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Zero anaphora and object reference in Japanese child-directed speech

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Abstract

To learn the meanings of words, children must connect referents in the world around them with the sounds they hear. One proposed mechanism for this process is cross-situational word learning: tracking associations between words and objects across time. We consider the problem of anaphora for a cross-situational word learner: after an object has been introduced it is unlikely to be named in every succeeding reference to it. This problem is particularly pronounced in Japanese, which uses "zero anaphora," where pronouns can be omitted from utterances. We analyze a corpus of Japanese mothers talking to children about sets of objects, originally recorded by Fernald and Morikawa (1993). Overall rates of anaphora were much higher for Japanese mothers compared with English mothers. Zero anaphora was primarily used when the discourse topic was already established, suggesting that a discourse-finding strategy may be important for word learning in Japanese. In addition, unexpectedly, due to the existence of zero anaphora as a common referential strategy, pronouns were more likely to be used when the topic was new than when it was given (reversing common results for English).

Keywords: Child-directed speech; Japanese; zero anaphora; discourse analysis; language acquisition.

Introduction

From the perspective of a scientist, early word learning seems a difficult problem. Although infants quickly learn to pair sound sequences in their caregivers' speech with concepts and entities in their environment, it is still uncertain how they associate words and concepts. One proposed mechanism for this process is cross-situational word learning: tracking associations between words and objects across time (Siskind, 1996; Yu & Smith, 2007). Though possible for even very young children in simple contexts (Smith & Yu, 2008) and in principle feasible for large lexicons (Blythe, Smith, & Smith, 2010), the effectiveness of pure cross-situational learning in natural contexts is still unknown.

One issue for cross-situational learning in the natural learning environment is *anaphora*: the use of shortened—or even absent—expressions that refer back to a previously-named entity. If learners are keeping track of associations between words and objects, the tendency towards anaphoric reference should cut down considerably on these associations. Although anaphora is pervasive in language use, object names are typically repeated frequently in the speech of English-speaking mothers to their children (Fernald & Morikawa, 1993). This repetition has allowed models of cross-situational word learning to succeed in establishing word-object mappings even in small natural datasets (Yu & Ballard, 2007; Frank, Goodman, & Tenenbaum, 2009).

Repetition of object labels is not nearly as prevalent in some other languages, however. In the same study that established the presence of repetition in English mothers' speech,

Fernald and Morikawa (1993) noted that Japanese mothers used far fewer noun labels and the labels they used were generally more diverse, including onomatopoeia and diminutive forms as well as the prototypical labels used by American mothers. In addition, Japanese, unlike English, is a pro-drop language, meaning that the subject and object of verbs may be omitted. This omission is known as "zero anaphora." For example, when an English speaker might say "the dog barks," a Japanese speaker might say only "barks." One study suggests that zero anaphora in Japanese may lead to increased difficulty in early verb learning (Rispoli, 1995), but to our knowledge, no work has examined the direct relationship between zero anaphora and object reference, in Japanese or any other language.

What effect does the varied use of noun-labels and anaphora (especially zero anaphora) have for Japanese word learners? Under a pure cross-situational analysis, the sparse mappings between words and objects in this language might be very difficult to overcome. If objects that are being talked about often go unnamed in Japanese, a pure cross-situational learner might be more likely to learn, for example, "bark" rather than "dog" for the concept of a dog. If, however, word learners do not treat utterances as independent entities, but instead resolve reference within a *topical discourse*—a set of utterances about a particular topic—the problems posed by changing object labels and zero anaphora might be mitigated. A learner could figure out what topic was being talked about and then assume that future utterances refer to this topic, even if it was not named.

Recent work has taken up the suggestion that children could potentially aggregate information about word meanings—as well as other knowledge about a particular object referent—not just across sentences but also across these topical discourse units (Rohde & Frank, under review; Frank, Tenenbaum, & Fernald, in press). On this kind of view, a first utterance establishes the topic (in the cases we examine, often a simple object referent), and then future utterances contribute new information (Clark, 1996). For such a learner, zero anaphora might not be as problematic if the discourse topic were already known.

The current study examined zero anaphora in Japanese from this perspective. We conducted a reanalysis and annotation of Japanese infant- and child-directed speech from the Fernald and Morikawa (1993) study, focusing on anaphora. We asked when zero anaphora was used within topical discourses, in comparison with object naming and the use of other pronouns. We found that although overall rates of anaphora were much higher for Japanese mothers compared

with English mothers, zero anaphora was primarily used when the discourse topic is already established. Also, we found a trade-off between zero anaphora and pronominal anaphora that caused pronouns to be more likely when the discourse topic was newly established. This sensitivity of zero and pronominal anaphora to the discourse topic suggests that a discourse-finding strategy may be even more important for Japanese-learning children than it is for English learners.

Methods

Corpus Materials

Our data consisted of a set of transcribed videos of object-centered play between mothers and children in their homes, from a study by Fernald and Morikawa (1993). While the original corpus contained both American and Japanese mother-child pairs, the current analysis focuses primarily on the Japanese mothers (American data was analyzed in Frank et al., in press). Discourse from 29 Japanese mother-child pairs with audio and video data was analyzed. The infants were divided into three age groups: 5-6 months (N=9, 5 males), 11-14 months (N=10, 5 males), and 18-21 months (N=10, 5 males).

Prior to recording, mother and child played comfortably together with the child's toys. Next, the child's own toys were removed and the video recording began. During the video the mothers were asked to play with the child using three standardized pairs of toys: dog and pig, car and truck, and brush and box. The mother was asked to play with the toys "as she normally would." The toys were introduced one pair at a time and removed before introduction of the following pair. The ordering of whether the dog and pig were introduced first or the car and truck were introduced first was counterbalanced across trials, but the brush and box were always introduced last (and only for the older two groups).

Towards the end of the play session, mothers of children from the two older age groups were asked to hide the toys and get the child to retrieve them using words alone. Because this scenario might affect how the mother referred to the objects (indeed it was inserted in order to elicit object names), we only considered utterances prior to this "hiding game." We also excluded utterances with sound and audio issues (167), and those spoken by the mother to the experimenter. In total, 8852 utterances taken from 6 hours and 51 minutes of video were analyzed in the current study.

Conventions for Annotating Object Reference

A native Japanese speaker first divided the mothers' speech into "utterances," or segments of speech separated by pauses, on the basis of prosodic and syntactic cues. Most utterances ranged from a single word to a complete sentence; complete sentences were usually not counted as multiple utterances unless there was a pause or interruption of the speaker's turn.

Next, using the video and transcript data, a native Japanese speaker annotated, for each utterance spoken by the mother

Table 1: Descriptive statistics for each file in the FM Corpus. Utts = utterances, Length = length in minutes and seconds.

Age Grp	Code	Gend	Age	Utts	Length
6mos	J29	M	6	208	10:59
	J30	M	5	158	10:25
	J31	F	6	299	12:51
	J32	M	6	203	12:57
	J33	F	5	342	11:28
	J34	M	5	322	11:51
	J35	F	5	334	13:17
	J36	M	6	127	10:51
	J37	F	5	289	11:33
12mos	J2	M	14	325	19:50
	J3	F	13	346	15:53
	J7	F	11	594	19:36
	J8	M	11	364	16:35
	J11	M	12	285	15:18
	J13B	M	12	269	11:49
	J18	M	13	331	17:40
	J20	F	13	241	14:43
	J23	F	11	384	12:51
	J26	F	12	280	12:40
18mos	J4	F	18	354	18:11
	J5	F	18	186	10:50
	J9	M	18	268	16:29
	J10	F	20	297	13:51
	J12B	F	18	385	15:54
	J16	M	21	330	12:47
	J19	M	21	410	15:02
	J24	F	19	295	15:50
	J27	M	19	325	14:47
	J28	M	18	301	14:36

to the infant, what object or objects (if any) were referred to. An object was considered to be referred to if A) the mother said the name of the object or B) the mother used a pronoun that the annotator judged to refer to the object. Although other toys and objects were occasionally referred to in the corpus, in the following analysis we will only examine references made to the six toys that were standardized across participating dyads (dog, pig, car, truck, brush, and box).

In Japanese, baby words for toys are often derived from onomatopoeia. We counted misnomers and onomatopoeia as references to the toy under clearly referential circumstances. For misnomers, this was when e.g. "moomoo" ("moo-moo," meaning "cow") was used in reference to the pig. We also counted alternative labels, such as "omocha" ("toy") and "nuigurumi" ("stuffed animal"), as references. However, we did not count misnomers and alternative labels as cases of "object naming," which we defined in a more restricted sense, described below. We counted onomatopoeia-derived noun phrases as references to objects, but not onomatopoeia that was used to describe sounds or actions. Our annotator made judgments about when the mother was using phrases such as "wanwan" as a noun and when she was using them to indicate sounds or actions that the toy was making. Thus, "wan-chan" ("Mr. woof") and, in some cases, "wanwan" ("woof-woof"), were coded as referring to nouns.

In Japanese, objects are frequently referred to without use of an explicit noun or pronoun. As noted above, grammat-
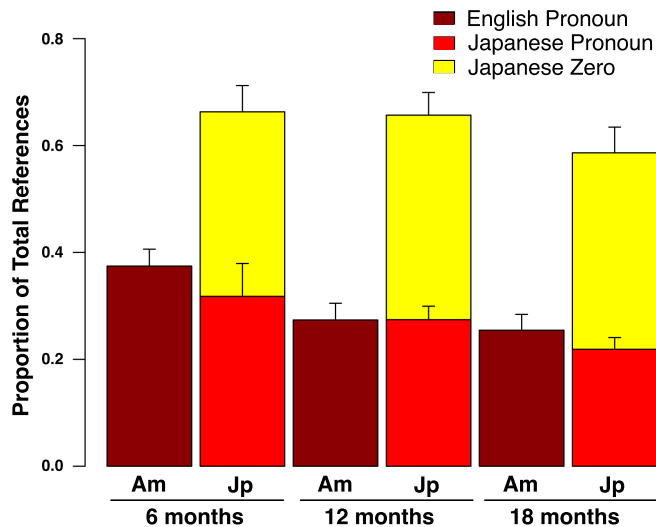
Figure 1: Proportion of total references that used pronominal or zero anaphora for American (Am) and Japanese (Jp) dyads. Error bars show standard error of the mean across dyads.

ical subjects and objects are frequently omitted in Japanese, where in English they would be marked using a pronoun. We included implicit subjects and objects as intended referents, but gave them a special marking. Whenever the subject or object of a verb or the noun modified by an adjectival phrase was omitted, we counted it as a case of implicit reference to the omitted noun, or "zero anaphora." We did not count objects as being referred to if they were a missing instrument of action, the possessor of an object that was explicitly mentioned, or if they had a spatial or some other relationship to the objects that were mentioned. While each of these might sometimes qualify as zero anaphora, our annotation scheme treated them conservatively (hence, zero anaphora counts would if anything be higher under a revised scheme).

We further categorized non-zero references to objects into two types: those that used a referential pronoun and those that named the object. We counted a reference as "naming" the object when: 1. the utterance was marked as referring to the object by our annotator and not marked as being a case of zero anaphora, 2. the utterance contained one of a list of character strings found in words for the referred object (including common misspellings), and 3. the English gloss (created by a second native speaker for the original Fernald & Morikawa, 1993 study) contained one of a list of possible glosses for words for the referred object. We counted a pronoun as being used referentially when: 1. the utterance was marked as referring to the object by our annotator and not marked as being a case of zero anaphora, 2. the utterance contained one of a list of pronouns, and 3. the reference had not already been marked as object naming.

Results

Mothers talked about each toy in alternating bouts of utterances. They frequently used onomatopoeia, and engaged in "social routines" (Fernald & Morikawa, 1993), such as re-

questing objects from the child and saying thank you. A plot of references to the six toys over a single video is presented in Figure 2, as a representative discourse structure.

We report three main sets of analyses. First, simple univariate counts of pronominal and zero anaphora. Second, analyses of transitions between different kinds of reference. Third, changes in use of zero anaphora across the corpus.

Anaphora Use Across Languages

Our first analysis counted pronominal and zero anaphora proportions in the corpus at each age. We normalized these counts by the total number of object references that were identified (including all anaphoric references)[1]. These data are shown in Figure 1, along with English data on pronoun use in object references from Rohde and Frank (under review).

Several trends are apparent in these data. First, pronoun use is approximately equivalent between English and Japanese speakers. Speakers of both languages use pronouns approximately one-third of the time. Second, Japanese use of zero anaphora constitutes an additional third of *all* object references. Unlike the English-speaking mothers, Japanese-speaking mothers were using anaphora more often than not to refer to the toys that they were playing with. Finally, pronoun use declined with the age of the children in our sample. This trend was somewhat modest compared with the large cross-linguistic differences, but was nevertheless significant in a simple linear regression predicting pronoun use by age in months (β = -.005, p <.001). However, this age difference likely reflects the fact that videos were shorter for the 6 month old group than the other two groups. As will be discussed below, pronoun use declined substantially over the discourse for all three age groups, and so proportion of pronoun use in the 6 month old group might have been inflated by the shorter video—and hence shorter discourse—length.

Discourse Continuity in Japanese

We next examined how likely each mother was to refer to the same object in two consecutive utterances. This analysis was used by Frank et al. (in press) as a first-pass indicator that discourse references to objects were relatively continuous. A high probability of repeated reference to an object suggests that a learner who "smoothed" their guesses about reference across time would be relatively successful. If they didn't know what a particular utterance was referring to, they could just guess that the referent was the same as in the previous utterances in the discourse.

Continuity of Reference We calculated transition probabilities between referential and non-referential utterances of

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[1]In the Japanese data, 281 out of 3642 references (7.7%) were marked as "ambiguous" as to whether the toy was referred to or not. Only non-ambiguous cases were used in the first analysis.
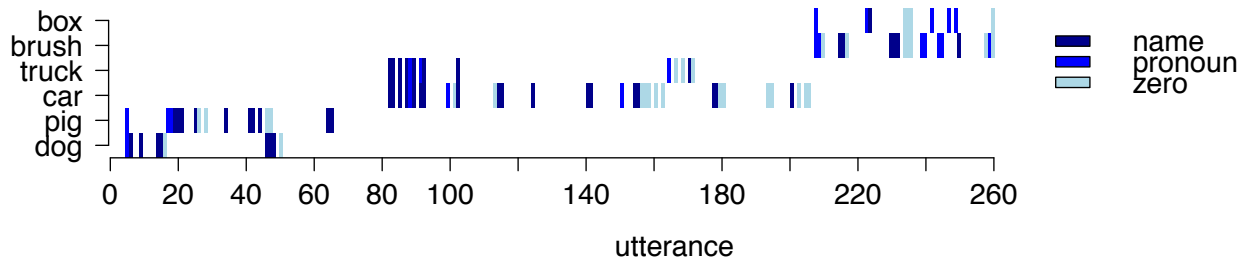
Figure 2: References to the six main toys in a sample video. Toys are plotted on the Y axis and blue lines signal that the toy was referred to in a particular utterance. name = object naming, zero = zero anaphora.

Table 2: Transition probabilities between referential and non-referential utterances of various types. P(Y|X) refers to the probability that in the current utterance an object is referred to using Y given that in the previous utterance it was referred to using X. zero = zero anaphora, name = object naming, nonref = nonreferential utterance.

X	P(name|X)	P(zero|X)	P(pronoun|X)	P(other|X)	P(nonref|X)
name	.25	.12	.06	.02	.55
zero	.04	.28	.05	.01	.62
pronoun	.10	.15	.19	.03	.53
other	.05	.06	.11	.08	.70

various types.[2] As in our previous work, transition probabilities were first calculated for each of the six toys, then averaged together, weighted by the number of times each toy was referred to in the video (or referred to using a particular reference type, as appropriate).

Mothers varied considerably in how likely they were to refer to an object in two consecutive utterances. The probability of referring to an object in the next utterance given it was referred to in the current utterance ranged between .20 and .57 for each mother (mean = .43). Probability of repeated reference remained relatively stable when calculated for the utterances in each age group, although it tended to rise with the age of the child, from .39 at 6 mos, to .44 at 12 mos, and .47 at 18 mos. Overall these levels were somewhat lower than those for English-speaking dyads.

When we removed utterances that consisted of backchanneling—checking for a response from the child—such as "nn," "n?," "a," and "hai hai hai" ("yes, yes, yes"), this slightly increased the probability of consecutive reference (mean = .49), and decreased variance between mothers. This analysis suggests that the higher tendency of Japanese mothers to use backchanneling, combined with the lower overall frequency of object reference, may account for the difference between Japanese and English-speaking dyads.

Transitions Between Reference Types We next examined transitions between referential and non-referential utterances of various types, including zero anaphora, pronouns, and object naming. The goal of this analysis was to understand the directionality of zero anaphora use in discourse. If zero

anaphora is used more after naming, then transition probabilities should be asymmetric: $p(zero|name)$ should be higher than $p(name|zero)$.

Results are summarized in Table 2. The largest trend was for referential utterances to be followed by non-referential utterances, indicating (as above) that Japanese discourses contained more non-referential speech overall than in English. Nevertheless, there were still distinct trends in which referential strategies were used earlier in discourses. Zero anaphora after object naming was three times as likely as object naming after zero anaphora. Zero anaphora after pronominal anaphora was three times as likely as pronominal anaphora after zero anaphora. Surprisingly, pronouns were more likely to be used before object naming than after it, unlike in English (Ariel, 1990; Gundel, Hedberg, & Zacharski, 1993).

Changes in Anaphora Use Across the Discourse

Zero Anaphora Over Time In our third analysis, we examined how often mothers used zero anaphora at different points in the discourse. For each utterance that referred to one of the six main toys, we calculated the number of times the object had been mentioned prior to that utterance. We call this the "number of previous references" (NPR) for the utterance. If an utterance refers to the dog for the fifth time in a video, that utterance has an NPR of 4. Next, we collapsed all references with a particular NPR across mothers and toy referents, and calculated the proportion of the time the references used zero anaphora.

The proportion of time that mothers referred to an object using zero anaphora increased with the log of the NPR at all ages (Figure 3). We created a mixed effects model of zero anaphora usage, with age group and NPR as fixed effects and mother as a random effect with random intercept and slope with respect to NPR. Because of the very large number of observations, we used the z approximation to esti-

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[2]We calculated transition probabilities between utterances both counting and discounting cases where the referent was ambiguous. However, none of the transition probabilities besides those for the "other" category changed by more than .02 when the ambiguous cases were counted as non-reference, and so we count them as non-reference in the current analysis.
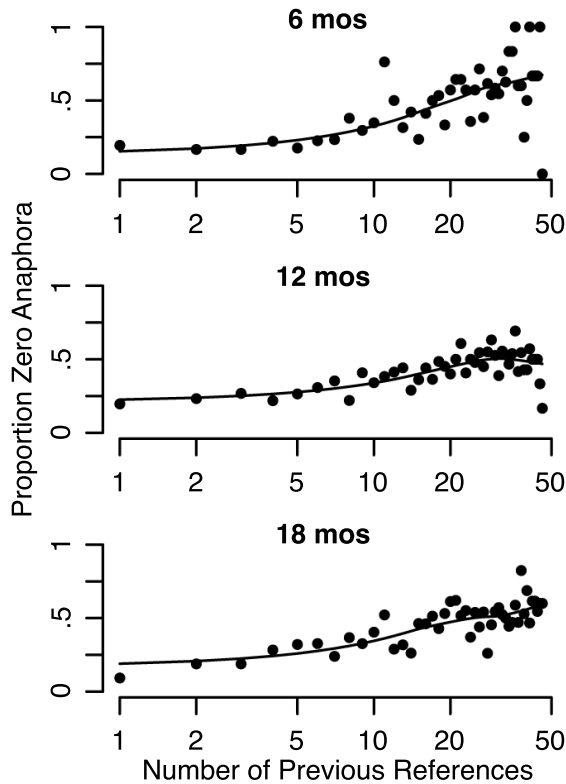
Figure 3: Proportion of total references that use zero anaphora as a function of the number of previous references to the object (NPR), plotted separately by age group. NPR depicted on a logarithmic scale, NPRs with fewer than 10 data points were dropped. A loess curve was fitted to each plot.

mate significance for individual coefficients. We found that zero anaphora use increased significantly with NPR (β = .049, $p < .001$), while age group had no effect ($\beta = -.001$, ns). We modified the model to include the interaction term of age group and NPR as a fixed effect, and found that the resulting coefficient was nonsignificant ($\beta = -.002$, ns).

We also examined whether mothers were more likely to use zero anaphora when referring to some toys than others. We created a mixed effects model with age group, NPR and toy as fixed effects and mother as a random effect with random slope and intercept with respect to NPR. There was no significant effect of any of the toys with the exception of the box, which had significantly higher zero anaphora use compared to all other toys (β values ranged between -.79 and -1.08, $p < .001$ for each of the other toy coefficients when box was used as the referent). This is likely due to the fact that mothers would repeatedly ask their children to "open" and "close" the box without specifying a direct object. We find this an intriguing hint that some objects may be referred to via associated verbs, especially when they provide salient action affordances.

Zero Anaphora vs. Other Reference Our final analyses examined the proportion of zero anaphora use as compared to the proportion of pronominal anaphora and object naming (Figure 4). As the log of the number of previous references increases, zero anaphora use increases substantially

and pronominal anaphora decreases substantially. However, object naming only decreased slightly at higher NPRs. For the first 20 times the mother referred to an object, the proportion of the time that she named the object stayed relatively flat. In other words, zero anaphora increases over time at the expense of pronominal anaphora, rather than object naming.

We also extracted discourses of consecutive references to the same object, and examined zero anaphora, pronominal anaphora and object naming at each "utterance position" in the discourse. The first utterance of a discourse has an utterance position of 1, the second has an utterance position of 2, etc. We examined a total of 791 discourses of three or more consecutive references to an object. Once again, the proportion of zero anaphora use increased with the log of the utterance position, and the proportion of pronominal anaphora decreased. For the first six utterance positions, the sum of the proportion of zero anaphora use and pronominal anaphora use was flat. (Over 90% percent of the discourses we examined were six or fewer utterances long). This analysis again indicates that the proportion of zero anaphora rises at the expense of pronominal anaphora before having any effect on the proportion of references that name the object.

General Discussion

We examined patterns of anaphora use in child-directed speech by Japanese mothers of infants aged 6, 12 and 18 months. We found that Japanese mothers used far more total anaphora than English-speaking mothers, although pronominal reference was about equally likely in Japanese and English. We examined the transition probabilities between zero anaphora, referential pronouns, and object naming, finding that pronouns are more likely to occur earlier in the discourse, while zero anaphora is more likely to follow both pronouns and object naming. Finally, we assessed how object naming and anaphora use evolve over the discourse, using two measures: the number of previous references to an object and the utterance position in discourses of consecutive reference. Zero anaphora use rapidly accelerated over the discourse at the expense of pronouns, while object naming persisted at a steady rate that only gradually declined later on.

These findings give insight into how object reference varies between languages like English, which have a two-tiered system of nominal and pronominal reference, and those like Japanese that have a third possibility: zero anaphora. In English, both pronoun use and elision are more likely when the referent is given information (MacWhinney & Bates, 1978). From this one might expect that both pronominal and zero anaphora use would increase with the givenness of the referent in Japanese.

However, the distribution of pronoun types differs drastically between these languages: both personal and demonstrative pronouns are frequent in English, while in Japanese, most pronouns are demonstrative, and zero anaphora is used in place of personal pronouns most of the time. According to Gundel's hierarchy of givenness (Gundel et al., 1993), per-
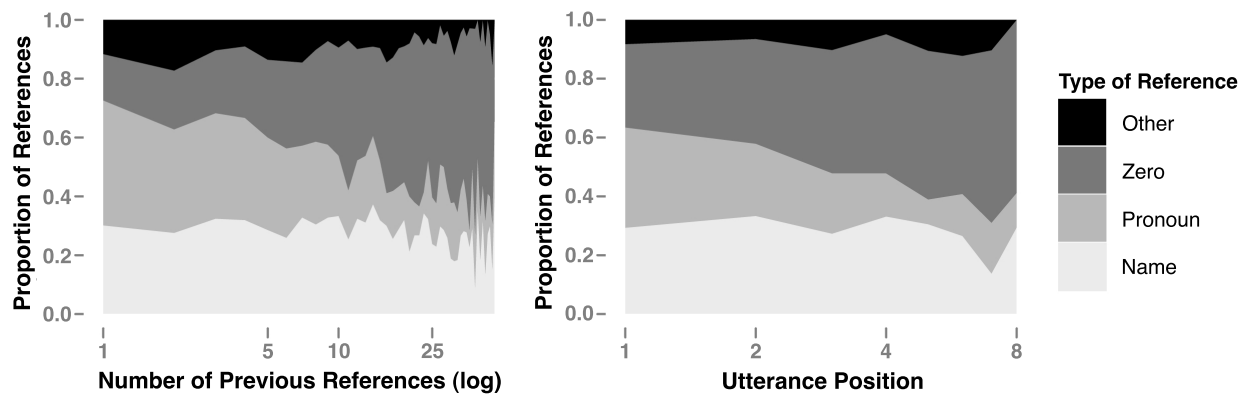
Figure 4: Proportion of total references that involve object naming, zero anaphora, or referential pronouns, as a function of the number of previous references to the object (NPR) and utterance position. NPR and utterance position depicted on a logarithmic scale, NPRs and utterance positions with fewer than 10 data points were dropped. Utterance position calculated using all discourses of three or more consecutive references to an object.

sonal pronouns and zero anaphora are used only when the referent is in focus, but demonstratives can also be used when it is out of focus but in working memory. By Grice's maxims, this leads to demonstrative pronouns being used more frequently when there is a topic shift, or when the referent has been introduced non-linguistically (Gundel et al., 1993; Gundel, Hedberg, & Zacharski, 2004). In our data, Japanese pronouns were more likely to be used in reference to an object the first time it was referred to than at any other point in the discourse. This suggests that in Japanese child directed speech pronoun use may signal topic change (e.g. "look at this!"), rather than topic continuity.

As suggested originally by Fernald and Morikawa (1993), pure word-object mapping in Japanese might be a very hard problem: Only about a third of references name the object, while the other two-thirds make use of pronouns and zero anaphora. Moreover, references to objects in Japanese (as in English) are not evenly distributed in discourse. But if children have some sense of what the current topic of discourse is—what is given, and what is new—this problem might be somewhat alleviated. A Japanese-learning infant could infer the topic of conversation and then assume that future comments, whether using names or anaphora, referred to that topic. Thus, this study underscores the importance of topical discourse in early word learning, suggesting that tracking the topic of conversation across utterances may be even more crucial to word learning success in pro-drop languages.

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