The Role of Knowledge of Counting Principles in Acquiring Counting Skill in Preschool Children

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Abstract: The aim of this study was to examine the role of counting principles in the acquisition of counting skill in preschool children. For this purpose, children's judgment of acceptability of a counting activity in one's application of counting principles in sequences of familiar (English) and unfamiliar (Turkish) count words were assessed. Data showed that children easily recognized the violation of one or more counting principles both in sequences of English and Turkish count words, implying that children have the understanding of counting principles. The sessions on counting in Turkish make it very likely that the children were responding to violations of rules rather than merely violation of well-learning of count words. These results give additional support to the assumption that there are innate counting principles that rule young children's counting.

Keywords: counting principles, error-detection task, mathematical development.

Özet: *Okul Öncesi Çocuklarda Sayma Becerisinin Edinilmesinde Sayma İlkeleri Bilgilerinin Rolü.* Bu çalışmanın amacı, ilkokul öncesi yaştaki çocuklarda sayma becerisinin edinilmesinde sayma ilkelerinin rolünü incelemektir. Bu amaç doğrultusunda, bir grup okul öncesi çocukların videodan izledikleri bir aktör çocuğun hem anadilinde (İngilizce) hem de bilmedikleri bir yabancı dilde (Türkçe) yaptığı sayma serilerinin kabul edilir olup olmadığı hakkındaki yargıları değerlendirilmiştir. Elde edilen veriler çocukların kolaylıkla hem İngilizce hem de Türkçe serilerinde hatalı uygulanan bir veya birden fazla sayma ilkelerini tespit edebildiğini göstermiştir. Türkçe sayma serilerinde elde edilen bulgular bize çocukların büyük bir olasılıkla ezberledikleri sayı sözcük dizilerindeki hatalardan çok, sayma etkinliği sırasında yapılan kural ihlallerine tepki verdiğini göstermektedir. Bu sonuç erken yaştaki çocukların sayma etkinliklerine rehberlik eden doğuştan getirdikleri örtük "sayma ilkelerine" sahip olduklarına ilişkin görüşleri destekler yönündedir.

Anahtar Kelimeler: sayma ilkeleri, hata-bulma görevi, matematiksel gelişim

Introduction

Children's counting ability is an inviting subject to study in mathematical development; because it is the first verbal numerical activity a young child shows. It is also widely believed to be basic for children's problem solving and other mathematical knowledge in further mathematical development (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Bryant, 1995; Gersten, Jordan, & Flojo, 2005; Jordan, Kaplan, Locuniak, & Ramineni, 2007; Krajewski & Schneider, 2009; LeFevre, Fast, Skwarchuck, Smith-Chant, Bisanz, & Kamawar, 2010; Passolunghi, Vercelloni, & Schadee, 2007; Resnick, 1989; Stock, Desoete, & Roeyers, 2009).

One of the earliest and most influential accounts of young children's understanding of number concepts was made by Jean Piaget. He minimized the importance of counting in the development of the number concept. He argued that, a young child can know number words and count objects, but this is just verbal knowledge which does not include understanding of the essential idea of number. That is why preschool children usually failed in the number-conservation tasks, i.e., figuring out whether or not two sets of objects are numerically equal, irrespective of their spatial arrangement. In Piaget's thought, children must reach the concrete operational period of cognitive growth, around 7 years of age, in order to understand the main mathematical principles and processes. For Piaget, therefore, the acquisition of number concepts is a part of general cognitive development emerging from gradual changes in the underlying logical structures of thought (Piaget, 1952; 1953: 1968).

Contrary to Piaget's view, Gelman and Gallistel (1978) proposed that there is a set of innate knowledge of counting principles guiding children, from a very early age, in learning to count. On the

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basis of their extensive of experimental and observational studies, Gelman and Gallistel (1978) identified five counting principles: one-to-one; stable-order; cardinal; abstraction and order irrelevance. The first three principles are also called "how-to-count principles".

The one-to-one principle dictates that each object in a set must be assigned a unique counting tag or symbol. The successful application of this principle requires the coordination of the partitioning and tagging processes, when counting given objects. The procedure of partitioning indicates that the items to be counted must be separated from those that have already been counted. The tagging procedure implies that each verbal label must be used for only one item. The number tags or symbols could be any set of tags, such as items of the alphabet, as long as each one is assigned to single item. The stable order principle states that the count symbols must be used in a stable or repeatable order and the sequence must be as long as the number of items in the array. Thus, young children can be attributed to use this principle even when they do not apply the conventional count words in the correct order, since this rule only requires the same word sequence to be used in consecutive counting. The cardinal principle means that children know that the last number assigned to a set implies the measure of the number of objects in that set. The abstraction principle allows children to apply counting to any item or event regardless of its kind (physical or non-physical). Finally, the order irrelevance principle indicates that the order in which items are tagged is irrelevant as the cardinal value remains the same.

For Gelman and Gallistel (1978), the preschooler’s failure in comparing two sets comes from lack of access to the numerical knowledge that is originally embedded in their counting rather than from lack of logical competence per se, as Piaget claimed. Thus, they claimed that children’s counting provides a basis for the development of number reasoning ability. According to them, children can acquire the representation of numbers by using counting procedure to determine numerical equivalence between sets. They argued that children’s reasoning errors, especially with larger set sizes, result from the execution of counting principles. The use of counting to reason about larger sets will take time. Before that, children need to practice applying the counting principles in the acquisition of counting procedures.

Support for Gelman and Gallistel’s argument came from Gelman and Meck’s (1983) error-detection experiment in which children aged 3 to 5 years were examined using four separate counting tasks. There were three error-detection tasks designed to test children’s ability to recognize violations in a puppet’s application of counting principles namely, the one-to-one, stable order and cardinal principles. In these conditions, the children’s task was to say whether the puppet was right or wrong after watching his counting. In the fourth condition, called the standard counting task, children were asked to count items in different set sizes. As children did not need to execute the counting in the error-detection experiment, Gelman and Meck predicted that children’s performance would be better on these tasks than the standard one which demands the production of counting. In the event, this was what their study found. Children were able to recognize violations in the puppet’s counting in most set sizes. On the other hand, in the standard counting experiment the children were not able to count properly, especially larger set sizes, although performance in counting increased with age. Several parallel studies have also reported a similar success in children’s performance in the error–detection task (e.g., Briars & Siegler, 1984; Kamawar, LeFevre, Bisanz, Fast, Skwarchuck, Smith-Chant, & Penner-Wilger, 2010; LeFevre, Smith-Chant, Fast, Skwarchuck, Sargla, & Arnup, 2006; Rodriguez, Lagoa, Enescoa, & Guerrero, 2013).

On the whole, Gelman and Gallistel (1978) grant more numerical competency to young children than Piaget suggests. They argued that the existence of counting principles provides a structure that rules or guides the child’s counting. Children will not show perfect skill and understanding when these principles first emerge, because they need time to grasp how and when to apply these principles. Accordingly, they give more credit to the idea that there are several distinct domains within cognition. Each has its own *innate* organizing principles or constraints functioning as cognitive organizers which support children for learning specific kinds of knowledge relevant to particular cognitive domains (e.g., Gallistel & Gelman, 1992; 2000; Gelman, 2000).

This study aims to investigate whether young children have an implicit knowledge of the counting principles that govern their counting activity. Unlike similar studies, in this study, children’s judgment of acceptability of a counting activity in one’s application of counting principles in sequences of not only familiar (English) but also unfamiliar (Turkish) count words were assessed. It was expected that if children’s counting ability is ruled by implicit knowledge as Gelman and Gallistel assumed, it will be easy for children to recognize and verbalize the violation of counting principles when the number tags are in any language, familiar or unfamiliar. The identification of the violation of counting principles in the counting activity in a sequence of Turkish count words will make it very likely that the children are responding to violations of rules rather than simply violations of well-learned sequences of count words.

Method

Participants

21 children took part in this study. They all attended a primary school in the Midlands, England. Their ages ranged from 4 years 6 months to 6 years 6 months. The mean age of subjects was 5 years 5 months and the standard deviation was 8 months. Before the study, the experimenter visited the school to explain the broader aims of the research to the class teachers. The visit also created an opportunity for the experimenter to get know and familiarize himself with the students under the guidance of their class teachers. There was no pressure whatsoever placed on children who were reluctant to take part for any reason. Children were not formally screened for any form of cognitive impairments or disabilities, but there was no indication from class teachers that any of the participants suffered from hearing and speech impairments or subnormal IQ.

Materials

Before testing procedure, a video was recorded by the experimenter. It showed a 6-year-old child, Tom, counting loudly by pointing to each of five small bricks scattered on a tabletop. Bricks were the same in size (2x2x2), but different in color (blue, white, red and green) to extend the children’s capacity to distinguish already-counted from to-be-counted objects.

Task

Children were tested over two sessions. The actor child used conventional English count words in the first and Turkish count words in the second session. Each child received 8 trials in random order in each session, making a total of 16 trials in all. Trials differed in counting procedure, so that they were “good counting” and “bad counting” trials. In the good counting trials the actor child counted loudly in the correct sequence from left to right by pointing to each brick. There was one trial with good counting. The bad counting trials included violations of the one-to-one and cardinal counting principles. There were two different violations for the one-to-one principle. In the first one, the actor child produced the right sequence of count words, but one time use the same count word for two different bricks, in other words, he repeated a count word. The second violation was produced by skipping an object, which is an object, was neither pointed to nor labeled with a word. This was called the word-object correspondence violation in this study. In the cardinal violation, the actor child’s response to the last count word was one more or less than the actual set size. Each violation type appeared in a separate trial. There were three other trials including two different violations in combination and one trial combined all them. After watching the video, the children’s task was to judge on each trial whether the actor child’s counting was a good counting or a bad counting. In addition each child’s comments on their response were taken to get the reason behind their answer.

Procedure

The daily numeracy hour was chosen for the assessment procedure to minimize any disruption to normal teaching schedules in other topics. Children were brought individually from their classroom to a quiet room to test. Before turning on the video, each child was told: “Please sit on this chair and as I turn on the video watch it very carefully to see Tom’s counting. Tom will be counting some small bricks on the table but he is reckless and sometimes when he counts he makes mistakes. I want you to watch him very carefully and tell me after he finishes counting whether his counting is good counting or bad counting.”

Results

This study was designed to assess children's knowledge of counting principles by asking them to make judgments about an actor child's counting activity in which one or more counting rules were violated. Therefore, children's own counting performance was not evaluated. Children's judgment performance on the actor child's counting is shown at Table1.

Table 1. *The number of subjects out of 21 who judged the trials as a good counting*

Trail type	English count word	Turkish count word
Standard correct	17	15
One-to-one violation	13	10
Cardinal violation	0	16
One-to-one and Cardinal violation	0	8
Word-object violation	5	4
Word-object and Cardinal violation	7	3
One-to-one and Word-object violation	0	4
Combination all violation	0	4

Session 1, English count words

As can be seen from table 1, 17 of 21 subjects accepted the trial in which no violations occurred as a good counting. The trial that includes the one-to-one violation was responded as a good counting by 13 children. There were 5 good counting judgments in the word-object correspondence violation. None of the children gave good counting answers to cardinal error trials.

The trial that violated both the one-to-one and the cardinal rule was rejected as a good counting by all subjects. On the other hand, the trial in which the cardinal and the word-object correspondence errors appeared was accepted as a good counting by 7 children. None of the subjects responded with good counting on the one-to-one and the word-object violation trial, nor on the trial in which all violation types occurred.

Session 2, Turkish count words

Table 1 also shows that 15 of 21 subjects accepted the trial in which no violations occurred as a good counting. The trial that leaves out only the one-to-one rule was responded as a good counting by 10 children. There were 4 good counting judgments in the word-object correspondence violation trial. Sixteen children gave good counting answers to the cardinal error trial.

The trial that violates both the one-to-one and the cardinal rule was rejected as a good counting by 13 subjects. On the other hand, the trial in which the cardinal and the word -object correspondence errors appeared was accepted as a good counting by 3 children. Four subjects responded with good counting to the one-to-one and the word-object violation trial. This was the same for the trial with all violation types.

Cochran's Q test was performed, separately for each session, on the children's responses among the trials. Tests revealed that the children's responses were significantly different among the trials in both sessions ($Q=73.29$, $d.f=7$, $p<001$; $Q=49.72$, $d.f=7$, $p<001$; respectively). To determine which conditions were different, McNemar's test was used to compare pairs of trials.

Table 2. *Mcnemar test results among the trials in English count words*

Trial type	12345	12245	12234	12346	1234	1235	1225
12234	.0000*	.0002*	--	--	--	--	--
12346	.0000*	.0002*	--	--	--	--	--
1234	.0063*	--	.0156*	.0156*	--	--	--
1235	.0018*	.0215*	--	--	--	--	--
1225	.0000*	.0002*	--	--	.0156*	--	--
1224	.0000*	.0002*	--	--	.0156*	--	--

Note. It should be noted that in these pairwise comparisons, no adjustment is made for multiple comparisons. A Bonferroni adjustment applied to $\alpha = 0.05$ gives a criterion of $\alpha' = 0.0018$

As can be seen from table 2, in the English count words session, the subjects' responses significantly differed in the good counting trial from all the other trials except for the one-to-one violation trial. The one-to-one violation trial differed significantly from all the other violation trials except for the trial with both cardinal and word-object correspondence violation. The cardinal violation trial differed significantly from the trial with both word-object correspondence and cardinal error, the one-to-one error trial and the good counting trial. And the word-object correspondence error trial was significantly different from the good counting and the one-to-one error trials.

Table 3. *Mcnemar test results among the trials in Turkish count words*

Trial type	12345	12245	12234	12346	1234	1235	1225
12234	.0391*	--	--	--	--	--	--
12346	--	--	.0078*	--	--	--	--
1234	.0005*	.0156*	--	.0002*	--	--	--
1235	.0010*	.0313*	--	.0005*	--	--	--
1225	.0010*	.0313*	--	.0005*	--	--	--
1224	.0034*	--	--	.0018*	--	--	--

Note. It should be noted that in these pairwise comparisons, no adjustment was made for multiple comparisons. A Bonferroni adjustment applied to $\alpha = 0.05$ gives a criterion of $\alpha' = 0.0018$.

As can be seen from table 3, in the Turkish count words session, the subjects' responses in the good counting trial were significantly different from trials with violation of word-object correspondence, one-to-one and cardinal principles, the cardinal and word-object correspondence principles, the one-to-one and word-object correspondence principles, and the trial with all these types of violations. The one-to-one violation trial differed significantly from the trials that violated word-object correspondence, one-to-one and word-object correspondence, and cardinal and word-object correspondence. The other significant differences were between the cardinal error trial and all the other trials except for the good counting trial and from the trials which violated one-to-one error trial. And also the word-object correspondence error trial was significantly different from the good counting trial and from the trials which violated the one-to-one and the cardinal principles.

The above results indicate that the 5 and 6-year-old children were able to recognize the violations of the one-to-one and the cardinal counting principles. Their own explanations for their judgments show that they are also able to articulate the violation in these principles. For example, most of the children explained that the trial in which the one-to-one error occurred was not good counting because "he (actor child) said *two two* (in English session) or *ikki ikki* (in Turkish session)". In the cardinal violation trial they said "he said six" or "he did not say five" (this explanation was only in the English words session). Finally, for word-object correspondence violation, some of the children could indicate that "he missed out one" or "one was out".

Another finding is that the children showed marked differences in the recognition of the violation types between sessions. All the subjects could grasp the cardinal violation in English counting. However, only 5 of the subjects accepted this violation as bad counting in Turkish. This is as expected. It is predictable that without being familiar with the language it is impossible to know the sequence of count words that is essential for the cardinal rule. On the other hand, the other violation types were detected by nearly the same number of the subjects in both sessions.

Discussion

In this study, the judgment of acceptability of a counting activity was used to determine whether young children are aware of a number of counting principles as suggested by Gelman and Gallistel (1978). The findings give an additional support the hypothesis that preschool children have implicit knowledge of counting principles that underlie their counting skill. Most of the children did not show any difficulties in distinguishing the good counting trials from the bad counting trials in which one or more counting rules were violated. Further support for this conclusion comes from the children's own explanation of their judgments. Most of the children were able to articulate what was odd with the actor child's counting. This finding is consistent with the literature on language development that showed that, from a very early age, children already use the rules of the language when they speak, at least within very wide limits. However, they are unable to talk about the rules of the language that they speak until they are about five years old (e.g., deVilliers & deVilliers, 1972; Gleitman, Gleitman, & Shipley, 1972).

The evidence this study provided directly supports one of Gelman and Gallistel's assumptions that any words, tags or symbols can be used as number tags as long as they are being used in a way that is consistent with one-to-one or stable-order principles. In Turkish count word sessions, most of the children could realize the violation of the one-to-one and the word-object correspondence. The cardinal violation was not detected, as expected. It is predictable that, without being familiar the language, it is impossible to know the sequence of count words that are essential for the cardinal rule. The findings from the sessions on counting in Turkish make it very likely that the children were responding to violations of rules rather than simply violations of well-learned sequences of count words.

Regarding the cardinality principles, this study also indicates that there might be a relationship between the proper application of counting principles and cardinality. All children were able to detect the cardinality violation in English count words session, but not in Turkish ones. On the other hand, in both sessions, nearly equal numbers of subjects accepted the trial as a good counting in which the cardinality was correct when the one-to-one violation occurred. However, the trial that included the one-to-one and the cardinal violation together was seen as a bad counting by all the subjects in English count word session, but around half of the subjects in Turkish count words. It seems that violation of the cardinality principle becomes important for the children and enough to reject the trial. On the other hand, correct cardinality is not enough to accept the trial in which the other counting principles are violated. This finding is consistent with Gelman and Gallistel's suggestion that children will reject correct cardinality after incorrect application of the one-to-one and stable order principles in a count, or that they will ignore true cardinality following incorrect counting.

The reliable assessment of children's early numerical competence is needed in order to establish whether young children have an adequate understanding of counting and related concepts before introducing further mathematical knowledge in the first years of schooling and beyond. Even before formal schooling, in their home environment or nursery classes, young children begin spontaneously to develop a basic understanding of number and counting principles by engaging in related activities if appropriate social contexts and materials are provided (e.g., Benigno & Ellis, 2004; Durkin, Shire, Riem, Crowther, & Rutter, 1986; Saxe, 1991; Saxe, Guberman, & Gearheart, 1987). However, the self-initiated activities do not seem to be enough to learn the meaning and utility of practiced procedures and any associated numerical knowledge unless the social functions of these experiences are made explicit (e.g., Fuson, 1988; Nunes & Bryant, 1996; Sophian, 1998; 2004). In addition, attention was paid to cultural differences, such as the nature of number systems, as one of the factors effecting young children's acquisition of different aspects of mathematics (e.g., Miller, Major, Shu, & Zhang, 2000; Miller, Smith, Zhu, & Zhang, 1995). Further investigation is needed, by means of longitudinal and cross-cultural studies in various social and linguistic contexts, to have more insight in the relationship between preschoolers' understanding of number, counting and further mathematical abilities.

Kaynakça

Aunola, K., Leskinen, E., Lerkkanen, M.-K., & Nurmi, J.-E. (2004). Developmental dynamics of mathematical

performance from preschool to Grade 2. *Journal of Educat ional Psychology, 96,* 699-713.

Benigno, J. P., & Ellis, S. (2004). Two is greater than three: effects of older siblings on parental support of preschoolers' counting in middle-income families. *Early Childhood Research Quarterly, 19,* 4-20.

Briars, D., & Siegler, R. (1984). A featural analysis of preschoolers' counting knowledge. *Developmental*

Psychology, *20,* 607-618.

Bryant, P. (1995). Children and Arithmetic. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 36,* 3-32.

deVilliers, J. G., & deVilliers, P. A. (1972). A cross-sectional study of the development of semantic and syntactic acceptability by children. *Journal of Psycholinguistic Research*, *1,* 299-310.

Durkin, K., Shire, B., Riem, R., Crowther, R. D. & Rutter, D. R. (1986). The social and linguistic contexts of early number word use. *British Journal of Development Psychology*, 28 (6), 998-1005.

Fuson, K. C. (1988). *Children's counting and concepts of number*. New York: Springer-Verlag.

Gleitman, L. R., Gleitman, H., and Shipley, E. (1972). The emergence of the child as grammarian. *Cognition, 1,* 137-
164.

Galllistel, C. R., & Gelman, R. (1992). Preverbal and verbal counting and computation. *Cognition, 44*, 43-74.

Galllistel, C. R., & Gelman, R. (2000). Non-verbal numerical cognition: from reals to integers. *Trends in Cognitive Sciences, 4,* 59-65.

Gelman, R., & Gallistel, C. R. (1978). *The child's understanding of number.* Cambridge, Mass., and London: Harvard University Press.

Gelman, R., & Meck, E. (1983). Pre-schoolers' counting: principles before skill. *Cognition*, *13,* 343-359.

Gelman, R. (2000). The epigenesis of mathematical thinking. *Journal of Applied Developmental Psychology, 21,* 27-37.

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics

difficulties. *Journal of Learning Disabilities, 38,* 293-304.

Jordan, N. C., Kaplan, D., Locuniak, M. N., & Ramineni, C. (2007). Predicting first-grade math achievement from

developmental number sense trajectories. *Learning Disabilities Research and Practice*, *22*, 36–46.

Kamawar, D., Lefevre, J. A., Bisanz, J., Fast, L., Skwarchuk, S. L., Smith-Chant, B., & Penner-Wilger, M. (2010).

Knowledge of counting principles: How relevant is order irrelevance? Journal of *Experimental Child Psychology, 105,* 138–145.

Krajewski, K., & Schneider, W. (2009). Exploring the impact of phonological awareness, visuo-spatial working

memory, and preschool quantity–number competencies on mathematics achievement in elementary school: Findings from a 3-year longitudinal study. *Journal of Experimental Child Psychology, 103*, 516–531.

LeFevre, J., Smith-Chant, B., Fast, L., Skwarchuk, S., Sargla, E., Arnup, J., et al (2006).

What counts as knowing? The development of conceptual and procedural knowledge of counting from kindergarten through Grade 2. *Journal of Experimental Child Psychology*, *93,* 285–303.

LeFevre, J., Fast, L., Skwarchuk, S., Smith-Chant, B., Bisanz, J., Kamawar, D., et al (2010). Pathways to

mathematics: Longitudinal predictors of performance. *Child Development, 81(6)*, 1753–1767.

Miller, F. K., Smith, M. C., Zhu, J., & Zhang, H. (1995). Pre-school origins of cross-national differences in

mathematical competence: the role of number-naming system. *Psychological Science*, 6, 56-60.

Miller, K., Major, S. M., Shu., H., & Zhang, H. (2000). Ordinal knowledge: Number names and number concepts in Chinese and English. *Canadian Journal of Experimental Psychology, 54,* 129-139.

Nunes, T., & Bryant, P. (1996). *Children doing mathematics*. Oxford, Blackwell.

Passolunghi, M. C., Vercelloni, B., & Schadee, H. (2007). The precursors of mathematics learning: working memory,

phonological ability and numerical competence. *Cognitive Development, 22,* 165-184.

Piaget, J. (1952). *The child's conception of number*. London: Routledge & Kegan Paul.

Piaget, J. (1953). How children form mathematical concepts. *Scientific American, 31,* 202-206

Piaget, J. (1968). Quantification, conservation, and nativism. *Science, 162,* 976-979.

Resnick, L. B. (1989). Developing mathematical knowledge. *American Psychologist, 44,* 162-169.

Rodríguez, P., Lagoa, M. O., Enescoa, I., & Guerrero, S. (2013). Children's understandings of counting: Detection of

errors and pseudoerrors by kindergarten and primary school children. *Journal of Experimental Child Psychology, 114,* 35-46.

Saxe, G. B., & Guberman, S., & Gearheart, M. (1987). Social and developmental processes in children's

understanding of number. *Monographs of the Society for Research in Child Development, 52,* 100-200.

Saxe, G. B. (1991). *Culture and cognitive development: Studies in mathematical understanding.* Hillsdale, NJ:

Erlbaum.

Sophian, C. (1998). A developmental perspective on children's counting. In C. Donlan (Ed.) *The development of mathematical skills: Cultural, cognitive and neuropsychological perspective*. Hove: Blackwell.

Sophian, C. (2004). Mathematics for the future: developing a Head Start curriculum to support mathematics learning. *Early Childhood Research Quarterly, 19,* 59-81.

Stock, P., Desoete, A., & Roeyers., H. (2009). Mastery of the counting principles in toddlers: A crucial step in the

development of budding arithmetic abilities?. *Learning and Individual Differences, 19,* 419-422.

Genişletilmiş Özet

Matematik işlemlerinin temeli olduğu kabul edilen "sayma" becerisi, okul öncesi çocukların matematik alanında gösterdiği en önemli gelişmelerden birisidir (örneğin, Bryant, 1995; Gersten, Jordan, & Flojo, 2005; Jordan, Kaplan, Locuniak, & Ramineni, 2007; LeFevre, Fast, Skwarchuck, Smith-Chant, Bisanz, & Kamawar, 2010). Saymanın matematik bilgisinin gelişimdeki rolü üzerine ilk çarpıcı açıklamaları yapan Jean Piaget, 7 yaşından küçük çocukların *sayı kavramına* sahip olamayacaklarını ileri sürmüştür. Ona göre, bu yaştaki çocuklar henüz "nicelik (sayı) korunumunu" anlayacak mantıksal-zihinsel gelişim düzeyine ulaşmamışlardır. Piaget'e göre, küçük yaştaki çocukların sayı sözcüklerini bilmesi, sıraya koyabilmesi yani sayabilmesi, basit toplama ve çıkarma işlemlerini yapabilmesi tamamen ezbere dayalıdır (Piaget, 1952; 1953; 1968).

Öte yandan Gelman ve Gallistel (1978; 1992; 2000) çocukların sayma etkinliklerine rehberlik eden doğuştan getirdikleri belirli örtük bilgilere sahip olduklarını belirtmişlerdir. Bunlardan üçü b*ire bir eşleştirme, sıralama ve kardinal temsil* sayma için olmazsa olmaz ilkeler olarak tanımlanmışlardır. *Bire bir eşleştirme* her bir sayılacak öğe için ayrı bir etiket gerektiğini ima eder. *Sıralama* sayı sözcüklerinin tekrarlanabilir bir sıra ve düzen içersinde olması gerektiğini belirtir. *Kardinal Temsil ise* bir sayma dizisinde söylenen son sayının sayılan kümedeki elamanların miktarını temsil ettiğini gösterir. Gelman ve Gallistel'e göre Piaget'in nicelik korunumu problemlerinde çocuklar saymayı etkin bir şekilde kullanamamalarının nedeni, deneyim eksikliği ve özellikle saymanın bir problem çözme stratejisi olarak hangi amaçla, ne zaman kullanılması gerektiği bilememelerinden kaynaklanmaktadır.

Gelman ve Gallistel görüşlerini sınamak için "hata bulma görevi" yöntemini kullanmıştır. Bu yöntemin kullanıldığı araştırmalarda (örneğin, Briars & Siegler, 1984; Gelman ve Meck, 1983; Kamawar, LeFevre, Bisanz, Fast, Skwarchuck, Smith-Chant, & Penner-Wilger, 2010; LeFevre, Smith-Chant, Fast, Skwarchuck, Sargla, & Arnup, 2006) genellikle önce çocukların değişik sayma örnekleri izlemeleri sağlanmış, sonrasında ise kendilerinden sayma etkinliği sırasında varsa eğer yapılan hataları bulmaları istenmiştir. Bu yaklaşımın altında yatan varsayım, çocukların sayma ilkeleri ile ilgili rehber edindikleri örtük bilgilere sahip olsalar dahi, eğer yeterli uygulama deneyimleri yoksa bunları doğru şekilde uygulayamayacakları, ancak örnek sayma uygulamaları gözlemlediklerinde (performans baskısı azalacağından) bu bilgileri daha rahat ifade edecekleri olmuştur. Bu amaçla, çoğunlukla çocukların dikkat ve ilgisini artırmak için o dönemde popüler olan bir kukla kullanılmıştır. Örneğin, çocuklar *Mickey Mouse*'u bir grup nesneyi sayarken izlemişler ve bu arada herhangi bir yanlış yapıp yapmadığını bulmaya çalışmışlardır.

Bu çalışmada ise Gelman ve Gallistel'in okul öncesi çocuklarda sahip olduğunu iddia ettiği örtük sayma kuralları yine "hata bulma görevi" ile test edilmiştir. Fakat benzer çalışmalardan farklı olarak, kukla yerine deneklerle aynı yaşta olan bir çocuğun (bu çalışmada İngiliz) başka bir dilin sayma sözcükleri ile (bu çalışmada Türkçe) yapmış olduğu farklı sayma serileri kullanılmıştır. Çocuklardan, videodan izledikleri kendi yaşıtı bir çocuğun bilmedikleri bir yabancı dilde yaptığı sayma serilerinin doğru ya da yanlış olup olmadığı belirtmesi istenmiştir. Eğer Gelman ve Gallistel'in iddia ettiği gibi çocuklar çok erken yaştan itibaren uygulamasında zorlanmalarına rağmen sayma ile ilgili örtük bilgilere sahip iseler, bilmedikleri bir dilde olsa dahi, bir grup nesnenin sayımında yapılan hataları tespit etmekte anlamlı bir ölçüde başarı göstermeleri gerekmektedir.

Yaşları 4 ila 6 yaş arasında değişen İngiltere'nin Midlands yöresindeki ilköğretim okulunda eğitim alan 21 İngiliz çocuk bu çalışmaya katılmıştır. 11'i kız 10'u erkek olan çocukların yaş ortalaması 5 yıl 5 ay, standart sapma 8 aydır. Deneklere sunulmak üzere hazırlanan videonun içeriği ise şu şekilde kurgulanmıştır. 6 yaşındaki Tom isimli aktör çocuk hem anadilinde (İngilizce) hem de önceden bilmediği yabancı dilde (Türkçe) sayma sözcüklerini kullanarak masa üzerinde düzenli bir şekilde sıralanmış beş adet küp şeklindeki plastik nesneleri yüksek sesle sayması sağlanmıştır. Tom'un hem İngilizce hem de Türkçe nesneleri sayarken biri hata içermeyen (doğru sayma) sayma serisi dışında 7 farklı hatalı sayma serisi uygulamıştır. Örneğin, serilerinden birinde aynı sayma sözcüğünü iki faklı nesne için kullanırken (hatalı bire-bir eşleştirme), bir diğerinde son sayma sözcüğü hatalı bir miktar belirtmiştir (hatalı kardinal temsil).

Test edilen çocuklar tek tek değerlendirmeye alınmış ve kendilerinden seyrettikleri videodaki Tom'un her bir sayma denemesinde masa üzerine sıralanmış renkli küpleri "doğru" bir şekilde sayıp saymadığına karar vermesi istenmiştir. Çocuklar İngilizce sayma oturumunda 8 ve Türkçe sayma oturumunda 8 olmak üzere toplamda 16 sayma serisini için değerlendirmede bulunmuşlardır. Elde edilen bulgular Cochran's Q testi kullanılarak incelenmiş, hem İngilizce yapılan sayma oturumundaki seriler arasında (Q=73.29, d.f=7, p<001), hem de Türkçe yapılan sayma oturumundaki seriler arasında anlamlı bir fark olduğu bulunmuştur (Q=49.72, d.f=7, p<001). Her iki dildeki sayma oturumunda sayma serileri arasında anlamlı farkı ortaya çıkaran koşulları belirlemek için ise McNemar's test uygulanmıştır.

Test sonuçlarına göre ortaya çıkan bulgular Gelman ve Gallistel'in "sayma ilkeleri" görüşünü destekler yönündedir. Örneğin, gerek İngilizce sayma serilerinde, gerekse Türkçe serilerde, "standart (doğru) sayma" serisi diğer tüm serilere göre anlamlı ölçüde daha fazla "doğru" bir sayma olarak değerlendirilmiştir. Bu seride Türkçe bilmedikleri halde çocuklar sayma kurallarının ihlal edilmediği, diğer bir değişle her bir nesnenin sayılması ve her biri için bir sözcük (etiket) kullanılması gerektiğinin farkında olmuşlardır. Öte yandan, Türkçe sayma serilerinde, beklenilebileceği gibi "hatalı kardinal temsil" serisi çocuklar tarafından başarılı bir şekilde tespit edilememiştir. Çocukların yabancı bir dilde kullanılan ilk defa duyacakları sayma sözcüklerinin (etiketlerinin) sabit sıralarını bilemeyeceklerinden, sayılan serilerdeki son nesne için söylenilen yeni sözcüğün olması gerekenden (doğru miktarı belirten) farklı olmasını tespit etmeleri mümkün olamayacaktır. Bu bulgular bize çocukların büyük bir olasılıkla ezberledikleri sayı sözcük dizilerindeki hatalardan çok, sayma etkinliği sırasında yapılan kural ihlallerine tepki verdiğini göstermektedir.

Matematik, günümüzde neredeyse tüm dünyada temel eğitiminin vazgeçilmelerinden olan alanlarından biridir. Matematik öğreniminde rol oynayan önemli süreçlerin daha anlaşılır kılınması ve böylece matematik bilgisinin kazanılmasında ve matematiksel düşüncenin gelişiminde zorlanan önemli sayıda çocuk ve bireylere dönük destekleyici programların geliştirilmesi için, farklı bağlamlarda ve özellikle kültürler arası karşılaştırmalar içeren daha fazla çalışmalara ihtiyaç vardır.