1 (percentages are given in brackets).

<table>
<thead>
<tr>
<th>Knower level</th>
<th>1 knowers</th>
<th>2 knowers</th>
<th>3 knowers</th>
<th>4 knowers</th>
<th>5 knowers</th>
<th>CP knowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number (%) of children performing at a given level</td>
<td>8 (11.8%)</td>
<td>7 (10.3%)</td>
<td>7 (10.3%)</td>
<td>5 (7.4%)</td>
<td>4 (5.9%)</td>
<td>37 (54.4)</td>
</tr>
</tbody>
</table>

The above findings are unusual because in earlier studies almost no-one has reported 5 knowers. In some studies 4-knowers are reported (Le Corre et al, 2006; Sarnecka & Carey, 2008) and in some even 5-knowers (Sarnecka & Gelman, 2004) but it is argued that they (the 5-knowers) are cardinality principle knowers and thus they are classified that way. In this study 5-knowers are not classified as cardinality principle knowers, because they do not understand the cardinality principle as measured by the give-a-number task, and their weak performance on this task (not being able to give 6 items) is not solely due to procedural errors (as claimed in other studies). One child could not give 6 items, but could give 5. He was not counting the items, and he also erred the first time 4 items were asked. When asked “how do you know that it is four” he said “I know”. When asked if he can make sure somehow that it is 4 he did not resort to counting but remained silent. The second time he succeeded at giving four, and he had 2 successes at 5 (gave one by one) but none at 6 (gave one by one, but the wrong number, see Chetland & Fluck, 2007 for similar findings). The other child just refused to give 6 items to the lion declaring that he could not do that. When prompted to guess he said “Well how many is six?”. This
child could count to ten, and she also counted to give 4 and 5 items, but did not think of counting as a strategy to give 6-items. Therefore she has not mastered the cardinality principle completely, because she did not think of producing 6 in the same way as she did for 5 or 4. Thus, she was classified as 5 knower. The other 2 children also did not count to give 6 items. They gave 5 items one by one, so presumably they were counting silently, but when asked for six items one child gave all 15 on the first trial, and when asked to count them, she realized that there were more than was asked for, so she separated with her hand about half of them and moved them towards the lion. The fourth child gave 5 items the first time and the second time she was asked to give 6 she resorted to asking how much is that and when prompted to guess separated several cubes from the pile with her hand at once, and moved them towards the lion declaring “this is six”. These behaviors served as a basis for classifying these children as 5 knowers.

The average age and the range for each knower level is given in Figure 1.

Figure 1: Age of subjects at each knower-level. Boxes enclose the middle 50% of values; horizontal line in box indicates the mean for each group; extending lines indicate the top 25% and bottom 25% of values; circles indicate outliers and stars extreme cases.
In one girl an interesting observation was made during the give-a-number task. When asked to give 3 items to a lion she said “this is three” and put 3 fingers up. Then, she picked up one cube and touched it to the first finger of the 3 fingers that were up. She put the cube by the lion and she picked up another one, repeating the procedure (touching the cube to the second finger). She did that for the third cube as well. Apparently she managed to give three items through a means of one to one correspondence. When asked for four items, she managed to give 4 only at the second attempt with the help of gestural one to one correspondence (Graham, 1999), and she was asking “how much is four” the first time. She did not manage to do this for 5. Although this was observed only in one girl, it seems as if children have learned that if a particular set has a given numerosity, they can produce another set with that numerosity by one to one correspondence means. For example, if they know by subitising (Kaufman, Lord, Reese & Volkmann, 1949), or as it is in this case by memorising, or any other means that a given collection of entities is 4, than they might use this knowledge to form another set of 4 entities. It is as if the items from the known set serve as a placeholder for the creation of a new set. This finding is also consistent with findings that one to one correspondence principle develops before the cardinality principle (Butterworth, 2005) but also with the idea that finger use might serve as a basis for numerical knowledge (Gracia-Bafalluy & Noël, 2008). The use of fingers in this girl also demonstrates in a nice way how item-to-item correspondence and cardinality are related (Muldoon, Lewis & Freeman, 2009).

**DISCUSSION**

In general, this study confirmed the stage-like acquisition of the cardinality principle. However, based on this sample, it would appear that the average age for the cardinality principle knowers in this sample as well as for each particular knower level, was somewhat higher than in other reported studies (Wynn, 1990, 1992; Bermejo, 1996; Sarnecka & Carey, 2008, Le Corre et al., 2006). There are several alternative explanations. The sample was consisted entirely of Macedonian children who do not start school until the age of 6 (and it was until age of 7 until one year ago). The majority of the studies concerning cardinality principle knowers are done in the United States where presumably there are somewhat different activities organized for the children attending kindergartens. Children in Macedonian kindergartens generally do not spend a lot of time in structured activities such as counting because they are left to pursue their own interests (laissez-faire style).

Of course, children might be involved in counting activities at home, with their parents or siblings. Children do not reinvent counting by themselves, but are shown the right way to count by an adult or older peer. Parents almost never just recite the counting sequence, but by gesturing simultaneously, by pointing or touching the items to be counted, try to direct the child’s attention to the activity. The adults, also,
stress each number word as they count, in such a way as to indicate that these are separate words, thus providing implicit cues to the child that counting is not merely a recitation of a long string of words (for example, onetwothreefourfive) but that these are several words and each word is matched with a different item. When adults provide feedback that the child has not done everything all right, for example when a child skips an item or double counts, the child learns what rules are important for counting (that is to say, one to one correspondence principle in the example above). All these activities contribute for the child’s understanding to be advanced from procedural level to conceptual level. Thus, the social interactions play an important role in children’s development of numeracy. For example, the earlier one-to-one correspondence activities, such as distributing objects to people, are embedded in social interactions (Mix, 2002). We should not expect differences in the time Macedonian and western parents spend with their children practicing counting. It is more likely that the difference observed has to do with the age at which children start schooling and the importance of the preparation for formal schooling given in the different cultures.

The discrepancy could be as a result of a procedural error or scoring criteria which skewed the results towards the higher age. Unfortunately, there is no separate English speaking sample tested with the same experimenter and the same procedure in order to compare the results between the samples and possibly provide insights whether this is due to procedural error. However, the procedural error seems unlikely because the same procedure and scoring criteria as in other studies were used (more specifically, Sarnecka and Carey, 2008), and the classification was double-checked by the experimenter after the transcripts were done. It was being looked especially at whether some of the subset knowers were counting or not and if they were not whether they were giving the items one by one (information of this was also taken during the testing) because this could be heard on the recordings. However the children were classified all right. Therefore one possible conclusion that remains is that perhaps the early acquisition of the cardinal principle in other samples is also as a result of counting practice children have had.

Why were the 4 knowers younger than the 2- and 3-knowers and almost as young as the 1-knowers? That is probably so because of the individual differences. Different children acquire the cardinality principle at different age, and go through the phases of subset knowing at different ages. These children will probably acquire the cardinality principle sooner than the majority of the children do.

The give-a-number task confirms the stage-like acquisition of the meaning of number words reported in other studies. In this study, however, 5-knowers were also observed. When asked for 6 they would give another number, sometimes even the whole pile of cubes. Even if some of them did manage to count to give 5, they could not do so for 6, and 6 was within their counting range. Therefore, the conclusion is that these are genuine 5-knowers, because they could not apply counting to other contexts (to give 6 items). The 5-knowers were also asked (once) for 8 items as well, in order to be certain that they do not use counting as a general strategy to give the number asked for. These children could not give 8 items, as compared to the
cardinality principle knowers who could. It is, however, unlikely that all children go through phases of 5- and perhaps even 4-knowers. These children are very rare in the literature, and even if presumably they go through these phases, it is likely that they do not remain for a long period of time at those levels. It is also very likely that some do not go through those phases at all, but after acquiring the meaning of 4 simultaneously acquire the meaning of all number words within their counting range. It is also possible that these observed 5-knowers, are in fact cardinality principle knowers which failed to show that in this particular context. Perhaps if they were given more than 2 chances to give 6 items they would have eventually succeeded. But the mere fact that they did not succeed, even if hypothetically having acquired the cardinality principle, means that this concept is still fragile.

The conceptual knowledge and the procedural knowledge are not floating independent of each other in some kind of vacuum. On the contrary, they are intervened and influence each other. Therefore the concepts cannot be studied separately from the procedure. In order the child to demonstrate that he understand the cardinality principle he needs to give a certain amount of toys in the give-a-number task, that is, he needs to perform a given procedure. If he fails we could conclude that he does not have the concept, or that he has the concept but that other factors, such as lack of procedural knowledge, influence his lack of demonstration of the concepts. But procedural knowledge was demonstrated for 4 and 5 items, and therefore cannot be held responsible for lack of demonstration in the case of 6 items. It could be argued that 6 is more difficult number to give, and the child may still have a concept (of how counting determines cardinality) but lack of procedure. However, even in that case, the mere fact that 6 is more difficult to give, implies something not only about the procedure, but about the concept as well. From merely procedural level, the procedure is the same as in the case of 4 and 5 items, but in the case of 6 items something appears to be more difficult.

Some children would take the items one by one and take it in their arms until they had made the entire set instead of putting the cubes one by one in front of the lion. They were taking the cubes one by one, and counting them, but they apparently wanted to make the whole set before they put them all in front of the lion. Surely in this case the children had difficulties producing a set of 6 items because the cubes would start to fall of their arms. In that case a tip was given to them “why don’t you try putting them in this box first, that way they won’t fall of”. These children were classified as CP knowers. But this pattern of behavior was not evident for the children classified as 5-knowers. The 5 knowers did not use counting to try to make a set of 6.

Almost all of the children who could give 6 items could also give 8 items when asked for 8, which is in agreement with the claim that children learn the meaning of all number words in their counting range as soon as they acquire the cardinality principle. The children who failed to give eight all used counting, but made a procedural error such as loosing track of the items that have been counted, realized that and started to count all over again. When asked to count the items and make sure it is the correct number, if there was a mistake, they realized the mistake and
they knew how to correct it – by taking one cube out of the pile of 9 for example. This pattern of behavior is clearly different from the one observed with 5-knowers. Also, these behaviors of the cardinality principle knowers confirm the idea that once children learn the cardinality principle they learn the meaning of all number words within their counting range.

Even within children classified as cardinality principle knowers, there are levels of understanding. As mentioned above some could correct a wrong number of items in a set, by adding or removing items (for example, remove one item from a set of 9 to make that set with 8 items). However, other girl produced a set of 6 items when asked for 8, and when she was prompted to count the items and make sure she realized that they are 6, so she put another cube and started counting again, counted 7 items, and she added one more cube, started counting again and after counting 8 items, she proclaimed that there were “eight now”. Apparently she could not make the inference that 6+1=7 so she needed to count the items again. This is opposite behavior of the one described above where children could add one item and knew right away that there were N+1 items. Although this girl was cardinality principle knower, she was less proficient in determining the cardinality of a set than her peers. This suggests that even within the cardinality principle group there are levels of understanding cardinality. Presumably, this girl was “new” to the cardinality principle and she was still exploring it, where as the other children were “proficient users” of the cardinality principle and knew shortcuts to determining cardinality. Whether all children go through this “novice” phase of knowing the cardinality principle or some learn “the shortcut” immediately cannot be answered from these data and is a possible research topic for some other study.

It might be argued that the mean age at each knower level is higher than in other studies because the children tested were older as well. (In other studies the age range is approximately 2;9-4;2). However, this should be excluded as a possible reason because if the children all over the world progress at the same ages then using an older sample would have restricted the findings to the 3-knower or cp-knower groups. The fact that in the current study 1-knowers and 2-knowers were also detected means that the results are not moved towards higher ages but children in this sample progress at each stage at different age than their western peers.

In order to make more powerful statements about the difference between Macedonian and western children in understanding of the cardinality principle, more extensive research is needed.

CONCLUSION

Children’s early addition and subtraction strategies are based on counting. However, learning how to count is a long and complex process. Children may appear as if they have mastered counting because they seem confident in reciting the
counting sequence and repeating the last number word used in the count to answer the question “how many”, but what this appearance might reflect is just an observational learning. Most of the researchers dealing with the development of the counting principles, especially the cardinality principle agree that in this domain the skills develop before the principles. Before children master the cardinality principle they go through phases of subset knowing.

This study has provided some significant insights. Namely, the children tested were Macedonian preschool children attending state kindergartens. It was found that some of these children are 5-knowers, a result very rarely reported in other studies. This might be due to less counting experience children have compared to their western counterparts, and thus they need additional phase of 5 knowing before they master the concept of counting. Also, children progressed at each stage at a much higher age than in western countries. It was argued here that this is probably a result of less formal curricula in the kindergartens in Macedonia and subsequently less counting experience. More systematic study of this issue would be worthwhile.

Taken all together, counting represents a basic skill that children acquire very early in life. These results suggest that practicing counting may play an important role in the mastery of the cardinality principle. Knowing that early mastery of the counting principles is correlated with better arithmetic performance (Stock, Desoete & Roeyers, 2009), it may be worthwhile if teachers practice counting with children more often.

REFERENCES


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DEVELOPMENT OF THE CARDINALITY PRINCIPLE IN MACEDONIAN PRESCHOOL CHILDREN

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Ključne reči: brojanje, principi brojanja, razvoj principa kardinalnosti