Choosing quantity over quality: syntax guides interpretive preferences for novel superlatives

Alexis Wellwood (wellwood@umd.edu)  
Department of Linguistics  
1401 Marie Mount Hall  
College Park, MD 20742 USA

Justin Halberda (halberda@jhu.edu)  
Department of Psychological and Brain Sciences  
3400 N. Charles Street  
Baltimore, MD 21218 USA

Abstract

Acquiring the correct meanings of number words (e.g., seven, forty-two) is challenging, as such words fail to describe salient properties of individuals or objects in their environment, referring rather to properties of sets of such objects or individuals. Understanding how children succeed in this task requires a precise understanding not only of the kinds of data children have available to them, but also of the character of the biases and expectations that they bring to the learning task. Previous research has revealed a critical role for language itself in how children acquire number word meanings, however attempts to pinpoint precisely the strong linguistic cues has proved challenging. We propose a novel “syntactic bootstrapping” hypothesis in which categorizing a novel word as a determiner leads to quantity-based interpretations. The results of a word learning task with 4 year olds indicates that this hypothesis is on the right track.

Keywords: Number, quantity, language acquisition, learning, determiners, adjectives, quantifiers, syntax.

Words for quantities

While it is uncontroversial that young children necessarily make use linguistic and extralinguistic information when they set about learning the meaning of novel words, the idea that some pairing of “situation and sound” is sufficient has been repeatedly questioned (e.g., Landau & Gleitman 1985, Waxman & Lidz 2006). An especially difficult problem for any view that posits a simple mapping from a portion of experience to the meaning of a novel word has been the acquisition of number words (e.g., five, sixty-seven). This is particularly challenging as numbers refer to properties of sets of objects rather than to properties of any object in particular (Frege 1893; Bloom & Wynn 1997). Understanding how number words are learned must be informed not only by a precise understanding of the kinds of data children have available to them, but also of the character of the biases and expectations they bring to the learning task.

In this paper, we consider the question of how children decide that a novel word describes numerosity and not some other salient property. To take a simplified example of the problem, consider the novel word gleeb in (1).

(1) The gleeb cows are by the barn.

The novel word gleeb appearing in an adjectival position may describe any number of properties relevant to the cows, for instance their color (e.g., they may be blue), texture (e.g., especially soft), size (e.g., for cows, quite big), or even their number (e.g., approximately many, or exactly seven). Under what circumstances would a child prefer to assume that number is the intended property? Finding such circumstances would aid researchers in finding the unique biases and expectations children must bring to the task in order to accurately acquire number words.

Research on the acquisition of exact number words suggests that language itself must provide critical support for the child to map new words onto such abstract meanings. Wynn (1992; see also Condy & Spelke 2008) found that children at 2:6, who do not yet understand the relationship between the words in the count list and exact cardinalities, nevertheless understand that the number words describe numerosities. This result is striking, as it takes children another full year to gain the knowledge that which exact quantities are intended (Wynn 1992, Carey 2009). Bloom and Wynn (1997) examined the distribution of the numerals in the CHILDES database of child-directed speech to determine what syntactic cues might prompt quantity-based interpretations. They proposed that the appearance of an item in the partitive frame (e.g., as X of the cows) was a strong cue to number word meaning. The plausibility of such a view is bolstered by the linguistics literature: partitivity has been said to signal to the semantic role of quantification (Jackendoff 1977).

This proposal was recently investigated by Syrett, Musolino and Gelman (2012). Conducting their own corpus study, they pointed out that a great variety of non-quantity-referring expressions occur in the partitive frame (2), so perhaps we should not expect it to be a strong cue to numerical meanings.

(2) a. Amount: all, two, seven, most, some  
b. Segment: back, front, edge, side, top  
c. Measure: mile, hour, pound, bucket

Regardless, if the partitive were a strong cue, then a novel word embedded in the partitive should lead children to pick a quantity-based interpretation even when the environment supports both this and an alternative interpretation. That is, in a novel word learning task, the novel word pim appearing with
the partitive (as in *pim of the trains*) should be analyzed as
referring to the quantity TWO but not the quality RED\(^1\) when both interpretations were supported. Syrett et al found that
the partitive predicted quantity-based judgments only in re-
stricted cases,\(^2\) casting doubt on the robustness of a “syntactic
bootstrapping” account based on the partitive as a strong cue.

The puzzle raised by Wynn’s (1992) original finding re-
mains. Indeed, it appears to raise the question whether it may
be necessary to understand how children decide that novel
words describe quantities at all before we can understand
how they learn the meanings of words for exact numerosity
(see also Barner, Chow & Yang 2009 for discussion). The
numerals pattern with a larger class of expressions in natu-
ral language called *quantifiers* (i.e., the Amount terms in (2)),
which share a similar syntactic distribution. If a child could
figure out (as Bloom & Wynn suggested) that a certain bit of
syntax corresponded in a stable fashion with the semantics
of quantity, they might have a foothold on deciding a novel
word referred to numerosity. To get a sense of the problem,
consider the sentences in (3a) and (3b) with the novel word
gleebest against the image in Figure 1.

(3) a. The gleebest cows are by the barn.
b. Gleebest of the cows are by the barn.

For adults, gleebest in (3a) could in principle describe some-
thing about the numerosity or some other property of the cows
by the barn in contrast to those in the field. Indeed, the mean-
ing one perceives is similar to that conveyed either by the
familiar most or e.g. spottiest. However, if adults were ex-
posed to the novel word in the syntactic context given in (3b),
they would never suppose it to designate something about the
spottiness of the cows by the barn, only their numerosity.

Adults, however, have had a lifetime of language experi-
ence. Under what conditions would a child still in the process
of mastering their native tongue hypothesize that gleebest
means most as opposed to spottiest? Would their pat-
tern of preferences be the same if presented with either of the
sentences in (3a) or (3b)?

While the evidence for the partitive frame (...of the cows)
as a strong cue to quantity-based meanings is mixed, we think
pairs of sentences like the above suggest that a stronger cue
might be whether something occurs to the left of X. Of the
classes of counterexamples provided by Syrett et al given in
(2), we may note that only amount terms can appear without
a determiner (a or the) on the left:

(4) a. Two/most of the cows lowed.
b. * Back/side of the fridge is blue.
c. * Mile/hour of the race was hard.

\(^1\)We follow custom in using italics for linguistic expressions and
small caps as shorthand for their meanings.

\(^2\)Only when it was used at test; when the partitive was used dur-
ing training but not at test, children were at chance at picking the
quantity interpretation.

Figure 1: The gleebest cows are by the barn.

Such data illustrate an important linguistic generalization.
Amount terms, or quantifiers, can occur in a privileged syn-
tactic position (e.g., Barwise & Cooper 1981): that of de-
terminers, instantiating the category D. Unlike the partitive
frame, Ds have a stable syntax-semantics mapping: their in-
terpretation only references quantities, never qualities, of in-
dividuals (van Benthem 1989, Gajewski 2002).\(^3\) Observing
this pattern leads us to a novel hypothesis: if a child cate-
gorizes a novel word as D, she will understand that word to have a
quantity- rather than quality-based meaning.

A test of this would be to make both numerosity and spot-
tiness salient, and test children’s preferences for interpreting
a novel word across syntactic contexts. To construct such a
test, we turn to superlatives. As we will see, superlatives (the
result of combining a word like heavy with the morpheme
-*est*) allow for a direct comparison of the hypothesis that syn-
tactic category, and not partitivity, is a strong cue to positing
quantity-based meanings.

Combining a word with a quality-based meaning like heavy
with the morpheme -est allows the formation of expressions
like the heaviest animals, with a meaning like THE ANIMALS
THAT ARE HEAVIER THAN ANY OTHERS. Similarly, com-
bining many with -est\(^4\) gives the most animals, with a mean-
ing like THE ANIMALS THAT ARE MORE NUMEROUS THAN
ANY OTHERS. Importantly for our purposes, both of these
types of superlatives surface in the position of an adjective
(5a) where the instantiates the syntactic category D), but only
the quantity-based superlative most can appear bare on its left,
instantiating D (contrast (5b) with (5c):

(5) a. The heaviest/most animals are happy.
b. Most of the animals are happy.
c. * Heaviest of the animals are happy.

\(^3\)As a simple rule to determine which word in a string is D, take
X in X of the cows to be D unless the precedes X. Since the cannot
appear without an element to its right before of (cp. *the of the
cows), it instantiates D whenever it is present. In the most cows, the
instantiates D, but most instantiates D in most of the cows.

\(^4\)It is widely assumed that most is the superlative of many,
following Bresnan 1973; cf. Bobaljik 2007 who argues most is
more+*est.
This restriction can’t be conceptual: where we understand the sentence in (5b) to mean MORE THAN HALF OF THE ANIMALS BY NUMBER ARE HAPPY, by analogy we might have expected (5c) to mean MORE THAN HALF OF THE ANIMALS BY WEIGHT ARE HAPPY. To see what this would mean, consider a situation in which the only animals are a cow C, a lamb L, and a rabbit R. It is clear that (5b) is true if any two of the animals are happy. But (5c) requires more information: if C weighs 700kg, L weighs 35kg, and R weighs 8kg, we would know (5c) is true only if C is happy. Individuals and their particular properties matter for quality-based superlatives, where only set cardinality matters for most. While it is clear that no conceptual necessity rules out a determiner-like meaning for a quality-based adjective, why it is excluded remains a mystery.

Lastly, regardless of whether they have quantity- or quality-based meanings, superlatives can appear in the partitive frame:

(6) a. * The spotty of the cows were by the barn.
    b. * The many of the cows were by the barn.
    c. The spottiest of the cows were by the barn.
    d. The most of the cows were by the barn.

In the next section, we put our hypothesis that syntactic category cues category meanings to the test in a novel word learning task. At the same time, we contrast this hypothesis with that suggesting partitivity as a strong cue.

Testing superlatives

In the previous section, we hypothesized that representing a novel word as an instance of the category D was a strong cue to the learner that the word should be assigned a quantity-based meaning. An alternative was presented that suggested presence of the partitive frame alone was a strong cue. We test these ideas by examining children’s preferences when embedding gleepest in a variety of syntactic contexts, using a variant of the Picky Puppet task (Waxman & Gelman 1986).

Method

In this task, the experimenter first explains that the game is to sort cards according to whether a puppet likes them or not. The puppet is described as picky, but friendly enough to share the reasons for why he likes what he does. The experimenter explains the puppet’s criterion by showing preferred and dispreferred cards along with the sentence: “The puppet said he likes the cards where target sentence, but he doesn’t like the ones where it’s not true that target sentence”. The target sentence always contained the novel word gleepest (see Table 1). The experimenter explains that she doesn’t know what gleepest means, but was hoping the child could help her figure it out. In the Training phase, the child is shown 6 training cards (Figure 2), the ones the puppet had “already told” the experimenter it liked or didn’t like.

Table 1: Target sentences: “The puppet likes the cards where DP are by the barn.”

<table>
<thead>
<tr>
<th>cond</th>
<th>DP</th>
<th>the</th>
<th>partitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADJ</td>
<td>the gleepest cows</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>CON</td>
<td>the gleepest of the cows</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>DET</td>
<td>gleepest of the cows</td>
<td>×</td>
<td>✓</td>
</tr>
</tbody>
</table>

While the training cards are perfectly ambiguous (the group by the barn is both the most numerous and the most spotty), the test cards are perfectly unambiguous. The same cards (in counterbalanced order) were presented to each participant. The form of the target sentence was our between-subjects factor, with gleepest appearing in adjectival (ADJ), confounded (CON), and determiner (DET) positions, so our conditions feature different combinations of presence/absence of the and the partitive, as schematized in Table 1.

5This is especially surprising, given recent proposals in the formal semantics literature that nothing much semantically distinguishes most from spottiest (Hackl 2009). Yet, it is difficult to see how appeal to numerosity would be possible in formulating a syntactic constraint to make sense of facts like (5b)-(5c).

6For our test cards, the ratio of the numerosities of the cows was inversely proportional to the ratio of the spots of the cows.
At the beginning of the Test phase, the experimenter handed each test card to the child with the question “Do you think he likes this one?”. The child was to place each card below a green circle with a checkmark on it if the puppet likes it, and below a red circle with a black X if he doesn’t like it. At the end of the experiment, the child was probed as to what s/he thought *gleebest* meant, and responses were recorded.

We hypothesized that categorizing a novel word as *D* restricts a child’s hypothesis about the word’s meaning to a quantity-based interpretation. Another proposal was that the presence of the partitive frame itself was a strong cue to such interpretations. Thus the relevant hypotheses are schematized in Table 2 according to whether they predict a greater-than-chance quantity-based response (indicated by +).

Table 2: Predicted neutral (−) versus increased quantity-based responses (+).

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>ADJ</th>
<th>CON</th>
<th>DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category as strong cue</td>
<td>−</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Partitive as a strong cue</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>No bootstrapping</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
</tbody>
</table>

36 children participated (range 4;0-5;2, mean 4;7), recruited from families in the University of Maryland area. Each child was given a small gift for participating. Four additional children were tested and subsequently excluded—2 due to experimenter error, 1 due to presenting with a strong “yes” bias (i.e., the participant indicated the puppet “liked” 11/12 of the test cards), and 1 due to a strong “no”-bias (i.e., they said the puppet “didn’t like” 12/12 of the test cards). We measured the percentage of cards sorted consistent with a quantity-based interpretation.

**Results**

Across our three conditions, responses were significantly different from chance (sign tests: ADJ $p < 0.0001$, CON $p < 0.05$, DET $p < 0.0001$). These differences were in different directions, however. Children sorted cards consistent with a quantity-based interpretation in DET 72% of the time, compared to 29% in ADJ and 40% in CON. In addition, DET was significantly different from both ADJ (t-test, $p < 0.0001$) and CON (t-test, $p < 0.0001$). These results are presented graphically in Figure 4.

It is noteworthy that these results are not simply an averaging effect: 8 out of 12 of the children in DET sorted at least 9 out of 12 test cards consistent with a quantity-based interpretation, while only 2 out of 12 children did so in ADJ and 3 out of 12 in AMB.

![Figure 4: Percent quantity responses by condition.](image)
As there were no differences between our conditions except for the syntactic context in which gleebest occurred, these results support the idea that syntax cues children into quantity-based meanings, with syntactic category playing a strong role. Partitivity, on the other hand, is a fairly weak cue: while there was a slight effect (CON had slightly higher quantity-based responses than ADJ, $p < 0.05$), in neither of these conditions did children sort cards consistent with a quantity-based interpretation, in fact both conditions displayed lower than chance sorting of cards consistent with that interpretation. A table summarizing the predicted versus actual results is given in Table 3.

Table 3: Predicted neutral (+) versus increased quantity response (+): prediction met (✓) versus not (×).

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>ADJ</th>
<th>CON</th>
<th>DET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category as strong cue</td>
<td>−</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Partitive as strong cue</td>
<td>−</td>
<td>✓</td>
<td>×</td>
</tr>
<tr>
<td>No bootstrapping</td>
<td>−</td>
<td>✓</td>
<td>−</td>
</tr>
</tbody>
</table>

Of the three hypotheses sketched, only syntactic category as a strong cue captures the results we found.

**Discussion**

Our results show that a syntactic bootstrapping hypothesis for acquiring novel superlatives is supported. An additional hypothesis, that the presence of the partitive frame is a strong cue to quantity-meanings, was not supported. These results are important for a number of reasons. As observed in the introduction, choosing number as the relevant property from a set of available properties is potentially challenging for children. Our results highlight the role of the child’s syntactic representations in narrowing her hypotheses about what matters when she tries to determine the meaning of a novel word, in particular the role of the syntactic category D as a strong cue to quantity-based meanings.

A different but related question that this work raises is the strength of the bias towards quality-based meanings in ADJ and CON. Given that children had no problem deciding that gleebest referred to numerosity in DET, we cannot assume some inability to reason about number. One might speculate that the bias is due to the child’s distribution of known adjective (or superlative) meanings: since many more words in this category refer to object properties than set properties, the prior distribution of meanings biases her towards the former, absent syntactic cues to the contrary. Future work with younger children could examine the degree to which this bias emerges as a function of the size of their lexicons. The line of thought just outlined predicts that the youngest children would show less of a bias in this direction.

**Acknowledgments**

This work was made possible by generous support from a Social Sciences and Humanities Research Council of Canada doctoral award (#752-2010-0499) to Alexis Wellwood. The authors would especially like to thank Tim Hunter, Research Assistants Leah Whitehill and Jessica Lee, the University of Maryland’s infant and preschool labs, the Center for Young Children, and the audience at the Linguistic Society of America’s 2012 annual meeting.

**References**


