Title
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Journal
Psychology of Language and Communication, 19(2)

ISSN
1234-2238

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Publication Date
2015-10-01

DOI
10.1515/plc-2015-0007

Peer reviewed

Psychology of Language and Communication 2015, Vol. 19, No. 2

DE GRUYTER
OPEN

DOI: 10.1515/plc-2015-0007

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GENERIC AND SPECIFIC NUMERAL CLASSIFIER INPUT AND ITS RELATION TO CHILDREN'S CLASSIFIER AND NUMBER LEARNING

In Japanese, numeral classifiers—or measure words—co-occur with numbers in counting phrases. The present study characterized parent numeral classifier use and its relation to children's classifier acquisition and number learning. Twenty-four Japanese-speaking parents and their two- to six-year-old children viewed and talked about two wordless picture books about counting to each other. Children also participated in a Counting task and Give-N task. Results revealed (1) parents' classifier use changed in relation to children's age and classifier use, and (2) parents' increased use of specific classifiers was uniquely associated with children's number understanding. These results suggest that aspects of children's language and numerical development are related to parents' language input, demonstrating the importance of examining the relation between language and cognition in a developmental context..

Key words: cognitive development, language development, Japanese numeral classifiers, number learning

It is well established that language input plays a critical role in children's language learning (e.g., Cartmill, Armstrong, Gleitman, Goldin-Meadow, Medina, & Trueswell, 2013; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). Children who hear more words tend to know more words (Moerk, 1980), and their earliest acquired words are those most frequent in the language input they receive (Goodman, Dale, & Li, 2008; Vermeer, 2001). These findings suggest that the quantity and quality of language input matters for children's language learning.

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Furthermore, when children are learning words with unclear referents, the kinds of language input they receive may become even more important (e.g., Pitchford & Mullen, 2005; Sandhofer & Smith, 2007). One such case of words with unclear referents is number words. Though each number word refers only to a single, distinct magnitude, the referent of a number word can be unclear to children because number words are used to describe multiple, unrelated objects and require children to abstract the referent from collections of objects. The frequency of number word input thus plays an important role in young children's knowledge and use of number words: children whose language input more frequently includes number words also tend to know more number words themselves (Chang, Sandhofer, Adelchanow, & Rottman, 2011; Suriyakham, Levine, & Huttenlocher, 2006). Taken together, these findings point to the key role played by language input in children's language and number word learning.

Relation between numeral classifiers and number

In languages that use numeral classifiers, parental numeral classifier input may be an important factor in children's number learning. Numeral classifiers are measure words that identify the unit of count (Adams & Conklin, 1973; Dixon, 1986). In languages that use numeral classifiers, counting phrases almost always consist of a number word plus a numeral classifier, making numeral classifiers and number frequently co-occur (e.g., "two loaves of bread"). Classifiers are mandatory in languages such as Japanese, Chinese, Thai, Hmong, Yucatec Mayan, and American Sign Language (ASL), regardless of the type of noun being counted (Yamamoto, 2005). For example, the phrase "two cars" in Japanese (*kuruma ni-dai*) would be composed of the noun, *kuruma* (car); the number, *ni* (two); and the classifier, *–dai* (classifier for machinery). Similarly, the phrase "seventeen birds" in Japanese (*tori jyuunana-wa*) would be composed of the noun, *tori* (bird); the number, *jyuunana* (seventeen); and the classifier, *–wa* (classifier for winged animals). On the other hand, English uses numeral classifiers only in some specific situations—that is, in counting phrases with mass nouns (e.g., *furniture, sand, water, bread*). For example, when counting bread in English, it is ungrammatical to say "two breads"; the grammatically correct form of this counting phrase requires classifiers, such as *piece, loaf,* or *slice* (e.g., "two *pieces* of bread", "two *loaves* of bread", "two *slices* of bread"). In comparison, Classifier Languages (e.g., Japanese, Chinese, Thai, Hmong, Yucatec Mayan, ASL) *require* the use of classifiers for *all* counting phrases.

Given that counting phrases in Classifier Languages are composed of both the number and the classifier, it is likely that the classifier and the number will be related during learning. For example, classifiers may provide children with an additional linguistic cue that a quantity is being identified, and thereby direct children's attention to quantities and number words. Furthermore, classifiers may help children identify *what* is being counted or quantified: the classifier input children receive can differ in the degree of specificity of the classifiers (e.g., the difference in specificity between "*piece* of bread" and "*sliver* of bread"). When classifier input is more specific, it may be easier for children to identify what is being quantified, and therefore, attend to the correct referent for information about number. This differing degree of specificity in classifier input may thus change the ways in which children attend to number words, and in turn, learn number concepts.

Generic and specific classifiers in the Japanese numeral classifier system

Japanese has two types of numeral classifiers: generic and specific. Generic classifiers are numeral classifiers that can apply to a wide range of nouns that vary across dimensions. Specific classifiers, on the other hand, only apply to nouns that meet certain category criteria (e.g., *–wa* for winged animals, such as birds and butterflies; *–mai* for flat, thin, inanimate things, such as paper, DVDs, and cookies) and convey perceptual or conceptual information about the referent. Even though there are over 100 classifiers in Japanese (Downing, 1996), only four are considered generic (*–nin* and *–hiki* are the generic classifiers for animate nouns, with *–nin* being used for people and *–hiki* being used to refer generally to any animal; *–ko* and *–tsu* are the generic classifiers used to refer generally to inanimate nouns, such as rocks and candy; Yamamoto, 2005). All other classifiers are considered specific. The large majority of Japanese numeral classifiers are thus specific classifiers. Both generic and specific classifiers in Japanese are grammatically correct; the only difference is how specifically the classifier highlights dimensions of the referent. For example, though it is grammatically correct to count cookies with both the generic classifier *–ko* and the specific classifier *–mai*, the specific classifier *–mai* emphasizes the flatness of the referent being counted.

Although quite a few studies document that Japanese children learn generic classifiers early and specific classifiers later (e.g., Matsumoto, 1985, 1987; Muraishi, 1983, as cited in Yamamoto, 2005; Uchida & Imai, 1996), surprisingly little is known about how Japanese parents use generic and specific classifiers over time in child-directed speech. One cross-sectional study of Japanese-speaking mothers and their two- to four-year-old children revealed that the proportion of mothers who used specific classifiers in their child-directed speech increased as a function of children's age (Naka, 1999). Relatedly, Matsumoto (1987) reports a case study of a Japanese-speaking mother who used more types of specific classifiers in her child-directed speech when her child was three years of age (five types of specific classifiers) than when her child was two years of age (three types of specific classifiers). However, approximately 80% of all numeral classifiers uttered by the mother were the generic classifiers *–tsu* and *–nin* (Matsumoto, 1987). Similar findings have been reported with Japanese daycare teachers' use of numeral classifiers in their speech directed towards five- to six-year-old children

(Yamamoto & Keil, 2000, as cited in Yamamoto, 2005). These findings suggest that older children may be exposed to specific classifiers more frequently than younger children, but do not illustrate *how* parents' use of generic and specific classifiers may change in relation to their children's age, use of generic and specific classifiers, and understanding of number concepts.

Number words and number concepts

Similar to the ways in which children's word learning is guided by parent linguistic input, children's understanding of number concepts—or set size—is also guided by different types of number input. For example, children's understanding of number concepts has been found to improve over time when they are provided with certain types of number input that emphasize set size (e.g., number talk about large sets of present objects [Gunderson & Levine, 2011], number talk that labels the quantity of and then immediately counts present objects [Mix, Sandhofer, Moore, & Russell, 2012]). Children who understand number concepts not only are able to count and identify the size of a given set but also are able to produce sets of a requested quantity. Given that (1) children begin acquiring number concepts shortly after they begin using number words and numeral classifiers (e.g., Barner, Libenson, Cheung, & Takasaki, 2009; Condry & Spelke, 2008; Yamamoto, 2005), (2) numeral classifiers provide number input that emphasizes set size, and (3) specific classifiers provide number input that may clarify the referent of the number word, the present study examines whether the frequency of parents' generic and specific classifier input is related to children's understanding of number concepts.

Classifiers and number concepts

We propose two possibilities for the ways in which children's understanding of number concepts may be related to their parents' use of numeral classifiers. Because Japanese numeral classifiers almost always co-occur with number words, parents' numeral classifier input may be associated with their children's attention to and learning about number. First, it is possible that parents who use generic classifiers more frequently than specific classifiers may have children who better understand number concepts. Because there are only four generic classifiers in Japanese—compared to the over one hundred specific classifiers—parents who more frequently use generic classifiers may provide children with linguistic input about classifiers and number that has less variation than that of parents who more frequently use specific classifiers. Generic classifiers would thus be providing a more consistent linguistic context for number than would specific classifiers, and this consistency in linguistic context for number should act as a redundant cue that signals children to attend to number. That is, children who hear generic classifiers more frequently would also be hearing the *combination* of generic classifiers and number more frequently, and it is possible that the repeated exposure to the combined input of generic classifier with number would facilitate children's understanding of number concepts by highlighting number words and concepts (e.g., Yoshida & Smith, 2005). Because the generic classifier varies less than specific classifiers and provides more consistent morpho-syntactic framing than specific classifiers, the generic classifier may act as a cue for children to attend to and learn the number word that is combined with the generic classifier (e.g., Tomasello, 2005). Thus, similar to the ways in which previous work has demonstrated how redundant cues help children attend to, learn, and generalize concepts, the redundant cues between generic classifiers and number may facilitate children's attention to and subsequent learning of number concepts.

On the other hand, it is also possible that parents who use specific classifiers more frequently than generic classifiers may have children who better understand number concepts. Children who hear specific classifiers more frequently would be hearing a diverse combination of specific classifier and number, as there are far more specific classifiers than generic classifiers (Yamamoto, 2005); these children would thus be exposed to numbers in more varied linguistic contexts. This variability in classifier and number input may facilitate children's number learning, as previous work on children's word and concept learning have demonstrated that learning in variable contexts helps children disambiguate, learn, and generalize concepts (e.g., Goldenberg & Sandhofer, 2013; McDonald & Plauché, 1995; Smith & Yu, 2008).

The present study thus sought to understand whether and how Japanese-speaking parents' use of generic and specific classifiers is related to their children's understanding of number concepts. A secondary goal of this study was also to characterize how parents' generic versus specific classifier use changes with their children's age in a cross-sectional sample. In this study, Japanese-speaking parents and their preschool-aged children participated in a semi-naturalistic picture book task that provided parents with the opportunity to use generic and specific classifiers in their child-directed speech. This task not only provided a measure of the frequency with which parents used generic and specific classifiers, but also showed how parents' use of generic and specific classifiers in their child-directed speech differed for children of different ages. Children's understanding of number concepts was also measured via number understanding tasks.

Method

Participants

Twenty-four preschool-aged Japanese-speaking children and their Japanese-speaking parents were recruited for this study from two sites: a greater metropolitan area in Japan (n =12) and a greater metropolitan area in the United States (n = 12). We sought Japanese-speaking populations both in- and outside of Japan to examine a wide range of parents' generic and specific classifier use. One possibility was that Japanese adults in Japan may have more generic classifiers in their speech than specific classifiers because recent studies have reported greater use of generic classifiers than specific classifiers in the speech of Japanese adults in Japan (Matsumoto, 1985; Naka, 1999; Shimojo, 1997; Sumiya & Colunga, 2006; Yamamoto, 2005). However, parents and children at both data collection sites in this study were similar in their use of classifiers and number, which may be explained in part by the qualitative similarities in their experience with the Japanese language, described below.

Participant characteristics. Japanese-speaking parent-child dyads in Japan were all monolingual Japanese speakers, and the children were between two and six years of age (M_{age} = 4.28 years, SD_{age} = 1.12 years, $n_{age\ 2}$ = 2, $n_{age\ 3}$ = 3, $n_{age\ 4}$ = 2, $n_{age\ 5}$ = 4, $n_{age\ 6}$ = 1), with little or no exposure to another language. Though one Japanese child attended a weekly English class taught by a non-native English speaker, her parents did not speak any English; all other Japanese children had no reported exposure to another language. All families were of middle-class background and lived in middle-income neighborhoods in their metropolitan area.

Japanese-speaking parent-child dyads in the United States were more heterogeneous. All participating parents in the U.S. were native Japanese speakers who learned English as a second language and had been residing in the United States for anywhere between 7 and 26 years, M = 15.28 years, SD = 7.65 years. All U.S. children were between two and five years of age (M_{age} = 4.21 years, SD_{age} = 0.82 years, $n_{age\ 2}$ = 1, $n_{age\ 3}$ = 2, $n_{age\ 4}$ = 8, $n_{age\ 5}$ = 1) and were born and raised in the United States. All were also attending daycares or preschools in a greater metropolitan area on the West Coast. Furthermore, of the eleven parents who returned surveys about their child's linguistic and cultural experience, ten had a child who was attending or had attended Japanese language preschools in the U.S. Both U.S. parents and their children used Japanese more often during the day ($M_{parents}$ = 67.78%, $SD_{parents}$ = 17.87%; $M_{children}$ = 68.00%, $SD_{children}$ = 29.82%) than English ($M_{parents}$ = 32.22%, $SD_{parents}$ = 17.87%; $M_{children}$ = 31.55%, $SD_{children}$ = 28.87%). U.S. parents also reported their children as knowing a significantly greater proportion of words on the Japanese version of the MacArthur-Bates Communicative Development Inventory: Words and Sentences (MCDI; Watamaki & Ogura, 2004), M = 76.15%, SD = 18.07%, than the American English version of the MCDI: Words and Sentences (Fenson et al., 1994), M = 54.26%, SD = 30.10%, $t(9)$ = -2.63, p < 0.05. All families were of middle-class background and lived in middle-income neighborhoods in their metropolitan area.

Materials and procedure

For both the parent-child dyads in Japan and the United States, the study took place in a quiet location of the parents' and children's preference. For dyads in Japan, the study took place in the private home of the family or of a friend or relative. For dyads in the U.S., the study took place in the private home of the family or of a friend, a university laboratory, or a public location (e.g., a café). Explanation of the study and consent procedure to the parents and children were conducted entirely in Japanese in all cases.

Book readings. Picture books were used to elicit number use in speech between parents and their children, as previous work has demonstrated the low rate of number talk in naturalistic settings (Levine, Suriyakham, Huttenlocher, Rowe, & Gunderson, 2010). Parent-child dyads were given two wordless picture books to "read" together. The wordless picture books consisted of 20 realistic, color photographs of everyday objects, animals, or people (Appendix A). Between one and ten objects, animals, or people were featured in each photograph (e.g., three airplanes, seven carrots, one elephant, four rabbits, five kids, nine women), and each quantity between one and ten was represented twice in each book. In each photograph, the objects, animals, or people were the most salient component; furthermore, the photographs did not depict complex scenes (e.g., the photograph of four rabbits showed four rabbits sitting side by side on a picnic table—not of four rabbits hopping in a field). The objects, animals, and people in the photographs were selected to elicit not only different number input but also various classifiers: for example, when talking about the picture showing three airplanes, speakers could use the specific classifier for flying machinery, *−ki*; the specific classifier for general machinery, *−dai*; or the generic classifier for inanimate objects, *−ko*. Pages were randomly ordered to create two picture books, and no photographs appeared more than once across the two books. Parent-child dyads were handed both picture books sequentially, in random order.

Parents and children were both provided the opportunity to "read" to each other to maximize the amount of number talk produced by parents and children. Parents were first instructed in Japanese to "read" (i.e., describe the pictures in) the first wordless picture book out loud to their children; children were then given the second wordless picture book to "read" to their parents. When the parents and children were handed the first picture book, they were told in Japanese, "Here is a wordless picture book about counting. Please look at each page and talk about each picture with your child like you would do with any other picture book." When parents and children were handed the second picture book, children were told in Japanese, "Now it's your turn!" No other instructions were provided to the parents or children, and there were no explicit instructions to count or talk about numbers. All interactions during the book readings were video-recorded and later coded for frequency and type of number word and classifier use. Thus, the book readings produced six outcome measures: (1) total number of classifier types used by parents, (2) total classifier tokens used by parents, (3) frequency of number talk engaged in by parents, (4) total number of classifier types used by children, (5) total classifier tokens used by children, and (6) frequency of number talk engaged in by children. After the book readings, children were asked to participate in a Counting task and a Give-*N* task.

Counting task. In the Counting task (Sarnecka et al., 2007; Wynn, 1990), children were shown an array of ten 1-inch counter discs evenly spaced 1 inch apart on a 24-inch by 2-inch piece of plywood wrapped in white vinyl and asked to count the number of discs. Children were asked two questions in the following order:

(1) *Koko ni wa doredake arimasuka?*
'How many are there?'
(2) *Zenbu de doredake arimasuka?*
'How many are there in all?'

The questions were worded in such a way that completely avoided the use of numeral classifiers (Matsumoto, 1985).

Give-*N* task. In the Give-*N* task (Wynn, 1990; 1992), children were given a pile of twenty small counter discs and asked to give a small stuffed animal (e.g., a teddy bear) two, three, six, or seven discs by placing the discs on a paper plate in front of the stuffed animal. For example, children were asked,

(1) *Kuma-san ni mit-tsu watashitekureru? San-ko.*
'Can you give Mr. Bear three? Three.'

The child was then expected to place three discs on the paper plate in front of the teddy bear. Children were asked with both inanimate generic classifiers, *–tsu* and *–ko,* to ensure that children knew what number they were being asked to give, regardless of which inanimate generic classifier they were more familiar with (cf. Sarnecka, Kamenskaya, Yamana, Ogura, & Yudovina, 2007). Each child was asked to give four different quantities of discs in random order. These quantities are commonly used in Give-*N* tasks (e.g., Sarnecka et al., 2007), as they represent small (i.e., two, three) and large (i.e., six, seven) numbers and thus reflect different levels of difficulty of number concept knowledge for children in this age range. Both number-understanding tasks were video-recorded and were coded for frequency of correct versus incorrect responses.

All children first participated in the Counting task and then participated in the Give-*N* task. Children in Japan participated in these tasks only in Japanese; children in the United States participated in both tasks first in Japanese and then in English, and thus had the opportunity to demonstrate their conceptual number understanding, regardless of their language proficiency in Japanese.

Questionnaires. Three questionnaires were used in this study. The purpose of the questionnaires was to better understand the children's language acquisition and language background. Parents filled out the questionnaires while their children participated in the number-understanding tasks. The first questionnaire was a Japanese numeral classifier checklist that listed 25 common classifiers;

the checklist also listed numbers that children hear often in Japanese: numbers between one and ten, every multiple of ten up to one hundred, as well as one thousand, five thousand, and ten thousand—large numbers that are frequently spoken of in the context of the Japanese yen. This checklist provided information regarding classifier acquisition and number learning that may not have been elicited in the book-reading session or the number tasks. Parents were asked to mark the classifiers and number words that their child spontaneously says and/or only says when s/he is repeating after someone else. Parents were also permitted to list up to ten other classifiers that their child says.

The second questionnaire was a two-part comprehensive survey regarding the linguistic and cultural backgrounds of the child and his/her parents (modeled after the questionnaire used in Bent, 2014). The first part of the questionnaire asked about the child's demographic information, linguistic background, linguistic behaviors in English, and linguistic behaviors in Japanese, and asked about the parents' demographic information and linguistic background. The second part of the questionnaire asked for linguistic information regarding another parent or primary caregiver, as well as other caregivers with whom the child has spent a considerable amount of time (e.g., tutors, babysitters, grandparents). This questionnaire provided information regarding the linguistic environment to which the child was exposed on a daily basis.

The third measure was the MacArthur-Bates Communicative Inventory: Words and Sentences (MCDI; Fenson et al., 1994)—a vocabulary checklist that asked parents to mark the words that their child understands and/or says. Only parents in the United States were asked complete this questionnaire and were asked to do so in both English and Japanese (Watamaki & Ogura, 2004). Though this measure is usually used to assess monolingual children's language development up to the age of 30 months, this measure was collected to ensure that the bilingual children—who may follow a different language development trajectory than monolingual children—had a basic understanding of both languages and were familiar with all of the nouns for the objects and people being depicted in the picture books. This questionnaire also provided a measure of the ratio of words the bilingual children knew in each language. Parents in Japan were not asked to complete the MCDI, as the MCDI would not have been age-appropriate for the monolingual Japanese-speaking children.

Coding and analyses

All book readings and both number understanding tasks were transcribed and coded by Japanese-English bilingual research assistants who spoke both languages natively. Each utterance from both book readings was coded according to speaker, tokens of number words used, types of generic and specific classifiers used, and tokens of generic and specific classifier used. For both parents and children, use of number words and classifiers were taken from both the first and second book readings. Reliability for the identification of generic and specific classifer types was 100% between the two bilingual coders.

Preliminary results

This study aimed to understand the relation between parent language input and children's cognitive development. To answer this, we first addressed two preliminary questions. First, our study sampled from two different sites: Japan and the United States. Given that our two samples were qualitatively similar in their experiences with the Japanese language, did our two samples also use classifiers and number in similar ways? Second, we also examined how children's age may be associated with children's number understanding.

Sample comparisons across sites. Independent-samples t-tests revealed no significant differences across U.S. and Japanese sites in the number of types of generic, $t(22) = -0.20$, $p = 0.84$, *n.s.*, or specific, $t(22) = -0.84$, $p = 0.41$, *n.s.*, classifiers used by parents. Moreover, no differences were observed across sites in how frequently parents used generic, $t(22) = -1.52$, $p = 0.14$, *n.s.*, or specific classifiers, $t(22) = -1.39$, $p = 0.18$, *n.s.* Children also did not differ across sites in the number of types of generic, $t(22) = -0.13$, $p = 0.21$, *n.s.*, or specific, $t(22) = -0.77$, $p = 0.45$, *n.s.*, classifiers they used, or in the frequency with which they used generic, $t(22) = -1.47$, $p = 0.16$, *n.s.*, or specific classifiers, $t(22) = -1.22$, $p = 0.24$ *n.s.* Parents and children in the two samples thus used classifiers to similar extents.

The two samples were also examined in terms of the frequency with which parents and children engaged in number talk, as well as children's performance on the two number understanding tasks. Number talk was defined as any utterance of a number word by the parent or child. Parents' frequency of number talk did not differ across the two sites, $t(22) = -0.25$, $p = 0.80$, *n.s.* Children's engagement in number talk, on the other hand, did differ across sites, with children residing in the U.S. using number words more frequently than those residing in Japan, $t(22) = -2.53$, $p < 0.05$. Because all number talk was in Japanese, these results suggest that the children residing in the U.S. were comfortable not only speaking in Japanese but also using number words in Japanese. This difference in frequency of number talk by children, however, was not reflected in children's number understanding: no differences were found across sites in children's performance on the Counting task, $\chi^2(1) = 0.25$, $p = 0.62$, *n.s.*, or the Give-*N* task, $t(22) = -0.36$, $p = 0.72$, *n.s.* Furthermore, there was no significant difference between U.S. children's responses in Japanese and English to the numerosity question ("How many are there in all?") in the Counting task. As a result, we only report U.S. children's data from the number understanding tasks in Japanese and not English. Additionally, in both samples, children's frequency of correct responses on the Give-*N* task corresponded to knower-level (e.g., Sarnecka et al., 2007; Wynn, 1990), such that children who got one of four trials correct only got the lowest number (2) correct, children who got two of four trials correct only got the two lowest numbers (2, 3) correct, and children who got three of four trials correct got the three lowest numbers (2, 3, 6) correct. Taken together, these results indicate that parents in the two samples talked to their children about number at similar rates and that children in the two samples understood number at similar levels. Thus, all further analyses collapsed across the two data collection sites.

Children's age and number understanding. Children rapidly learn number and number concepts during the preschool years (e.g., Barner, Libenson, Cheung, & Takasaki, 2009; Sarnecka, Kamenskaya, Yamana, Ogura, & Yudovina, 2007). In accordance with previous work, we also found children's number understanding—as indexed by their performance on the Give-*N* task—increased with age, r=.85, p<.0001. Given that children's number understanding generally increased during a period when parents' numeral classifier input may also be changing (Naka, 1999), it is reasonable to expect to find a relation between parents' numeral classifier input and children's number understanding.

Results

This study had two goals: (1) to characterize parent use of numeral classifiers in child-directed speech and (2) to examine how differences in parent numeral classifier input relate to children's number understanding.

Characterizing changes in parent generic and specific classifier use

The first goal of this study was to characterize how parents used classifiers during the book readings. An average of 8.06% of all parent words were comprised of numeral classifiers, and parents generally used numeral classifiers more frequently than their children. On average, parents used classifiers twice as often as their children, and among the 24 parent-child dyads, 23 parents used classifiers more frequently than their children. Furthermore, parents generally used classifiers more frequently with older children and less frequently with younger children, $r = 0.38$, $p < 0.10$, and especially used specific classifiers more often with older children than with younger children ($r = 0.41$, $p < 0.05$). Figure 1 shows the relation between children's age and parents' classifier use. Such results demonstrate that parents' use of numeral classifiers differs as a function of children's age.

There was great variability in parents' classifier input, however. Though some parents used classifiers as infrequently as two times during the book reading, other parents used classifiers as often as 232 times during the book reading. Though five parents used generic classifiers less than 10 times, two parents used generic classifiers over 100 times. Similarly, though ten parents used specific classifiers less than 10 times, one parent used specific classifiers over 100 times. Thus there are large individual differences in parents' frequency of classifier input. Table 1 provides the descriptive statistics for the types and frequency of classifier use by parents and children. Altogether, these results demonstrate that though all parents used numeral classifiers in their speech to children, the frequency with and ways in which parents used classifiers varied among the 24 parent-child dyads.

Because classifiers and number words frequently co-occur, parent number input was examined as well. On average, 16.70% of all parent words were comprised of number words. Because parents sometimes used number words without using classifiers (e.g., counting a set of items and only using a classifier on the last number word of the counting phrase: "1, 2, 3, 4, 5-*hiki*"), parent use of number words was greater than that of classifiers. Parents' use of number words was not significantly associated with children's age, neither in terms of counting (e.g., "1, 2, 3, 4, 5") nor cardinal (e.g., *five dogs, nine carrots*) uses of number words (counting uses: r=-.093, p=.67, *n.s.*; cardinal uses: r=-.042, p=.85, *n.s.*). Such results demonstrate that parents' use of number words—unlike parent classifier use—do *not* differ as a function of children's age in this paradigm.

Classifiers: Parent input and children's production. Because parent language input has been found to consistently have a significant role in children's word learning (e.g., Huttenlocher et al., 1991), we asked whether classifier input would also be significantly related to classifier learning. Figure 2 characterizes parents' and children's use of generic versus specific classifier types and tokens and shows the mean number of generic versus specific classifier tokens and types that were used by parents and children during the book readings. On average, parents used generic classifiers more frequently than specific classifiers, but tended to use more types of specific classifiers than generic classifiers. On average, children also used generic classifiers more frequently than specific classifiers, but tended to use equal numbers of generic and specific classifier types. To examine whether parent classifier input was associated with children's use of classifiers, first-order partial correlations between parent classifier input and children's use of classifiers were calculated, controlling for the effect of children's age. Classifier use was examined in terms of both classifier tokens and types, to allow for a more comprehensive examination of the variability in parents' and children's use of classifiers.

Classifier tokens. The relation between the frequency of parent classifier input and children's classifier use was examined to see if parents' and children's use of classifiers were related. The frequency with which parents used classifiers was related to how often their children used classifiers over and above the effect of age for both generic, $r = 0.80$, $p < 0.0001$, and specific classifiers, $r = 0.90$, $p < 0.0001$. First-order partial correlations were also recalculated after excluding data points that were greater than two standard deviations from the mean. Exclusion of these data points still resulted in a significant relation between the frequency of parent classifier input and children's generic, $r = 0.53$, $p < 0.05$, n = 22, and specific classifier use, $r = 0.83$, $p < 0.0001$, n = 23, over and above the effect of children's age. In other words, like previous work on the role of parent language input in children's word learning (e.g., Huttenlocher et al., 1991), the frequency with which parents used classifiers was highly related to the frequency with which children used classifiers in their own speech.

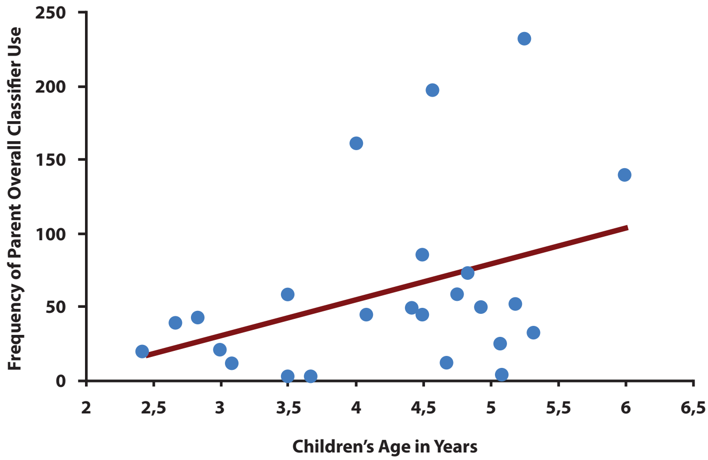
Classifier types. Because looking at classifier use only in terms of frequency does not provide any information about how many different classifiers the parents and children used, classifier use was also examined in terms of types. Thus, the relation between the number of classifier types used by parents and children were examined, controlling for children's age. Though the number of generic classifier types used by parents was not significantly related to the number of generic classifier types used by children over and above the effect of children's age, $r = 0.39$, $p = 0.07$, *n.s.*, the number of specific classifier types used by parents predicted children's use of specific classifier types over and above the effect of children's age, $r = 0.69$, $p < 0.001$. That parent use of generic classifier types is not significantly associated with children's use of generic classifier types is not surprising, however, given that there are only four generic classifier types in Japanese and 20 of the 24 parents in this study used three or four types of generic classifiers. Thus, similar to the way in which frequency of parent classifier use was highly associated with frequency of children's classifier use, the number of specific classifiers types used by parents was also highly associated with the number of specific classifier types used by children.

Differences in classifier input and children's number understanding

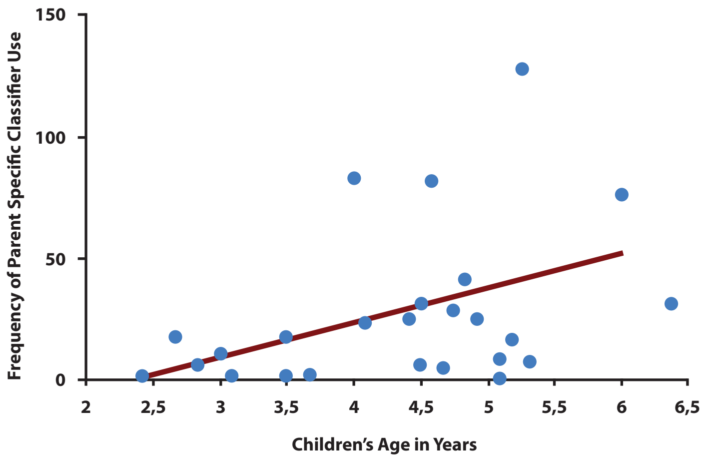
The second goal of this study was how classifier input is related to number understanding. To answer this, we compare parent classifier input to children's performance on the Give-*N* and Counting tasks. Both classifier input and number understanding are related to children's age. Because classifier input and number understanding are related to children's age, it is thus reasonable to expect parent classifier input to be related to children's number understanding. This is likely, given that children's exposure to classifier input coincides with children's developing understanding of number concepts. To examine the unique relation between parent classifier input and children's number understanding, we control for children's age in the following analyses.

Children's performance on the Give-*N* task was examined against the frequency of parent classifier input, controlling for children's age and parent number input. Both children's age and parent number input were included as covariates, in order to isolate the unique contribution of parent classifier input on children's understanding of number. Because (1) there are only four types of generic classifiers in Japanese and (2) so few types of specific classifiers were used by parents (M = 5.5 types, SD = 3.39 types), there was not enough variability in types of generic and specific classifiers used to examine parent classifier input in terms of types. Parent classifier input was thus examined in terms of frequency

Figure 1. The relation between children's age and frequency of parents' (a) overall classifier use and (b) specific classifier use. Though parents' overall classifier use did not significantly change as a function of children's age, parents used specific classifiers significantly more often with older children than with younger children



(A)



(B)

of generic and specific classifier use. Initial results showed no significant relation between children's performance on the Give-*N* task and parent classifier input (generic classifier input: $r = 0.26$, $p = 0.23$, *n.s.*; specific classifier input: $r = 0.32$, $p = 0.13$, *n.s.*) due to floor and ceiling effects found among the younger and older children's performance on the Give-*N* task. Thus, given that the majority of the variability in children's performance on the Give-*N* task was among the three- and four-year-old children, all further analyses using data from the Give-*N* task

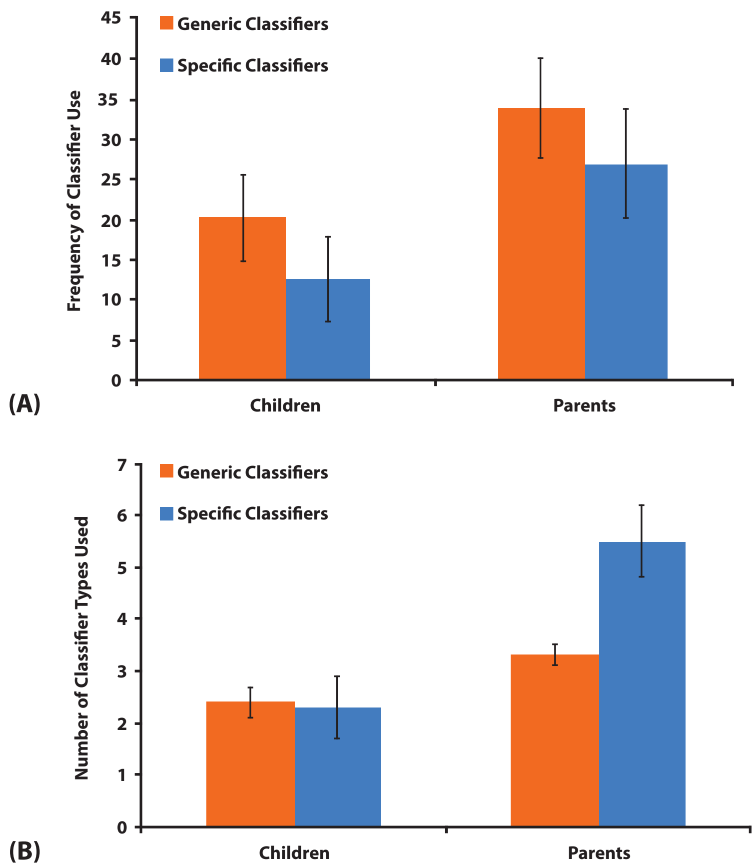
Table 1. Types and frequency of classifier use by parents and children

	Parents			Children		
	M	*SD*	*Range*	*M*	*SD*	*Range*
Types						
Overall	8.79	3.91	2-15	4.67	3.92	0-14
Generic	3.29	0.99	0-4	2.38	1.44	0-4
Specific	5.50	3.39	1-11	2.29	2.88	0-10
Frequency						
Overall	60.71	61.54	2-232	32.58	47.95	0-174
Generic	33.79	30.30	0-115	20.13	26.6	0-109
Specific	26.92	32.94	1-128	12.46	25.58	0-107

include only the three- and four-year-old children (n = 16). These analyses with just the three- and four-year-old children revealed that though the frequency with which parents used *generic* classifiers was not significantly related to children's performance on the Give-*N* task, $r = 0.40$, $p = 0.18$, *n.s.*, the frequency with which parents used *specific* classifiers indeed was related to children's performance on the Give-*N* task over and above the effect of age and parent number input, $r = 0.59$, $p < 0.05$. That is, during the time when children are starting to make progress in number learning, parents' use of specific classifiers was significantly associated with their children's developing understanding of number concepts. Furthermore, parents' specific classifier use was not significantly related to their own number talk, neither in terms of counting uses of number words ($r = -0.039$, $p = 0.89$, *n.s.*) nor cardinal uses of number words ($r = -0.044$, $p = 0.88$, *n.s.*), demonstrating that the relation between children's number understanding and parents' specific classifier use is not simply a result of parents' use of number words with the specific classifiers. Altogether, such results suggest that parents may be unconsciously scaffolding their children's number understanding via the use of specific classifiers, or that parents may be increasing their specific classifier input as their children better understand number. These possibilities will be further considered in the discussion.

Number input and children's classifier and number learning. To rule out the possibility that the relation between classifier input and number understanding is actually due to number input, we examined the relation between number input and children's classifier use and number understanding. Because classifiers are often heard with number words, it is possible that parent number

Figure 2. The mean number of generic versus specific classifier (a) tokens and (b) types that were used by parents and children during the book readings. Though children used, on average, equal numbers of generic and specific classifier types (b), they tended to use generic classifiers more often than specific classifiers (a). Parents used, on average, more types of specific classifiers than generic classifiers (b), but tended to use generic classifiers more often in their child-directed speech (a)



input is also associated with both children's number understanding and classifier use. We thus compared parent number input to children's use of classifiers and performance on the Give-*N* and Counting tasks. Parent number input was defined as any utterance of a number word by the parent.

Parent number input and children's classifier use. To further investigate the ways in which number and classifier may be related, parent number input and children's classifier use was examined. Second-order partial correlations controlling for children's age and parent classifier input revealed that parent number talk was not significantly associated with children's frequency of generic and specific classifier use, $r = -0.04$, $p = 0.85$, *n.s.*, and $r = 0.42$, $p = 0.06$, *n.s.*, respectively. Such results suggest that parent number input alone may not play a role in children's classifier use and that parent classifier input may be a stronger predictor of children's classifier use.

Parent number input and children's number understanding. Children's performance on the Give-*N* task was also examined against the frequency of parent number input, as previous work suggests number input to be related to children's number learning (Chang et al., 2011; Suriyakham et al., 2006). Unexpectedly, parents' overall number input was not significantly associated with children's performance on the Give-*N* task, $r = -0.08$, $p = 0.78$, *n.s.*, nor with children's number use, $r = 0.13$, $p = 0.66$, *n.s.*, over and above the effect of children's age. Parent number input was further divided into counting and cardinal uses of number words; counting uses of number words were number word utterances in which parents counted ("1, 2, 3, 4, 5"), whereas cardinal uses of number words were number word utterances in which parents identified the quantity of a set of items (e.g., *five dogs, nine carrots*). Neither parents' frequencies of counting nor cardinal uses of number words were significantly associated with children's performance on the Give-*N* task (counting: $r = 0.20$, $p = 0.50$, *n.s.*; cardinal use: $r = -0.21$, $p = 0.48$, *n.s.*), over and above the effect of children's age. Such unexpected results may be due to the fact that parents sometimes used number words independent of classifiers (e.g., only using a classifier on the last number word of a counting phrase). Thus, despite the fact that parent classifier use was related to children's performance on the Give-*N* task, the frequency of parent number input during the book reading was not related to children's understanding of number concepts—as measured by performance on the Give-*N* task—nor with how often children used number words themselves during the book reading.

Children's counting ability. Children's performance on the Counting task was also examined in relation to children's age. Though studies often find variability in children's performance on Counting tasks (e.g., Wynn 1990; 1992), most children in this study either could correctly count to ten or did not count (i.e., they either did not know how to count or simply did not count) on the Counting task. Nineteen children correctly counted to ten in response to the question "How many are there?", whereas four children did not count; one child counted only to seven. Similarly, 17 correctly responded "ten" in response to the question "How many are there in all?", whereas six children did not answer this question; one child responded "five." These results appeared to be explained by children's age; that is, children younger than three-and-a-half years of age did not respond to one or both of the questions, and those older than three-and-a-half years of age did correctly respond to both questions. Due to the lack of variability in children's responses to these two questions, children's performance on the Counting task was not considered in analyses examining the relation between parent linguistic input and children's number understanding.

Altogether, these results demonstrate that classifiers in speech to children may be more strongly related to children's understanding of number than number words in speech to children. Though parent number input was not significantly associated with children's performance on the Give-*N* task, the frequency with which parents used specific classifiers predicted children's performance on the Give-*N* task over and above the effect of age and parent number input. Furthermore, these results characterize how parents' use of generic and specific classifiers differ depending not only on their children's age, but also on their children's knowledge of classifiers and number.

Discussion

The present study examined one intersection between language and cognitive development and demonstrated how Japanese-speaking parents' use of generic and specific classifiers changed over time and related to their children's use of classifiers and understanding of number concepts. Notably, parents' use of generic and specific classifiers were found to differ as a function of their child's age, with parents of older children using more types of specific classifiers and using classifiers more frequently in general than parents of younger children. Moreover, parents' use of specific classifiers was associated with children's number understanding, suggesting that parent linguistic input relates to children's cognitive development.

Although previous studies have indicated that parents' use of classifiers in child-directed speech differs depending on children's age (Naka, 1999; Matsumoto, 1987), our study is the first to characterize and systematically demonstrate that parents' use of generic and specific classifiers increase with children's age. These findings extend previous research (Naka, 1999; Matsumoto, 1987) by demonstrating that parents not only use classifiers more frequently with older children than younger children, but also increase their use of specific classifiers with older children.

Changes in how parents use generic and specific classifiers may be related to children's learning of generic and specific classifiers over time. For instance, parents who used more classifiers unsurprisingly had children who also used more classifiers. This result is consistent with the existing literature that has found parent linguistic input to be an important and reliable predictor in children's language development (e.g., Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Suriyakham et al., 2006; Vermeer, 2001). Moreover, these findings—along with our results showing changes in parent classifier use—point to parents' attunement to their children's understanding of classifiers, as well as parents' ability to adjust their linguistic input to children based on their children's understanding of classifiers. It is possible, however, that parents' linguistic input does not change over children's development and is not adjusted according to children's learning; rather, some parents may simply use more classifiers in their child-directed speech regardless of their children's understanding of classifiers. Thus, a longitudinal study tracking parent-child dyads' use of classifiers is needed to examine if individual parents' change in generic and specific classifier use over time relates to their children's learning of generic and specific classifiers.

We also found that parent classifier input was associated with children's number understanding. Use of specific classifiers was uniquely related to children's number understanding, such that only specific classifier input—but not generic classifier input or number input—was significantly associated with children's number understanding. Because only *specific* classifier input was associated with children's number learning, it is unlikely that children's number learning was simply a result of number input alone. We propose three possibilities for why parent frequency of specific classifier input was significantly associated with children's number understanding, such that parents who used specific classifiers more often had children who exhibited greater number understanding.

One possibility is that parent classifier input facilitates children's learning of number concepts. Previous work on children's word learning suggest that children learn and generalize words and concepts better when they are exposed to these words and concepts in varied contexts (e.g., Landau & Gleitman, 1985; Gleitman, 1990; Goldenberg & Sandhofer, 2013; Naigles & Hoff-Ginsberg, 1998; cf. Tomasello, 2005). Because there are more types of specific classifiers than generic classifiers, children who hear specific classifiers are more often exposed to number words in more varied linguistic contexts than those who hear generic classifiers more often. That is, hearing specific classifiers more often may lead to hearing numbers in more varied contexts, which in turn may help with number learning. Thus, children's number learning may be facilitated by parents' more frequent use of specific classifiers. It is further possible that the use of classifiers affords a type of number input that denotes quantity (e.g., *two* lions, *five* ducks)—that is, cardinal numbers. In fact, Chang et al. (2011) found that parents who speak Mandarin Chinese—a classifier language—used cardinal numbers more frequently in their child-directed speech than their English-speaking counterparts. As classifier languages require the use of cardinal numbers with numeral classifiers to convey plurality, it is possible that children who hear more classifiers in their parents' speech may also be receiving a type of input that facilitates their number concept learning.

A second possibility is that parents may be adjusting their classifier input as a function of children's number understanding. Parents are accurate reporters of what their child does or does not know (e.g., Bates, Camaioni, & Volterra, 1975), indicating that parents are likely aware of the degree to which their child understands something. Therefore, it is possible that parents of children who are still learning number concepts may use specific classifiers less often in order to simplify their number-classifier input; in contrast, parents of children with better number understanding may have a sense for their child's "readiness" for more linguistic complexities to be added to their number input and increase specific classifier input. In other words, parents may be consciously or unconsciously aware of their children's readiness to learn more complex number speech, and thus scaffold their children's number learning via increasing specific classifier input.

A third possibility is that characteristics other than the generality or specificity of a classifier may be promoting number understanding. Because the generality or specificity of classifiers is continuous rather than dichotomous (e.g., Downing, 1996), dividing classifiers into generic versus specific categories—as we did in this study—may be masking other characteristics highlighted by different classifiers. For example, the classifiers *–ko* and *–tsu* were categorized as generic classifiers in this study because they are used to refer to inanimate objects more broadly than many other classifiers are (e.g., Matsumoto, 1985). However, *–ko* and *–tsu* are not completely general and are still constrained in the types of objects they can refer to; it would be ungrammatical to use *–ko* or *–tsu* to refer to animate beings or inanimate one- or two-dimensional objects, such as pencils or disks (e.g., Matsumoto, 1985; Yamamoto, 2005). Moreover, *–tsu* could be argued as being more general than *–ko*: whereas *–ko* is a shape-based classifier predominantly used with any inanimate objects that are "roundish," *–tsu* is a shape-based, function-based, quality-, and kind-classifier used with all inanimate objects (Downing, 1996). Thus, in addition to conveying generality/specificity, *–ko* and *–tsu* also highlight characteristics such as the animacy, dimensionality, and semantic content of objects; these other characteristics of classifiers—rather than simply generality/specificity—may be promoting number understanding.

Though data from the present study cannot speak to whether parent classifier use in languages other than Japanese would also promote children's number understanding, it is possible that linguistic markers of quantity in any language may facilitate number understanding in young children. For instance, linguistic markers of singular versus plural have been found to help young children learn the meaning of "one": monolingual children learning English or Russian—languages that have singular versus plural markers—learned the meaning of "one" at an earlier age than children learning Japanese—a language that does not have singular versus plural markers (Sarnecka et al., 2007). Additionally, English-speaking children's knowledge of numerals is highly correlated with their knowledge of quantifiers such as "some," "most," or "all" (Barner, Chow, & Yang, 2009). The syntactic structures within which numeral phrases occur in a language have also been found to produce cross-linguistic differences in children's acquisition of numerals (Barner, Libenson, et al., 2009). Such findings—combined with the findings from the present study—point to the complex, intertwined relation between language and numerical development.

Considering the study sample

The present study found surprisingly little variability in children's performance on the Counting task, especially considering the wide age range represented in our sample. Though most children in the present study could correctly complete the Counting task, it is unclear whether the children who did not respond when prompted (1) did not know how to respond or (2) knew how to respond but simply chose not to respond. It is thus possible that any variability in Japanese children's counting ability is masked by non-responses—that is, children who could not count all the way to 10 may have simply chosen not to count at all. Such non-responses on the Counting task are not uncommon among Japanese children, however: Japanese children have been reported to have significantly higher rates of non-response on the Counting task than American and Russian children (Sarnecka et al., 2007). Though we cannot be certain why such non-responses are common among Japanese-speaking children, the lack of variability in children's performance on the Counting task found in the present study may be due to Japanese-speaking children's propensity for non-responses.

Additionally, our data were collected from parent-child dyads in Japan and the U.S. Though our sample included data from two different countries, the dyads from Japan and the U.S. were qualitatively and quantitatively similar in many ways. First, parents in both data collection sites were native Japanese speakers who were of middle-class backgrounds and were born and raised in Japan; U.S. parents had only learned English as a second language. Thus, Japanese was the dominant language for all participating U.S. parents, and on average, Japanese was used more often during the day than English. Second, most of the U.S. children were attending or had attended Japanese preschools. Thus, many of these children were also receiving Japanese linguistic and cultural input from a larger environment than just their family. Third, parents reported their children as knowing significantly more Japanese words than English words on the MacArthur-Bates Communicative Development Inventory. These linguistic, socioeconomic, and cultural similarities between the two samples may have contributed to parent-child dyads' similar use of classifiers between the two data collection sites in this study, as well as to children's non-responses on the Counting task. Further research examining a larger, more diverse sample of Japanese-speaking parents in the United States may result in *differences* in linguistic input between parents in Japan and the U.S., as opposed to the similarities found in this study.

Conclusion

The broader goal of this study was to examine in what ways the relation between language and cognition might develop. Our results demonstrate how parent linguistic input and children's number learning are uniquely and intricately related, providing an account for how language and number learning influence one another during the preschool years. As a large body of literature has now provided evidence for a strong relation between language and cognition (Boroditsky, 2003; Gleitman & Papafragou, 2012; Gumperz & Levinson, 1996), it is critical to examine and understand the ways language and cognition not only interact to influence one another but also develop together.

Funding source

This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE-0707424 and the Foundation for Psychocultural Research-UCLA Center for Culture, Brain, and Development Research Grant, both to the first author.

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Appendix A
Objects depicted in wordless picture book and their corresponding classifiers

Objects in each book	**Classifiers typically used with each object**
Book A	
6 tennis rackets	-tsu (generic classifier for inanimate objects)
	-hon (specific classifier for long, thin, inanimate objects)
9 pairs of shoes	-tsu (generic classifier for inanimate objects)
	-soku (specific classifier for pants and footwear)
5 children	-nin (generic classifier for people)
5 grand pianos	-tsu (generic classifier for inanimate objects)
	-dai (specific classifier for machines and vehicles)
7 rings	-tsu (generic classifier for inanimate objects)
	-ko (generic classifier for inanimate objects)
3 bowls	-tsu (generic classifier for inanimate objects)
	-hai (specific classifier for cups, glasses, mugs, bowls, etc.)

1 dog	-hiki (generic classifier for animals)
	-tou (specific classifier for large animals)
10 birds	-hiki (generic classifier for animals)
	-wa (specific classifier for winged animals)
10 dorayaki (Japanese sweet pastry)	-tsu (generic classifier for inanimate objects)
	-ko (generic classifier for inanimate objects)
9 books	-tsu (generic classifier for inanimate objects)
	-satsu (specific classifier for books)
1 cake of tofu	-tsu (generic classifier for inanimate objects)
	-chou (specific classifier for servings of food)
6 cookies	-tsu (generic classifier for inanimate objects)
	-ko (generic classifier for inanimate objects)
	-mai (specific classifier for flat, thin, inanimate objects)
2 horses	-hiki (generic classifier for animals)
	-tou (specific classifier for large animals)
8 glasses of water	-tsu (generic classifier for inanimate objects)
	-hai (specific classifier for cups, glasses, mugs, bowls, etc.)
4 plates	-tsu (generic classifier for inanimate objects)
	-mai (specific classifier for flat, thin, inanimate objects)
4 rubber ducks	-tsu (generic classifier for inanimate objects)
	-hiki (generic classifier for animals)
	-wa (specific classifier for winged animals)
8 colored pencils	-tsu (generic classifier for inanimate objects)
	-hon (specific classifier for long, thin, inanimate objects)
7 carrots	-tsu (generic classifier for inanimate objects)
	-hon (specific classifier for long, thin, inanimate objects)
2 flowers	-tsu (generic classifier for inanimate objects)
	-rin (specific classifier for flowers and wheels)
	-hon (specific classifier for long, thin, inanimate objects)
3 airplanes	-ki (specific classifier for aircraft and flying machinery)

Book B

2 slices of bread	-tsu (generic classifier for inanimate objects)
	-mai (specific classifier for flat, thin, inanimate objects)
7 bears	-hiki (generic classifier for animals)
	-tou (specific classifier for large animals)
10 keys	-tsu (generic classifier for inanimate objects)
	-ko (generic classifier for inanimate objects)

5 pajama sets	-tsu (generic classifier for inanimate objects)
	-setto (specific classifier for pairs or sets of inanimate objects)
10 dolls	-tsu (generic classifier for inanimate objects)
	-nin (generic classifier for people)
5 guitars	-tsu (generic classifier for inanimate objects)
	-ko (generic classifier for inanimate objects)
8 forks	-tsu (generic classifier for inanimate objects)
	-hon (specific classifier for long, thin, inanimate objects)
2 pairs of pants	-soku (specific classifier for pants and footwear)
3 cars	-dai (specific classifier for machines and vehicles)
4 spoons	-tsu (generic classifier for inanimate objects)
	-hon (specific classifier for long, thin, inanimate objects)
4 rabbits	-hiki (generic classifier for animals)
	-wa (specific classifier for winged animals, but rabbits are an historical exception to the "winged" category)
7 lions	-hiki (generic classifier for animals)
	-tou (specific classifier for large animals)
1 house	-ken (specific classifier for houses and buildings)
3 glasses of juice	-tsu (generic classifier for inanimate objects)
	-hai (specific classifier for cups, glasses, mugs, bowls, etc.)
1 frying pan	-tsu (generic classifier for inanimate objects)
	-hon (specific classifier for long, thin, inanimate objects)
8 dolphins	-hiki (generic classifier for animals)
	-tou (specific classifier for large animals)
9 women	-nin (generic classifier for people)
6 rocks	-tsu (generic classifier for inanimate objects)
	-ko (generic classifier for inanimate objects)
9 candles	-tsu (generic classifier for inanimate objects)
	-hon (specific classifier for long, thin, inanimate objects)
6 leaves	-tsu (generic classifier for inanimate objects)
	-mai (specific classifier for thin, flat, inanimate objects)