

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/228542830>

# When one cue is better than two: Lexical vs. Syntactic Cues to Verb Learning

Article

CITATIONS

0

READS

69

2 authors, including:



[Jeffrey Lidz](#)

University of Maryland, College Park

137 PUBLICATIONS 2,386 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



double object constructions and applicatives in Spanish [View project](#)



Verb learning in infancy: Morphosyntactic cues, prosodic cues and learning biases [View project](#)

# **When one cue is better than two: Lexical vs. Syntactic Cues to Verb Learning**

Jeffrey Lidz, *University of Maryland*

Ann Bunker, *University of Delaware*

Erin Leddon, *Northwestern University*

Rebecca Baier, *University of Maryland*

Sandra Waxman, *Northwestern University*

## Contact Info:

Jeffrey Lidz

Department of Linguistics

University of Maryland

Marie Mount Hall

College Park, MD 20742 USA

Email: [jlidz@umd.edu](mailto:jlidz@umd.edu)

Phone: +1 301-405-8220

Fax: +1 301-405-3770

Keywords: verb learning, information processing, syntactic bootstrapping, language acquisition, word learning.

## **Abstract**

Prior results with adults (Gillette, Gleitman, Gleitman, & Lederer, 1999; Snedeker & Gleitman, 2004) and preschoolers (Piccin & Waxman, 2007) have established that certain information sources are more powerful than others in their utility as cues for verb learners. The current paper tests the predictions of these results with infant verb learners. We show that the informativity of a cue is offset to some extent by the amount of processing required to utilize that cue. Consequently, the best condition for word learning for adults and older children is less effective for infant learners. We show that infants can learn the meaning of a novel verb better when it takes a pronominal subject than when it takes a lexical NP as subject. This effect, however, is not due to the special status of pronouns as cues to syntactic category (Childers & Tomasello, 2001; Bernal, Lidz, Millotte, & Christophe, 2007), but rather to the extra processing demands imposed by contentful lexical nouns.

A well-known problem for the acquisition of language generally and of words in particular is the stimulus-free nature of language use (Chomsky 1959). Extralinguistic context is not a very good predictor of what someone is going to say. For example, when looking at a Rembrandt painting, one might say, “Dutch,” “It’s crooked,” “I prefer abstract expressionism,” “Remember our camping trip last summer?” or just about anything else. Hence, if the language learner is to learn about what is being said on the basis of what is happening in the world, the lack of reliable correlations between language and events represents a serious obstacle.

Worse, even when someone is talking about the here and now, the world makes available many different possible descriptions of the visible scene. Consider a scenario in which a boy and his mother are flying a kite. A novel word used in this context might refer to the kite, the string, nylon, wind, boredom, clouds, blue, anticipation, lunch, force, flying, waiting, saying, hoping, thinking, breathing, etc. Given the multiplicity of interpretations of any given context, the learner faced with a novel word needs to determine which of the objects, events and properties made available by perception/conception that word refers to. A theory of word learning must therefore determine a procedure by which alternatives are eliminated. At minimum, such a theory must allow the learner to compare across situations to narrow down the number of alternative hypotheses. But even allowing for cross-situational comparison, a word-to-world pairing procedure still cannot overcome Quine’s (1960) cooccurrence problem: rabbits always occur with rabbit-ears, jumping always occurs with legs, giving always occurs with receiving, and sugar always occurs with sweetness.

One set of solutions to the cooccurrence problem points to linguistic biases about what words encode. Such solutions are based on observations that children are likely to believe that a novel word, applied to an unfamiliar object, will refer to an object, as opposed to a property of that object or a relation between objects (Gentner, 1982; Waxman & Markow, 1995), that a novel word is likely to be interpreted as the whole object, as opposed to its parts or texture (Markman & Hutchinson, 1984; Soja, Carey, & Spelke, 1991), and that a novel word is likely to refer to a basic-level kind (Markman, 1989; Mervis, 1987; Waxman, 1992). This approach to word learning leads us to expect that nouns (more specifically, words that refer to object kinds) will be learned first because children have a bias to interpret novel words as referring to object kinds. Indeed, it has been widely observed that nouns are massively overrepresented in the earliest child vocabularies (Caselli et al., 1995; Gentner & Boroditsky, 2001; Goldin-Meadow, Seligman, & Gelman, 1976; Huttenlocher, 1974; Woodward & Markman, 1998).

Of course, biases in the learner to interpret words as referring to object kinds can only take us so far, since language is filled with words referring to properties, events, and relations, and with words that quantify over objects (*the, every, most*) and events (*always, never, sometimes*). The language learner must ultimately come to understand the mapping between a wide range of linguistic devices and the meanings they convey.

In recent years, an approach to word learning has developed which, first, explains the early appearance of nouns in child vocabulary and the apparent bias for early words to refer to objects and, second, presents a clear hypothesis about how learning of words that do not refer to object categories might proceed (Gleitman, 1990; see also Fisher, 1996; Fisher, Hall, Rakowitz, & Gleitman, 1994; Gillette et al., 1999; Mintz & Gleitman,

2002). On this view, the preponderance of nouns in child vocabularies derives from the different informational requirements of the different grammatical categories. Adjectives and verbs, for example, are predicates that require arguments. Thus, the meanings expressed by these kinds of words cannot be learned until after the learner has acquired some nouns to head the noun phrases that serve as arguments to these predicates. As a consequence, words referring to object categories, which have no such grammatical prerequisites, can be learned first, providing a foothold for subsequent learning of words from other grammatical categories.

This syntactic bootstrapping approach highlights the different informational requirements associated with learning different kinds of words and hypothesizes that syntactic information can be used to guide lexical acquisition, especially for verbs and adjectives (Gleitman, 1990; Landau & Gleitman, 1985; Syrett & Lidz, in press; Waxman, 1999; Waxman & Booth, 2001; Waxman & Lidz, 2006). Indeed, a great deal of research has shown that infants and children can use information about syntactic distribution to identify important aspects of verb meaning (Arunachalam & Waxman, in press; Bungler & Lidz, 2004, 2006; Fisher, 1996; Fisher et al., 1994; Fisher 2002; Landau & Gleitman, 1985; Lidz, Gleitman, & Gleitman, 2003; Naigles, 1990, 1996; Waxman, Lidz, Braun, & Lavin, 2009) and that they can use syntactic information to distinguish adjectives from nouns, to identify the meaning of a novel adjective (Klibanoff & Waxman, 2000; Mintz & Gleitman, 2002; Waxman, 1999; Waxman & Booth, 2001) and to identify the subclass of a novel adjective (Syrett & Lidz, in press).

Moreover, research in this line has revealed that the bias to interpret novel words as referring to objects does not reflect the initial state of the language learner. Rather, the

bias to interpret words as referring to object kinds is true only of count nouns, not all words, and does not appear until 14-months of age, when the learner can distinguish (on the basis of morphosyntactic properties) count nouns from other syntactic categories. Earlier in development, both nouns and adjectives are equally likely to be interpreted as referring to either object kinds or object properties (Waxman & Booth, 2001, 2003). Consequently, it appears that at least some word learning biases emerge as a function of the acquisition of syntactic categories.

The observation that word learning biases reflect knowledge of syntactic categories lends plausibility to the idea that features of syntactic distribution play a critical role in word learning. More narrowly, this observation lends initial support to the idea that asymmetries between nouns and verbs in word learning derive in part from asymmetries in the syntactic prerequisites for learning words from these categories (Snedeker & Gleitman, 2004; Waxman & Lidz, 2006). This idea is further supported by experiments with adult subjects placed in a word learning environment (Gillette et al., 1999). Whereas participants were able to learn nouns to some degree solely through observation of extralinguistic context, verb-learning required additional syntactic information. Gillette et al. (1999) presented adults with a series of video-taped scenes which all depicted the context of a parent uttering a word to their child. The participants' task was to identify the meaning of a word presented in a range of conditions which differed by how much information was given about the linguistic context of the utterance. Crucially, the proportion of words that were correctly identified and the type of words that were identifiable varied significantly as a function of information type. When presented with no information beyond the visual scene, adult participants correctly

identified nouns more often than they correctly identified verbs. For verbs, the contribution of various information sources is most evident. Participants were least successful at guessing the verb when only the visual scene was presented (7.7% correct). However, providing the set of nouns that co-occurred in the sentences with the unknown verb led to a significant increase in correct guesses (29% correct). Further increases were observed when the syntactic frame of the novel verb was given along with nonsense words serving as the arguments (51.7% correct). Putting the latter two conditions together, by providing both the syntactic frame and the co-occurring nouns led to still further successes in identifying the novel verb (75% correct). Finally, when all of this information was given with the visual scene, participants approached perfect performance (90.4% correct). Taken together, these results indicate (a) that syntactic information was more effective than the co-occurring nouns in leading subjects to the correct identification of the verb and (b) that the combination of these cues was more effective than either of these alone. These results lend support to the idea that successful verb learning requires information beyond extralinguistic context. In particular, syntactic argument structure and the cooccurrence of known nouns serving as syntactic arguments provide information that is crucial for the acquisition of novel verbs.

These adult simulations create the following hierarchy of informativeness of cues for the meaning of a novel verb, with cues on the left being less informative than cues on the right.

(1) **scene < co-occurring nouns < syntactic frame < syntactic frame + cooccurring nouns**

This research with adults provides evidence about the potential informativeness of syntactic and lexical cues to verb meaning. However, it does not tell us how the



theoretical insights gleaned from adult studies relate to infant language acquisition. Piccin and Waxman (2007) found strikingly similar patterns of data with 7-year-old participants, with children needing more linguistic information for successful verb learning than for successful noun learning. Nonetheless, while a good deal of research with children ranging from 22-months to 4-years of age has shown that children can use syntactic information to identify the event labeled by a novel verb (Bernal et al., 2007; Fisher, 1996; Fisher et al., 1994; Naigles, 1990, 1996; Waxman et al., 2009), none of these studies has explicitly manipulated the variables which were shown to be differentially effective in adult verb identification. Moreover, while research on the acquisition of adjectives by infants has revealed that count nouns provide a foothold for adjective learning (Mintz & Gleitman, 2002; Klibanoff & Waxman 2000), similar evidence is lacking in the domain of verb learning in children younger than 3 years of age.

The current paper takes an initial step towards bringing this theoretical and empirical work into alignment. In particular, we wish to consider whether the informativeness of the cues to verb-learning interact with the processes required to make use of these cues. It is possible that as a cue carries more information with it, it also brings along a substantial processing burden. The cues that are most informative to older children and adults might be less useful to infant learners because the processing requirements for utilizing these cues make it harder to exploit them in a real learning situation.

To address the possible trade-off between informativity and the cost of processing, we examine whether infants learn verbs in accordance with the hierarchy derived from adult simulations. In particular, we compare infants' ability to learn an

intransitive verb when it is presented with solely syntactic information about its argument as compared to both syntactic and lexical-semantic information about its argument, as in

(2):

- (2) a. It is blicking (syntactic information alone)
- b. The flower is blicking (syntactic and lexical information)

We chose intransitive manner of motion verbs for this study for three reasons.

First, these verbs have the simplest possible argument structure and so potential difficulties associated with the relative salience of multiple arguments or with the identification of subject and object do not arise. Second, because the events have only one participant, the only asymmetry in informativeness between the subject noun phrases in (2a) and (2b) is linguistic, not in the mapping from noun phrases to referents. Third, these verbs refer to events with no natural endpoint. As such, they can present stable visual profiles over a period of time, eliminating visual features of the internal structure of the event as potential attractors of attention.

The conditions in (2) provide a naturalistic analog of the rightmost two conditions in the hierarchy in (1). In (2a), the sentence contains information that the novel word is a verb, and that that verb takes a subject argument. However, because the subject is a pronoun, no information in the sentence specifies what the subject refers to. In (2b), on the other hand, the sentence contains the same information as (2a) (the novel word is a verb that takes a subject argument) and adds the information that the subject argument refers to a flower.

If the hierarchy of informativity is an accurate representation of infants' use of cues to verb meaning, then we predict that learning the verb meaning will be easier in

(2b) than in (2a) because (2b) contains more relevant information than (2a). On the other hand, if there is an additional processing cost associated with accessing the lexical meaning of the argument “the flower” in (2b) that is absent from the processing of the pronoun, which carries no lexical content with it, then we predict that verb learning will succeed in (2a) but not (2b).

### **Experiment 1**

This experiment asks whether infants’ verb learning reveals differential sensitivity to syntactic and lexical factors, as predicted by the human simulation paradigm (Gillette et al., 1999; Snedeker & Gleitman, 2005). In particular we ask whether infants learn better when both lexical and syntactic information is presented than when only syntactic information is presented. If the human simulations represent an accurate model of infant learning, then we expect learning to be superior when both cues are present. However, if the utility of a cue is a combination of both the benefits of the information expressed and the cost of the processing demands associated with accessing that information, then we might expect superior learning when the syntactic cue is presented in the absence of lexical information.

### *Method*

*Participants.* Thirty-two children ranging in age from 21 to 23 months ( $M = 22;9$ ) were included in the final sample for this study. Participants were recruited from the communities surrounding Evanston, IL and College Park, MD and were acquiring English as their native language (with  $\leq 10\%$  input in a language other than English). Caregivers completed the MacArthur Communicative Development Inventory: Words

and Sentences questionnaire (MCDI), which is designed to provide a measure of productive vocabulary for children between the ages of 16 and 30 months (Fenson et al., 1993). Mean productive vocabulary for children in this study was 190 words (range 3–528, out of a possible 680). In addition, 77% of the children were reported by their caregivers to know all of the nouns used in the stimuli and all but one of the children were reported to know at least 3 of them. An additional 8 children were excluded due to caregiver-reported speech or hearing problems ( $n = 1$ ), inattention for more than 30% of the test phase on more than two trials ( $n = 2$ ), and experimenter error or equipment malfunction ( $n = 5$ ).

*Materials.* This experiment employs the preferential-looking paradigm developed initially by Spelke (1979) and Golinkoff, Hirsh-Pasek, Cauley, & Gordon (1987) to study intermodal perception in infants. In our version of this paradigm, which parallels that of Waxman et al. (2009), participants are presented with two dynamic event scenes displayed simultaneously on opposite sides of the screen of a large video monitor accompanied by a speech stimulus.

Visual stimuli consisted of digital videos of events that involved live actors and familiar real-world objects. Events were videotaped against a neutral background. Auditory stimuli consisted of recordings of a female native speaker of American English producing sentences from a script using child-directed speech intonation. Digital speech recordings were made in a sound-attenuated booth and were live-monitored for gross misarticulation, hesitation, and inconsistency of speaking rate. These recordings were edited by hand for duration and timing and were then synchronized with the visual stimuli. Visual and auditory stimuli were digitized to a single source to ensure consistent

presentation of stimuli across participants and experimenters, and were edited to create the sequence of events described in Table 1. Each participant was presented with four 71-second trials that followed this sequence.

Each trial consisted of three phases: word-form familiarization (25 seconds), word-event familiarization and test. During the word-form familiarization phase, participants saw a video of two puppets talking to each other. Each sentence included a use of a novel verb, with the conversation providing a broad range of syntactic contexts indicating that the novel word was a verb. There was no referential context to provide cues to meaning during this phase. The purpose of the word-form familiarization phase was to help make the word easier to segment from the speech stream (cf. Jusczyk & Aslin, 1995) so that segmentation difficulties did not interfere with the ability to learn the meaning of the novel word. During the word-event familiarization phase (34 seconds), participants saw a video of an event and heard it described by a sentence that included a novel verb (see (7) below). The events all involved an inanimate object undergoing a particular motion. For example, in one event the head of a plastic garden flower spins. A complete list of the events used as familiarization stimuli is given in Table 2.<sup>i</sup> During the familiarization phase, a given event was shown four times (6 s each presentation, each separated by 1 s of black screen) and on both sides of the screen, first once on each of the left and right sides in sequence, and then twice on both sides simultaneously. The order of left-right position was counterbalanced across trials.

Each of the four events was paired with a different novel verb used intransitively.  
The particular sentences in which the novel word occurred differed according to  
condition. Children in the *high lexical content* condition heard the novel word used with a

full lexical noun phrase as subject, as in (7a). Children in the *low lexical content* condition heard the novel word used with semantically light subject noun phrases, as in

(7b).

(7) a. Look! The flower is blicking.  
Do you see the flower blicking?

b. Look! That thing is blicking.  
Do you see it blicking?

**Table 1**  
***Schematic of Trial Design, Experiment 1***

Phase	Time	Left side of screen	Right side of screen	Audio track
Recentering	5 s	baby		giggle
Word-form Familiarization	25s	Cow puppet and dinosaur puppet engaged in discussion		“I love to blick. I can blick better than anyone else. Blicking is my favorite thing to do....”
Familiarization	6 s	Flower spins	black screen	Look! [The flower/That thing] is blicking. Do you see [the flower/it] blicking?
	6 s	Black screen	Flower spins	Wow! [The flower/It] is blicking. Do you see [the flower/it] blicking?
	6 s	Flower spins	Flower spins	Yay! [The flower/It] is blicking. Do you see [the flower/it] blicking?
Contrast	6 s	(centered) flower waves from side to side		Oh no! Now [The flower/It] is not blicking. [The flower/That thing] is not blicking.
Familiarization	6 s	Flower spins	Flower spins	Yay! Now [The flower/It] is blicking. Do you see [the flower/it] blicking?
Test	12 s	<u>Same Event</u>  Flower spins	<u>Different Event</u>  Flower moves up and down	Oh look, they’re different. Do you see blicking? Which one is blicking? Where’s blicking now?

Between the third and fourth presentations of our familiarization events, participants saw a 6-second contrast event in which the event participant was engaged in a different activity which, unlike the familiarization events, involved two participants (Table 2). Accompanying this contrast event, they heard an event description that repeated the novel verb presented during familiarization, but that made it clear that the referent of that verb was not depicted (e.g., “Oh no! Now the flower/it is not blicking.”). Previous studies of verb learning have suggested that in an experimental context, young children tend to include an event’s patient in the meaning of a novel verb labeling the action performed on it, such that they have trouble extending the novel verb to label the same action performed on a new object (e.g., Imai, Haryu, & Okada, 2005; Imai et al., 2008). The goal of our contrast phase was, in part, to constrain the hypotheses postulated for our novel verbs by pointing out the event features that were not included in the meaning of the novel verb (viz., the event participants). In addition, the contrast phase helps the infant participants recognize that some events do not fall under the novel label, thus helping them overcome task demands. Novel verbs were presented a total of 10 times during each familiarization phase (Table 1).

**Table 2**  
***Familiarization and Contrast Events***

<b>Novel verb</b>	<b>Familiarized event</b>	<b>Contrast event</b>
<i>blick</i>	flower spins	boy waves flower back and forth
<i>flurb</i>	light flashes	girl puts light on her head
<i>larp</i>	ring-tower rocks back and forth	boy turns ring-tower over and over
<i>krade</i>	ball deflates	girl bounces ball

On each trial, the familiarization phase was immediately followed by a test phase in which participants saw two new events presented simultaneously on opposite sides of the screen and were directed by the auditory stimulus to find the action represented by the novel verb introduced during familiarization. Both test events involved the same event participant presented during familiarization, but only one was the same event category. In one of the test events, the object participated in the same event type as during familiarization. The other test event depicted the same participant involved in a different event (e.g., it moved in a different way). The auditory stimulus accompanying these test events directed participants to find the action represented by the novel verb introduced during familiarization.

Participant attention was (re)centered before each trial by the presentation of a 5-s stimulus (a picture of a baby accompanied by the sound of giggling). The side of the television screen on which the familiarization event was first presented during familiarization was counterbalanced, as was the location (right vs. left side) of the new events shown during the test phase.



*Procedure.* Children and caregivers were greeted and given a brief description of the experimental procedure. While the child played freely in the laboratory play area, caregivers signed a consent form and filled out language questionnaires, including the MCDI. When both the child and the caregiver appeared to be at ease, the experimenter led them to the adjoining testing room. Children were tested individually, seated in a booster chair facing and situated approximately 6 ft in front of a 61" television screen. Caregivers either stood behind the children or sat out of the child's line of vision. Caregivers were asked to refrain from talking or offering nonverbal encouragement while in the testing room.

Visual stimuli were projected to a 3.9 by 2.6 ft area of the projection screen. Audio stimuli were presented at 65 dB,  $\pm$  5 dB. Presentation of the stimuli and recording of participant responses were controlled by the experimenter from behind a black curtain that extended across the entire height and width of the room behind the television, completely blocking the apparatus from view of the participants. Attention to the stimuli was recorded using a digital video camera situated just below the projection screen.

### *Coding*

The videotaped sessions were coded off-line with sound removed to ensure that coders, who were blind to the experimental hypotheses and to the right-left position of the novel and familiar test scenes, were also blind to condition assignment. Coders identified for each frame (30 frames per second), whether the infant's eyes were oriented to the left scene, the right scene, or neither scene. This frame-by-frame coding permitted us to create two types of measures.

First, we created a record of the time-course of infants' looking behavior throughout the test phase. We calculated for each infant on each frame, the proportion of looks directed toward the familiar test scene (total number of looks devoted to the familiar test scene, divided by the total number of looks to the familiar and to the novel test scene) across trials. We then computed an average, across infants for each frame in each condition, to produce a high-resolution record of the time-course of infants' looking behavior in each condition.

Second, for the purposes of statistical analysis, we selected two 'windows', one from the baseline period of the test phase, and another from the response period of the test phase. The response window began with the onset of the novel word and ended 2 seconds later.<sup>3</sup> The baseline window included the last 2 seconds of the baseline period.<sup>4</sup> Within each window, we calculated for each infant and each trial, the mean proportion of looking time devoted to the familiar test scene (total time accumulated looking toward the familiar test scene divided by the total time accumulated looking toward both the familiar and novel test scenes).

A primary coder coded all of the infants. A second coder independently coded six infants, three per condition. Agreement between coders in both the baseline and response windows (computed for each trial and then averaged across trials) was 88% (Cohen's kappa = .8). For cases in which we found a disagreement between coders (n=2), a third research assistant provided a tiebreaking code of the data.

Trials in which participants attended to the test events for less than 70% of the test period were excluded from analysis. Participants with more than two excluded trials were

replaced in the design, as were those who exhibited a fixation bias across trials of more than 75% to a single side of the projection screen.

### *Predictions*

We considered two hypotheses.

**Informativity Hypothesis:** The impact of a cue on learning is strictly determined by its informativity.

**Informativity + Processing Hypothesis:** The impact of a cue is a function of both its informativity and the processing resources required to access the information that it conveys.

The informativity hypothesis predicts that infants will learn the meaning of the verb better in the high lexical content condition than in the low lexical content condition. The Informativity+Processing Hypothesis predicts that infants will learn the meaning of the verb better in the low lexical content condition than in the high lexical content condition.

### **Results**

#### **EXPERIMENT 1**

Table 3 gives mean proportions of looking times to the familiar event during the baseline and response window in each of the two conditions.

Window/Condition	Baseline	Response
Low Lexical Content	0.30 (.035)	0.51 (.062)
High Lexical Content	0.37 (.039)	0.35 (.047)

Table 3. Mean proportion looking time to the familiar event in each of two windows by condition. Standard error of the mean is given in parentheses.

To determine whether and how the lexical content of the subject noun phrase affected infants' construals of a novel verb, we computed the proportion of looking time

devoted to the familiar test scene in each condition, and submitted this to an analysis of variance with condition (2: High lexical content vs. Low lexical content) as a between-participants factor and window (2: baseline, response) as a within-participants factor. This analysis revealed no main effect for condition,  $F(1, 31) = 0.99, p > 0.32$ ; a main effect for window,  $F(1, 31) = 3.85, p < .05$ ; infants looked reliably longer at the familiar scene in the response window ( $M = .43$ ) than in the baseline window ( $M = .34$ ). These main effects were qualified by a window x condition interaction,  $F(1, 31) = 6.01, p < .02$ . Post hoc analyses of this effect revealed that infants in the Low Lexical Content condition showed a significant increase from baseline ( $M=.30$ ) to test ( $M=.51$ ) (Tukey test,  $p<.05$ ), whereas infants in the High Lexical Content condition showed no such increase (baseline:  $M=.35$ ; test:  $M=.37$ ). Infants in the latter condition maintained their preference for the novel test scene, both  $p$ 's  $< .001$ , but those in the Low Lexical Content condition showed no such preference. It is important to notice that in both conditions looking times to the familiar event in the baseline window are significantly below chance (High Lexical Content  $M = .35, t(15) = -5.35, p<.0001$ ; Low Lexical Content  $M = .30, t(15) = -4.2, p<.001$ ). This pattern reflects a novelty preference for the video that was not present during familiarization. Thus, baseline performance in this experiment is not expected to be 50%. Consequently, although performance in the Low Lexical Content condition did not differ from the level of responding expected by chance (50%), within the context of the current experiment this should not be considered a null effect since the pattern of responding is significantly different from the baseline.

*Discussion:*

The results of Experiment 1 indicate that 22-month-old infants were better able to learn the meaning of a novel verb when the subject of that verb was a pronoun than when

it was a full Noun Phrase. These results are consistent with the hypothesis that there is an extra processing cost associated with the lexical access and rich semantic representation of a contentful count noun as compared to the processing cost of a subject pronoun. Recall that most of the infants in this study were reported to know most of the nouns used in the high lexical content condition, so it is reasonable to conclude that this effect was driven to some degree by the information contained in these nouns. Although contentful count nouns contain more semantic information than pronouns, this extra information may come with a processing burden that impacts verb learning negatively. Importantly, the average number of critical nouns known by infants in the High Lexical Content conditions was not statistically different from the average number known by the infants in the Low Lexical Content condition ( $t(31) = 0.6$ , ns).

However, there are several additional hypotheses that are also consistent with these results. First, it is possible that learners succeeded only in the Low Lexical Content condition because pronouns are a better cue to the syntactic category of the novel word than a full Noun Phrase is. Pronouns could be a better cue for two reasons. First, pronouns are highly frequent. Second, pronouns may be better predictors than any individual count noun that a verb is likely to follow. If pronouns are a better cue to syntactic category than full noun phrases are, then it is possible that children did not construct syntactic representations of the sentences containing the novel verb at all. Rather, the infants may have used cooccurring function words as a cue to syntactic category (Bernal et al., 2007; Hicks, 2006; Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004; Mintz, 2003). On this view, infants succeeded in the low lexical content condition because the adjacency of the pronoun to the novel word was a cue to its status

as a verb, and that they know a mapping between verbs and categories of events. By the same token, it is possible that infants failed to learn in the high lexical content condition because there was no immediately adjacent function word in that condition.

This latter hypothesis is supported by independent work showing that preschool-aged children learned novel verbs better when they occurred in the context of pronouns than when they occurred in the context of lexical Noun Phrases (Childers & Tomasello, 2001). Pronouns and other function words have also been shown to be used by infants as a cue to the syntactic category of a novel word (Bernal et al., 2007; Hicks 2006; Höhle et al., 2004).

In order to rule out this alternative hypothesis, we conducted an additional experiment in which we aimed to lessen the processing burden associated with the lexical Noun Phrase. If we can successfully reduce this burden, then we predict that learners will now be able to succeed at discovering the meaning of the novel verb. Alternatively, if the results of experiment 1 are explained solely by the potency of pronouns as the only cue to the syntactic category and indirectly the meaning of the novel word, then reducing the processing burden associated with the lexical NP should have no effect on learners.

### *Experiment 2*

*Participants.* Thirty-two children ranging in age from 21 to 23 months ( $M = 22;9$ ) were included in the final sample for this study. Participants were recruited from the communities surrounding Evanston, IL and College Park, MD and were acquiring English as their native language (with  $\leq 10\%$  input in a language other than English). Mean productive vocabulary for children in this study was 192 words (range 3–526, out of a possible 680). An additional 10 children were excluded due to age ( $n = 2$ ), caregiver-reported speech or hearing problems ( $n = 1$ ), inattention for more than 30% of the test

phase on more than two trials ( $n = 4$ ), and experimenter error or equipment malfunction ( $n = 1$ ).

*Method:* Experiment 2 was identical to Experiment 1, except that we added an additional noun familiarization scene to each trial after the word-form familiarization and before the novel word familiarization. This noun familiarization presented in succession 4 still images of the object that would serve as the event participant in the familiarization events (e.g., the flower). As each image was presented, the audio track said, “It’s a flower. Do you see the flower? There’s the flower again. Wow! It’s a flower.”

*Predictions:* If the failure to learn the novel verb in the High Lexical Content condition of experiment 1 derived from difficulty processing the lexical noun in the subject noun phrase, then successive presentation of the noun prior to introduction of the novel verb should lessen this difficulty and consequently enable verb learning.

On the other hand, if infants’ success only in the Low Lexical Content Condition of experiment 1 derived from the special potency of pronouns as a cue to the next word being a verb, then no amount of familiarization to the lexical NP should facilitate learning.

## EXPERIMENT 2

### Results

Table 4 provides mean looking times to the familiar event in the baseline and response windows in the two conditions.

Window/Condition	Baseline	Response
Low Lexical Content	0.36 (.039)	0.49 (.061)
High Lexical Content	0.39 (.044)	0.60 (.046)

Table 4. Mean proportion looking time to the familiar event during the baseline and response window in two conditions. Standard error of the mean is given in parentheses.

To determine whether and how the lexical content of the subject noun phrase affected infants' construals of a novel verb, we computed the proportion of looking time devoted to the familiar test scene in each condition, and submitted this to an analysis of variance with condition (2: High lexical content vs. Low lexical content) as a between-participants factor and window (2: baseline, response) as a within-participants factor. This analysis revealed no main effect for condition,  $F(1, 31) = 1.68, p > 0.22$ ; a main effect for window,  $F(1, 31) = 18.5, p < .0002$ ; infants looked reliably longer at the familiar scene in the response window ( $M = .55$ ) than in the baseline window ( $M = .38$ ). Unlike in experiment 1, however, we found no window x condition interaction,  $F(1, 31) = 0.97, p < .33$ , indicating that the increase in looking time from baseline to response was consistent across conditions. Indeed in the High Lexical Content condition, we saw a significant increase in looking time to the familiar event in the response window ( $M=.60$ ) as compared to the baseline window ( $M=.39$ ) that mirrored the pattern in the Low Lexical Content Condition (response:  $M=.50$ , baseline:  $M = .36$ .), (Tukey test,  $p<.05$ ).

### *Discussion*

The results of experiment 2 support our initial interpretation of experiment 1. By reducing the processing load associated with the lexical noun phrase subject in experiment 2, we were able to see infants learning the novel verb in both the High and Low lexical content conditions. This suggests that the advantage conferred on verb learning by subject pronouns is related to the ease of processing them, as compared to lexical Noun Phrases, and not to their special status as good statistical indicators of the grammatical category of the following word.

### *General Discussion.*



A dominant approach to the study of language acquisition is to determine what sources of information contribute to learning, asking both what sources of information are available and what information sources learners utilize. The current results push this perspective further by assessing the information processing consequences associated with particular cues to learning. We have found that for infants, the demands imposed by recognizing a cue can overpower the informativity inherent in that cue. In other words, the availability of a cue is independent of its utility for learning, as described below.

More narrowly, we have shown that the advantage for verb learning conferred by the verb's occurring adjacent to a pronoun derives not from the utility of the pronoun as a cue, but from the ease of processing it relative to a lexical Noun Phrase. The finding that the condition with less semantic information in it is more effective for learning conflicts with the results from the Human Simulation Paradigm reported in Gillette et al. 1999 and Snedeker & Gleitman 2004. However, once we consider the information processing requirements of utilizing the extra information associated with lexical noun phrases, then these results follow straightforwardly. More information entails more work for the learner and this extra work can interfere with learning.

In this particular case, we have hypothesized that differences in the lexical status of the subject NP can impact verb learning in the following way. If the subject NP is easy to access from the lexicon, then it can easily be integrated into the structure of the sentence and function as a structural cue to word learning. This ease can come from inherent properties of the subject NP, like whether it is a pronoun or a lexical NP. Alternatively, this ease can come by increasing the baseline lexical activation of the

lexical NP, as when we repeated the lexical NP several times prior to using it in a sentence containing the novel verb.

If it is true that the difficulty for intransitive verb learning that is introduced by having a lexical NP derives from difficulty in building a phrase structure representation prior to the introduction of the novel verb, then we would expect that this difficulty would not be found in cases where the subject noun phrase occurred after the verb, as in the Spanish example in (3b):

- (3)    a.      La pelota está caendo  
              The ball is falling  
              ‘The ball is falling.’
- b.      Está caendo, la pelota  
              is falling, the ball  
              ‘The ball is falling.’

Similarly, in transitive structures, we should find a subject-object asymmetry where a lexical subject would interfere with verb learning (relative to a pronominal subject), but a lexical object Noun Phrase would not. These predictions are being pursued in ongoing work in our labs.

In contrast to the current result, Arunachalam & Waxman (2009) report an advantage for lexical noun phrase arguments over pronouns when a novel verb is presented in a transitive clause. That is, they report successful verb learning with “the man is pilking the balloon,” but not with “he’s pilking it.” It may be that the asymmetry between learning in the transitive vs. intransitive cases also reflects the interaction between informativity and processing costs. Unlike the intransitive case presented here, in a transitive clause the learner is faced with the dual challenge of mapping two Noun Phrases to their referents and learning the verb. In this case, the lexical noun phrases

provide more information because they help to identify what role each participant plays in the event labeled by the verb. Although this extra information may come with a processing cost, this cost may be offset by the benefit of using the lexical content to identify the referent, a cost which was not present in the current experimentation. Future work will need to more finely articulate the cost-benefit analysis associated with any particular set of cues.

It is important to recognize that while this study examines verb learning, we provided no contrast between verbs and words from other grammatical categories. From these data we cannot be sure that the effects we see here are a function of verb learning and not of word learning more generally. However, in other work (Bernal et al., 2007; Waxman et al., 2009), we have shown that infants of this age are aware that verbs and nouns present different options for word meaning, with nouns referring to object categories and verbs referring to event categories.

Finally, the work reported here highlights the need to integrate models of infant language learning with models of language processing (Christophe et al., 2008; Gagliardi, Shenk, & Lidz, 2009). Understanding how language is processed by infants, children and adults enables us to identify places where processing demands vary and to measure the impact of these demands on infants' ability to draw inferences about the words and structures they are learning.

## References

- Arunachalam, S., & Waxman, S. R. (2009, November). *24-month-old infants' use of syntactic context in noun and verb learning*. Paper presented at the Society for Research in Child Development Biennial Meeting, Denver, CO.
- Arunachalam, S., & Waxman, S. R. (In press). Meaning from syntax: Evidence from 2-year-olds. *Cognition*.
- Bunger, A., & Lidz, J. (2004). Syntactic bootstrapping and the internal structure of causative events. *Proceedings of the Annual Boston University Conference on Language Development*, 28, 74–85.
- Bunger, A., & Lidz, J. (2006). Constrained flexibility in the acquisition of causative verbs. *Proceedings of the Annual Boston University Conference on Language Development*, 30, 60–71.
- Bernal, S., Lidz, J., Millotte, S., & Christophe, A. (2007). Syntax constrains the acquisition of verb meaning. *Language Learning and Development*, 3, 325–342.
- Caselli, M., Bates, E., Casadio, P., Fenson, J., Fenson, L., Sanderl, L., et al. (1995). A cross-linguistic study of early lexical development. *Cognitive Development*, 10, 159–199.
- Childers, J. B. & Tomasello, M. (2001). The role of pronouns in young children's acquisition of the English transitive construction. *Developmental Psychology*, 37, 739–748.
- Chomsky, N. (1959) Review of B.F. Skinner's Verbal Behavior. *Language* 35:26-58.

- Christophe, A., S. Millotte, S. Bernal and J. Lidz. Bootstrapping Lexical and Syntactic Acquisition. *Language and Speech* 51:61-75.
- Fenson, L., Dale, P. S., Reznick, J. S., Thal, D., Bates, E., Hartung, J., Pethick, S., & Reilly, J.S. (1993). *User's guide and technical manual for the MacArthur Communicative Development Inventories*. San Diego, CA: Singular Press.
- Fisher, C. (1996). Structural limits on verb mapping: The role of analogy in children's interpretations of sentences. *Cognitive Psychology*, 31, 41–81.
- Fisher, C. (2002). Structural limits on verb mapping: The role of abstract structure in 2.5-year-olds' interpretations of novel verbs. *Developmental Science*, 5, 56–65.
- Fisher, C., Hall, D. G., Rakowitz, S., & Gleitman, L. (1994). When it is better to receive than to give: Syntactic and conceptual constraints on vocabulary growth. *Lingua*, 92, 333–375.
- Gagliardi, A., Shenk, T., & Lidz, J. (2009, March). *The acquisition of filler-gap dependencies in 15- and 20-month-olds*. Paper presented at the CUNY Conference on Human Sentence Processing, Davis, CA.
- Gentner, D. (1982). Why nouns are learned before verbs: Linguistic relativity versus natural partitioning. In S. Kuczaj II (Ed.), *Language development, vol. 2: Language, thought, and culture* (pp. 301–334). Hillsdale, NJ: Lawrence Erlbaum.
- Gentner, D., & Boroditsky, L. (2001). Individuation, relativity and early word learning. In M. Bowerman & S. Levinson (Eds.), *Language acquisition and conceptual development* (pp. 215–256). Cambridge, UK: Cambridge University Press.
- Gillette, J., Gleitman, H., Gleitman, L., & Lederer, A. (1999). Human simulations of vocabulary learning. *Cognition*, 73, 135–176.

- Gleitman, L. (1990). The structural sources of verb meanings. *Language Acquisition*, 1, 3–55.
- Goldin-Meadow, S., Seligman, M. E., & Gelman, R. (1976). Language in the two-year old. *Cognition*, 4, 189–202.
- Golinkoff, R. M., Hirsh-Pasek, K., Cauley, K. M., & Gordon, L. (1987). The eyes have it: lexical and syntactic comprehension in a new paradigm. *Journal of Child Language*, 14, 23–45.
- Hicks, J. P. (2006). *The impact of function words on the processing and acquisition of syntax*. Unpublished doctoral dissertation, Northwestern University.
- Höhle, B., Weissenborn, J., Kiefer, D., Schulz, A., & Schmitz, M. (2004). Functional elements in infants' speech processing: The role of determiners in the syntactic categorization of lexical elements. *Infancy*, 5, 341–353.
- Huttenlocher, J. (1974). The origins of language comprehension. In R. Solso (Ed.), *Theories in cognitive psychology* (pp. 331–368). Hillsdale, NJ: Erlbaum.
- Imai, M., Haryu, E., & Okada, H. (2005). Mapping novel nouns and verbs onto dynamic action events: Are verb meanings easier to learn than noun meanings for Japanese children? *Child Development*, 76, 340–355.
- Imai, M., Li, L., Haryu, E., Okada, H., Hirsh-Pasek, K., Golinkoff, R., & Shigematsu, J. (2008). Novel noun and verb learning in Chinese-, English-, and Japanese-speaking children. *Child Development*, 79, 979–1000.
- Jusczyk, P. W., & Aslin, R. N. (1995). Infants' detection of the sound patterns of words in fluent speech. *Cognitive Psychology*, 29, 1–23.

- Klibanoff, R. S., & Waxman, S. R. (2000). Basic level object categories support the acquisition of novel adjectives: Evidence from preschool-aged children. *Child Development*, 71, 649–659.
- Landau, B., & Gleitman, L.R. (1985). *Language and experience: Evidence from the blind child*. Cambridge, MA: Harvard University Press.
- Lidz, J., Gleitman, H., & Gleitman, L. (2003). Understanding how input matters: Verb-learning and the footprint of universal grammar. *Cognition*, 87, 151–178.
- Markman, E. M. (1989). *Categorization and naming in children*. Cambridge, MA: Bradford Books.
- Markman, E. M., & Hutchinson, J. E. (1984). Children's sensitivity to constraints on word meaning: Taxonomic versus thematic relations. *Cognitive Psychology*, 16, 1–27.
- Mervis, C. B. (1987). Child-basic object categories and early lexical development. In U. Neisser (Ed.), *Concepts and conceptual development: Ecological and intellectual factors in categorization* (pp. 201–233). Cambridge: Cambridge University Press.
- Mintz, T. H. (2003). Frequent frames as a cue for grammatical categories in child directed speech. *Cognition*, 90, 91–117.
- Mintz, T. H., & Gleitman, L. R. (2002). Adjectives really do modify nouns: The incremental and restricted nature of early adjective acquisition. *Cognition*, 84, 267–293.
- Naigles, L. (1990). Children use syntax to learn verb meanings. *Journal of Child Language*, 17, 357–374.

- Naigles, L. R. (1996). The use of multiple frames in verb learning via syntactic bootstrapping. *Cognition*, 58, 221–251.
- Piccin, T. B., & Waxman, S. R. (2007). Why nouns trump verbs in word learning: New evidence from children and adults in the Human Simulation Paradigm. *Language Learning and Development*, 3, 295–323.
- Quine, W. V. O. (1960). *Word and Object*. Cambridge, MA: MIT Press.
- Snedeker, J., & Gleitman, L. (2004). Why it is hard to label our concepts. In D.G. Hall & S.R. Waxman (Eds.), *Weaving a lexicon* (pp. 257–294). Cambridge, MA: MIT Press.
- Soja, N., Carey, S., & Spelke, E. (1991). Ontological categories guide young children's inductions of word meanings: Object terms and substance terms. *Cognition*, 38, 179–211.
- Spelke, E. S. (1979). Perceiving bimodally specified events in infancy. *Developmental Psychology*, 15, 626–636.
- Syrett, K. & J. Lidz (in press). “30-month-olds use the distribution and meaning of adverbs to interpret novel adjectives.” *Language Learning and Development*.
- Waxman, S.R. (1999). Specifying the scope of 13-month-olds’ expectations for novel words. *Cognition*, 70, B35-B50.
- Waxman, S. R., & Booth, A. E. (2001). Seeing pink elephants: Fourteen-month-olds’ interpretations of novel nouns and adjectives. *Cognitive Psychology*, 43, 217–242.
- Waxman, S. R., & Booth, A. E. (2003). The origins and evolution of links between word learning and conceptual organization: New evidence from 11-month-olds. *Developmental Science*, 6(2), p 130 – 137.



- Waxman, S. R., & Markow, D. B. (1995). Words as invitations to form categories: Evidence from 12-month-old infants. *Cognitive Psychology*, 29, 257–302.
- Waxman, S. R., & Lidz, J. (2006). Early word learning. In D. Kuhn & R. Siegler (Eds.), *Handbook of Child Psychology, 6th Edition, Volume 2* (pp. 299–335). Hoboken NJ: Wiley.
- Waxman, S. R., Lidz, J., Braun, I. E., & Lavin, T. (2009). Twenty-four-month-old infants' interpretations of novel verbs and nouns in dynamic scenes. *Cognitive Psychology*, 59, 67–95.
- Woodward, A. L., & Markman, E. M. (1998). Early word learning. In W. Damon & D. Kuhn & R. Siegler (Eds.), *Handbook of child psychology, Volume 2: Cognition, perception and language* (pp. 371–420). New York: John Wiley and Sons.

---

<sup>i</sup> Example videos of the stimuli for these experiments can be found at:  
<http://ling.umd.edu/labs/acquisition/?page=stimuli>