Learning and Individual Differences 32 (2014) 238–245

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

The role of number naming systems and numeracy experiences in children's rote counting: Evidence from Turkish and Canadian children

Ozlem Cankaya [a,b,*], Jo-Anne LeFevre [a,c], Kristina Dunbar [c]

[a] Institute of Cognitive Science, Carleton University, 1125 Colonel By Drive, Ottawa, ON K1S 5B6, Canada
[b] Child & Youth Data Laboratory, Alberta Centre for Child Family and Community Research, 601, 9925-109 Street, Edmonton, AB T5K 2J8, Canada
[c] Department of Psychology, Carleton University, 1125 Colonel By Drive, Ottawa, ON K1S 5B6, Canada

ARTICLE INFO

Article history:
Received 5 March 2013
Received in revised form 4 February 2014
Accepted 20 March 2014

Keywords:
Counting
Number naming system
Board games
Language
Learning
Early numeracy

ABSTRACT

How important is the regularity of a number naming system when young children are learning to count? Three- and four-year-old English- and Turkish-speaking children ($N = 75$) played one of two versions of a board game. The number game involved counting and naming numbers from 1 to 20 whereas the color game involved naming colors. All of the Turkish-speaking children in the number game condition showed some improvement in their rote counting skills whereas almost half of the English-speaking children did not. Despite the advantage of the regular number naming system, however, the Turkish-speaking children had lower scores than the English-speaking children on other early numeracy tasks. These results support the view that both the characteristics of the number language and factors such as children's numeracy-related experiences must be considered when comparing children's early numeracy skills across language groups.

1. Introduction

Counting to 10 in many languages requires mastering an arbitrary but ordered set of number names (e.g., *one*, *two*, *three* … *ten* in English; *bir*, *iki*, *üç*… *on* in Turkish). After 10, in some languages the number naming systems are regular and transparent; in other languages the number naming systems are irregular; they have rules, but with exceptions. For example, in Chinese and Turkish, 13 translates to 'ten three'; thus, counting between 11 and 19 involves learning a rule to combine the words from one to nine with ten to create larger number words. In contrast, in English and many other languages the numbers between 11 and 19 are denoted by unique words that can be learned only through memorization. How closely the number language reflects quantity determines the level of regularity in a number naming system (Dowker, Bala, & Lloyd, 2008; LeFevre, Clarke, & Stringer, 2002; Miller & Stigler, 1987). The structural differences in number languages and the regularity of the counting sequence influence children's early numeracy knowledge and have long-term implications for processing numbers (Colomé, Laka, & Sebastián-Gallés, 2010; Krinzinger et al., 2011; Zuber, Pixner, Moeller, & Nuerk, 2009).

In the present research, we hypothesized that providing young children who spoke either Turkish or English with systematic exposure to the counting string would result in greater learning for the Turkish-speaking children than English-speaking children due to the regularity of the Turkish number naming system.

1.1. Linguistic influences on children's early numeracy

Children whose languages have regular number systems often have better early numeracy skills than children whose number languages are not regular (Aunio, Aubrey, Godfrey, Pan, & Liu, 2008; Fuson & Kwon, 1992; Geary, Bow-Thomas, Liu, & Siegler, 1996; LeFevre et al., 2002; Miller, Smith, Zhu, & Zhang, 1995; Miura, Okamoto, Chungsoon, Steere, & Fayol, 1993). For instance, Miller et al. (1995) compared the early numeracy skills of 99 three- to five-year old English- and Chinese-speaking preschool children from the U.S. and China, respectively. Children completed: rote counting (i.e., verbally counting as high as possible), enumeration (i.e., counting a set of objects), and cardinality tasks (i.e., producing sets of 'n' objects). Fifty percent of the English-speaking children could not count up to 20 compared to only 25% of the Chinese-speaking children. In contrast, children's object counting and cardinality knowledge did not differ by language, indicating that not all aspects of early numeracy knowledge were influenced by the number naming systems. Miller et al. (1995) concluded that English-speaking children need substantially longer time to master the counting sequence than

* Corresponding author at: Child & Youth Data Laboratory, Alberta Centre for Child Family and Community Research, 601, 9925-109 Street, Edmonton, AB T5K 2J8, Canada. Tel.: +1 780 496 1331; fax: +1 780 944 8637.
E-mail addresses: ocankaya@research4children.com (O. Cankaya), jo-anne.lefevre@carleton.ca (J.-A. LeFevre), kdunbar@connect.carleton.ca (K. Dunbar).

http://dx.doi.org/10.1016/j.lindif.2014.03.016
1041-6080/

Chinese-speaking children because of the relative regularity of the number naming systems.

Several other comparisons of children's counting performance between regular versus less-regular number languages exist for English and Asian languages (Fuson & Kwon, 1992; Geary et al., 1996; Huntsinger, Jose, Liaw, & Ching, 1997; Miura et al., 1993), English and French (LeFevre et al., 2002), and English and Welsh (Dowker et al., 2008). In all cases, children speaking the more-regular number language had an advantage on rote counting and sometimes on other early numeracy measures than children speaking the less-regular language. However, many of the comparisons were confounded with dramatic differences in the amount of early numeracy experience (e.g., Pan, Gauvain, Liu, & Cheng, 2006; see also LeFevre et al., 2002). Because these group comparisons are correlational, the role of other factors, including experience and cultural differences, cannot be ruled out as causes of the observed differences.

Furthermore, studies with young bilingual children suggest that language is not the only factor affecting children's learning of the number words and the counting sequence (Aunio et al., 2004; Rasmussen, Ho, Nicoladis, Leung, & Bisanz, 2006; Song & Ginsburg, 1988). English–Chinese bilingual children's rote counting was correlated with the children's relative proficiency in each language rather than the level of regularity of the associated number naming system (Rasmussen et al., 2006). Similarly, for three-and-a-half year-old Korean children who were learning two systems simultaneously in Korean, one regular and one irregular, performance even in the regular number naming system was not as good as that of their Chinese peers until after they had about two additional years of practice (Song & Ginsburg, 1988). These results with bilingual children suggest that the relative amount of numeracy experience across groups with different number naming systems should be evaluated when exploring the effect of number naming systems.

1.2. Non-linguistic influences on children's early numeracy

The development of children's numerical knowledge is active, constructed, and culturally specific (Saxe, 1991) and therefore the variability across cultures in factors other than language can affect children's early numeracy learning. Children's early involvement in numeracy-related activities (Chen & Uttal, 1988; Pan et al., 2006), practice at home with parents (Kleemans, Peeters, Segers, & Verhoeven, 2012; LeFevre et al., 2002, 2009; Skwarchuk, 2009), and the frequency of direct instruction about numbers is positively correlated with young children's numerical knowledge (Aunio et al., 2008; Blevins-Knabe & Musun-Miller, 1996; Huntsinger, Jose, Larson, Balsink-Krieg, & Shali-gram, 2000; LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010; LeFevre et al., 2002, 2010; Skwarchuk, Sowinski, & LeFevre, 2014). Thus, exploring the demands of the culture in which children learn is critical in understanding numeracy development.

Previous studies evaluating the effects of number naming systems on numerical cognition failed to address an important question of how similar or different children's numeracy-related experiences were in addition to differences in their number language. One way to equate children's experience is to provide controlled exposure to the skills of interest. Numerous researchers found that playing numerical board games was an effective method for improving children's familiarity with early numeracy concepts, especially for children who have little experience with the number system (Laski & Siegler, 2014; Ramani & Siegler, 2008; Ramani, Siegler, & Hitti, 2012; Siegler & Ramani, 2009; Whyte & Bull, 2008). Through playing structured numerical board games, young children learn basic numeracy skills such as counting and number recognition in relatively short periods of time. We used exposure to the counting string through a number board game to control young children's experiences with the number system and to observe the learning process across language groups.

1.3. Objectives of the study

The goal of the present research was to examine the influence of different number naming systems and numeracy experiences on young children's acquisition of early numeracy skills, particularly rote counting. We hypothesized that when children who did not have much prior counting knowledge were exposed systematically to number names and the counting string, a relatively regular number naming system (Turkish) would facilitate children's acquisition of counting words more than an irregular number naming system (English). Also, we expected that number game exposure, relative to color game exposure, would facilitate early numeracy skills for both English- and Turkish-speaking children, because previous research has shown benefits on various numerical skills including counting (e.g., Ramani & Siegler, 2008; Ramani et al., 2012; Siegler & Ramani, 2009; Whyte & Bull, 2008). To test these hypotheses, children were exposed to a numerical intervention that has been shown to facilitate children's acquisition of a variety of numerical skills (e.g., counting, recognizing numbers, knowledge of number names; Laski & Siegler, 2014; Ramani & Siegler, 2008; Whyte & Bull, 2008). Thus, the present research used a quasi-experimental rather than a correlational design.

2. Methods

2.1. Participants

Fifty-nine English-speaking and 88 Turkish-speaking children between the ages of three and four-and-a-half years were recruited from six daycares in Ottawa, Canada and three kindergartens and a daycare in Istanbul, Turkey. The data were collected simultaneously in Turkey and Canada within the first months of the school year. More Turkish-speaking children were pretested than English-speaking children as part of a large study. Children were selected randomly for the pretest. Children who could not count higher than 20 (without making an error) during the pretest session were randomly assigned to one of the two training conditions (number or color board game) such that approximately equal numbers of boys and girls and equal numbers of children from each daycare and kindergarten participated in each training condition. Sixteen English-speaking children participated in a different number game condition, but their data were not analyzed in the current study because Turkish-speaking children did not participate in that number game. The distribution of children across conditions is shown in Table 1. For the training sample, mean ages were 44.1 months (SD = 5.7) for the English-speaking children and 46.4 months (SD = 5.9) for the Turkish-speaking children, F (1,73) = 2.87, p = .095. All of the Turkish-speaking children were monolinguals. The English-speaking group spoke English at daycare; however, 43% of the children also spoke another language at home. There were no significant differences on any of the pretest measures between the monolingual English-speaking children and those who spoke another language at home (for complete details see Cankaya, 2013).

2.2. Measures

The measures were developed in English and then translated into Turkish in consultation with early childhood education experts in both countries to ensure cultural appropriateness. As part of the large-scale study, some additional measures were also given to the children to assess the different components of early numeracy knowledge and skills

Table 1
Number of participants in each condition (girls).

	English-speaking	Turkish-speaking
Color board game	16 (8)	21 (9)
Number board game	14 (8)	24 (10)