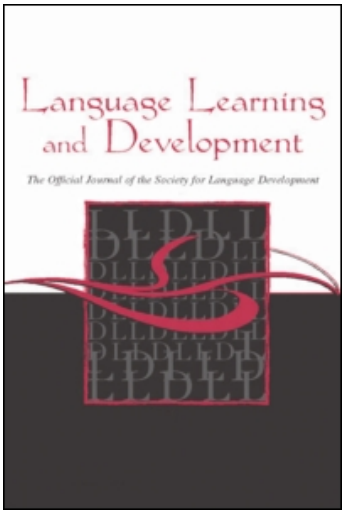

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Quantifier Spreading: New Evidence from Japanese

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Quantifier Spreading: New Evidence from Japanese

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This study uses two experimental tasks to investigate 'quantifier spreading' (the incorrect inference that *Every boy rode an elephant* entails that every elephant was ridden by a boy). The performance of four and five year olds on the type of judgment task that first uncovered this phenomenon was compared with their performance on an act-out task in which they had to construct for themselves the scenario described by sentences containing quantifiers. A sharp decrease in the number of 'spreading' responses was observed in the act-out task, suggesting that children's difficulty with the interpretation of *every* is highly sensitive to the experimental methodology. The existence of a task-based difference in the rate of spreading responses raises important questions about the nature of this interpretation and its relevance for our understanding of semantic development.

INTRODUCTION

A curious phenomenon involving quantifier interpretation has frequently been observed in the literature on language acquisition. First reported by Inhelder and Piaget (1964), it is most often manifested in situations such as the one depicted in Figure 1, in which there is a near one-to-one pairing between children and elephants.

When asked whether a sentence such as (1) is true in such situations, many pre-school children respond by saying 'no', explaining that there is one elephant that is not being ridden (e.g., Philip, 1995; Kang, 1999; Geurts, 2003; Roeper, Strauss, & Pearson, 2004).

(1) Every boy is riding an elephant.

The question of how children arrive at such an interpretation, variously dubbed spreading, exhaustive pairing, and the symmetrical response, has become "the most controversial topic in current research on young children's semantic competence" (Gualmini, Meroni, & Crain, 2003, p. 135).

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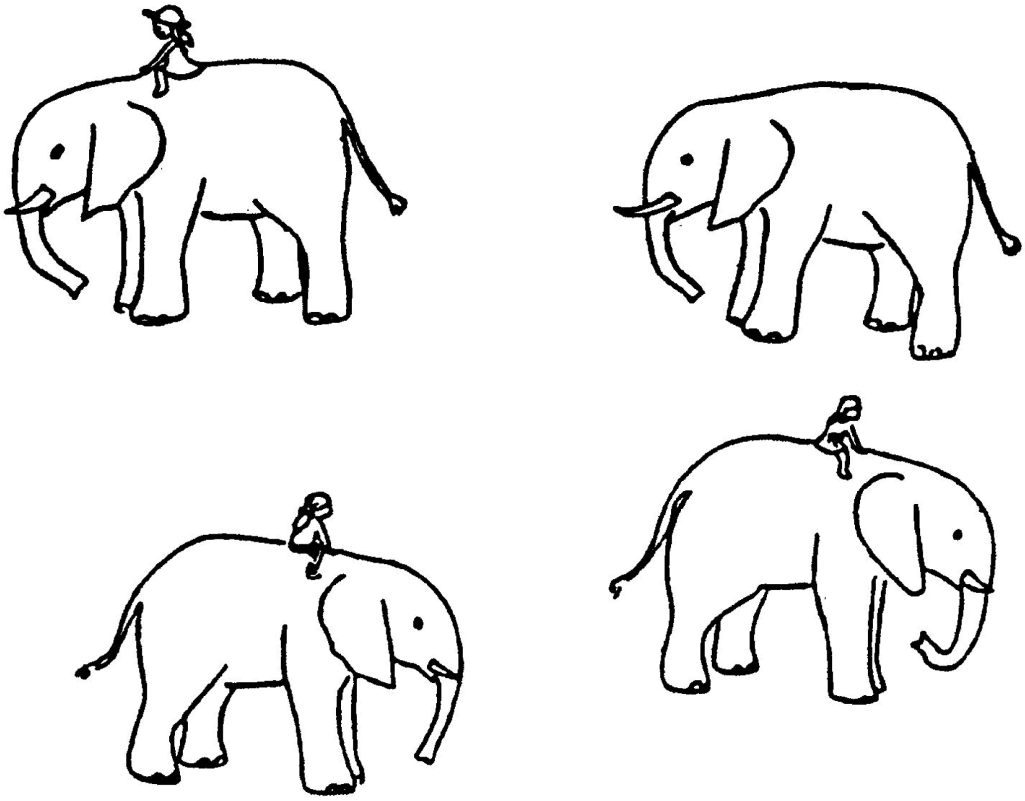

FIGURE 1 Picture accompanying sentence (1) in typical comprehension experiment.

One view holds that children's semantic representations are deficient in that the quantifier is interpreted as an adverb that ranges over events rather than individuals (Philip, 1995; Roeper et al., 2004; Geurts, 2003), perhaps reflecting an early parameter setting (Roeper, 2009). This yields the 'spreading' interpretation paraphrased in (2).

(2) For all events *e*, in which a boy participates or in which an elephant participates (or both), a boy is riding an elephant in *e* (e.g., Philip & Avrutin, 1998, p. 67).

An alternative implementation of the deficient representation view, put forward by Drozd and van Loosbroek (1999), holds that *every* in sentences such as (1) can apply to the set denoted by either NP—depending on which is more salient in a particular context. This in turn opens the door for the 'every elephant' interpretation.

Such proposals contrast sharply with the 'full competence hypothesis,' which holds that children have an adult-like grasp of the semantics of *every* and that spreading responses can be traced to defects in experimental design rather than shortcomings in linguistic competence. A well-known suggestion along these lines comes from Crain, Thornton, Boster, Conway, Lillo-Martin, and Woodams (1996), who argue that the question *Is every boy riding an elephant?* is not felicitous in a context that does not leave room for an alternative outcome (the 'Principle of Plausible

Denial'). In an experiment designed to test this idea, Crain et al. modified the context preceding the test sentence so that (for example) one or more of the three boys considered riding a horse (the alternative) before choosing an elephant. Crucially, this led to a dramatic reduction in the number of spreading responses, despite the presence of a riderless elephant.

Yet another feature of the experimental design that may affect children's responses involves the manner in which the situation described by the test sentence is depicted. For instance, it has been suggested by Freeman, Sinha, and Stedmon (1982) that the near perfect one-to-one relationship between agents and patients in a scene such as the one depicted in Figure 1 invites the inference that there is a fourth boy who happens not to be present in the picture. This in turn justifies a negative response to queries about whether every boy is riding an elephant—the 'missing boy' isn't atop an elephant. Alternatively, it has been proposed by Rakhlin (2007a) that children may focus on the riderless elephant, restricting the domain of the indefinite *an elephant* to just this entity and arriving at the interpretation 'There is an elephant that everyone is riding', which is indeed false.

Independent evidence for ideas along these lines comes from experiments that increase the size, number, and/or variety of objects that are unaffected by the action denoted by the verb, thereby reducing the appearance of an intended symmetry between agents and patients. As reported by Sugisaki and Isobe (2001), Gouro, Norita, Nakajima, and Ariji (2001), Geurts (2003), and Rakhlin (2007b), the participants in such experiments manifest far fewer instances of spreading. Moreover, Rakhlin (2007a) reports an intriguing error on patterns such as *Nobody is riding an elephant*, which some children treat as true—apparently arriving at the interpretation 'There is an elephant that nobody is riding' by focusing on the riderless elephant, as suggested in the preceding paragraph.

We take no position on which, if any, of these ideas best accounts for children's spreading errors on truth value judgment tasks involving picture stimuli. Instead, we report on an attempt to probe children's semantic competence with respect to *every . . . a . . .* patterns by examining their performance on an act-out task. Whereas typical judgment tasks present an adult-created scenario against which the truth and appropriateness of a test sentence must be judged, the act-out task that we use requires the children themselves to construct the situation described by the sentence. This has the effect of reducing (and perhaps even removing) the salience of the single extra object that some take to be the critical feature of experiments that elicit strong spreading effects. If this line of thinking is correct, the tendency to interpret test sentences symmetrically should significantly diminish when this feature is no longer present.

To test this idea, we conducted an experiment with children acquiring Japanese as a first language who, like their English-speaking counterparts, are susceptible to 'spreading' interpretations (Philip, 1995; Sugisaki & Isobe, 2001; Gouro, Norita, Nakajima, & Ariji, 2001). We begin by reporting on the experiment itself and then turn to an evaluation of our results with respect to the larger issue of children's understanding of the semantics of *every*.

THE EXPERIMENT

Method

Our experiment consisted of a simple truth value judgment task and an act-out task, conducted in that order with an interval of three days. All subjects were tested individually in a quiet room.

The first experimental session began with four intransitive practice sentences (e.g., *Every mouse is sleeping*) in order to ascertain that the children could assess the truth of sentences with a universally quantified subject NP. Two of the practice sentences accurately described a corresponding picture, and two failed to do so.

The practice sentences were followed by a judgment task in which the experimenter read a series of simple transitive sentences (see below) to the subjects, who judged the truth of each statement with respect to a corresponding picture. We deliberately provided no discourse context for the test statement (contra, e.g., Crain et al., 1996), both to keep the task maximally simple and to increase the chances of replicating the spreading response reported in earlier work using this type of task. Because it is sometimes difficult to elicit 'yes' and 'no' responses from Japanese children, the subjects were allowed to indicate their response by pointing to one of two cards bearing symbols widely used in Japanese kindergartens and schools—a circle (for 'yes') and an X (for 'no'). The task took approximately five minutes to complete.

The act-out task, which was administered three days later, called for the children to use props to illustrate the meaning of the test sentences (which were identical to those used in the judgment task). The children were tested individually in a quiet place by two native Japanese experimenters, one of whom interacted with the subjects while the other assisted with the props. At the beginning of the experiment, the lead experimenter said to the child:[1]

> Now, I'm going to tell you a story. So, please try to show how the story goes by using these [cut-outs] here. When you finish, let me know by saying 'done'. If you cannot do it with these [cut-outs], let me know by saying 'can't.'

In cases where the children said 'can't,' they were asked to explain why they were unable to proceed.

The instructions were followed by eight training sentences designed to illustrate the task and to familiarize the child both with sentences whose meaning could be acted out with the available props and those whose meaning could not be acted out in this way. Each session, which lasted between 20 and 30 minutes per child, was videotaped for later analysis.

Subjects

A total of 20 subjects participated in the experiment—10 boys (4;10 - 5;9; mean age 5;4) and 10 girls (4;11 - 5;8; mean age 5;4). All the subjects were monolingual native speakers of Japanese enrolled in Sumire Kindergarten of Kyoto Sangyo University in Kyoto, Japan.

Test Materials

Both tasks made use of the same two types of test items (four tokens of each; see the appendix for a complete list). The experiment included an additional four sentences not relevant to the point under investigation.

[1]Japanese: *Ima kara ohanasi-o suru ne. Sorede, sono ohanasi-no toori-ni kore-o tukatte koko-ni yattemite ne. Sorede, owattara 'owatta'tte osiete ne. Mosi, kore-de dekinakattara 'dekinai'tte osiete ne.*

- First type of test item: 'Extra object' sentences containing a universal quantifier

  (3) Dono neko mo sakana-o kandeimasu.
  every cat Particle fish-Acc biting
  'Every cat is biting a fish.'

  Materials for corresponding judgment task: A picture illustrating three cats, each of which is biting a (different) fish, plus a fourth fish.

  Material for corresponding act-out task: A set of props consisting of three cats and four fish.

  Sentences of this type constitute the crucial probe for the 'spreading' interpretation, which requires that each cat be paired with a fish and vice versa. A child who forms this interpretation in the judgment task will reject the sentence as false on the grounds that there is a fish that is not being bitten—the classic spreading response. On the other hand, a child who realizes that the quantifier applies just to the denotation of the subject NP will take the sentence to be true since each of the cats is in fact biting a fish.

  In the act-out task, a child who adopts the spreading interpretation can be expected to indicate that the meaning of the sentence cannot be acted out with the available props, on the grounds that there are either too few cats or too many fish. In contrast, a willingness to construct a scene corresponding to this sentence even in the presence of an 'extra' fish indicates that children are not irrevocably predisposed to the exhaustive-pairing interpretation associated with the spreading phenomenon.

- Second type of test item: sentences in which there are too few agents

  (4) San-biki-no neko-ga suika-o tabeteimasu.

  three-Cl-Gen cat-Nom watermelon-Acc eating
  'Three cats are eating a watermelon.'

  Material for corresponding judgment task: A picture illustrating two cats, each of which is eating a (different) watermelon, plus two more cats who are eating nothing.

  Material for corresponding act-out task: A set of props consisting of two cats and four watermelons.

  Children's responses to these sentences allow us to assess their attentiveness to the number of entities in a context and their ability to reject sentences as false and/or impossible to act out under the appropriate circumstances. A correct response in these cases involves labeling the sentence as untrue in the judgment task and indicating that it is impossible to proceed in the act-out task.

Results and Discussion

Table 1 offers a detailed look at children's performance in our experiment.

Of the 20 subjects who participated in the judgment task, four were unable to understand the task, as evidenced by their inability to succeed on the training sentences. Therefore, they did not participate further in the experiment (lines 1 through 4 in Table 1).

TABLE 1
Children's Performance on the Judgment and Act-out Tasks (Response Types)

Subject #	*Training for the Judgment Task*	*Judgment Task Too Few Agents*	*Act-out Task Too Few Agents*	*Judgment Task Extra-object*	*Act-out Task Extra-object*
1	Failure				
2	Failure				
3	Failure				
4	Failure				
5	√	4	2	0	0
6	√	3	0	2	0
7	√	4	2	0	4
8	√	4	0	0	4
9	√	4	0	0	4
10	√	4	4	0	4
11	√	4	4	0	4
12	√	4	4	0	4
13	√	4	4	2	4
14	√	4	4	0	4
15	√	4	4	0	4
16	√	4	3	0	3
17	√	4	3	1	0
18	√	4	4	0	0
19	√	4	3	0	0
20	√	3	4	0	0

An additional five subjects (lines 5 though 9) responded correctly on fewer than three of the four act-out test items in which there were too few agent props (as in (4) above). Instead of declining to carry out the called-for action, they either made as many pairs as the available props permitted (two children) or refused to proceed without giving an appropriate justification for their decision. Recall that the purpose of these test items was to ensure that the participants in our experiment would decline to act out sentences when there were an inappropriate number of props. In the interest of caution, we therefore decided to exclude the results from these five children, even though three of the five responded correctly on all of the 'extra object' test items used to test for the spreading phenomenon.[2]

This leaves us with 11 subjects, all of whom performed poorly on the extra object items in the judgment task (mean no. correct = .27 out of 4). Crucially, six of these subjects responded correctly on all four of the extra object sentences in the act-out task, and one responded correctly on three of the four cases (the final column, lines 10 through 16). In each case, this response involved, for example, having each of the three cats bite a different fish, leaving the fourth fish untouched. This is especially noteworthy in light of the fact that these same seven children had virtually always adopted the spreading interpretation in the judgment task (the second-to-last column).

[2]One of these children specifically noted that there was an extra object, wondering what he was expected to do with it.

TABLE 2
Mean Number Correct Out of Four (and Standard Deviations) for the 'Extra Object' Sentences

	Judgment Task	*Act-out Task*
Correct	.27 (.65)	2.45 (1.97)
Spreading	3.73 (.65)	.82 (1.60)
Other	0	.73 (1.62)

Of the remaining four subjects, two produced an abbreviated response in the act-out task, announcing that they had finished after making just one agent act on one object (lines 17 and 18). Only two subjects (lines 19 and 20) maintained the spreading interpretation first manifested on the judgment task, insisting that they could not comply with the experimenter's request because there was an extra object or there were too few agents. [3]

Table 2 summarizes the results on the crucial extra object sentences for the 11 children who manifested a satisfactory understanding on the task and on whom our discussion is focused. As can be seen here, there was a dramatic nine-fold increase in correct responses—from a mean of just .27 on the judgment task to 2.45 on the act-out task ($t = 3.546$, $df = 10$, $p = .005$, by a paired t-test). Not surprisingly, there was a corresponding sharp drop in the frequency of the 'spreading' response—from a mean of 3.73 on the judgment task to just .82 on the act-out task.

In sum, whereas our subjects scored very poorly on the extra-object judgment task, which presented them with a ready-made setting, they did far better on the act-out task, in which they were able to construct an appropriate setting for the test sentence themselves.

CONCLUDING REMARKS

As noted at the outset, earlier work has shown that features of the context in which quantified sentences are presented (whether the principle of plausible dissent is satisfied, the number and prominence of the 'extra' objects, and so on) can dramatically affect children's performance. We have gone in a quite different direction—eliminating the adult-created discourse context in favor of situations that allow children to create their own scenario in accordance with their understanding of the semantics of *every*. This manipulation helps minimize a potential problem associated with much earlier work—the possibility that children's understanding of adult expectations will influence their performance, leading them to focus excessively on the 'extra' elephant in scenarios such as the one depicted in Figure 1 and perhaps even to assume that there is a missing fourth child. As we have seen, use of an act-out task led to a sharp decrease in the rate of 'spreading' responses and their full suppression in several cases. This sheds new light on quantifier spreading, pointing to yet another factor to which it is sensitive. However, we acknowledge that caution is required in the assessment of its broader implications.

[3]It is possible that these children interpreted the near-match in the number of agents and patients as evidence that a one-to-one relationship was intended. If this is the case, then the act-out task reduces but does not entirely eliminate the possibility of such interpretations—not a surprising outcome, given the challenges associated with controlling for all possible variables that might influence a child's interpretation of an adult's intent.

The debate over the nature of the spreading phenomenon turns on a basic question:

> Does the spreading response reflect a semantic deficit that is alleviated under particular experimental conditions, or does it reflect a mature grasp of the semantics of quantification that is obscured by particular experimental conditions?

The variation in children's interpretation of *every* observed in our experiments (and those of others) does not in itself establish that the spreading response constitutes a task effect. This is because proponents of the semantic deficiency hypothesis do not hold that children *must* assign a spreading interpretation. Rather, the claim is simply that children's early grammar *permits* them to arrive at such an interpretation. Task-dependent variation in the interpretation of *every* is therefore potentially consistent with both possibilities raised above—full semantic competence obscured by a task effect or a semantic deficit alleviated by favorable experimental conditions.

To date, there have been two principal attempts to resolve this impasse. The first, pursued by Crain, Meroni, and Minai (2004), involves appeal to methodological considerations: full competence should be seen as the default for reasons relating to learnability. If children initially believe that the quantifier in *Every boy is riding an elephant* can optionally apply to the denotation of the verb and/or the direct object NP, the argument goes, how are they able to recover from this mistake? Hearing the sentence used in a context where *every* applies unambiguously to the denotation of the subject will not suffice, since that does not rule out the possibility that *every* might be used in other ways in other sentences. No such problem arises on the full competence account, according to which children have an adult-like interpretation of *every* from the outset.

A second type of approach, manifested in the work of Crain et al. (2004) and Gualmini et al. (2003), appeals to the apparent exceptionality of spreading errors, given children's otherwise remarkably detailed understanding of the semantics of *every*. For example, as Crain et al. note, children realize that *every* is downward entailing with respect to its restrictor (the head noun) in patterns such as (5). They thus know that things that are true of every koala bear are also true of every subtype of koala bear.

(5) *Every* is downward entailing in a neutral context.

He fed every koala bear.
> He fed every big koala bear.

The children in Crain et al.'s (2004) experiment also demonstrated knowledge of the fact that *every* becomes upward entailing with respect to its restrictor when it lies in the scope of a negative. Thus things that are true of any subtype of koala bear must also be true of koala bears in general in a sentence such as (6).

(6) *Every* is upward entailing in the scope of negation.

Nobody could feed every big koala bear.
>Nobody could feed every koala bear.

As the authors note, it is difficult to reconcile such a refined grasp of the semantics of *every* with the claim that children lack the knowledge required to interpret it in extra object sentences, as the deficit hypothesis contends.

Such approaches make a strong circumstantial case for full competence, but there is still a need for a general theory of why and how children's grammatical knowledge is set to the side in the presence or absence of particular experimental conditions. To be fully persuasive, such a theory would have to build on crucial assumptions concerning the nature of grammatical rules (are they 'hard' or 'soft' constraints?), the conditions under which they can be overridden, and the precise nature of the interaction between the grammar and other cognitive systems, including pragmatics (on this, see especially Rakhlin, 2007a). Unfortunately, there is no consensus on any of these matters, and therefore little immediate prospect of a general theory of task effects either.

These considerations notwithstanding, the experimental results reported here contribute to our understanding of the spreading phenomenon in two ways. First, and more generally, they confirm that the rate of spreading can be diminished (sometimes to a negligible level) by manipulating experimental conditions. Second, and more specifically, this effect was achieved in our experiment not by adding to or refining the linguistic context but rather by removing it altogether, allowing children to construct for themselves a scenario compatible with their interpretation of universally quantified sentences. It is hoped that further work along these lines can shed additional light on the precise conditions under which spreading occurs and perhaps even on the underlying cause.

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APPENDIX — TEST ITEMS

'Extra object' sentences

Every cat is biting a fish. (3 cats and 4 fish)
Every fox has a watermelon. (3 foxes and 4 watermelons)
Every mouse is touching a cake. (3 mice and 4 cakes)
Every frog is eating a rice ball. (3 frogs and 4 rice balls)

Sentences with too few agents

Two mice have a rice ball. (1 mouse and 3 rice balls)
Three frogs are touching a fish. (2 frogs and 4 fish)
Three cats are eating a watermelon. (2 cats and 4 watermelons)
Two foxes are biting a cake. (1 fox and 3 cakes)