Linguistic Cues Influence Acquisition of Number Words

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Abstract

A cross-linguistic study investigated how syntactic cues influence young children s number representations. We compared how English monolinguals and Russian-English bilinguals perform on number discrimination task. Subjects performances strongly suggest that linguistic cues, such as plural markings, guide children s initial acquisition and representation of number.

Introduction

Many researchers agree that there is a special cognitive structure that is devoted to representation of number (Gallistel & Gelman, 1992; Whalen, Gallister, & Gelman, 1999; Wynn, 1990a.b). For example, *analog magnitudes* represent a number of items as a single magnitude proportional to the target number (Meck and Church, 1983). Because the magnitudes exhibit scalar variability, the discriminability of two given quantities accords with Webers law, in that it increases with the ratio. Accordingly, even 6-month infants can discriminate between both visual and auditory arrays of stimuli based on number, when the ratio in the array is 1:2 (Liption and Spelke, 2002; Xu and Spelke, 2000). Non-human primates have also been shown to succeed on number discrimination tasks (Hauser, McNeilage and Ware, 1996).

Despite infants success on number discrimination tasks, children need as long as 6-9 months to learn new number word (Wynn, 1992; Skwarchuk and Anglin, 2002). Thus, mapping analog-magnitude representation onto number-words is gradual and effortful. One reason for this apparent paradox is that analog-magnitude representation is approximate, while correct application of number words requires exact representation of numbers. How do children accomplish this mapping of approximate representational system onto exact number line? One possibility is that children use linguistic cues to arrive at the correct exact meanings of number words (Bloom and Wynn, 1997). For example, English marks nouns that refer to sets of objects with cardinality larger than 1 (singular-plural distinction). Children might use this cue to make an inference about the meaning of number word *one*, and how it is different from the rest of number words. One implication of this hypothesis is that speakers of languages with different plural markings use different strategies to acquire and initially represent number words. We investigated this hypothesis by comparing the performance of English monolinguals and Russian-English bilinguals on number discrimination task.

Russian language is different from English in that it has two plural markers. Russian marks sets with only one object (by putting the noun in nominative case, singular form); sets with 2, 3, or 4 objects (by putting the noun in genitive case singular form); and finally sets with more than 5 objects, by putting the noun in genitive case plural form (see Table 1).

Table1: Examples in English and Russian.

English	One book	2-4 book**S**	5 book**S**
Russian (Feminine)	Odna knig**A**	2-4 ning**I**	5 knig

Experiment

Experiment 1 compared how children who Russian and English languages discriminate between two pictures with different numbers of objects. For example, we showed the participants two cards, with one and two balls each, and asked them to point to the card with only one or only two balls (adapted from Wynn, 1999). Wynn (1999) showed that English speaking kids easily learn the contrast between one and other numbers. She suggested that English plural marking puts these numbers into different categories. Because Russian language breaks the number line into three categories (*one*, *small numbers*, *large numbers*), we predicted that Russian speaking children will perform very well discriminating between small and large numbers (e.g., 3 vs. 6). Therefore, we predicted that in both languages, children will perform better making cross-categorical comparison, than making within categorical comparison, where category is a group of numbers organized together by the plural markers of children s native language.

Method

Participants The participants were 12 Russian-English bilingual children and 11 English monolingual children (age range from 39 to 56 months).

Design Both groups of children completed number discrimination task, during which they were presented with two cards, and each card showed a different number of identical objects. The participants were asked to point to a card with X objects. There were four within subject comparisons: 1 vs. another number; small number vs. small number (2 vs. 3, vs. 4); small number vs. large number (4 vs. 6 and 3 vs. 6), and large number vs. large number (5 vs.10 and 6 vs. 9). The pairs of numbers in each comparison were constructed such that they had 1 to 2 and 2 to 3 ratios. Overall, there were 8 discriminations between 1 and another number, and 4 discrimination within each additional type (small vs. small, small vs. large, and large vs. large). All children were expected to succeed at discriminating between 1 and any other number. All children were expected to perform at chance, while discriminating between large numbers. However, we expected the language-specific differences in children s discriminations between small vs. small and small vs. large numbers. Russian-English bilinguals completed two sessions: in English and in Russian. There was a one-week break between the sessions, and the sessions were conducted by two different experimenters. The pairing of experimenters with the sessions and the order of the sessions were counterbalanced across the participants.

Materials We constructed two sets of pictures of four different familiar objects (e.g., bunny, dog, star, and tree). The two sets of pictures were counterbalanced across the two sessions for the bilingual subjects, and across the monolingual subjects. Within each set, we constructed four blocks, with different objects each, such that each block of objects had all four types of discriminations.

Procedure The experiment started with two pretests. The experimenter showed children 5 toy frogs or chickens (counterbalanced across sessions for the bilingual subjects) and asked: How many frogs/ chickens are here? If a child counted correctly, the experimenter added one more toy. If a child made a mistake, the experimenter removed one toy and asked to count again. Each child was encouraged to count out loud, and to point at the objects while counting. The task was conducted to determine the range of participants counting routine. The second pretest was Give-a-Number task developed by Wynn (1990). During this task the participants were asked to put only a specific number of toys in the box. The experimenter always started requesting 3 toys, then the experimenter increased or decreased the number of toys by one, depending on subject s performance. Then, the participants moved on to the main experimental task, discriminating between different number of objects in two pictures.

Results

Counting The mean highest number that English monolingual produced correctly was 7.2 (std=4.08). The mean highest numbers for the bilinguals were 6.8 (std=3.32) in Russian and 7.9 (std=4.12) in English. The were no significant difference between the two groups of children, in either language.

Give a Number On average, the monolingual children correctly put 3.4 (std=1.34) objects in the box, while the bilinguals put 3.0 (std=1.79) objects in Russian, and 3.8 (std=1.83) in English. Again, there were no significant differences between the two groups of children. The results of the pretests suggest that the two groups of children were at a comparable acquisition stage

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Discriminations The results of number discriminations are summarized in Figures 1 and 2. As expected, both groups of children performed equally well discriminating between 1 and another number (Monolinguals: 98% correct discriminations; Bilinguals Russian: 98% correct and English: 95%). Monolinguals successfully discriminated between small numbers (91% correct), while bilingual children s performance dropped to 59% correct in Russian and 72% correct in English. Monolinguals made 76% of correct discriminations between small and large numbers, while bilinguals made 77% of correct discriminations in Russian and 84% in English. Finally, monolingual children made 51% of correct discriminations between large numbers, while bilinguals made 45% of correct

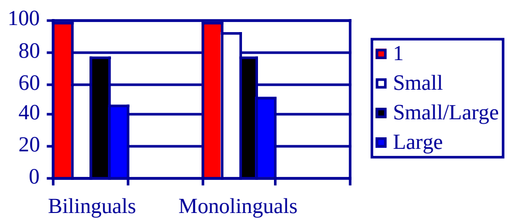

Figure 1

discriminations in Russian and 54% in English (see Figures 1 and 2). We conducted ANOVA to compare the performances of bilingual children on different types of number discrimination in English and Russian. The ANOVA revealed a significant effect of Type of Discrimination, $F(3, 9) = 28.998$, $p<.000$; no significant effect of Language, and no interaction between the Language and Type of Discrimination. Because there was no effect of Language for bilinguals, we collapsed across languages, and compared bilinguals and monolinguals. ANOVA revealed a significant effect of Type of Discrimination,

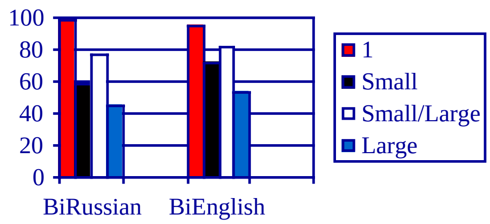

Figure 2

$F(3, 20)=56.290$, $p<000$, a significant effect of Group, $F(1,20)=742.330$, $p<.000$; and a significant interaction between Group and Type of Discrimination, $F=3.57$, $p<.025$.

General Discussion

Bloom and Wynn (1998) proposed that linguistic cues guide acquisition of number words. For example, acquiring number word *one* in English is facilitated by the plural marking that makes the contrast between *one* and *many* salient Wynn (1992b). Consistent with this proposal, we found that for Russian speaking children discriminate between 3 vs. 6 (cross-categorical contrast) more accurately than between 2 vs. 4 (within-categorical contrast). In contrast, English monolinguals performance gradually declined, as the numbers became larger. Interestingly, the bilingual children exhibited this language-specific pattern, even when tested in English, suggesting the salient contrast between small and large numbers is conceptualized, and children s performance is not directly triggered by the linguistic input at the time of testing.

Although, bilinguals performed better on the cross-categorical questions, overall, they performed worse than monolingual children did. There are two possible answers for their relatively inferior performance. First, learning number words in two languages is more difficult than in one language (especially when the languages send competing cues). However, when the bilinguals made cross the categorical discrimination, their performance recovers up to the level of English monolinguals, probably because Russian plural marking made this contrast particularly salient. Alternatively, bilingual children might be confused by the specific plural marker that puts nouns combined with number words *two*, *three* and *four*, in genitive case, singular form. Putting the nouns in the singular form might obscure the fact that the number words themselves refer to the sets with multiple members. Thus, rather than acquiring each number word independently, Russian speaking children appear to group them into three discreet categories: *one*, *some* and *many*. While constructing this representation probably slows down initial acquisition of number words, it might provide children with the structure that eventually enables them to realize the principles of the number line and the counting routine. Either one of these possibilities is consistent with the initial proposal that number word acquisition is in part depends on the cues provided by child s language. Further cross-linguistic research is necessary to shed light on how linguistic and numerical representations interact in children s early conception of number words.

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