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30-month-olds use the distribution and meaning of adverbs to interpret novel adjectives

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ABSTRACT

We examine the acquisition of subcategories of Gradable Adjectives (GAs). We first show that robust patterns of adverbial modification in natural language sort GAs according to scalar structure: proportional modifiers (e.g., completely) tend to modify absolute maximum standard GAs (e.g., full), while intensifiers (e.g., very) tend to modify relative GAs (e.g., big). We then show in a word-learning experiment that 30-month-olds appear to be aware of such distributional differences and recruit them in word learning, assigning an interpretation to a novel adjective based on its modifier. We argue that children track both the range of adjectives modified by a given adverb and the range of adverbs modifying a given adjective, and use such surface-level information to classify new words according to possible pre-existing semantic representations.
1. Introduction: Adjectives in Word Learning

A central challenge of word learning, classically presented by Quine (1960), is the following: given a word produced in a discourse context, there are simply too many possible interpretations available for the young word learner to enable them to home in on one in particular. Thus, other sources of information must be available to guide word learning. One such information source resides in a word’s syntactic context. (See Woodward (2000) for a review of other possible sources.) Because different syntactic contexts are associated with different semantic features, learners can narrow down the space of possible word meanings by restricting the meaning to those that fit with the syntactic context. The usefulness of syntactic context has been appealed to in many accounts of noun, adjective and verb learning (e.g., Brown, 1957; Fisher, 2002; Gleitman, 1990; Katz, Baker, & Macnamara, 1974; Landau & Gleitman, 1985; Naigles, 1990; Booth & Waxman 2003; Hall, 1994; Waxman & Booth, 2001; see Waxman and Lidz 2006 for a review). In this paper, we examine the role of the syntactic context in the acquisition of gradable adjectives, such as *big* and *full* – and more specifically, subcategories of these adjectives. To do this, we must first identify the relevant subcategories, the linguistic motivation and diagnostics for them, and the way in which distributional patterns in the syntax highlight differences among these subcategories.

Although in the child language literature, adjectives are typically talked about as referring to ‘object properties’, in contrast to nouns, which are said to refer to ‘object kinds’, this differentiation does not capture the full range of adjective meanings that a child must acquire. Some adjectives, such as *herbivorous, wooden*, and *six-legged*, can be treated this way. When combined with a noun the referent of the resulting phrase is found in the intersection of the set of things bearing the adjectival property with the set of things bearing the nominal property (Clark,
1970; Kamp, 1975; Montague, 1974; Parsons, 1972). For example, a ‘herbivorous mammal’ stands at the intersection of things that are herbivorous and things that are mammals. However, not all adjectives denote properties that are all-or-none. Gradable adjectives, for example, allow for objects to possess varying degrees of the relevant property.

Gradable adjectives (GAs) are distinguished from non-gradable adjectives by their ability to appear in comparative constructions, as illustrated in (1-2).

1. a. How expensive was Boston’s Big Dig?
   b. The Big Dig was more expensive than officials had anticipated.

2. a. #How extinct/herbivorous is the diplodocus?
   b. #The diplodocus is more extinct/herbivorous than the mammoth.

This contrast follows from the difference in meaning associated with gradable vs. non-gradable adjectives. Non-gradable adjectives such as extinct or herbivorous predicate a property of an individual. In contrast, GAs such as big or expensive measure the degree to which an entity possesses a property (e.g., SIZE, PRICE etc.). One way to think of this difference is that with GAs, the relevant question is not necessarily, Does the object have the property? but rather To what extent does the object have the property?

Because reference to degrees is encoded in the meaning of GAs, even in the non-comparative, or positive, form (i.e., big, vs. bigger, tall vs. taller, and so on), GAs are always implicitly comparative. Taking as an example the GA big and the scale in (3), let us say that we are comparing the size of entities. The standard size for what counts as big in that context is represented by (s), while (x) represents the degree to which x is big. In this scenario, the sentence x is big is true, because (x) exceeds (s). If instead the degree to which x is big were represented...
by (x'), then the sentence x is big would be false, since (x') does not exceed (s).¹

3.  

![Diagram: (x') (s) (x)]

2. **The Semantics of Gradable Adjectives**

Our interest is not so much on the non-gradable versus gradable distinction, but rather on a distinction within gradable adjectives. GAs fall into two subcategories. One subcategory of gradable adjectives, *relative GAs*, require reference to a comparison class (cf. Bartsch & Vennemann, 1972a; Klein, 1980; Rusiecki, 1985; Siegel, 1979; Unger, 1975). For example, it is not possible to say whether something is *big* until we know about its set membership (i.e., what counts as *big* for a mouse is not what counts as *big* for an elephant). This has implications for the truth value of the sentence in which such adjectives appear: holding Mickey’s size constant, the sentence *Mickey is big* might be **false** if Mickey is an elephant, or **true** if Mickey is a mouse.²

In fact, one distributional feature of relative GAs is their ability to be followed by a *for an X phrase*, as in (4).

4. a. That is **expensive for a gallon of gas**.

b. #That dinosaur is **extinct for an animal**.

The other subcategory of gradable adjectives, *absolute GAs*, can also appear in comparative environments, as in (5), but do not depend on a comparison class for interpretation, as shown in (6). For example, you can compare degrees of a container’s fullness without

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¹ We leave aside discussions of vagueness and how the standard is set in a given context. See Syrett, Kennedy & Lidz (2010) for discussion.

² This comparison class can be provided by a variety of sources (e.g., the modified noun, the discourse context, etc.). See Kamp & Partee (1995) for further discussion.
reference to other containers.3

5. a. How full is the pitcher?

   b. The pitcher was fuller than I had anticipated (so I spilled water all over the table).

6. ??That is full for a pitcher.

   This difference between GAs such as big and full arises from differences in their scalar structure. Relative GAs such as big, which depend on a contextually-determined comparison class and standard of comparison, map objects onto an open-ended scale, such as the one in (3) above. In contrast, absolute maximum standard GAs (or maximal GAs) such as full, which do not depend on the context for the standard, map objects onto a scale that is closed at one or both ends, and the endpoint(s) serve(s) as the standard. For example, with full, the endpoint signals maximal fullness (or alternatively, zero degree of emptiness).

   Thus, GAs differ with respect to their scalar structure on two separate, but intimately related aspects: the presence or absence of scalar endpoints and the role of the endpoint or

3 While we refer to differences among GAs, we are actually discussing differences among possible interpretations, or readings, of these adjectives. Thus it is possible for a GA to have multiple interpretations, with a default or primary interpretation relative interpretation and a secondary absolute interpretation, or vice versa.
context in determining the standard of comparison. This difference is captured in (7).

7. a. relative GAs (open-ended scale) (e.g., big/small, old/young)
    b. maximal GAs (scale closed on one/both ends) (e.g., full/empty, clean/dirty)

Previous work has demonstrated that by three years of age, young children are aware of the role of the comparison class in the interpretation of relative GAs such as big (Barner & Snedeker, 2008; Ebeling & Gelman, 1988, 1994; Gelman & Ebeling, 1989; Smith, Cooney, & McCord, 1986) and are also aware of restrictions on the variable role of the context in the interpretation of different subcategories of GAs (Syrett, 2007; Syrett, Kennedy, & Lidz, 2010). In the current paper, we ask how preschoolers could have arrived at this knowledge and how children could know how to map a newly encountered GA onto the right representation. We propose that one strategy is for children to appeal to the linguistic environment in which a GA appears and take advantage of a strong correlation between surface-level distributional patterns and abstract meaning.

3. Form, Meaning, and Adverbial Modification

The distributional feature that we examine here is different patterns of adverbial modification.

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As we mentioned, GAs come in two varieties: relative and absolute GAs. We concentrate here on the contrast between relative GAs, which map objects onto open scales, and absolute maximum standard GAs, which map objects onto maximally closed scales, leaving aside absolute minimum standard GAs, such as dirty and wet. As we hint at in this discussion, maximal and minimal GAs go hand in hand, in referring to the absence or presence, of the relevant property, respectively. See Kennedy & McNally (2005) and Rotstein & Winter (2004) for further discussion.
Different GAs are modified by different adverbs. As (8) illustrates, proportional modifiers such as *almost*, *completely*, and *half* are able to modify some GAs, but not others.

8. a. The glass is *almost/completely/half* full.
   
b. #Her brother is *almost/completely/half* big.

This pattern can be contrasted with the one in (9), which illustrates that *intensifiers* such as *very* have a more widespread distribution.

9. a. The glass is *very* full.
   
b. Her brother is *very* big.

These patterns of modification fall out directly from the restrictions that these adverbs place on the scalar structure of the adjectives they modify. Proportional modifiers such as *half*, *almost*, and *completely* can only modify GAs that are able to supply a maximal scalar endpoint (Cruse, 1980; Paradis, 1997; Kennedy & McNally, 2005; Rotstein & Winter, 2004), whereas *intensifiers* such as *very* can modify any GA which allows for a relative interpretation, even if it is not relative by default (cf. footnote 3). Thus, surface patterns of modification are informative about underlying differences in the abstract semantic representation of these lexical items.

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5 Note that although our focus is on adjectives here, the same selectional restrictions will hold for any lexical item being modified, regardless of grammatical category, since the selectional restrictions are semantic, not syntactic. Thus, for example, no matter what *almost* modifies, it will require there to be an endpoint or boundary (e.g., *almost full, almost ran 5 miles, almost passed the bill, almost ate the entire cake*).

6 In fact, the rampant imprecision in language usage ensures that intensifiers modify adjectives that are not by default relative GAs more often than would be predicted by a strictly semantic account, even non-gradable adjectives (e.g., *very pregnant, very guilty*).
As noted in the introduction, discussions of similar form-meaning correspondences have played a central role in research in language acquisition, most prominently in discussions of syntactic bootstrapping in verb learning (Gleitman, 1990; Landau & Gleitman, 1985). There is by now considerable evidence that infants and young children recruit distributional information about sentence structure (i.e., the number and type – e.g., NP, PP, or S – of syntactic arguments and their position in the sentence with respect to the verb) to inform hypotheses about the semantic representation of a verb (Fisher, 2002; Naigles, 1990; Naigles, Fowler, & Helm, 1992; see also Wagner, 2006). This mapping from syntactic distribution to semantic interpretation is also well attested in other areas of word learning where young children demonstrate an awareness of the role of lower-level morphosyntactic information (e.g., presence and type of determiner, affixation encoding aspctual or grammatical category status) when assigning a novel word to a grammatical category (Bernal, Lidz, Millotte & Christophe, 2007; Booth & Waxman, 2003; Brown, 1957; Gelman & Markman, 1985; Hall, 1991, 1994; Hall & Graham, 1999; Hall & Moore, 1997; Hall, Waxman, & Hurwitz, 1993; Katz, Baker, & Macnamara, 1974; Taylor & Gelman, 1988). Such knowledge is language-specific, and there is evidence that the ability to correctly distinguish among these forms in English and recruit them in word extension tasks improves with age (cf. Soja, Carey, & Spelke, 1991; Waxman & Booth, 2001, *inter alia*), suggesting that from the outset, language learners are paying close attention to the distributional features of the input and the correlation between the distributional properties of a word and its meaning.

The contribution of the current study is twofold. First, we offer evidence that young children attend to patterns of adverbial modification (and the concomitant adverbial meanings) in order to partition the adjectival category into distinct subcategories. Second, this research weds
together two approaches – linguistic corpus analysis and word learning experimentation – to demonstrate (a) that robust distributional differences between categories are evident in natural speech, and (b) that children are sensitive to such distributional information at a very young age when learning new adjectives.

4. Corpus Analysis

A. Corpus and Searching Procedure

The purpose of the corpus search is to demonstrate that patterns of adverbial modification in natural language partition gradable adjectives (GAs) into two distinct subcategories – those with an open scale (which are more likely to be modified by intensifiers such as very), and those with a maximally closed scale (which are more likely to be modified by proportional modifiers such as completely). Having illustrated this pattern, we can then proceed with a set of language learning experiments relying upon such differences. The corpus of natural language we selected for analysis was the British National Corpus (BNC). The entire BNC has over 100 million words collected from spoken and written texts. We narrowed our search to the set of transcripts of
spoken language (approximately 10,365,000 words).\textsuperscript{7}

Using the Zurich BNCweb Query System, we targeted two sets of lexical items in our search. The first is a set of 10 adverbs, further divided into two sets: five proportional modifiers and five intensifiers. The second is a set of 10 adjectives, further divided into two sets: five maximal GAs and five relative GAs. The entire set of targeted items is presented in Table 1. In this search, we targeted canonical exemplars from each set of lexical items that are frequently cited in discussions of GAs in the semantics literature.

\begin{table}[h]
\centering
\caption{Targeted Lexical Items}
\begin{tabular}{|c|c|}
\hline
| Adverb | 5 Proportional Modifiers | 5 Intensifiers |
\hline
\end{tabular}
\end{table}

On the standard query page, with the corpus restricted to the spoken subset, we entered the lexical item (adverb or adjective) into the search field. Once the search results were displayed, we conducted a post-query ‘tag sequence search’ to gather collocations of adverbs and adjectives.

\textsuperscript{7} This approach to our corpus analysis allowed us to present baseline evidence for the targeted distinctions and perhaps at the same time capture distinctions that may be present in the exposure language. That is, whereas with a search of transcripts in the Child Language Data Exchange System (CHILDES) database (MacWhinney, 2000), we would need to be cautious about projecting from a caregiver’s child-directed speech to a larger speech sample, with the BNC, we are already searching over a more realistic speech sample. An additional consideration is that the CHILDES corpus is relatively small and contains relatively few instances of the adjectives and adverbs in question. To ensure that our corpus was a realistic estimate, we compared a portion of the CHILDES corpus with a comparably sized subset of the BNC. We found parallels in those corpora with respect to adjective and adverb distribution which warrants treating the BNC as a realistic sample of both speech in general and speech to children (see Syrett (2007) for details).
adjectives. For each adverb, we searched for adjectives in the positive (i.e., non-comparative) form (tagged as “AJO”) in the “+1” position (i.e., immediately after the adverb). For each adjective, we searched for adverbs (tagged as “AVO”) in the “-1” position (i.e., immediately before the adjective). This set of results was then downloaded and compiled in a Microsoft Excel workbook, and the lists were then reviewed and coded by hand by the first author and reviewed by at least two other linguists with a background in semantics.

Adverbs were coded as proportional modifiers or not (i.e., whether the adverb selects for a maximally closed scale) if the resulting phrase meant that possession of the property was almost achieved, that it applied without exception, or that it picked out proportions of coverage. Each adjective modified by one of the 10 target adverbs was coded as maximal (i.e., maximally closed) if it could be modified by 100% or almost (cf. Kennedy & McNally, 2005; Cruse, 1980; Rotstein & Winter, 2004), if the property corresponding to its antonym is absent in the adjective’s meaning (e.g., healthy, clean vs. sick, dirty), or if the adjective is by default non-gradable, but has a highly frequent alternative allowing for an imprecise interpretation (e.g., equal, identical).^8 Two main sets of analyses were then conducted on these results. In the first, we examined the distribution of adverb-adjective bigrams with a frequency greater than one, evaluating modificational patterns for adverbs and adjectives separately. In the second, we

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^8 Proportional modifiers included examples such as nearly, half, and spotlessly, to be contrasted with intensifiers such as fairly, quite, and really. Maximal adjectives included examples such as clear, new, separate, true, and universal, to be contrasted with non-maximal adjectives such as busy, good, horrible, recent, and sensible. Note that non-maximal adjectives include not only relative GAs, but all other adjectives that are not maximal GAs (i.e., minimal GAs and non-gradable adjectives).
calculated the conditional probability that each set of adverbs modifies an adjective with a maximally closed scale.

Given the discussion in §3, we make two predictions. First, proportional modifiers, which require a closed scale, will be more likely to appear with maximal GAs, which supply a scalar endpoint these adverbs require. (That is, we expect to see examples such as *completely full* more often than *completely big.*) Second, intensifiers, despite being able to modify a wide range of adjectives, will be more likely to appear with relative GAs, since these adjectives by default provide the open-ended scale these adverbs require. (That is, we expect to see examples such as *very big* more often than *very full.*) Finally, the same pattern should hold for GAs, for all of the same reasons: maximal GAs should be more likely to be modified by proportional modifiers than relative GAs are, and relative GAs should be more likely to be modified by intensifiers than maximal GAs are.

B. Results

**Distribution of Adverb-Adjective Bigrams**

The distribution of adverb-adjective bigrams demonstrates a clear split in adverbial modification and the scalar structure of adjectives, based on reference to scalar endpoints. An analysis of the adjectives appearing with the 10 target adverbs (see Table 2) reveals two trends. First, proportional modifiers are almost twice as likely to modify maximal GAs than non-maximal ones. And while maximal GAs are modified by both types of adverbs, approximately one third of the cases of adverbial modification of these adjectives (32.7%) involve proportional modifiers (compared to a mere 1.3% of non-maximal adjectives). Second, intensifiers are 19 times more
likely to modify non-maximal adjectives than maximal GAs ($\chi^2 = 4547.66, p < 0.001$).\(^9\)

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**An analysis of the adverbs modifying the 10 target adjectives reveals highly similar results** (see Table 3). Relative GAs are much more likely than maximal GAs to be modified by intensifiers, and maximal GAs are more likely to be modified by proportional modifiers than relative GAs are (about seven times and nearly 10 times, respectively). While just over one tenth (10.6\%) of maximal GAs are modified by proportional modifiers, less than one percent (0.2\%) of the relative GAs are ($\chi^2 = 231.85, p < 0.001$).

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**Conditional Probabilities**

In the second analysis, we looked at conditional probability, which allowed us to answer to the following question: when a target adverb modifies an adjective, what is the probability that the adjective maps onto a maximally closed scale (i.e., is a maximal GA)? The results are presented in Table 4. Column A indicates the total number of appearances in the corpus. Column B indicates the number of instances in which members of the target group modify or are modified by GAs.

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\(^9\) In fact, removing the intensifier that is by far the most frequent, *very*, the picture is even more dramatic, given the ability of *very* to modify a wider range of adjectives as discussed earlier (an ability that is arguably frequency-driven): approximately 73\% of the cases of adverbial modification of maximal GAs is by proportional modifiers (490 vs. 178, compared to 490 v. 257 in Table 2), and the remaining four intensifiers together are approximately 30 times more likely to modify non-maximal adjectives (5270 v. 178, compared to 18957 v. 1010 in Table 2).
by members of the other group. Column C is the number of instances in which the adjective is a maximal GA. Finally, Column D takes the information from Columns B and C and returns a conditional probability that reflects patterns of adverbial selectional restrictions related to adjectival scalar structure.\textsuperscript{10}

\begin{center}
\textbf{INSERT Table 4 ABOUT HERE.}
\end{center}

The $\phi$ for proportional modifiers ranges from 0.26 to 0.63, with an average of 0.49, while the $\phi$ for non-proportional modifiers ranges from 0.03 to 0.16, with an average of 0.06.\textsuperscript{11} A two-tailed t-test reveals that these distributions are significantly different ($t(8) = 6.25, p < 0.0003$). The data in the table offer two main conclusions. First, proportional modifiers have a much higher probability of selecting for maximally closed scales than intensifiers do. Thus, a learner positing a maximally closed scale in an adjective’s representation is more likely to be correct when the adjective is modified by a proportional modifier. Second, the extremely low conditional probability for the intensifiers indicates that the appearance of these adverbs is a strong cue to the open-ended scalar structure of the adjectives they modify. As an illustration of this difference, we note that among the most frequent adjectives modified by proportional modifiers are adjectives such as \textit{certain}, \textit{different}, \textit{new}, \textit{separate}, and \textit{wrong}. By contrast, the most frequent adjectives modified by intensifiers include canonical relative GAs such as \textit{good}, \textit{bad}, \textit{difficult}, \textit{important}, \textit{late}, and \textit{nice}.

\textsuperscript{10}See Goldberg, Casenhiser, and Sethuraman (2005) for a similar analysis of distributional information in verb learning.

\textsuperscript{11}For reasons of space, we collapse across lexical items in these sets. Probabilities for individual lexical items are reported in Syrett (2007).
A look at which adverbs appear as modifiers with the two sets of GA is also revealing. Combined, the adverbs *a bit, as, fairly, quite, really, so, too,* and *very* account for 80% of the adverbs modifying the target relative GAs and only 41% of the adverbs modifying the maximal GAs (two-tailed t-test: \(t(4) = 6.4, p = 0.003\)). Relative GAs are significantly more likely to be modified by these intensifiers or comparative adverbs than by proportional modifiers (two-tailed t-test: \(t(4) = 42.3, p < 0.00001\)). Thus, while relative GAs are in general much more frequent than maximal GAs and are more likely to be modified by adverbs in general (i.e., have more tokens), they are actually modified by a narrower range of adverbs (i.e., have fewer types), which are for the most part intensifiers that highlight their open-ended scalar structure.

C. Discussion

Two sets of analyses of natural language, as captured by the spoken subset of the BNC, converge to demonstrate two things. First, maximal GAs such as *full* are more likely to be modified by proportional modifiers such as *completely* than relative GAs such as *big* are. Second, intensifiers such as *very* are more likely to modify non-maximal GAs. Consequently, the lion’s share of adverbs modifying relative GAs are intensifiers highlighting the adjectives’ open scalar structure. This pattern is clearly driven by differences in the adjectives’ scalar structures. Thus, these surface-level differences observed in natural language may be informative to the language learner about the semantic representation of these lexical items. We now ask whether children appear to track such information and recruit it in word learning. The following set of experiments was designed to address this question.

5. Experiment 1

The purpose of this experiment was to determine whether information that is available to children in the form of adverbial modification could be used to assign an interpretation to novel
adjectives that is consistent with the corresponding semantic restrictions and distributional
tendencies discussed above.

A. Method

i. Participants

The participants were 33 children (19 girls, 14 boys; M = 29 months 9 days; range = 28 months 0
days to 32 months 2 days).\(^{12}\) An additional 14 children were excluded because of fussiness
ending the session (n = 2), inattentiveness\(^{13}\) (n = 9), or technical difficulties/experimenter error
(n = 3). Children’s average vocabulary production was 515 words, as measured by parents’
responses on the MacArthur-Bates CDI: Words and Sentences (toddler form). Age, gender, and

\(^{12}\) Children were recruited from College Park, MD, and the surrounding area. In Experiment 2,
children were also recruited from the North Shore and greater Chicagoland area. Only those
parents whose children were in the process of acquiring English as their native language and who
had reported that less than 20% of a non-English language was spoken in the home environment
were contacted.

\(^{13}\) Data were excluded from children who were inattentive for more than 30% of the time for
three or more of the five trials. While this may seem like too stringent a measure, when we look
at all of the individual children whose data were excluded over Experiments 1 and 2 for reasons
of inattentiveness, it appears less so. There was only one child whose average ‘attentive time’
over all five trials approached 70% (69%); only three others were above 60%, and all others –
with the exception of one child whose average attention was 33% – were between 50 and 60%.
In addition, for those children whose two remaining trials averaged over 70% attentive time,
their excluded trials averaged less than 50%, which the exception of one child, whose average
was only 60% for the excluded trials.
vocabulary production scores were balanced within and across three experimental conditions: 
completely (6 girls 5 boys, M = 30 months; average vocabulary: 483), very (6 girls 5 boys, M: 29 months; average vocabulary: 522), no adverb (7 girls 4 boys, M = 30 months; average vocabulary: 539). Paired t-tests revealed no significant difference in overall vocabulary production between these three conditions. A set of adult controls also participated; their results are reported along with Experiment 2.

ii. Materials
The materials for both Experiments 1 and 2 consisted of five videos (each constituting one trial), each presenting a set of five objects, images of which were either photographs or computer-generated. Each set of five objects was labeled by a different novel adjective (pelgy, wuggin, zaipin, vickel, keetel). The auditory stimuli were recorded by a female native speaker of American English in a sound-attenuated recording booth. The speaker read from a script and was instructed to produce the stimuli in a style modeling the prosody of child-directed speech. Sound files were edited using Praat software (Boersma & Weenink, 2005), controlling for articulation, pitch, amplitude, length, and overall consistency. Once finalized, the sound files were synchronized with the video files using Final Cut Pro software by Apple Inc. These files were presented to participants on a computer in the laboratory at a rate of 30 frames per second.

iii. Procedure
Experiments 1 and 2 employed the intermodal preferential-looking paradigm (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Hollich, Rocroi, Hirsh-Pasek, & Golinkoff, 1999; Spelke, 1979). The structure of the experimental trials and analysis was loosely modeled after the design used in Booth and Waxman (2003, 2009), Waxman and Booth (2001), and Waxman et al. (2009). Children were run individually in our experimental laboratory, in a quiet and dimly lit
Images were projected on a screen. Children were seated directly facing the screen approximately 6' away, either in a highchair with their caregiver seated behind them, or on their caregiver’s lap while the caregiver wore a visor. Caregivers were asked to refrain from talking or offering any form of encouragement to the child. During the experimental session, if children solicited their caregiver’s attention, the caregiver was permitted to direct the child’s attention back to the general direction of the screen. The experimenter remained in the control room, out of view of the participants. Children’s looks to the experimental stimuli were recorded with a Sony EVI-D100 Color Video Camera centered inconspicuously above the screen. These videos were captured digitally onto an iMac computer using QuickTime.

Each experiment consisted of five experimental trials designed to assess children’s interpretation of five different novel adjectives. Trials were presented in one of two orders, counterbalanced within conditions and across subjects. Participants were randomly assigned to one of the two orders and one of three conditions, depending on whether and how the novel adjective was modified: completely, very, and no adverb. Prior to each trial, a still black-and-white photograph of a smiling infant appeared at the center of the video screen for four seconds, accompanied by the sound of a baby giggling. This segment was followed by the actual trial.

The child participants were run in two different laboratories, both designed and equipped to run the intermodal preferential looking paradigm. There were two differences between the two locations, based on room size and the screen on which the images were presented. One room was 14’ x 7’ and stimuli were presented via computer to a 44” x 24.5” wall-mounted plasma television screen with speakers to the sides of the screen. The other room was 14’ x 10’; visual stimuli were presented via a ceiling-mounted projector onto a 4.5’ by 4.5’ projection screen, and audio stimuli were presented from two speakers located directly below the screen.
Table 5 captures a representative trial sequence. The trial began with a four-second introduction in which participants were shown a white screen and heard the female speaker invite them to look at some objects. At this point, the speaker uttered the novel adjective without the adverb to help participants segment the adverb and adjective separately from the speech stream in the adverb conditions. Following the introduction, each trial consisted of three distinct phases in which the participants were shown a series of objects labeled by the novel adjective: familiarization, contrast, and test. Participants in all experimental conditions saw the same objects. What varied was what the participants heard (i.e., how the objects were labeled).\(^\text{15}\)

\begin{center}
INSERT Table 5 ABOUT HERE.
\end{center}

During the familiarization phase, participants saw two objects (e.g., containers), presented simultaneously, one on either side of the screen, then one at a time and heard a female voice describe the objects. Both objects could be described by a relative GA (e.g., tall) and a maximal GA (e.g., clear). This method of presentation was designed to facilitate comparison of the objects and abstraction of the common properties (cf. Booth & Waxman, 2009; Kovack-Lesh & Oakes, 2007; Namy & Gentner, 2002). A two-part contrast phase then followed. Here, participants were first shown a distractor object that instantiated the opposite properties of those seen in the familiarization phase (e.g., short and opaque versus tall and clear) and heard the speaker explicitly state that it could not be referred to with the adjective. This exemplar helped to

\(^\text{15}\) Other object pairs included 2 long, straight sticks (contrast: short, curly); 2 wide smooth balls (contrast: narrow, bumpy); 2 large, patterned blocks (contrast: small, solid); and 2 high, closed windows (contrast: low, open). The corresponding test phase items were selected as described in the text.
narrow the range of possible referents by providing limits as to what can be described by the novel adjective. Participants were then shown one of the familiar target objects from the familiarization phase. Intonation in this segment of the contrast phase was controlled so that contrastive focus was placed on the adverb, when present, or on the copula *is* in the ‘no adverb’ condition.

Finally, during the *test* phase, two images related to those seen during the familiarization and contrast phases were displayed simultaneously on either side of a video screen. One object could be described with the relative GA from familiarization, but not the maximal GA (e.g., it was tall, but not clear), while the other could be described with the maximal GA, but not the relative GA (e.g., it was clear, but not tall). At the beginning of the test phase, the speaker drew the participants’ attention to the new objects. The screen then went momentarily blank for .33 seconds. The two objects then reappeared, and the speaker asked the participants to turn their attention to the object fitting the description of the novel adjective. The left-right position of the anticipated match was counterbalanced across trials.

iv. Coding

Children’s eye gazes during the experimental sessions were recorded and saved as .mov files on a Macintosh computer, which were then coded off-line frame by frame by a trained experimenter using the SuperCoder software (Hollich, 2003). The sound was removed to ensure that the coder, who was blind to the experimental condition, only coded the direction of visual fixation during the test phase. Following previous studies (cf. Booth & Waxman, 2009; Bunger, 2006; Waxman *et al.*, 2009), we targeted two same-size windows of the test phase (*baseline* and *response*) for
analysis. Each window lasted 60 frames, or 2 seconds. The first window, baseline, began 10 frames (approximately 333 ms) after the onset of “Look! They’re different” and was designed to assess child participants’ baseline attention. The second window, response, began 10 frames after the onset of the novel adjective and was designed to assess the interpretation participants

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16 The windows lasted long enough to get a snapshot of children’s decisions – as indicated by their gazes – during the relevant sections of the test phase. Shortly after making their choice, children generally looked elsewhere, so these looking patterns were not informative to the study. Other researchers employing the intermodal preferential looking paradigm have also restricted their analysis of eye gaze to much smaller timeframes within the test phase. Halberda (2006) targeted 2-second windows following the onset of the target word. Booth & Waxman (2009) targeted one-second windows within the test phase to track the divergence of experimental conditions and the time course of infants’ mapping of novel words. Having divided their test phase into four two-second intervals, Gertner et al. (2006) observed that two-year-olds exhibited a preference for the video screen matching the target utterance within the first two seconds. Finally, using the ‘looking while listening’ paradigm, Thorpe & Fernald (2006) also restricted the range of time for interpretation, under the assumption that reactions after a certain period of time could be considered noise.
assigned to the adjective.\textsuperscript{17}

Over the length of each window, the relevant measure was the proportion of time spent looking to the object that could be described by the relative GA (the ‘relative GA object’) out of the total time spent looking at either object. This information was averaged across individual trials for each child (excluding trials in which children were inattentive for more than 30\% of the time), then across children in each condition.\textsuperscript{18} One experimenter was designated as the primary coder for each of the infant videos. A second experimenter independently coded the test phase portion of five randomly-selected videos in each of the experimental conditions of both experiments. There was 96\% agreement between coders.

\textbf{v. Predictions}

Since the only difference between the experimental conditions is the presence and type of adverbial modifier, any differences observed across experimental conditions should be attributed to the interpretation participants assigned to the novel adjective, driven by their knowledge of the

\textsuperscript{17} This short lag time between the beginning of the lexical information and the beginning of the window allows time for the participants to process the relevant lexical information. Previous psycholinguistic research on spoken word recognition has demonstrated that both adults (cf. Marslen-Wilson, 1987; Marslen-Wilson & Zwitserloood, 1989) and children as young as 18 months of age (cf. Fernald \textit{et al}., 1998; Swingley, Pinto, Fernald, 1999; Fernald, Swingley, & Pinto, 2001) recognize and respond to speech stimuli before the offset of a target word, approximately 300 ms into the speech signal. The timeframe of 333 ms after the onset of the lexical item for online processing of speech has also been used by e.g., Thorpe & Fernald (2006) with 24-month-olds.

\textsuperscript{18} See Bunger (2006) for a similar approach for data inclusion/exclusion.
semantic consequences of the adverb’s selectional restrictions and/or conditional probabilities of adverbial modification. Thus, if children are able to use different adverbs as a cue to the meaning of the novel adjectives they modify, then we predict the following.

First, children in the ‘no adverb’ condition will show no difference between the baseline and response windows of the test phase, since there is no adverb present to constrain the interpretation of the novel adjective. Second, children in the two adverb conditions will display differences in looking time that differ significantly between the two test phase windows and that differ from each other. Now, because it is not clear what factors control attention during the initial portion of the test phase (the baseline window), we are abstracting away from any variability across conditions by only analyzing deflections from the baseline window, measured as a difference in looking time between the baseline and response windows. Measuring looks to the object that can be described by the relative GA property highlighted during familiarization (e.g., the tall, solid container), hereafter the ‘relative GA object’, children in the very condition should show a significant increase in looks from the baseline to the response window, while children in the completely condition should show a significant decrease in looks to this object from baseline to the response window.

B. Results

The results bear out our predictions. (See Figure 1.) Not only does the presence of an adverb matter, but the kind of adverb matters. Children in the ‘no adverb’ condition showed no evidence of learning a meaning for the novel adjective; they exhibited no difference in looking time between the baseline and response windows (Wilcoxon signed-rank test: \( W = 22, p = 0.17 \), one-tailed, \( r = .20 \)). Children in both of the adverb conditions, however, pulled away from this baseline in the response window, in opposite directions, suggesting that the meaning assigned to
the novel adjective differed in the two adverb conditions (very: \( W = -52, p = 0.01, r = -0.49; \)
completely: \( W = 44, p = 0.03, p = .41 \)). This difference in looking time between the two windows
held for the majority of children (9 out of 11) in both of the two adverb conditions, regardless of
their overall level of vocabulary production, an indication that the effect was not driven by
overall vocabulary level, but rather by children’s knowledge of these specific lexical items. The
asymmetry between the two adverb conditions underscores the role of different types of
adverbial modifiers in assigning an interpretation to a novel adjective. While one adverb (very)
pulled children’s attention toward the relative GA object during the response window, the other
adverb (completely) pulled their attention away from it.

Children in the very condition devoted equal attention to the two objects during the
baseline window, but spent more time looking at the relative GA object during the response
window. This significant increase in looking time to the relative GA object (from baseline to
response) suggests that the children assigned a relative meaning to the adjective when it was
modified by very. This behavior fits naturally with the results of the corpus analysis. While this
intensifier has the potential to appear with a wide range of adjectives, it is much more likely to
modify those without a maximal endpoint (i.e., non-maximal GAs, and more specifically,
relative GAs). Hence, children recruited the distributional features of the adverb in assigning a
meaning to the novel adjective.

Children in the completely condition showed a very different pattern. These children
showed a significant decrease from baseline to response in their looking time to the relative GA
object. This suggests that they mapped the adjective to an absolute maximal (not relative)
meaning. This behavior also fits naturally with the results of the corpus analysis. The adverb
completely occurs predominantly with maximal GAs. Hence, children recruited this
distributional property in assigning a meaning to the novel adjective.

A 2 x 3 repeated-measures analysis of variance was performed over the percentage of time spent looking at the relative GA object with condition (completely, very, no adverb) as the between-subject factor and test phase window (baseline, response) as the within-subjects factor. While the analysis revealed no overall main effects of condition (F(2, 32) = 1, p = 0.38, \( \eta^2 = .43 \)) or window (F(1, 33) = 0, p = 1.0), there was a significant condition x window interaction (F(2, 30) = 7, p = 0.003), driven by the two different patterns in the adverb conditions. Planned comparisons of the baseline and response windows for each condition reveal significant main effects for both the very condition (F(1, 10) = 7.13, p < 0.03) and the completely condition (F(1, 10) = 5.81, p < 0.04), but no significant main effect for the ‘no adverb’ condition (F(1, 10) = 1.33, p = 0.28).

C. Discussion

In this experiment, we sought to determine whether young word learners recruit adverbial modification as a cue to the semantic structure of a novel adjective. The results suggest that they do. Children who hear a novel adjective that is not modified by an adverb show no systematic preference for one or another object property, suggesting that they were unable to assign a meaning to the novel adjective in the absence of adverbial modification. In contrast, children who hear the same novel adjective modified either by the proportional modifier completely or by the intensifier very display a very different pattern – the former apparently mapping it onto an maximal GA meaning and the latter mapping it onto a relative GA meaning.

However there may be an alternative explanation for the set of results we obtained in this
experiment. While  *completely*  and  *very*  differ in terms of their selectional restrictions, they also differ with respect to their lexical frequency. In the spoken BNC,  *very*  has a frequency of 25,041, or 2421.36 instances per million words. By contrast,  *completely*  has a frequency of only 822, or 79.48 instances per million words, making  *very*  over 30 times more frequent. In fact, only one child in our sample was reported to be producing  *completely*, while 16 were reported to be producing  *very*.  

It is possible that this frequency asymmetry is somehow responsible for the asymmetry in response patterns.

Imagine, for example, that the children knew nothing about the meaning of  *completely*, and only recognized it as a novel adverb. It is possible, then, that their response pattern in the  *completely*  condition merely reflects the pattern that derives from hearing a novel adverb. Children might have responded appropriately in the  *very*  condition because they knew the semantic consequences for adjectives modified by that adverb. At the same time children might have responded appropriately in the  *completely*  condition just because they did the opposite of what they would have done with a known adverb like  *very*. Now, not only did children in the  *completely*  condition show a significant decrease from baseline to response, but their looks to the relative GA object actually began above chance in the baseline window. If children in this condition were simply driven by the novelty of the adverb  *completely*, we would expect that they would pattern similarly given any low-frequency or novel adverb – regardless of its semantics. In Experiment 2, we put this hypothesis to the test by examining what children do with an

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19 There was no statistical difference in the performance between children who were reported to be producing this adverb and those who were reported to be producing no adverbs (two-tailed t-test  *t*(30) = 1.33,  *p* = 0.19).

20 We comment on this pattern of looks in the Discussion section of Experiment 2.
additional low-frequency adverb and a novel adverb.

6. Experiment 2

The purpose of Experiment 2 was to determine whether a low-level feature – namely, (relative) lexical frequency – was responsible for the pattern of results we saw in Experiment 1. Here we introduced two new adverbial modifiers to address this question. One – extremely – shares similar selectional restrictions and distributional tendencies with that of the high-frequency intensifier very, but like completely, has a low lexical frequency (and in fact, has an even lower frequency). The other – the novel adverb penticly – is phonologically similar to completely, but as a novel adverb, has no lexical frequency. A summary of these features is presented in Table 6.

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| INSERT Table 6 ABOUT HERE. |
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If the pattern of responses we observed in the completely condition in Experiment 1 can be attributed to a sheer novelty effect, driven by its simply being distinct from the high-frequency intensifier very, then we expect to see that the results of the two new adverb conditions in Experiment 2 parallel those of the completely condition in Experiment 1. If, however, the pattern we observed in Experiment 1 was actually due to the meaning of completely, then we should see a difference between the completely condition and these two new conditions.

Under this hypothesis, children in the penticly condition should pattern no differently between the two test phase windows, as the children in the ‘no adverb’ condition did. The pattern of behavior in the extremely condition, however, will depend on whether they know the meaning of this adverb. If they do, they should pattern with the children in the very condition of Experiment 1. If they do not, they should pattern with the children in the penticly condition in this experiment and the ‘no adverb’ condition of Experiment 1. To be clear, a lack of effect in
Experiment 2 would be a welcome result, because it would indicate that children in the *completely* condition in Experiment 1 actually appealed to information specific to this adverb when assigning a meaning to the novel adjectives it modified. That is, the argument depends not simply on the lack of effect in Experiment 2, but on the comparison of response patterns between Experiments 1 and 2.

A. Method

i. Participants

The participants were 22 children (11 girls, 11 boys; M: 29 months 8 days; range: 28;2 to 31;3 months). An additional 12 children were excluded because of fussiness (n = 4), inattentiveness (as described in Experiment 1, n = 6), or equipment error (n = 2). Children’s average vocabulary production was 556 words. As in Experiment 1, age, gender, and vocabulary production scores were balanced within and across conditions: *pentically* (5 girls 6 boys, M: 30 months; avg. vocabulary: 439), *extremely* (6 girls 5 boys, M: 30 months; avg. vocabulary: 556). Paired t-tests revealed no significant difference in vocabulary production between the participants in the two experiments. 50 adult controls (Northwestern University undergraduates fulfilling an experimental requirement for a Linguistics course) also participated, completing a pen and paper version of the task. Data from three additional adults were excluded, because the participants indicated that a language other than English was their native language.

ii. Materials and Procedure

The materials and procedure were identical to Experiment 1, with the exception of the two new adverbs: the low-frequency intensifier *extremely* and the novel adverb *pentically*. Children were randomly assigned to one of these two experimental conditions, as in Experiment 1. Coding of children’s eye gazes was also conducted as in Experiment 1.
Adult participants were also randomly assigned to one of five experimental conditions from Experiments 1 and 2. Adults were told they were participating in an experiment designed for young children. They viewed the same videos as the children did and were run in groups of one to three in a 9' x 10.5’ dimly-lit room in our laboratory. The video was projected from a Sony Digital8 Handycam onto a 60” Sony rear-projection television set. Participants were seated approximately 6' from the TV. They were each given a clipboard and a response packet and were instructed to shield their response packets from each other during the experimental session. The experimenter either waited unobtrusively in a back corner of the room while the video played, or else waited outside the door of the room until the video was finished. Adults’ choice of one of the two objects during the test phase of each trial was averaged across the five trials and across subjects. The dependent measure was the overall percentage of times adults chose the relative GA object.

B. Results and Discussion

Children
Response patterns for children across all conditions from Experiments 1 and 2 are presented in Figure 2. Unlike in Experiment 1, where the responses for children in both of the adverb conditions diverged from the ‘no adverb’ baseline, the responses for children in the extremely and penticly conditions patterned no differently from the ‘no adverb’ condition in Experiment 1. There was no difference between the baseline and response window for either condition (extremely: \( W = -2, p = 0.47 \); penticly: \( W = 26, p = 0.13 \), one-tailed), and neither condition resembled the pattern observed in the completely condition in Experiment 1.

A 2 x 2 analysis of variance was performed over the percentage of time spent looking at
the relative GA object with condition (extremely, penticly) as the between-subject factor and test phase window (baseline, response) as the within-subjects factor. This analysis revealed no main effect of condition \( (F(1, 21) = 1.5, p = 0.23, \eta^2 = .65) \), no main effect of window \( (F(1, 22) = 0, p = 1.0) \), and no interaction \( F = 1, p = 0.33 \). A one-way analysis of variance run on the difference in looking time between the baseline and response windows in the five conditions in Experiments 1 and 2 revealed a significant main effect \( (F(4, 50) = 3.75, p < 0.01) \). A post hoc Tukey’s HSD analysis \( (p < .01) \) revealed that this effect was driven by a difference between the very and completely conditions.

These analyses show that the appropriate interpretation of these data requires a comparison between the two windows for each condition. What matters is whether the experimenter’s question about the meaning of the novel word drew children’s attention toward one object or another and away from an initial looking preference. The results show that it is only in the completely and very conditions that this happened, although – importantly – in opposite directions. This claim is supported graphically in Figure 3, which illustrates difference between the baseline and response windows among the conditions.

We would like to take some space here to reflect on the eye gaze patterns in two different conditions. First, consider the baseline window in the completely condition of Experiment 1. Unlike every other condition, children in this condition began by looking to the relative GA object more often than predicted by chance \( (t(10) = 3.47, p < 0.01) \), then switched their gaze away from it in the response window. What could account for this pattern? We think the most likely possibility is that it was driven by an initial preference for a property that is novel with...
respect to the meaning assigned to the novel adjective, given the selectional restrictions of the adverb *completely*. That it is not simply a novelty preference based on the objects alone is reflected in the lack of such a pattern in the ‘no adverb’ and *pentically* conditions.\(^1\)

Given that *completely* selects for a maximal endpoint, at the beginning of the test phase children are drawn to inspect an object that lacks the corresponding property. Then, upon hearing the experimenter’s question containing the novel adjective – whose meaning they assigned earlier in the trial based on the adverb – they switch their gaze away from the relative GA object to the other object. Thus, it is precisely *because* of the meaning of this adverb that children respond this way, and do not do so in any of the other conditions. While one might expect children in the *very* condition to pattern in the opposite direction, their looking pattern is easily explained by appealing to the corpus data: because this intensifier has the potential to appear with a wide range of adjectives, children await hearing the novel adjective before directing their gaze to one object or the other.

Next, consider the comparison between the baseline and response windows in the *extremely* condition of Experiment 2. Unlike the adverb conditions in Experiment 1, in the *extremely* condition, children did not pattern differently between the baseline and response windows. Thus, neither the semantic representation nor the distribution of this adverb guided children’s responses. Recall that *extremely* is about half as frequent as *completely*. It may be that although *extremely* is much more likely to modify a non-maximal adjective than a maximal one (in our corpus data, 390 vs. 10, respectively), it is simply too infrequent for children to have

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\(^1\) See Waxman & Markow (1995) for discussion of the effects of a novel word on novelty preferences and Matsuo *et al.* (2008) for a potentially similar meaning-driven above-chance looking pattern during baseline.
formed a hypothesis about its selectional restrictions. Given this pattern, it follows that the asymmetry between *very* and *completely* in Experiment 1 was not due to the relative difference in frequency between them, but rather to children having acquired appropriate representations for both of these adverbs.

**Adults**

Adults patterned in the predicted direction, choosing the relative GA object the least often when the novel adjective was modified by *completely* (see Table 7). Interestingly, for one of the five trials adults never selected the relative GA object (the long and curly object rather than the short and straight one), regardless of their condition. Excluding this trial from the analysis results in a similar trend of percentages. Two-tailed t-tests (df = 9) on these data revealed that only the *completely* and *extremely* conditions are significantly different than chance (though in opposite directions from each other), and the difference between the *penticly* condition and chance is marginally significant (*completely*: $t = 3.48, p = 0.007$; *very*: $t = 1.15, p = 0.28$; no adverb: $t = -0.36, p = 0.73$; *extremely*: $t = -4, p = 0.003$; *penticly*: $t = -1.97, p = 0.08$).

The fact that adults resisted selecting the relative GA object when the novel adjective was modified by the intensifier *very* may reflect the fact that as a result of its widespread distribution and high frequency, this intensifier has a diluted meaning for adults (cf. footnote 9). By contrast, modification of an adjective by *completely* has a clear implication for adults: the adjective most likely corresponds to a maximal GA interpretation. And modification by the lower frequency intensifier *extremely* – which may also indicate a more sizable divergence from the standard of comparison than *very* does – signals a relative GA interpretation. That is, although *very* is more likely to modify adjectives with a relative GA interpretation by default, it can also modify those
adjectives that have a default absolute GA or non-gradable interpretation, but which also lend themselves to a relative GA interpretation. Adults may also have been economical in their decision. Relative GAs by definition encode the context in their semantic representation. Adults may in general hold off on assigning a novel adjective an interpretation that is not linked to the context unless they have good reason to do so (cf. Kennedy, 2007). Thus, when given a choice between a relative GA and absolute GA interpretation, they might opt for the latter, because its standard is not context-dependent.

7. **General Discussion**

The current research contributes to our understanding of how children classify novel adjectives according to their abstract semantic representations. First, the results of a corpus analysis demonstrate that robust patterns of adverb-adjective bigrams exist in natural language, and may provide children with evidence as to how to sort adverbs according to their selectional restrictions, and adjectives according to their scalar structure. Specifically, proportional modifiers such as *completely*, which select for a scale with endpoints, are likely to be paired with maximal GAs, which map objects onto a maximally closed scale, while intensifiers such as *very*, which indicate divergence from the standard of comparison, are drawn to relative GAs such as *big*, which map objects onto an open scale and have a contextually-based standard of comparison.

Second, the results of our word-learning experiments are consistent with the view that 30-month-olds are aware of such information and recruit it when assigning interpretations to novel words. In these experiments, children were familiarized to two objects that had a property best described by relative GA and another best described by a maximal GA and heard the objects labeled by a novel adjective. This adjective was modified by either no adverb, or one of four
different adverbs varied by their semantics and lexical frequency. At test, when the object properties were teased apart and children were asked about the interpretation they assigned to the adjective, they were more likely to turn their attention toward the relative GA object if the adjective had been modified by very, but away from this object and toward the maximal GA object if the adjective had been modified by completely. Children in the ‘no adverb’ and two control adverb conditions (extremely and penticly) remained at chance. Because the presence and type of adverbial modifier was the only variable among the conditions, children’s decision to associate the meaning of the adjective with one object property or another must have been guided by the information provided by the adverbs. Thus, even children who are reported to not yet be producing these adverbs seem to have capitalized on their distribution in the language environment in order to acquire something about their meaning, and moreover to use this information as a cue to the meaning of their adjectival arguments.

We might take our conclusion one step further and suggest that adverbs may be doing for adjectives what clausal argument structures do for verbs. In both cases, distributional differences of surface-level cues are informative about abstract differences that partition the lexical items according to their semantic representations (cf. Fisher, Gleitman & Gleitman, 1991). It has been argued that language learners may track the relative frequency with which a given verb appears across a range of frames, and the relative frequency with which frames appear across a range of verbs (Alishahi & Stevenson, 2005a, b; Naigles & Hoff-Ginsberg, 1995) in order to reach conclusions about that verb’s meaning. In parallel fashion, learners may track the relative frequency with which adjectives are modified by a range of adverbs and the relative frequency with which adverbs modify a range of adjectives in order to reach conclusions about adjectival meaning. The process of acquisition may be a reciprocal word learning process, whereby
children use what they have learned about adverbs to infer something about the meaning of the adjectives they modify, and at the same time use what they have learned about adjectives to infer something about the selectional restrictions of the adverbs that modify them.

Importantly, learners must have some prior knowledge about what gives rise to these diverging patterns of modification, since mere surface-level differences in distribution and conditional probabilities will not be directly informative about what underlies differences in relative frequency. It therefore seems likely that children bring some expectations about the range of possible adjectival subclasses to bear in using the distributional features of the exposure language as a cue to adjective meaning. In other words, children know that adjectives can vary in their scalar structure and they expect this variability to leave a distributional signature in the exposure language. In English, one place where this distributional signature can apparently be found is in adverbial modification. Moreover, it appears that children can utilize this distributional signature as a cue to the meaning of a novel adjective.

\[22\] Here, we leave open the question of whether the subclasses of adjectives are specific to language or are reflective of cognitive representation outside of language. In addition, we leave open the questions of whether the expectation about subclasses of adjectives is innate or has simply developed by the time children begin tracking the distributional information that enables them to succeed at our task by 30 months of age.
References


British National Corpus (BNC). Available from the British National Corpus Online service, managed by Oxford University Computing Services on behalf of the BNC Consortium. All rights reserved. (http://www.natcorp.ox.ac.uk/)


Development, 65, 1299-1317.


gradable adjectives. *Language, 81*, 345-381.


inductions of word meanings: Object terms and substance terms. *Cognition, 38*, 179-211.


### Tables

**Table 1: Targeted lexical items (adverbs and adjectives)**

<table>
<thead>
<tr>
<th>adverbs</th>
<th>adjectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>proportional modifiers</td>
<td>absolute maximum standard (maximal) GAs</td>
</tr>
<tr>
<td><em>almost, completely, entirely, half, totally</em></td>
<td><em>clean, dry, empty, full, straight</em></td>
</tr>
<tr>
<td>intensifiers</td>
<td>relative GAs</td>
</tr>
<tr>
<td><em>extremely, really, relatively, too, very</em></td>
<td><em>big, high, long, tall, wide</em></td>
</tr>
</tbody>
</table>

**Table 2: Adjectives appearing with the 10 target adverbs**

<table>
<thead>
<tr>
<th>maximal GAs</th>
<th>relative GAs</th>
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<td>490</td>
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<tr>
<td>intensifiers</td>
<td>1010</td>
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</tbody>
</table>

**Table 3: Adverbs appearing with the 10 target GAs**

<table>
<thead>
<tr>
<th>maximal GAs</th>
<th>relative GAs</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>intensifiers</td>
<td>330</td>
</tr>
</tbody>
</table>
Table 4: Probability of modifying an adjective with a maximal scalar endpoint

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<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td># instances</td>
<td>proportional: 9359</td>
<td>1126</td>
<td>585</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>intensifier: 50167</td>
<td>21281</td>
<td>1078</td>
<td>0.06</td>
</tr>
<tr>
<td># modifying adjective</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># modifying maximal adjective</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Phi(\text{modifies a maximal GA</td>
<td>modifies an adjective}) ) (C/B)</td>
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<td></td>
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</table>
Table 5: Representative trial sequence used in Experiment 1

<table>
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<th>familiarization phase</th>
<th>contrast phase</th>
<th>test phase</th>
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</thead>
<tbody>
<tr>
<td>4 sec</td>
<td>18 sec (6 s, 6 s, 6 s)</td>
<td>7 sec</td>
<td>7 sec</td>
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<tr>
<td></td>
<td>(distractor)</td>
<td>(target)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(blank screen)</td>
<td>short, opaque</td>
<td>tall, clear jar</td>
</tr>
<tr>
<td></td>
<td>2 tall, clear jars</td>
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<tr>
<td></td>
<td>tall, opaque jar</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>short, transparent jar</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Let’s look at some things that are pelgy!

- Look!
- These are both {adverb / ∅} pelgy!
- This one is not pelgy!
- Which one is pelgy?
- Yay! This one is {completely / is very / is ∅} pelgy!
- Look! They’re different!
- This one is pelgy!
- and this one is {adverb / ∅} pelgy!
Table 6: Adverbs used in Experiments 1 and 2

<table>
<thead>
<tr>
<th>adverb</th>
<th>frequency</th>
<th>instances per million</th>
<th>semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>very</td>
<td>25,041</td>
<td>2421.36</td>
<td>intensifier</td>
</tr>
<tr>
<td>completely</td>
<td>822</td>
<td>79.48</td>
<td>maximally-closed scale selecting</td>
</tr>
<tr>
<td>extremely</td>
<td>480</td>
<td>46.41</td>
<td>intensifier</td>
</tr>
<tr>
<td>penticly</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Table 7: Percentage of time adults chose the relative GA object

<table>
<thead>
<tr>
<th></th>
<th>all trials</th>
<th>4 of 5 trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>completely</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>very</td>
<td>34</td>
<td>43</td>
</tr>
<tr>
<td>no adverb</td>
<td>42</td>
<td>53</td>
</tr>
<tr>
<td>extremely</td>
<td>56</td>
<td>70</td>
</tr>
<tr>
<td>penticly</td>
<td>54</td>
<td>65</td>
</tr>
</tbody>
</table>
Figures

Figure 1: Children’s responses as measured by comparing the average time spent looking at the relative GA object during key sections of the baseline and response windows of the test phase (Experiment 1)
Figure 2: Children’s responses as measured by comparing the average time spent looking at the relative GA object during key sections of the baseline and response windows of the test phase (Experiments 1 and 2)
Figure 3: Children’s responses as measured by the difference between key sections of the baseline and response test phase windows of the test phase.