

BUCLD 35 Proceedings
To be published in 2011 by Cascadilla Press
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Quantifier Spreading is not Distributive

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“Quantifier spreading” has captured the imagination of researchers on different sides of the grammar interface: syntax, semantics, and pragmatics (Philip, 1995; also Brooks, Braine, Jia, & da Graca Dias, 2001; Crain, Thornton, Boster, Conway, Lillo-Martin, & Woodams, 1996; Drozd, 2001; Guerts, 2003, among others). Piaget (Inhelder & Piaget, 1958) was among the first to have reported this phenomenon over fifty years ago, yet much remains unknown about the micro-path of quantifier acquisition.

The classic experimental example for spreading is shown in Figure 1.

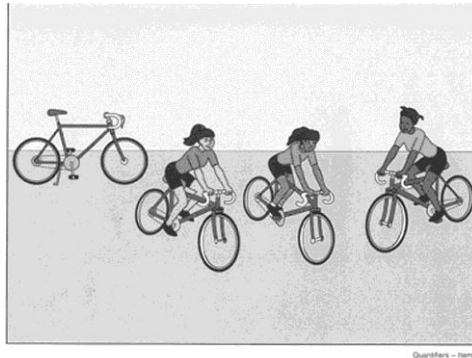


Figure 1. Example spreading item from the Dialect Sensitive Language Test (Seymour Roeper & de Villiers, 2000).

Shown three girls riding bikes plus an empty bike, and asked, “Is every girl riding a bike?” many children point to the empty bike, saying “no, not this bike.” The child exhaustively distributes all girls to all bikes and all bikes to all girls in a one-to-one fashion. Thus, both distributivity (one-to-one) and exhaustivity (including all present entities) appear to be involved. It also appears that the scope of the quantifier is not restricted to the NP in which it occurs, but can apply either to the object NP or both NPs, as in “Is a girl riding every bike?” or “Is every girl riding every bike?”

In this paper, we present evidence that exhaustivity, not distributivity is at the root of children’s spreading. The experimental protocol also produces examples that demonstrate the syntactic operation of quantifier “floating”

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(Bobalik, 1998) that Roeper, Pearson, and Strauss (2006) argued gives rise to the spreading interpretation.

1. The acquisition path

Quantifier spreading is very persistent. The following data from the *Dialect Sensitive Language Test (DSLTL)*, Seymour, Roeper, & de Villiers, 2000) are consistent with the general finding. Figure 2 charts the results for the 333 typically developing European-American GAE speakers in the nationwide *DSLTL* field testing sample. They show that spreading was more frequent than the target response through age 8 years. As shown in the figure, the percentage of children who gave spreading responses (in the gray bars) increased through age 7-8. Although such responses declined after age 8, they did not disappear. Forty percent of the participants at ages 9 to 10 years and 28% at ages 11 to 12 years gave at least one answer analogous to “not that bike.”

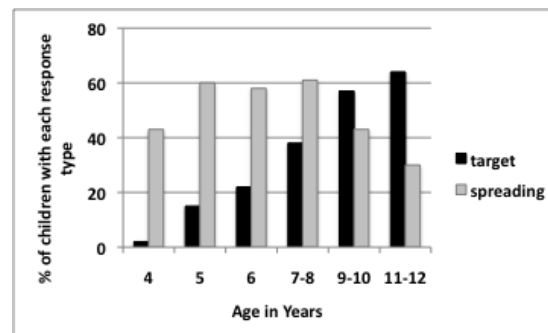


Figure 2. Spreading Answers by Age, Typically Developing General American English Speakers (N= 333)

It is important to note that although there has been disproportionate attention to *every*, the phenomenon of spreading has been found with other quantifiers, e.g. *some*, *most*, and *both* (Roeper & de Villiers, 1991; Roeper & Mattei, 1974; Stickney, 2006). Working on *all* and *each* in English, Mandarin, and Portuguese, Brooks, Braine, Jia and da Graca Dias (2001) also found that until around age 9 “the English learning children did not seem to “pay attention to the location of *each*,” (that is, which noun phrase it was associated with).

1.1 The Acquisition Challenge

To show its semantic, lexical, and syntactic sides, we enlarge on the challenge facing the child in learning not to spread. We hint at pragmatic factors involved, but they are beyond the scope of this paper.

Consider first a semantic contrast between collectivity and distributivity which is illustrated in the difference in meaning between *every* and *each*. While

every allows distributivity, it does not require it like *each* does. For example, when a waiter lifts a tray of glasses, the sentence in (1a) is true, while the sentence in (1b) is not (Tunstall, 1998).

- (1) a. The waiter is lifting every glass.
- b. *The waiter is lifting each glass.

The sentence with *each* requires that each glass be lifted individually while *every* allows the glasses to be lifted collectively.

We know from corpora and diary studies of early speech that children begin early with collective readings, such as *allgone*, *allgone milk*, or *allgone cookies* (Roeper et al., 2006). These are also exhaustive, a concept which has also been shown to be part of children's very early repertoire (Strauss, 2006). With respect to distributivity, 3- and 4-year-olds have given evidence of the cognitive ability to distribute, for example, with plurals (Avrutin & Thornton, 1994), but it is not clear how and when this distinction is *lexically* linked to quantifiers. Thus, beyond the semantic concepts, there are lexical, and as we shall see, syntactic elements to be acquired.

Children's first uses of *every* occur in collective compounds like *everyone* and *everybody* (Roeper et al., 2006). Within the compound, as in (2a), a collective reading may be required, whereas outside the compound as in (2b), the collective reading is impossible.

- (2) a. Everybody surrounded the house.
- b. *Every person surrounded the house.

In addition to the semantic distinction between collective and distributive, several other distinctions are illustrated by the contrast of *every* and *each*, as in examples (3) to (5).

- (3) a. *Every* => Generic
 Does every cow have one tail => every cow in the world
- b. *Each* => Specific
 Does each cow have one tail => presupposes a defined set

and only *each* allows a partitive:

- (4) a. each of the boys
- b. *every of the boys

Furthermore, *each* can float, but *every* cannot. By "floating" we mean that the quantifier is not tied to one location in the sentence, but can occur elsewhere (Bobaljik, 1998), as in (5a and 5b), or even be copied as in (5c), with no change in meaning.

- (5) a. All the children are here
 b. The children are all here
 c. All the children are all here

Moreover, floating applies generally to all quantifiers that can appear outside the DP, but it is lexically specific. It does not apply to *every* in English (6b), but it does apply to *jeder* in German (6c), indicating that the properties are not universal, but must be learned within the context of specific languages:

- (6) a. Every boy is here
 b. *the boys are every here
 c. Die Kinder singt jeder allein [‘the children sing every alone’]

Floating does not entirely constrain scope assignment, which remains somewhat ambiguous. For adults, the floated element typically has scope over the object, imposing 1-to-1 distributivity as can be seen in the contrast in (7).

- (7) a. Each of the children has one angle on the view
 b. The children have one angle each on the view

In (7a), several children could share one angle, but in (7b), there is one angle for each child. The scope of the quantifier in the typical *every*, or *each* sentence is ambiguous for a child and may be subject to various interpretations. For example, the child’s quantifier often applies entirely to the second NP, or can be applied to both, as we will see in the discursive examples below in 2.6.4.

These facts involving scope, plus the semantic diversity of the other quantifiers that undergo spreading, like *most* and *some*, suggest that a semantic approach alone will not capture all of the facts.

1.2 Semantic Approaches

A prominent semantic approach, Weak Quantification, for example, has been followed to explain the transfer of scope from the subject NP to the object NP. It proceeds from the well-known semantic phenomenon in which weak quantifiers (those that do not presuppose a defined domain, such as *many*) in subject position are allowed to apply to objects as in (8):

- (8) Many Scandinavians won the Nobel Prize
 => many Nobel Prize winners are Scandinavian (Drozd, 2001)

This is contrasted with strong quantifiers, which obey conservativity for adults, such that the Q applies only to the NP and requires the truth of the VP. Hence Weak Quantifiers (*many*) involve Context variable *c* (an unfixed context) and a formula (in Smits, 2011):

(9) $\text{many}^3(A)(B) = \text{many}^3(A)(A \cap B)$ where $|A \cap B| > c \cdot |B|$

A = set of Scandinavians, B = set of Nobel prizes and c = set of contextually relevant Scandinavians. In other words, it is pragmatically conditioned on how the speaker fixes the relevant context.

Smits (2011) directly investigated how children determine the relevant sets and found that children ages 4 to 7 years preferred the strong reading for *many* (with a fixed set readingxx) but they allowed the weak reading as well for examples like (10):

- (10) 5/20 parrots are wearing hats
- a. Are many parrots are wearing hats?
 - b. Are many hat-wearers parrots?

Under the Strong reading, the answer to (10a) is “no”—most parrots are not wearing hats. But if it is read as (10b), then it is true, and the relevant set is hat-wearers and not parrots. It is conceivable that the child begins without the assumption of a fixed specific set and therefore the Weak reading should be more available until they realize that the interpretation depends on how they fix the set.

1.4 Syntactic approaches

In general, semantic accounts of spreading, such as Event Quantification (Philip, 1995) and Weak Quantification (Drozd, 2001; Guerts, 2003), have utilized a non-syntactic LF representation to capture the child’s meaning. Looking more to syntax, Roeper and de Villiers (1991) proposed that the quantifier behaves like an adverb which can move through a clause and appear in many positions, although with subtle scope effects, as Cinque (1999) has shown. This would be similar to a quantifier like *only* which can apply either to NPs, as in (11a) or clauses (11b):

- (11) John needs to go. Only he needs a snack.
- a. [IP [only HE] needs a snack.
 - b. Only [IP he needs a snack]

If children first adjoin high, as proposed by Lebeaux (2000) and Potts (2003) among others, then it is not unnatural that the child could project *every* as a sentence-level adverb as well. The child must then re-analyze the quantifier as applying to the NP only and as limited to NP scope.

Roeper, Strauss, and Pearson (2006) make a more refined syntactic proposal based on syntactic studies of focus in Hungarian by Kang (1999), where quantifiers can be lifted out of NPs to a higher focus node where it c-commands an entire clause, as in the tree in Figure 3.

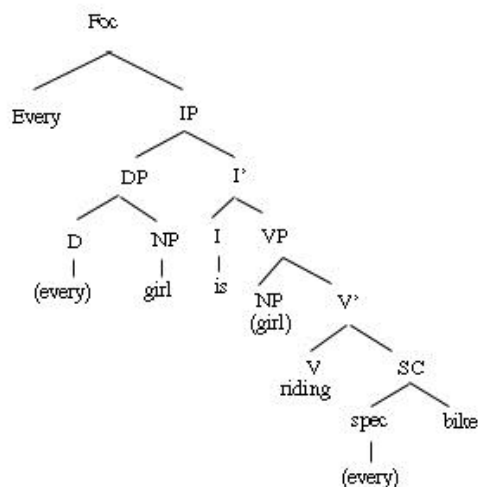


Figure 3. Quantifier as a higher Operator as argued for Hungarian (see Kang,1999; Brody, 1990).

In English, the *every*, like *only*, could attach inside the DP or higher up. We argue that the child first attaches it high and then later learns to put it lower. In the higher position it can function as an Operator which c-commands the second NP. The first stage is identical to quantification in Hungarian. A syntactic misanalysis that involves high attachment could allow floating, which in turn could have diverse semantic consequences.

Our general hypothesis is that every syntactic, semantic, and pragmatic feature will have an impact on the acquisition path. Some may be linked and acquired in concert---following the deeper notion of parametric links---and careful work should reveal what they are.

2. Experimental Explorations

2.1 Objectives

Separating distributivity and exhaustivity. Since experiments on spreading like the one in Figure 1 entail both exhaustivity and distributivity, the two concepts are not distinguishable. The experiments do not reveal whether children seek to satisfy distributivity, or exhaustivity, or are targeting both properties. In this experiment, we separated distributivity and exhaustivity in spreading examples as follows. Three picture choices of vases and flowers were presented (adapted from Brooks et al., 2001):

A



B



C



Figure 4. Stimuli for *every* and *each*

A and B both invite spreading with empty vases, but differ on distributivity. C has no opportunity for spreading, and its distributivity is not individual-by-individual, (although it can be construed as “partial distributivity” [Lima, 2010]). Thus, there were three conceptual options:

- 1-1 Distributive/ NOT exhaustive
- Exhaustive/ NOT 1-1 distributive
- Collective (not distributive)/ NOT exhaustive

Crucially, no scene satisfied both spreading and distributivity, (although that condition was tested separately). Sentence prompts tested *each* as well to push the child more toward distributivity (Tunstall, 1998) with a quantifier less fixed within its NP that would permit floating.

Eliciting spreading in the children’s own words. We proposed an experimental protocol that allowed children to describe the prompts at greater length than is typical and so they could produce sentences spontaneously that might show the ambiguous scope of the quantifiers in their grammars, in particular, the movement of *every* out of the first NP in the surface structure.

2.2. Hypothesis/ predictions

In the current experiment, we predicted 1) that children would give evidence of incomplete lexical learning, to the extent that *each* and *every* would not be distinguished and would have the same semantic properties for them; 2) that *exhaustivity*, the more general property would be more prominent for the children than *distributivity*, whose subtle properties make it harder to learn; 3) that children would adjoin the quantifier high where, as an Operator in the CP, it could c-command the whole sentence, and therefore allow a “floated” interpretation on the object noun; and 4) there would be no strong age effect, but exhaustivity would diminish among the older children, and distributivity would be more salient to older children than younger children.

2.3 Participants

Participants were 38 children, ages 5;4 to 9;4 in kindergarten through third grade in a middle to lower middle-class school in western Massachusetts. Forty native English-speaking adults (3/4 from the U.S.; ¼ from the U.K. and Canada) provided a baseline for response patterns to the prompts used.

Table 1. Participant ages

Age in years	5	6	7	8	9	20+
N =	2	10	12	10	4	40

(For the statistical analyses, the 5- and 6-year-olds were combined, as well as the 8- and 9-year-olds.)

2.4 Materials

The prompt for this analysis was embedded in a larger sequence of questions testing aspects of quantifier interpretation in several everyday contexts and in mathematics word problems: a 22-slide powerpoint for the children, and a 39-item web survey for the adults¹. The actual display was from Brooks et al. (2001), which depicts the alternatives shown in Figure 4.

2.5 Procedures

Children were questioned individually in a quiet room in their school. They were shown the display as in Figure 4 and asked which picture or pictures matched the sentences, “Every flower is in a vase” and “Each flower is in a vase,” in that order. They were told explicitly that they could point to zero, one, two, or three pictures. If they pointed to just one picture, that was considered their best response and they were then asked if any of the others could also “be okay.” If they picked out more than one picture, they were asked which one was best. Following either question, they were asked “Why?” or “Why not?” Responses were written down by a second examiner and video-recorded for later confirmation.

The experiment explicitly pursues preferences and explanations as important indicators of interpretations.

2.6 Results

2.6.1 Adult baseline

Table 2. Percentage of people who gave responses of each type.

	<i>Every</i> (flower)	<i>Each</i> (flower)
All ok	94%	17%
Prefers A	21%	--
Prefers B	36%	90%
Prefers C	8%	--
Only B	--	20%

¹ The web survey is available at http://www.kwiksurveys.com/online-survey.php?surveyID=OIHKG_7f21b1b7 (accessed 1/25/2011)

2.6.2 Children's responses

Figures 5 and 6 show the percent of children with each response, compared to the adult baseline.

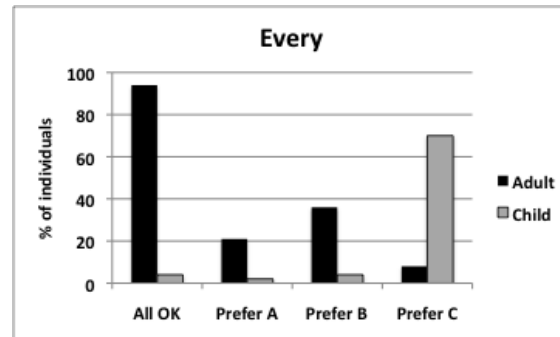


Figure 5. Children's *Every* (with adult as reference)

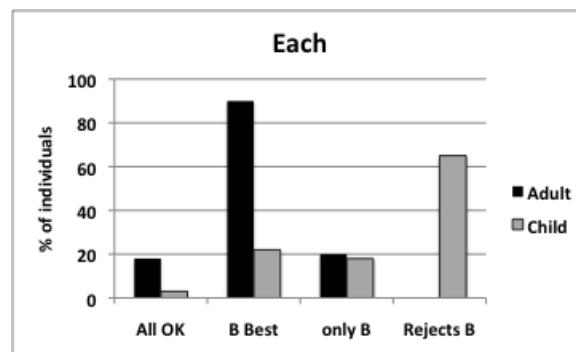


Figure 6. Children's *Each* (with adult as reference)

Not shown in the chart, children chose the "best" responses for *each* relatively equally: A, B, and C, 24%, 26%, and 32%, respectively.

Summary of differences. Thus, the strongest adult-child differences for *every* stemmed from the level of acceptance of all pictures: almost all adults accepted all and almost no children did. C was the clear favorite for the children, but it was not a preference and was even slightly dispreferred by the adults. For *each*, adults clearly preferred B, whereas over 60% of children specifically rejected B for it. Although many adults found A and C acceptable for *each*, no adult chose either of them as best; for children both A and C were strong choices, but not disproportionately so.

Adults showed clearly different preferences for *every* and *each*. By contrast, 15 (40%) of the children treated *each* and *every* the same. When asked

“why?” after the *each* questions, several said “I just told you,” referring to their answer for *every*.

2.6.3 Age patterns in children’s responses

There was no age effect for target interpretations of either quantifier ($F[2,35] \leq 1$, n.s., $\eta^2 = .08$, for both) but exhaustive answers declined significantly overall ($F[2, 34] = 3.3$, $p = .05$, $\eta^2 = .16$). Post hoc tests showed that only the difference between age 7 and age 8 was significant ($p = 0.02$). Ten children (26%) showed at least a rudimentary sensitivity to distributivity, 17% of 6- and 7-year-olds and 43% of 8-year-olds, but the age difference did not reach significance, $\chi^2(2, N = 38) = 3.1$, $p = .21$.

2.6.4 Discursive responses

The discursive responses to the “why” questions gave further, more direct evidence of the children’s interpretations of the quantifiers.

2.6.4.1 Responses showing adult interpretations (ages in parentheses)

Focus on flowers. Four children (two 5-year-olds and two 8-year-olds) gave adult interpretations for *every* to the extent that the justifications for their answers focused on the first NP, flowers, not the vases.

“All the flowers have vases that they’re in” (5;4) or

“There are empty vases, but where there are flowers, they are in a vase” (8;1).

Articulating sensitivity to the configuration of flowers for each. Three of the four “*every*-knowers” also gave somewhat adult interpretations for *each* in their rejection of A for *each*. Their explanations showed an awareness of its distributive requirement, such as saying that *each* couldn’t have “all in one vase” (6;5). Another child (8;1) explained that “[B is better] because it’s spread out.” The fourth *every*-knower also responded that *each* is better “when it has [only] one flower,” but then described the picture inaccurately. Six other children (ages 6;5; to 9;0) preferred B and also articulated an awareness of whether the flowers were distributed or not.

2.6.4.2 Responses showing non-adult interpretations (exhaustivity and quantifier floating.)

The most striking result is that the questions elicited spontaneous productions of the floated quantifier (applying to a second NP).

Responses focusing on vases, not flowers (and then rejecting the alternatives that were not exhaustive with respect to vases). X of Y children explained their choices explicitly in terms of empty vases.

- * “[C, It’s] the only one where vases are filled with flowers” (8;0)
- * “these two vases don’t have flowers” (6;2) (6;5)
- * “not A or B, no flowers in those two vases” (7;8)
- * “no, the others have empty vases” (6;11) (7;4) (8;4)
- * “no, because some of the vases are empty” (7;9)
- * “not A, [it has] only one filled vase” (8;2)

Floating a quantifier to vases

- * “all vases are full” (8)
- * “flowers in all [vases]” (7;9)
- * “could be C, if there was just one flower in each, in all the vases” (7;1)
- * “these two vases don’t have flowers” (6;2)
- * “not A or B, no flowers in those two vases” (7;8)
- * “Each flower has its own vase” (xx)
- * “No, they don’t have flowers in all vases.” (9)

Floating every and/or each to vases.

- * “[C], it’s the only one with flowers in every vase.” (9;4)
- * “Not B, there’s just one in each [vase]” (6;1)
- * (for every flower in a vase), “could be 1 flower in each vase” (9)
- * “one [flower] in each [vase]” (8;1)

Copying the quantifier in the second NP

- * “looks like each flower is in each vase” (8;0)

Not associating distributivity with each. Two 9-year-olds showed they were paying attention to the distributive configuration, but they did not associate it with *each*. That is, they preferred A for *each* because in B and C “[the flowers] weren’t all in the same vase.” (which to them would have been preferable). One 7-year-old appealed to configuration to explain his choice of C for *every*: “only C, [because] all in same is wrong and 1 in 1 is wrong.”

3 Discussion

A primary finding in this analysis is that children—unlike the adults—preferred exhaustivity as a defining feature for both *every* and *each*, as we predicted. Thus they appear to identify this property first as a lexical property of these quantifiers. The distributive property, though recognized elsewhere, is not yet projected as a lexical feature. This is not surprising. Many semantic notions appear in syntactic environments before they are represented lexically or on all relevant lexical items. For example, notions of time may be found in tense phrases, nouns (such as *noon*), prepositions and conjunctions (*before*, *after*), and adjectives (*late*) without a necessary order of triggering (Roeper, 2007).

3.1 Acquisition Theory

3.1.1 Proposed developmental sequence

These results are consistent with the syntactic account provided by Roeper et al. (2006) where a quantifier is initially projected as an Operator and is overgeneralized, an explanation that converges with many other traditional observations in acquisition. Syntactic overgeneralizations may produce negative concord “I don’t want none” and tense concord: “did lifted” or “had came.” Lexical plurals (e.g. *feet* or *men*) overgeneralize and appear in forms like: “feetses.” In addition, extensive evidence shows that children allow plurals to spread (Roeper, 2007). In cases like (12), a “yes” answer would be captured if we assume that there is a plural Operator that allowed the plural to be a higher Operator:

(12) Does a dog have tails from: dogs have tails => plural [dog have tails]

Finally recent results on *wh*-forms (Schulz, 2010) show that children who allow pairing for double *wh*- (*who ate what*) immediately extend it to triple *wh*- as in *who gave what to whom* (Schulz, 2010). This, too, suggests that the Pairing property is linked to an Operator that will control every *wh*-word in its c-command domain.

3.1.2 How do children eliminate quantifier spreading?

If our representation is correct, it immediately raises the question of how children advance to the realization that, for instance *every* must be a Determiner within the Determiner Phrase with scope only over its NP. The option is, of course provided by UG, but we need triggering evidence that will block the higher Operator projection. One possibility is that the child grasps the impact of two quantifiers which is immediately incompatible with spreading, as in (13):

(13) Every dog has some bones.

The prediction is that if there is an extra bone, then the child will not say “not this bone.” If this perspective is on the right track, the child will simultaneously pragmatically grasp a situation, semantically grasp quantifier interaction, and syntactically block an Operator. Thus every step is an “interface” action. But this experiment remains to be done.

3.2 General conclusion

What emerges from our discussion is how intricate the interface for quantification is, engaging lexical, syntactic, and semantic phenomena, even before considering the extensive presence of implicatures in the comprehension of quantification. The acquisition path must reflect all of these threads. We

need, ultimately, to imagine every ingredient as a part of each stage, and then see how evidence will push the child forward.

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Add LeBeau and Potts??

Acknowledgments

* Some of the materials in the current experiment were assembled and piloted while Pearson was a visiting researcher at the Centre for Research on Bilingualism in Theory and Practice in Bangor, Wales.