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## Grammatical Form and Semantic Context in Verb Learning

Sudha Arunachalam and Sandra R. Waxman

*Department of Psychology, Northwestern University*

Decades of research have documented that young word learners have more difficulty learning verbs than nouns. Nonetheless, recent evidence has uncovered conditions under which children as young as 24 months succeed. Here, we focus in on the kind of linguistic information that undergirds 24-month-olds' success. We introduced 24-month-olds to novel words (either nouns or verbs) as they watched dynamic scenes (e.g., a man waving a balloon); the novel words were presented in semantic contexts that were either rich (e.g., *The man is pilking a balloon*) or more sparse (e.g., *He's pilking it*). Toddlers successfully learned nouns in both the semantically rich and sparse contexts but learned verbs only in the rich context. This documents that to learn the meaning of a novel verb, English-acquiring toddlers take advantage of the semantically rich information provided in lexicalized noun phrases. Implications for cross-linguistic theories of acquisition are discussed.

Toddlers and young children acquire words at an astonishing pace, apparently requiring very little exposure to add a new word to their vocabularies (e.g., Carey & Bartlett, 1978). Ultimately they will extend a novel word beyond the particular object or scene in which it was initially introduced. But when they are first introduced to a novel word, what kind of representation do they initially assign? If a child first hears the word “kick” at a soccer match, is her representation sufficiently abstract to permit her to understand this same word in different linguistic and social contexts, for example, “Don’t kick your brother”? Or is her initial representation so specific as to be tied to the situation in which the word was first encountered?

The answer to this question may depend on the kind of word involved. By 13 months, toddlers will systematically extend a novel noun applied to a particular object (e.g., a horse) to other objects from the same object category (other horses) (Booth & Waxman, 2003, 2009; Waxman, 1999; Waxman & Markow, 1995). This is not to say that toddlers immediately grasp the full, nuanced meaning of the novel noun. Instead, the claim is that their initial representation is sufficiently abstract to include other members of the same kind, and that over time and with repeated encounters the details of the noun’s meaning will be filled in.

However, other kinds of words may evince a different pattern of acquisition than that observed for nouns. In particular, verb learning appears to require access to different, and perhaps more detailed, information than is the case for nouns. For example, because verbs are predicates that

take nouns as arguments, knowing which nouns occur with a novel verb may be a prerequisite for learning its meaning (e.g., Fisher & Gleitman, 2002; Gentner, 2006; Gleitman, Cassidy, Papafragou, Nappa, & Trueswell, 2005; Hirsh-Pasek & Golinkoff, 2006; Waxman & Lidz, 2006). This fits well with the evidence that early in lexical acquisition, nouns tend to predominate; only later, at roughly 24 months, do verbs typically begin to appear in appreciable numbers. Moreover, even at this point, young learners continue to encounter obstacles: several laboratories have documented toddlers' difficulty extending newly learned verbs beyond the particular scenes on which they were initially introduced (Behrend, 1989; Forbes & Farrar, 1993; Haryu et al., 2005; Hirsh-Pasek, Golinkoff, Maguire, & Imai, 2005; Imai, Haryu, & Okada, 2005; Imai, Haryu, Okada, Iirsch-Pasek, Golinkoff, & Shigematsu, 2008; Kersten & Smith, 2002; Meyer, Leonard, Hirsh-Pasek, Golinkoff, Imai, & Haryu, 2003; Poulin-Dubois & Forbes, 2002).

Toddlers' difficulty extending verbs to new situations is puzzling: After all, in their spontaneous language use, toddlers *produce* verbs with a range of participant objects. For example, in a corpus study focusing on toddlers' first verbs, Naigles, Hoff, and Vear (2009) found that 89% of toddlers' first verbs were produced with more than one participant object. Also puzzling is the fact that this apparent difficulty extending novel verbs (but not nouns) has been documented not only in toddlers but also in preschool-aged children as well. For example, Imai et al. (2008) introduced 3-year-old children to dynamic scenes in which an agent (e.g., a woman) performed a novel action on a novel object (e.g., a woman twirled a novel object in a novel way). Children who heard these scenes described with a novel noun (e.g., "Look! This is a pilk!") successfully extended that noun to new scenes involving the same object, even if it was engaged in a different action. However, children who heard the scenes described with a novel verb (e.g., "Look! She is pilking it!") had considerably more difficulty: They failed to extend verbs to new scenes involving the same action, if the action was carried out using a different object.

Toddlers' and preschoolers' difficulty in this apparently straightforward task suggests that even once verb learning is underway, it requires access to different—and perhaps more—information than noun learning (see Gleitman et al., 2005, or Waxman & Lidz, 2006, for reviews; see Gillette et al., 1999; Piccin & Waxman, 2007; Snedeker & Gleitman, 2004, for experimental evidence). In a recent investigation focusing on 24-month-olds, Waxman and her colleagues provide additional support for this interpretation (Waxman, Lidz, Braun, & Lavin, 2009). In this series of experiments, toddlers were introduced to scenes in which an animate agent performed an action on an inanimate object (e.g., a man waved a balloon). However, they were offered considerably richer information than in previous investigations of verb learning. During a familiarization phase, toddlers viewed each novel event several times; they also heard the novel word several times, each time embedded in a rich semantic context (e.g., "Look! The man is pilking a balloon" (verb condition) or "Look! The man is waving a pilk" (noun condition)). Next, toddlers viewed two test scenes, presented side-by-side: a) the familiar agent performing the familiar action on the familiar object (e.g., the man waving a balloon) and b) the agent performing a new action on the familiar object (e.g., the man tapping a balloon). Toddlers were directed to seek the referent of the novel word (e.g., "Which one is he pilking?" (verb condition) or "Which one is the pilk?" (noun condition). In the context of this rich observational and linguistic information, 24-month-olds successfully mapped novel verbs to actions.

With this finding as a foundation, in the current experiment we go on to address several questions about verb learning that remain unanswered, including a) whether 24-month-olds can extend their newly learned verbs more broadly to scenes involving the same action but

different objects, b) whether their success requires access to such rich linguistic information as that presented in Waxman et al. (2009), and c) whether their success, measured thus far only in looking-time tasks, is sufficiently robust to hold up in a pointing task, a more active and explicit measure. We discuss each of these issues in turn.

### EXTENDING NEWLY LEARNED VERBS BEYOND THE SCENES ON WHICH THEY ARE INITIALLY INTRODUCED

Recall that corpus analyses document that toddlers apply their earliest verbs to activities that involve a range of participant objects (Naigles et al., 2009). In the current experiment, we move on to consider toddlers as they are engaged in the process of acquiring novel verbs. This permits us to discover whether toddlers can extend newly learned verbs to events involving new participant objects, even after only a few exposures.

Addressing this question required that we modify the structure of the Waxman et al. (2009) test trials. As in Waxman et al. (2009), toddlers were familiarized to scenes in which an animate agent performed an action on an inanimate object (e.g., a man waved a balloon). However, at test, they viewed *two novel scenes*: (a) the agent performing the familiar action on a *new* object (e.g., the man waving a *rake*) and (b) the agent performing a *new* action on the familiar object (e.g., the man *tapping* a balloon). If they can extend newly learned verbs beyond the particular instances on which they were introduced, toddlers in the verb condition should be able to abstract over a change in the participant object, selecting test scene (a) over (b).

### CONSIDERING THE “RICHNESS” OF THE LINGUISTIC INFORMATION

A second goal of the current study is to home in on the kinds of information that young word learners require for successful noun and verb learning. There is strong evidence that they take advantage of social (e.g., Behrend & Scofield, 2006; Golinkoff & Hirsh-Pasek, 2008; Poulin-Dubois & Forbes, 2002; Sabbagh & Baldwin, 2001; Tomasello & Barton, 1994; Trueswell, Nappa, Wessel, & Gleitman, 2007) and observational cues (e.g., Golinkoff & Hirsh-Pasek, 2008; Imai et al., 2008; Maguire, Hennon, Hirsh-Pasek, Golinkoff, Slutzky, & Sootsman, 2002; Maguire, Hirsh-Pasek, Golinkoff, & Brandone, 2008; Piccin & Waxman, 2009; Waxman et al., 2009). Recall also that in Waxman et al. (2009), toddlers were offered rich information, both observational and linguistic. What remains unanswered, however, is which aspects of this rich information were essential to 24-month-olds’ success.

To address this issue, we hold constant the social and observational cues provided, focusing on the contribution of *linguistic* information. We consider two kinds of linguistic information: grammatical form class (manipulating whether the novel word is presented as either a noun or verb) and semantic richness (manipulating the semantic richness of the sentential contexts in which the novel words are presented). At issue is how rich the surrounding linguistic information must be for toddlers to successfully map novel words to meaning.

For verbs in particular, this issue is the focus of considerable debate. On one hand, frequent contexts, such as contexts involving pronouns rather than fully lexicalized noun phrases, may be ideal for verb learning. English-acquiring 24-month-olds often hear verbs presented

in pronoun contexts (e.g., Cameron-Faulkner, Lieven, & Tomasello, 2003), and experimental evidence indicates that pronoun contexts help learners determine a novel word's grammatical category (Mintz, 2003; Weisleder & Waxman, 2009) and extend it syntactically (Childers & Tomasello, 2001). Indeed, because they are so frequent in the input to young children, pronoun contexts figure largely in theories in which frequent language chunks drive the acquisition process (e.g., Tomasello, 2003). On the other hand, despite their frequency in the input, pronouns provide sparse semantic information. Several studies have shown that learners rely on the semantic content of a novel verb's context to determine its meaning (Fisher et al., 1994; Gillette et al., 1999; Gleitman et al., 2005; Piccin & Waxman, 2007; Snedeker & Gleitman, 2004). Contexts that are rich in semantic content, then, may be better than pronoun contexts for discovering a novel verb's meaning.

In the current experiment, we address this question directly, systematically manipulating the richness of the semantic contexts in which we embedded novel nouns and verbs. For toddlers in the Rich condition, novel words were embedded in sentences containing full noun phrase descriptions of each event participant (e.g., "The man is pilking a balloon"/"The man is waving a pilker"). For toddlers in the Sparse condition, we stripped back the semantic information, embedding the novel words in sentences containing pronouns, rather than full noun phrase descriptions, of the event participants (e.g., "He's pilking it"/"He's waving a pilker").

We expected that toddlers would successfully learn novel nouns in both the Rich and Sparse conditions. At issue was their performance with novel verbs. If pronoun contexts are ideal for learning the meaning of a novel verb, then toddlers should successfully learn the novel verbs in the Sparse condition and may encounter difficulty in the Rich condition (e.g., the rich descriptions of the participant objects may distract them from focusing on the action). On the other hand, if toddlers rely on the surrounding semantic information to help them discover the meanings of novel verbs, then they should more successfully learn novel verbs in the Rich than the Sparse condition.

## GATHERING CONVERGING EVIDENCE FROM POINTING

Our third goal in the current experiment is methodological: to ascertain whether toddlers' recently documented success in verb learning tasks, identified primarily in looking-time measures, is also evident in their pointing responses. Pointing, which requires a more active response than looking-time, has served as a reliable measure of word learning in participants as young as 27 months of age (Arunachalam & Waxman, 2010a, b; Fernandes, Marcus, DiNubila, & Vouloumanos, 2006; Maguire et al., 2008). However, there is considerably less evidence from younger toddlers. To the best of our knowledge, only one experiment used pointing as a dependent measure at 24 months (Bernal, Lidz, Millotte, & Christophe, 2007). Twenty-four-month-olds' performance on Bernal et al.'s pointing task converged well with performance on a similar task using looking time (Waxman et al., 2009). Interestingly, however, the number of participants excluded due to their difficulty producing pointing responses was high (40%)<sup>1</sup>

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<sup>1</sup>Throughout this manuscript, we compute attrition rates by calculating: N excluded due to failure to point during training / (total N included in the experiment + N excluded due to failure to point in training).

(Bernal et al., 2007). In the current experiment, our goal was to gather pointing responses from 24-month-olds to explore further the suitability of pointing as a dependent measure at this age.

We adapted the Waxman et al. (2009) task to address these three goals. We modified the structure of the test trials to ascertain whether 24-month-olds are able to extend novel nouns and verbs to new scenes. We manipulated the richness of the semantic contexts in which the novel nouns and verbs were presented to shed light on the conditions that best support noun and verb learning. We elicited pointing responses as our dependent measure and considered which differences, if any, distinguished toddlers who successfully point in this task from those who do not.

Finally, one additional modification to the task bears mention. Before each trial, toddlers viewed videotaped scenes in which two females engaged in an animated dialogue incorporating the novel word. Recent evidence reveals that toddlers can extract information about a novel word's meaning from such dialogues, even before they have had an opportunity to observe the relevant scene (Arunachalam & Waxman, 2010a; Choi, Arunachalam, & Trueswell, in preparation; Yuan & Fisher, 2009). We therefore expected that these dialogues would support toddlers' ability to identify the novel word and its grammatical category, permitting them to focus on mapping the word to its meaning once the relevant test scenes appeared.

## METHODS

### Participants

Eighty typically developing 24-month-olds (40 males; mean age: 24.0, range: 22.1 to 26.9) were included in the final sample. All were recruited from Evanston, Illinois, and surrounding communities. All were acquiring English as their native language and heard other languages less than 25% of the time. Caretakers completed the MacArthur Long Form Vocabulary Checklist: Words and Sentences (Fenson et al., 1993). Toddlers' production vocabulary ranged from 40 to 693 words, with a mean score of 393 in the Noun-Rich condition, 377 in the Verb-Rich condition, 353 in the Noun-Sparse condition, and 392 in the Verb-Sparse condition; there were no significant differences in vocabulary among conditions. To support 24-month-olds' tendency to provide systematic pointing responses, we began the session with a pointing game (described below); any toddler who failed to point correctly on at least two of the four trials during the game was replaced ( $n = 25$ ). An additional 24 were excluded due to fussiness ( $n = 14$ ), parental interference ( $n = 3$ ), or failure to respond on at least one test trial ( $n = 7$ ). There were no significant differences in the number of toddlers excluded in each condition.


### Materials






#### *Visual Stimuli*

Videos were digitized recordings of live actors, edited to create the sequences described in Table 1. In the Dialogue scenes, two actors were seated next to each other. In the Action scenes, human actors performed continuous actions on inanimate objects. The actors and actions in these latter scenes were taken from Waxman et al. (2009). Videos were presented on a 20-inch screen.

TABLE 1  
Representative Set of Stimuli

Dialogue		
Noun	Rich/Sparse	A: Guess what?
		B: What?
		A: The girl painted the pilker.
		B: Really? She painted the pilker?
		A: And the man is going to wave the pilker.
		B: Wow, he is going to wave the pilker.
Verb	Rich	(both laugh)
		A: Guess what?
		B: What?
		A: The girl pilked the flag.
		B: Really? She pilked the flag?
		A: And the man is going to pilk the balloon.
	Sparse	B: Wow, he is going to pilk the balloon.
		(both laugh)
		A: Guess what?
		B: What?
		A: The girl pilked the flag.
		B: Really? She pilked the flag?
		A: And the man is going to pilk something else.
		B: Wow, he is going to pilk something else.
		(both laugh)



Familiarization				Test			
Noun	Rich	The man is waving a pilker. The man is waving another pilker. Do you see the man waving a pilker? Look, the man is waving a pilker!		Uh-oh, that's not a pilker.	Yay, that is a pilker!	Now look, they're different.	Where is the pilker?
	Sparse	He's waving a pilker. He's waving another pilker. Do you see him waving a pilker? Look, he's waving a pilker!					
	Rich	The man is pilking a balloon. The man is pilking another balloon. Do you see the man pilking a balloon? Look, the man is pilking a balloon!		Uh-oh, he's not pilking that.	Yay, he is pilking that!		Where is he pilking something?
	Sparse	He's pilking it. He's pilking another one. Do you see him pilking it? Look, he's pilking it!					
						Familiar object	Familiar action
							



### *Auditory Stimuli*

Auditory stimuli were presented via a speaker centered below the screen. In the Dialogue scenes, the actors used child-directed speech, maintaining a comparable speech rate across conditions. In the Familiarization and Test scenes, auditory stimuli were adapted from Waxman et al. (2009); a female native English speaker adopted a child-directed speech register. These stimuli, edited to control for duration and amplitude, were synchronized with the visual stimuli.

### *Apparatus and Procedure*

Toddlers and their caretakers were welcomed into a playroom. While the toddler and experimenters played, the caretaker completed the vocabulary checklist. The toddler and caretaker then accompanied the experimenters into an adjoining test room. The toddler was seated in an infant seat, 12 inches from the screen. The caretaker, seated behind the toddler, was asked not to talk during the study or otherwise influence the toddler's behavior. One experimenter controlled the procedure from behind a curtain. The other, seated beside the toddler, elicited pointing responses, which were recorded with a video camera centered above the screen. Sessions lasted approximately 10 minutes.

### *Pointing Game*

To begin, toddlers participated in a game designed to encourage them to point to a scene on the screen. This game did not introduce any novel words. Our goal was to identify toddlers who would point systematically to the screen when requested. Toddlers were shown two side-by-side dynamic video-clips and were encouraged to point to one. On two trials, they were asked to point to a particular person or object in the scene (e.g., Elmo); on another two, they were asked to point to a particular action (e.g., dancing). Toddlers who pointed to the incorrect scene were gently corrected.

### *Experiment Proper*

Toddlers were randomly assigned to either a Noun or Verb condition. Within each condition, they were randomly assigned to either a Rich or Sparse condition. All toddlers viewed the same visual materials; only the auditory stimuli varied as a function of condition (i.e., Noun-Rich, Noun-Sparse, Verb-Rich, Verb-Sparse). Each trial included a Dialogue, Familiarization, and Test phase (see Table 1). Each toddler participated in six trials, each featuring a different target action and object (e.g., waving a balloon). Trials were presented in one of two random orders, balanced across conditions. The left-right position of the test scenes was counterbalanced across trials.

### *Dialogue Phase*

Toddlers first viewed a video of two women engaged in conversation. The novel word (presented either as a noun or verb) was uttered eight times in several different sentential contexts

(e.g., different tenses, different event participants). In the Noun condition, dialogues were identical across both the Rich and Sparse conditions. In the Verb condition, dialogues were identical with one exception: On the last mention of the novel verb, toddlers heard the novel verb in either a Rich or Sparse context. In the Verb-Rich condition, they heard, for example, “The man is going to pilk the balloon”); In the Verb-Sparse condition, they heard, for example, “The man is going to pilk something else.”

### *Familiarization Phase*

(40 s) For each trial, toddlers saw four different examples of a given event category, one at a time, on alternating sides of the screen. In each scene, an actor (e.g., a man) performed the same action (e.g., waving) on one of four objects of the same kind (e.g., four different balloons). The accompanying audio varied by both Grammatical Form and Semantic Context. In the Verb condition, for example, toddlers heard either, for example, “The man is pilking a balloon” (Rich condition) or “He’s pilking it” (Sparse condition).<sup>2</sup>

Next, toddlers viewed two scenes, presented sequentially in the center of the screen. In the first, the actor performed a different action on a different object (e.g., the man playing a saxophone), with the accompanying audio in the Verb condition, “Uh-oh, he’s not pilking that.” Next, toddlers saw one of the now-familiar scenes (e.g., the man waving a balloon). Toddlers in the Verb condition heard, “Yay, he is pilking that” (see Waxman et al., 2009; Booth & Waxman, 2009). During this phase, the novel word was presented six times.

### *Test Phase*

(13.5 s) Finally, toddlers viewed two test scenes, presented simultaneously on either side of the screen. Both involved the familiar actor (e.g., the man). In the Familiar Object scene, the man performed a novel action on the familiar object (e.g., tapping the balloon). In the Familiar Action scene, the man performed the now familiar action on a new object (e.g., waving a rake).

The test phase began with a 4 s inspection period: Toddlers in all conditions viewed both test scenes, hearing, “Now look, they’re different.” The screen then went blank (1.5 s) and a test question was posed (e.g., “Where is he pilking something?”). Next, the two test scenes reappeared in their previous locations (8 s) and the test question was repeated. The experimenter encouraged the toddler to point (e.g., “Can you show me?”), and gave encouragement whenever she did so (e.g., “Good pointing!”), regardless of where she pointed.

### *Coding and Analysis*

Two coders, blind to condition assignment, reviewed the videotapes (with sound removed) and coded all pointing responses. For each trial, the first point served as dependent measure. Inter-coder agreement was 100%, with the exception of a single trial for a single toddler (this trial

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<sup>2</sup>Note that all conditions contained some “richness” and some “sparsity.” The dialogues in all conditions incorporated some sentences with a full noun phrase in conjunction with the novel word, and the familiarization phase incorporated some sentences with pronouns (see Table 1).

was excluded from analysis). We calculated, for each toddler, the number of trials on which that toddler pointed to the Familiar Action scene and divided this by the total number of trials on which that child pointed.

## Predictions

If 24-month-olds can use the grammatical form of a novel word to establish meaning and can extend the word beyond the scene on which it was originally introduced, then toddlers hearing verbs should favor the Familiar Action test scene and those hearing nouns should favor the Familiar Object test scene. If 24-month-olds also depend upon rich semantic contexts to establish a novel word's meaning, then those in the Rich condition should be more successful than those in the Sparse condition. Finally, if toddlers rely more heavily on rich semantic information to establish the meaning of novel verbs than nouns, then they should have particular difficulty in the Verb-Sparse condition.

## RESULTS

See Figure 1. An ANOVA using Grammatical Form (2: Noun, Verb) and Semantic Context (2: Rich, Sparse) as between-subjects factors revealed a main effect of Grammatical Form ( $F(1, 76) = 25.12$ ;  $p < .001$ ;  $\eta^2 = .075$ ). As predicted, 24-month-olds were sensitive to the grammatical cues distinguishing verbs from nouns: They pointed to the Familiar Action scene more often in the Verb ( $M = 56\%$ ) than in the Noun condition ( $M = 28\%$ ). This reveals that for both nouns and verbs, 24-month-olds established representations that were sufficiently abstract to include scenes beyond the ones with which they were introduced. This main effect for Grammatical Form was mediated by a marginal Grammatical Form  $\times$  Semantic Context interaction ( $F(1, 76) = 3.60$ ;  $p = .06$ ;  $\eta^2 = .01$ ). Performance differed from chance (.50) in the expected direction in the Noun-Rich ( $t(1, 19) = 6.82$ ;  $p < .001$ ), Noun-Sparse ( $t(1, 19) = 2.77$ ;  $p < .02$ ), and Verb-Rich ( $t(1, 19) = 2.26$ ;  $p < .04$ ) conditions. Only in the Verb-Sparse condition was performance indistinguishable from chance ( $t(1, 19) = 0.15$ ). Toddlers' difficulty in the Verb-Sparse condition was not related to their vocabulary size. There was no correlation between verb learning in this experimental task and vocabulary size (Verb-Rich: ( $r(18) = -0.20$ ,  $p = .39$ ; Verb-Sparse:  $r(18) = 0.16$ ,  $p = .49$ ); both verb conditions combined: ( $r(38) = 0.036$ ,  $p = .83$ ). Toddlers' difficulty with novel verbs in the Verb-Sparse condition is consistent with the prediction that toddlers more readily learn novel words, especially verbs, when they appear in semantically rich (rather than sparse) sentential contexts.

An analysis of individual participants' patterns of performance provided additional support for this interpretation. We tallied the number of toddlers in each condition who favored either the Familiar Action or Familiar Object scene. Toddlers in both Noun conditions favored the Familiar Object scene, selecting it on more than 50% of their trials. In the Noun-Rich condition, this pattern held for 16 of the 20 toddlers, this pattern held for 16 of the 20 toddlers; in the Noun-Sparse condition, for 14 of the 20 toddlers. In the Verb-Rich condition, 12 of the 20 toddlers favored the Familiar Action scene. Only in the Verb-Sparse condition was the individual pattern indistinguishable from chance: nine of the 20 toddlers preferred the Familiar Action scene.

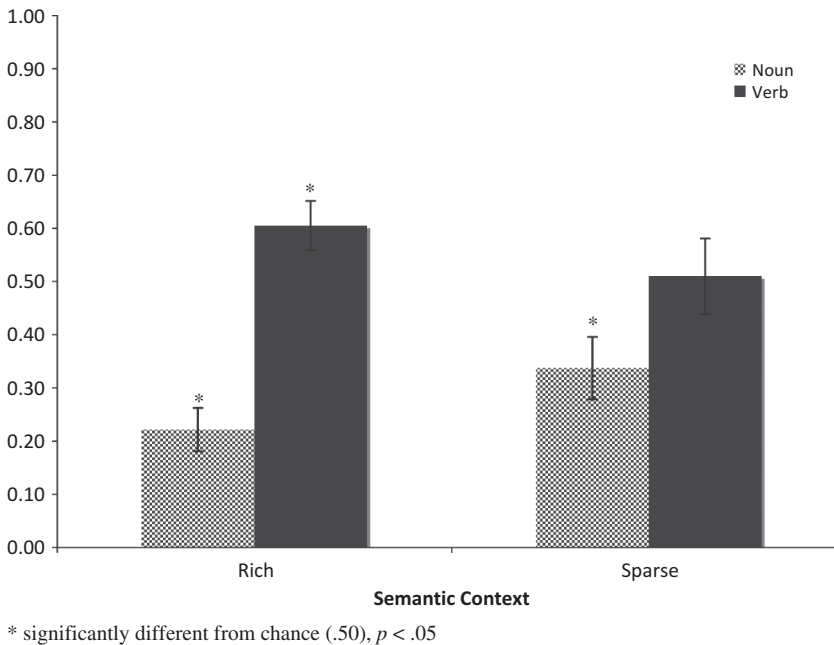


FIGURE 1 Mean proportion of points to the Familiar Action scene, expressed as a function of Grammatical Form and Semantic Context.

These analyses highlight the importance of linguistic information, including semantic context, for establishing a novel verb's meaning.

The results also offer insight into the use of pointing as a dependent measure in 24-month-olds. Recall that before participating in the experiment proper, toddlers participated in a training game; only toddlers who pointed correctly on at least two out of four trials in the training game were included in the analysis of the experimental trials. (Recall also that the training game, which was designed to encourage 24-month-olds to point systematically to a screen, did not involve word learning. On the contrary, toddlers viewed dynamic scenes featuring familiar characters (e.g., Elmo) engaged in familiar actions (e.g., dancing) and were encouraged to point.) We are confident, therefore, that the toddlers in the current experiment understood their task and were responding systematically. Our strict inclusion criteria, coupled with the strong convergence between 24-month-olds' performance here and in looking-time measures in a closely-related looking-time task (Waxman et al., 2009), bolsters our confidence in using pointing as a measure at 24 months.

In the current experiment, the attrition rate attributable to pointing difficulties (24%) was significantly lower than that in previous work with 24-month-olds (40% reported by Bernal et al., 2007,  $\chi^2(1) = 4.27$ ,  $p < .05$ ). Indeed, in the current study, the rate of attrition due to pointing difficulty is comparable to that reported in other studies using pointing as a dependent measure at 27 months (Arunachalam & Waxman, 2010; 26% attrition due to pointing failure during training) and at 28–34 months (Fernandes et al., 2006; 30% attrition rate due to pointing failure during training). These outcomes, considered in conjunction with evidence from participants ranging

from 30–35 months (Maguire et al., 2008; 5% attrition due to pointing difficulties), suggest that toddlers' tendency to point reliably to a screen in response to an experimenter's request improves over the third year of life, and that 24 months may represent a lower bound for pointing as a dependent measure in tasks like these involving novel words.

In addition to examining the attrition rate due to pointing, *per se*, we were able to go on to identify which characteristics, if any, might distinguish the 24-month-olds who met our pointing criterion from those who did not. There was no difference between these groups in terms of age, but there was a strong effect of gender. The 25 toddlers who failed to meet our inclusion criterion were predominantly boys (6 girls, 19 boys),  $\chi^2(1) = 6.76$ ,  $p < .01$ . In future work, it will be important to ascertain whether this gender difference at 24 months is related primarily to matters of compliance or volition (e.g., Kochanska & Aksan, 1995) or to vocabulary scores. In addition to being overwhelmingly male, the toddlers who did not meet our pointing criteria also had a lower mean vocabulary score than those who did point, but vocabulary score is of course correlated with gender at this age (e.g., Galsworthy, Dionne, Dale, & Plomin, 2000).

## DISCUSSION

The current experiment was designed to shed light on 24-month-olds' initial representations for a novel verb's meaning and on the kind of linguistic support on which they depend. Our findings strengthen the evidence that 24-month-olds' attention to a dynamic scene is mediated by the grammatical form of the novel word accompanying it (Waxman et al., 2009). But perhaps more importantly, these results advance our understanding of early verb learning in two ways.

First, these results establish that within minutes of their first encounter with a novel verb, 24-month-olds are able to form an initial representation of the verb's meaning that is sufficiently abstract to permit them to extend the verb beyond the scene with which it was introduced to other scenes that preserve the action but involve new participant objects. Again, the claim is not that toddlers immediately grasp the full meaning of a novel verb. Rather, we suspect that with repeated encounters, toddlers build upon their initial abstract representation, filling in the details of the verb's meaning.

Second, these results illustrate that verb learning at 24 months is supported not only by the grammatical form in which a novel word is presented (e.g., as a verb) but also by the semantic richness of the context (Childers & Tomasello, 2001; Imai et al., 2008; Lidz, Bunker, Leddon, & Waxman, 2007; Naigles, Bavin, & Smith, 2005). Note that toddlers successfully mapped novel nouns in both the Rich and Sparse contexts. Of course, this is not to say that toddlers are able to acquire noun meanings in any linguistic or observational context, no matter how sparse (see Fennel & Waxman, 2010, for evidence). But the current results for noun learning converge well with the evidence that even by 14 months of age, toddlers are able to map novel nouns and extend them systematically to object categories (Booth & Waxman, 2009). In contrast to the nouns, 24-month-olds' success with verbs did vary as a function of semantic context: They were successful in the Rich contexts (including full noun phrase descriptions of the participant object) but not in the Sparse contexts (replacing full noun phrase descriptions with pronouns).

Toddlers' reliance on rich semantic contexts in the verb condition converges well with other evidence that verb learning requires access to rich information. It also uncovers one important source of linguistic information—the rich semantic information inherent in fully lexicalized noun phrases—that supports toddlers' initial acquisition of novel verb meanings.

In future work, it will be important to pursue this finding to ascertain *why* the semantic information conveyed by the full noun phrases was instrumental to successful verb learning. We suspect that the semantic information inherent in fully lexicalized noun phrases helped toddlers 'zoom in' on the relevant part of the scene being labeled (e.g., Fisher et al., 1994). For example, to learn the verb "pilk," toddlers in the Rich condition could readily identify the referent of each noun phrase ('the man', 'the balloon'), and then use this information, along with grammatical form information, to infer that the novel verb referred to a relation between them. But toddlers in the Verb-Sparse condition may have had more difficulty identifying the precise referent of the pronoun "it" in our task, and as a result may have encountered more difficulty discovering the meaning of the verb. If this interpretation is correct, then toddlers introduced to scenes with fewer candidate interpretations (e.g., scenes with only one participant object) or to verbs taking fewer arguments (e.g., intransitive verbs) should be able to discover a novel verb's meaning even if pronouns are substituted for full noun phrases. Lidz et al. (2007) offers support for this possibility.

The current results, considered in conjunction with other recent work, offer several insights into what kinds of linguistic information best support word learning across development. Although it is difficult to compare the current results with 24-month-olds directly to those Imai et al.'s (2008) 3- and 5-year-olds, especially since the designs differed in several ways (e.g., age of the participants, the presence of familiarization trials), several parallels are nonetheless instructive. In Imai et al. (2008), English-acquiring 5-year-olds successfully learned novel verbs when they were presented in pronoun contexts (e.g., "She's pilking it"). Their success, along with 24-month-olds' failure in the pronoun contexts in the experiment reported here, suggests that over the course of development, children's ability to learn novel transitive verbs in pronoun contexts improves. Of course even 5-year-olds require some linguistic information to discover the meaning of a novel verb. Although Imai et al.'s English-speaking 5-year-olds succeeded when the verbs were presented in sentences with pronouns, they failed when the verbs were presented alone, in the absence of any arguments (e.g., "Pilking!"). This suggests that at both 24 months and 5 years of age, learners consult the information inherent in the linguistic context to establish the meaning of a novel word.

The current results also provide insight into the kinds of linguistic information that best support word learning across languages. Languages differ in the linguistic contexts in which verbs are typically presented. In Japanese, for example, as in many other languages, noun phrase arguments can be dropped from the surface of an utterance; as a result, verbs often appear alone in both adult- and child-directed speech (e.g., Nakayama, 1996). In contrast, in English, where noun-dropping is not a feature of the language, verbs almost always appear with at least some of their arguments; they rarely occur alone. This cross-linguistic difference has implications for word learning: the linguistic contexts that best support novel verb learning in one language may differ from those that best support it in another. Evidence from children acquiring Japanese is consistent with this view. Imai et al. (2008) report that 5-year-olds acquiring Japanese, unlike those acquiring English, encountered difficulty learning novel verbs when they were presented in pronoun contexts, but succeeded when the verbs were presented with no arguments. Why

might this be the case? In this task, in which the referents of the novel verb's arguments were visually present throughout, we suspect that explicit mention of the pronouns may have been disruptive for Japanese children, because Japanese speakers typically drop the nouns in such contexts.

In sum, we propose that the 'signal value' of a particular linguistic context will vary across development and across languages. In the experiment reported here, 24-month-olds' difficulty learning novel verbs in pronoun contexts illustrates a related point: The signal value of a particular linguistic context will also vary as a function of the particular learning task at hand. After all, pronoun contexts are useful for determining a novel word's grammatical category (Mintz, 2003), extending a novel verb syntactically (Childers & Tomasello, 2001), and possibly discovering its broad semantic category (Laakso & Smith, 2007). However, current results indicate that pronoun contexts are not ideal for all tasks: When it comes to establishing the meaning of a particular novel transitive verb, English-acquiring 24-month-olds require more informational support than pronouns provide. For these young word learners, the rich semantic information conveyed in full noun phrases offers at least one point-of-entry for successful verb learning.

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