Language Differences in Bilingual Parent Number Speech to Preschool-Aged Children

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Abstract

Number-specific parental language input has been shown to influence children's number word acquisition (Suriyakham, Levine, & Huttenlocher, 2006). That is, the more frequently children hear number words and concepts, the more readily they acquire them. In a cross-national study, Mandarin-speaking Chinese parents were found to use significantly more number language than their English-speaking counterparts when interacting with their preschool-aged children in naturalistic settings (Chang et al., under review). The current study examined parental numeric language input to preschool children in Mandarin-English bilingual speaking American parents. Results were consistent with a previous cross-national, cross-linguistic investigation, and suggest that early exposure to Mandarin Chinese, whether in a monolingual or bilingual setting, provides young children with more instances and examples of the cardinal number principle than their monolingual English-speaking peers.

Keywords: bilingualism; child-directed speech; cross-linguistic; language development; number.

Introduction

Prior to formal schooling, parental language input has been shown to be an important source of informal learning for young children. For example, a direct relationship has been shown between child vocabulary acquisition and the overall amount of parental language spoken to children during daily activities (Huttenlocher et al., 1991). More specifically, the types and tokens that appear in parents' speech to children appear to influence the words earliest acquired in children's vocabularies. For instance, the more often a particular verb is used in parents' speech, the more often that same verb appears in children's speech in subsequent weeks (Naigles & Hoff-Ginsberg, 1998). Although most input studies have suggested that breadth of vocabulary is directly related to input frequency, it is also noteworthy that depth of vocabulary, or understanding of words and their meanings, is also strongly related to frequency of input (Vermeer, 2001). Given the strong relationship between parental language input and children's acquisition, an understanding of the type of numeric language children hear is critical for understanding children's numerical development. While few studies have examined parental number speech specifically, previous findings on language input strongly suggest that parents who frequently talk about number should have children who acquire numerical terms more readily and more deeply than children who hear number terms less often. Such findings have strong implications for numeric input, and indeed, recent research (Suriyakham, Levine, & Huttenlocher, 2006) finds that children who hear more number words at 30 months of age say more number terms at 30 and 38 months of age. As a whole, these findings suggest that differences in numeric language input may result in different levels of numerical competence and thus may factor into the early differences between English-speaking and Mandarin-speaking children in tests of mathematical performance (e.g., Mullis et al., 2004).

Language and Number

Differences in mathematical achievement between Mandarin Chinese and English speaking children have been widely and consistently documented (e.g., the Trends in International Mathematics and Science Study (TIMSS); Mullis et al., 2004). Children in Mandarin speaking countries have outperformed their English-speaking counterparts in both the fourth and eighth grades on each successive year of the TIMSS since its inception in 1995. Moreover, other cross-national studies have found superior performance for Mandarin speakers at even younger ages. On achievement tests based on the content of their respective textbooks, Chinese first graders outperformed American first graders on computation and story problems (Stevenson, Lee, & Stigler, 1986). Although a majority of comparative research has focused on school-aged children, studies have shown that even prior to formal schooling, Chinese children outperform American children in mental addition (Geary et al., 1993). At the start of kindergarten, Chinese children, who had not yet received any formal education, showed a 3:1 advantage over their American counterparts on a paper-and-pencil test of addition.

While a wide body of research has examined educational, cultural, as well as linguistic factors that might account for the disparities in mathematical performance between Mandarin and English speaking children, the remainder of this paper will focus on structural and pragmatic differences

between the two languages that may lead to divergence in the amount and type of number speech that parents use when interacting with their children.

Cross-linguistic differences In a cross-national, cross-linguistic examination of naturalistic Mandarin Chinese and English transcripts from the CHILDES database (MacWhinney & Snow, 1990), Chang and colleagues (under review) found several distinct differences in the number language used by Mandarin speaking parents and English speaking parents when speaking to their preschool-aged children (mean age 23.4 months).

When examining all instances of number terms (e.g., "one," "twenty-seven") and questions or requests for quantities (e.g., "How many cats are there?" "Can you count these?"), Mandarin speaking parents talked about number more often than English speaking parents overall. However, there were also marked differences in the types of number constructions that were used between the two languages. While "one" was the most commonly used number term in both languages, English speaking parents most often used "one" as a pronoun (i.e., in place of a noun, such as that *one* instead of that *dog,* without directly naming its noun referent), rather than as a numeric label. Pronouns were also the most frequent type of number utterance found in the English speaking sample. Conversely, pronoun usages of "one" and other numbers were found significantly less often in the Mandarin speaking sample.

Chinese parents used numbers in *cardinal* constructions (e.g., "liang3[1] zhi1 lao2 hu3," or "two tigers") to directly quantify sets of objects most often, and significantly more often than English speaking parents. Classifiers, or measure words (e.g., "slice" or "sheet" in English), were found in the majority of cardinal number utterances in Mandarin, but were essentially absent across all English transcripts. References to written *numerals* (e.g., the numeral "3" or "san1" written as its Chinese character), as well as *ordinal* numbers, or sequences (e.g., "fourth," "di4 si4") were also significantly more frequent in the Mandarin sample.

In sum, the sheer amount of numeric language input that native Mandarin speaking children receive from their parents may contribute to earlier and deeper understanding and acquisition of number words and concepts. Further, the types of numeric input in Chinese parents' speech – especially cardinal numbers, which point to specific quantities – may guide young children's attention to the concept of set size, or the cardinal number principle, while giving them more practice with quantities than their English speaking peers.

However, despite the clear cross-linguistic differences in the content of parental numeric speech across the Mandarin and English samples, the nature of the data and each population makes it difficult to disentangle the influences of language alone from cultural context.

The present study Although the previous results (Chang et al., under review) indicated that there are definite differences in the ways Mandarin and English speaking parents talk to their children about number that might have a later impact on numerical vocabulary and concept acquisition, the naturalistic methods used to examine parental speech, as well as the nature of the transcripts analyzed did not allow careful examination of the reasons underlying the differences in parental input. More specifically, language and culture could not be uncoupled in each language group, as the observations transcribed were taken of monolingual speakers in different countries and cultural contexts. Thus, the individual influences of either language or culture alone on parent number speech could not be determined. Furthermore, the methodology used did not allow the original observers to control for the stimulation provided to each parent-child pair.

The current study considers similar questions, but focuses on the influences of language on parental numeric input, while employing an experimental design controlling for language as well as culture. In this design, Mandarin-English bilingual speaking parents and their preschool-aged children were recruited to serve as participants. All participants were residents of Southern California, and were proficient in both languages. Therefore, experimenters could instruct the parent to speak in one language at a time within the research paradigm and examine speech provided in each language. Additionally, culture was kept constant, as all recruited parents lived and worked in the Los Angeles and San Gabriel Valley areas, and all children were enrolled in English speaking daycare or preschool programs. Finally, a within-subjects design was used – each parent spoke in both English and Mandarin, using each language for half of the experimental session, providing equivalent control groups for each language, which was not possible in a cross-national design.

The design implemented in the present study allows examination of the linguistic influences on parental number input without the confound of culture. The results obtained from the present study were analyzed to determine any cross-linguistic differences in number speech. A survey was also given to assess the attitudes of bilingual, bicultural parents on math and education.

Method

Participants

Twenty-two Mandarin Chinese-English bilingual parent-child dyads volunteered to participate in this study. The participants consisted of 11 male and 11 female preschool-aged children (mean age 49.14 months, SD=10.60 months, range 29 months to 69 months), 20 mothers, and two fathers. The mean age of parent participants was 38.36 years (SD=4.02 years, range 31 to 49 years). At the time of

[1] Throughout this paper, *Hanyu pinyin*, a standardized Romanization system for Mandarin Chinese, is used to represent Chinese characters. The number next to each Romanized character denotes the tone (1-4) that is used to correctly pronounce the character in Mandarin.

testing, none of the children had yet to enter kindergarten. Parents and children were recruited from preschools, childcare centers, and Chinese language schools in Los Angeles and San Gabriel Valley area communities. Twenty-one parents identified as native Mandarin speakers, and one identified as a native Cantonese speaker who self-reported "good" speaking and listening Mandarin abilities. All parents reported English as their second language. Fourteen of the parents were natives of Taiwan, R.O.C., six reported that they originated from the People's Republic of China, and two were from Hong Kong, China. On average, parents had lived in the United States for 14.24 years (SD=7.29 years, range=3 to 26 years), and began learning English at 12.59 years of age (SD=2.68 years, range=5 to 20 years of age). Participants were tested in the laboratory, at their preschool or childcare center, or in their homes.

Materials

Forty full-color photographs of familiar objects were chosen as the stimuli for this experiment. Each stimulus appeared as an approximately 4 in by 5 in (10.16 cm by 12.70 cm) color photograph centered on a 8.5 in by 11 in (21.59 cm by 27.94 cm) sheet of white matte presentation paper. Objects were chosen to be familiar to both parents and children (e.g., common animals, toys, household items) and to be readily identifiable in both Mandarin and English. Twenty of these photographs were selected because they depicted good examples of cardinal number situations (easily quantifiable sets of objects, e.g., *nine* crayons) that did not require the use of a classifier (e.g., *piece* or *pair*) in English. The remaining 20 photographs were selected because they depicted good examples of settings where a classifier could be used when labeling quantities. Classifiers are nouns that indicate a unit of measurement (e.g., two *glasses* of water, liang3 *zhi1* mao1) when labeling quantities. Fluent bilingual speakers confirmed that these 20 objects typically co-occurred with a classifying noun in both Mandarin and English.

In each set of 20 photographs, all quantities from one to ten appeared twice. In order to minimize demand characteristics, stimuli were chosen such that they depicted several dimensions (including number) so that parents could discuss other attributes than number if they so chose, such as color and shape. The 40 photographs were counterbalanced for order and divided into two sets of 20 stimuli each (one for each language) for each subject. This process was repeated three additional times to create a total of four counterbalanced orders of stimuli. Across the four orders, each stimulus appeared an equal number of times in the first half and the second half, and never appeared more than once in each counterbalanced order of 40 stimuli. Orders were created to allow opportunities to use English classifiers during half of each set of stimuli.

Procedure

Parents were assigned to discuss 20 pictures in Mandarin or English with their child as if they were looking at a picture book at home. The researchers also requested that parents avoid code mixing, and told parents that they would be asked to switch languages later in the study. They were not timed. The entire session was recorded on digital camcorder.

After viewing and discussing the first set of 20 pictures in the assigned first language, children were given a five-minute play break during which they played with toys such as Play-Doh or stuffed animals. Parents were asked to continue playing with their child while using the first assigned language as if they were doing so at home. Approximately two minutes and 30 seconds into the play period, parents were asked to switch into the second assigned language, and to continue playing while speaking the second language. This break allowed children a rest period from looking at the photographs, and was further used as parent speech samples in each language, to assess parental fluency. Finally, the break served as a transition period in which subjects became accustomed to speaking in the second assigned language.

Parents and children were next presented with the second set of 20 stimuli. Parents were asked to discuss the second set of 20 pictures in the second assigned language with their child, as if they were doing so at home. They were not timed during the second picture book session.

After completing discussion of the second set of 20 photographs, the child's numerical competence was assessed by asking him to count and label quantities of objects.

Data Analysis

Recordings of the experimental sessions were examined for number-related speech. "Number utterances" were defined as speech that included a number term (e.g., one, two, first, second, etc.) or a counting question or request, such as "how many are there?" or "can you count these?" Bilingual coders viewed the recordings, identified, and categorized all number utterances. Interrater agreement between coders across over 20% of the recordings was 94.03%. Mandarin-English bilingual coders viewed the recordings and selected all number utterances that occurred with each stimulus, recorded the utterance and noted its speaker. Number utterances were also coded for the following types.

Cardinal Cardinal utterances included specific references to quantity when describing an object (e.g., *one* shirt, *yi1* ding3 mao4 zi) or a set of objects (*six* kittens, *liu4* zhi1 xiao3 ya1 zi).

Counting routine Counting routines occurred when the child or parent counted objects without specifically labeling them (e.g., "one, two, three, four, five," "yi1 er4 san1 si4"). These sequences typically occurred after parents asked *counting questions,* which were also identified and recorded.

Counting questions Counting questions occurred when the parent asked the child to count a set of objects or to

otherwise indicate a quantity (e.g., "How many are there?" "Can you count the ducks?" "You3 ji3 ge4 qian1 bi2?" "Shu3 yi1 shu3 kan4 you3 ji3 ge4 gou3 gou.").

Pronoun Pronoun usage, or the use of a number term without a direct cardinal referent in cases where the number term could be grammatically replaced with a noun (e.g., this *one*, these *two*, zhe4 *yi1* ge4, na4 *liang3* ge4), was also noted.

Idiom *Idiomatic* usage of number terms, particularly the number *one (yi1)*, which occurs regularly in Mandarin, was also identified and categorized. These types of utterances typically occurred when parents compared objects within pictures, and declared them "the same" or "one type," or "yi1 yang4" (e.g., "zhe4 liang3 zhi1 gou3 xiang4 ni3 de *yi1 yang4*," which translates to "these two dogs are the same as yours").

Other categories Other documented categories of number speech that occurred rarely during this experiment included references to money (e.g., $4.25), age (e.g., one year old), and other number utterances that did not fall into one of the previously mentioned categories.

Results

Figure 1 shows the average number of overall parental number utterances spoken in Mandarin and English. Across both languages, parents talked about number an average of 42.36 times (SD=43.97, range 0 to 154). When speaking Mandarin, parents made an average of 23.82 number utterances (SD=28.22, range 0 to 114). When speaking English, the same parents made an average of 18.59 number utterances (SD=18.66, range 0 to 75). There did not appear to be any particular stimuli that generally elicited significantly greater or fewer number utterances than other stimuli in either or both languages. A paired-samples t-test did not reveal significant differences in the amount of parental number speech between languages.

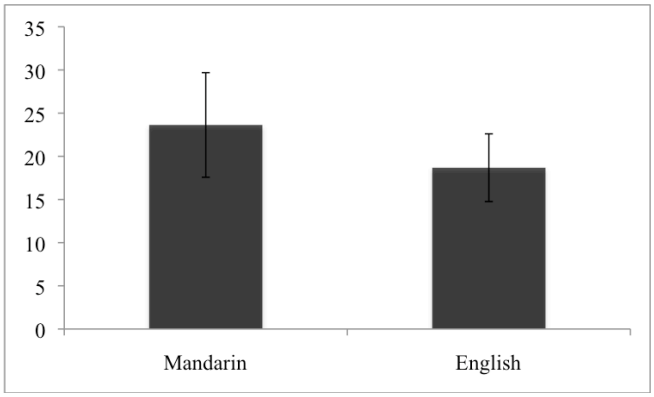

Figure 1. Mean overall parental number speech by language (n.s.)

Pronoun versus non-pronoun utterances

Parents used number terms in several ways in their interactions with their children. One of these forms was the pronominal form, which occurred when number terms such as "one" were used in place of a noun (e.g., "Which *one* do you like the best?" "Ni3 xi3 huan1 zhe4 yi1 ge4 ma?") without affecting the grammaticality or semantics of the sentence. That is, the parent could have replaced the number term with a noun such as "dog," or "[zhi1] gou3," without affecting the meaning of their speech. Pronominal number utterances were coded separately from non-pronoun usages of number, which were defined as the use of a number term that could not be grammatically replaced with another noun. Pronoun and non-pronoun forms of number statements were examined separately because they express slightly different meanings. For example, "this one is red" and "this crayon is red" share similar meanings, specifically that red is a property of a crayon. In these phrases, the number term does not serve as an explicit quantifier. The example "this one is red" would have been coded as a pronoun utterance in the present study. On the other hand, "there is one red crayon" emphasizes the quantity of crayons that are red, and would have been coded as a cardinal number utterance. Both "one" and "red" in this example act as descriptors of the crayon, with "one" serving as a quantifier.

In general, parents made more pronoun number utterances when they were speaking English (M=3.773, SD=4.09, for a total of 166 utterances) compared to when they were speaking Mandarin (M=2.068, SD=2.76, for a total of 91 utterances). Pronoun number utterances made up 40.39% of parental number speech in English, but only 17.5% of parental number speech in Mandarin. A paired-samples t-test showed a strong trend suggesting that pronoun number utterances are made more often when parents speak English (M=3.77, SD=4.09) compared to when parents speak Mandarin, $t(21) = 4.021$, $p = 0.058$.

Between Mandarin and English, the amount of non-pronoun number speech differed substantially. Figure 2 presents the average number of pronoun and non-pronoun number utterances spoken by parents in both languages. When speaking Mandarin, parents used a greater amount of non-pronoun number speech (M=9.750, SD=11.76, 429 total utterances) than when speaking English (M=5.57, SD=4.80, 245 total utterances). A paired-samples t-test revealed significant language differences, $t(21) = 7.212$, $p < 0.05$.

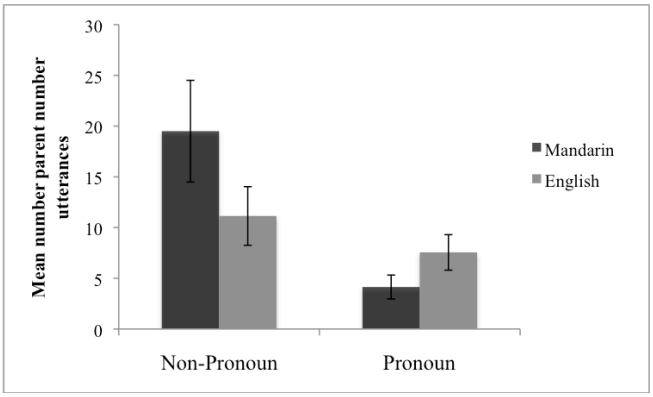

Figure 2. Types of parental number speech by language

Other number categories

Idiomatic phrases containing number were significantly more common in Mandarin, and parents tended to use cardinal numbers and ask counting questions more frequently in Mandarin as well. There were no significant differences in the frequency of counting routines between languages.

Classifiers

In a majority of Mandarin number speech, parents used classifiers, modifiers indicating units of measure (e.g., "slices" in seven *slices* of pizza, or "tiao2"in "jiu3 tiao2 ku4 zi") when discussing photo stimuli with their children. Classifiers were used in 69.39% of all Mandarin number utterances. On the other hand, classifiers were used in English extremely rarely – only five times overall. These comprised only 1.22% of all English parental number utterances.

A paired-samples t-test revealed significant language differences, such that parents made many more number utterances using classifiers when speaking Mandarin compared to when speaking English, $t(21) = 11.296$, $p < 0.01$.

Counting Tasks

Children were awarded one "point" for correct completion of each of the following ten counting tasks: counting in English and Mandarin, giving 3 and 5 objects in both languages, as well as choosing between 4 and 5, and 7 and 9 in both languages). Scores ranged from 1 to 10, with a mean score of 6.18 (Median=6.50, SD=3.22). Children with scores higher than 6.50 (the median score) were considered "higher skilled" and children with scores below the median were considered "lower skilled." Eleven children fell into each category. The average age of the children in the higher skilled group was 56.36 months (Median=58 months, SD=7.76), while the average age of children in the lower skilled group was 41.91 months (Median=42 months, SD=7.80).

To determine whether amount of parental number speech differed as a function of child counting skill, 2x2 within-subjects ANOVAs compared parental number language input across languages and levels of number skill. Analyses revealed a strong trend of parents speaking a greater amount of cardinal and other non-pronoun forms of number terms when discussing cardinal number stimuli to children with higher number skill (M=12.136, SD=9.147) compared to when they spoke to children with lower number skill (M=4.773, SD=8.01), $F(1,21) = 3.881$, $p = 0.077$. A significant interaction was also found between language and number skill when parents used number in non-pronominal forms while discussing cardinal number stimuli, such that children were most likely to receive Mandarin number speech in these categories if they were more highly skilled in counting, $F(1,21) = 5.038$, $p < 0.05$.

Discussion

The present study aimed to determine whether parental number speech to preschool aged children varies between Mandarin Chinese and English in bilingual speakers of both languages.

Similar to previous work, pronoun number utterances were made much more often in English than in Mandarin. Pronoun number utterances were relatively uncommon in Mandarin. This suggests that the similar trend among native monolingual speakers in English is not based in cultural differences between English and Mandarin speakers residing in different countries, as the same result was found within these bilingual subjects when speaking English. Also, because pronominal usage of number terms does not emphasize the dimension of quantity as clearly as cardinal number constructions ("that one," as opposed to "one shirt"), this finding suggests that even bilingual children receive less explicit numeric input in English compared to Mandarin. However, this result does not completely rule out culture as a contributor to cross-linguistic differences in input. The prevalence of pronoun number speech in English, and the greater amount of counting questions and cardinal constructions used in Mandarin suggests that these bilingual preschoolers may gain a greater understanding of the concepts of cardinality, quantity and number-related vocabulary words through Mandarin, but not necessarily English.

Indeed, when examining the non-pronominal number utterances between the two languages, these utterances occurred significantly more often when parents spoke Mandarin. The two most commonly spoken non-pronominal number utterances were cardinal numbers and counting questions. Both of these types of number speech occurred more often when parents spoke Mandarin.

In a cardinal number statement, the number term is used as a descriptor, or adjective, which modifies the noun it is quantifying. Previous research has indicated that children are more likely to learn the meanings of novel adjectives when the words are used as modifiers for "strong" nouns with coherent category information (e.g., Mintz & Gleitman, 2002). In the present study, all objects were chosen as familiar members of coherent categories such as animals,

food items, and household objects. In line with prior findings, the greater exposure to cardinal number statements that children receive when their parents speak Mandarin may help them learn the meanings of number terms when used in adjectival form to a much greater extent than when they hear number terms in a more indefinite form, such as the pronominal form commonly found in English number speech. Because true understanding of mathematical operations presupposes knowledge of the cardinal principle of number, the understanding of cardinality that may arise from Mandarin number input that bilingual children are receiving prior to formal schooling may in fact help them learn how to manipulate numbers earlier and with more ease than their monolingual English speaking peers. Because the children in the present study interact with their parents at home mostly in Mandarin, it may be reasonable to infer that in everyday interaction with their parents, they are receiving many more cardinal number statements than pronominal number statements, which not only suggests that their number-related Mandarin vocabulary and concept development may be more advanced than English monolingual children of the same age, but also supports the idea that these bilingual preschoolers may show similar mathematical advantages to the Chinese pre-kindergarteners in the Geary et al. (1993) study due to the numeric input they are receiving from their parents.

Nonetheless, the similarity in Mandarin number input between the bilingual sample in the present study and the Mandarin sample in the Chang et al. cross-national study suggests that parental number speech may not differ significantly based on the host culture in which the language is used. In the same way, the frequency of English pronominal number utterances was comparable between English monolingual speakers in the previous study and speakers of English as a second language in the present study. These results indicate that exposure to Mandarin Chinese during preschool ages provides children with more experience with direct quantification of objects and usage of classifiers, which imply cardinality. The amount and frequency of these types of number utterances may help children to develop an earlier understanding of the cardinal principle of number than their monolingual English speaking peers, who receive less input of this nature from their parents' speech. Therefore, speaking or hearing Mandarin as a first language, specifically as the majority language of interaction with caregivers, may be a contributor to the math advantage prior to entering formal schooling seen in Mandarin speaking children (Geary et al., 1993). Due to the strong coupling between language and culture, it is impossible to rule cultural influences out completely as a cause for the cross-linguistic differences seen in bilingual parental numeric input, although the results do suggest that the usage and knowledge of Mandarin Chinese alone may affect parents' number speech to their children. Consequently, child speakers of Mandarin, whether monolingual or bilingual, may already differ from monolingual child speakers of English in their understanding of, and their ability to count and manipulate numbers by the beginning of kindergarten, due to the disparate frequencies, amounts, and types of number language input they receive from everyday interaction with their caregivers. In this case, a preschool math advantage due to parental input may then be an early contributor to later differences in mathematical achievement seen across cultures and languages throughout formal education.

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