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24-Month-Old Infants' Interpretations of Novel Verbs and Nouns in Dynamic Scenes

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Abstract

The current experiments address several concerns, both empirical and theoretical in nature, that have surfaced within the verb-learning literature. They begin to reconcile what, until now, has been a large and largely unexplained gap between infants' well-documented ability to acquire verbs in the natural course of their lives and their rather surprising failures to do so in many laboratory-based tasks. We presented 24-month-old infants with dynamic scenes (e.g., a man waving a balloon), and asked a) whether infants could construe these scenes flexibly, noticing the consistent action (e.g., waving) as well as the consistent object (e.g., the balloon) and b) whether their construals of the scenes were influenced by the grammatical form of a novel word used to describe them (verb or noun). Infants successfully mapped novel verbs to event categories (e.g., waving events) and novel nouns to object categories (e.g., balloons). Moreover, infants' representations were sufficiently abstract to permit them to extend novel verbs and nouns appropriately beyond the precise scenes on which they had been taught.

Keywords

language acquisition; word learning; concept development

1. Introduction

Human infants accomplish many remarkable feats, presenting themselves by 24 months as walking, jumping, talking, tumbling, socially-engaging forces of nature. Among these accomplishments, infants' dramatic success in word-learning has captured special interest within the cognitive sciences. This interest derives largely from the fact that word-learning rests upon (at least) three essentially cognitive capacities: infants must identify words from the stream of human language in which they are immersed; they must build concepts that capture the relations among the objects and events that they encounter; and they must bring these into correspondence. It is now clear that even before they take their first steps, infants make important advances in each of these areas, and that from the onset of word learning, their conceptual and linguistic advances are powerfully linked.

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Imagine a scenario in which an infant observes a clown waving a balloon emphatically in the air, while his father says, "The clown is waving the balloon!" To learn a word from this scenario, the infant must solve a three-piece puzzle: (1) identify the relevant conceptual units (this may be an individual object (e.g., the clown; the balloon), a category of objects (e.g., clowns, balloons), an event (e.g., waving), etc.), (2) identify the relevant linguistic units (e.g., the words and phrases), and (3) establish a mapping between them. Word learning requires a certain degree of abstraction in solving each piece of this puzzle. Any given utterance of a word must be related to a more abstract phonological representation if it is to be recognized across speakers and contexts; any given individual or event must also be related to a more abstract concept if the word is to be extended beyond the particular scene in which it was introduced.

Moreover, every human language is comprised of different kinds of words (i.e., grammatical categories: nouns, adjectives, verbs, etc.), each highlighting a distinct aspect of a given scene and each supporting a unique pattern of extension. To be successful in word learning, learners must be sensitive to this feature as well. For example, to acquire the meaning of a noun (e.g., *clown*), learners must eventually come to understand that although this word may have been introduced in a scene in which a particular object (e.g., a clown) was engaged in a particular event (waving a balloon), that noun can be generalized to other objects of the same kind (other clowns) even if they are engaged in different actions (e.g., hitting a balloon or pedaling a unicycle). Adjectives are characterized by a very different pattern of extension. Here, the learner must somehow understand that an adjective (e.g., *yellow*) picks out a property of an object and not the object itself, and can be generalized to other instances of that property, independent of the particular entity embodying it (e.g., to other yellow things, including some clowns, toys, and blankets). Finally, verbs are characterized by yet another extensional pattern. A verb (*wave*) describes an event or relation among a set of individuals (e.g., clown, balloon) at a particular moment in time. To acquire the meaning of a verb, learners must eventually come to understand that it can be generalized to other events of the same kind (waving), even if they involve different participants at different times and different locations (e.g., waving a flag in a parade). In essence, then, successful learners will be ones who understand that extending a noun requires abstracting over the events that the labeled object is engaged in and that extending a verb requires abstracting over the participants in the labeled event.[1]

2. Word-learning in infancy: Overview of evidence

Despite this complexity, infants meet the challenge of word-learning with remarkable facility, typically producing their first words at roughly their first birthdays and adding new words rapidly thereafter. Infants' early lexicons tend to be predominated by nouns (or more precisely, by words for individual objects and categories of objects). Verbs (and other predicate forms, including adjectives) do not appear in appreciable number in infants' productive lexicons until several months later (between roughly 20 – 24 months). This developmental decalage, favoring the acquisition of nouns over verbs, reveals that these distinct grammatical forms differ not only in their meanings, but also in their developmental profiles. In contrast to infants' early and robust success mapping nouns to meaning, infants' ability to acquire verbs has proven more elusive.

[1]Although the participants in an event must be abstracted over in defining the event category labeled by a verb, individual verbs often exert selectional restrictions on their participants. For example, to qualify as a breaking event, something must be broken; consequently, the object of the verb 'break' must refer to a solid object. This fact -- that certain events require participants of a particular kind -- does not alter the fact that in assigning the meaning of a verb, we abstract over participants.

In this section, and in the experiments that follow, we address several concerns, both empirical and theoretical in nature, that have surfaced within the verb-learning literature (for recent reviews, see Hirsh-Pasek and Golinkoff, 2006; Lidz and Waxman, 2006; Tomasello, 1995). First, accounting for the developmental decalage favoring nouns has been the focus of intense debate. Although a thorough discussion of these accounts is beyond our scope here, several key observations are directly relevant. First, the very fact that nouns are acquired so early suggests that noun-learning may not be the paradigmatic case for word-learning. It also suggests that conceptual or linguistic underpinnings that are required to support the acquisition of verb meaning may differ importantly from that required for the acquisition of nouns. Focusing on conceptual underpinnings, recent evidence suggests that by 8 – 10 months of age, infants are sensitive to fundamental components of events, including animacy, agency and cause (Gergely & Csibra, 2003; Casasola & Cohen, 2000; Leslie & Keeble, 1987; Meltzoff, 2007; Sommerville, Woodward, & Needham 2005; Tomasello, 1992; Wagner, 2002; 2006; Wagner & Carey, 2005; Wilson-Brune & Woodward, 2004) as well as to other key elements of events, including changes of state, result, manner and path of motion (Bunger, 2007; Bunger & Lidz, 2004; Gropen, Pinker, Hollander, & Goldberg, 1991; Pruden, Hirsh-Pasek, Maguire, & Meyer, 2004; Pinker 1984, 1989; Pulverman, Sootsman, Golinkoff, Hirsh-Pasek, 2003; Pulverman, Hirsh-Pasek, Pruden, & Golinkoff, 2006). Thus, it is unlikely that infants' relatively delayed acquisition of verbs stems from an inability on their part to represent the kinds of concepts that underlie verb meaning (Buresh, Wilson-Brune & Woodward, 2006; Gergely, et al., 1995; Gergely & Csibra, 2003; Gertner, Fisher, & Eisengart, 2006; Golinkoff & Hirsch-Pasek, 2006; Leslie & Keeble, 1987; Meltzoff, 2007; Wagner & Carey, 2005). Indeed, Gordon (2003) has shown that by 10 months, infants' representations of events are sufficiently precise to support, in principle, "…a seamless and transparent mapping onto verbs…" (p. 192). Focusing on linguistic matters, recent research has converged to suggest a more likely possibility. Infants' relative delay in acquiring verbs may reflect the fact that the meaning of a verb depends upon the arguments that it takes (and the relation among them). Simply put, because nouns and noun phrases constitute those arguments, it is reasonable to assume that to identify the event labeled by a verb, learners will depend upon the noun phrases that represent the event participants and the linguistic relations among these phrases (Fisher, Hall, Rakowitz, & Gleitman, 1994; Gillette, Gleitman, Gleitman & Lederer, 1999; Gleitman, Cassidy, Nappa, Papafragou & Trueswell, 2005; Landau & Gleitman, 1985; Piccin & Waxman, 2007; Snedeker & Gleitman, 2004; Waxman & Lidz, 2006). Therefore, without the nouns, it should be difficult for learners to identify the arguments of a verb and impossible therefore to identify the event labeled by the verb in that context.

If this analysis is correct, then we should observe two consequences. First, once infants have acquired a store of nouns that can serve as arguments, verb learning should begin to proceed fluidly. Second, in the process of acquiring verb meaning, infants should be responsive to the particular noun phrases with which they are introduced and the relations among them.

Focusing in on the verbs

A review of the verb-learning literature suggests that both of these consequences are indeed observed. At roughly 24 months, infants typically begin to add a sizeable number of verbs to their productive lexicons, and use them systematically to refer to actions (e.g., eat, run), mental states (e.g., want, see) and relations (e.g., touch, move). At this point, they also demonstrate a clear capacity to map novel verbs onto categories of events in experimental tasks, and in doing so, they take into account syntactic information, including the number and types of frames in which novel verbs appear and the relations among the noun phrases in these frames, to narrow their hypotheses about possible verb meanings (Akhtar & Tomasello, 1996; Bunger & Lidz, 2006; Fernandes, Marcus, DiNubila, & Vouloumanos,

2006; Fisher, 2002; Gertner, et al., 2006; Gleitman, 1990; Gleitman et al., 2005; Hirsch-Pasek, Golinkoff, & Naigles, 1996; Landau & Gleitman, 1985; Naigles, 1990, 1996).

For example, in Naigles (1990), 25 month-old infants were familiarized to a complex event involving two participant objects: a duck and a bunny. The duck and bunny each circled one arm in the air while with the other arm, the duck pushed on the bunny's head, forcing him to squat. At issue was whether and how learners used syntactic context in which a novel verb was presented to decide which component(s) of an event were key to its meaning. When the verb was presented in a transitive frame (e.g., "The duck is gorping the bunny"), infants mapped the verb to the causative component (the duck pushing the bunny); when the verb was presented in an intransitive frame (e.g., "The duck and the bunny are gorping"), infants mapped the verb to either the causative or synchronous component. This outcome reveals that infants possess at least some rudimentary knowledge of noun phrases and argument structure (e.g., distinguishing transitive from intransitive constructions) and some rudimentary expectations about how structures map to events (e.g., mapping verbs in transitive constructions to causal rather than merely synchronous events) (Bunger & Lidz, 2004, 2006; Fisher, 1996; Lidz, Gleitman & Gleitman, 2003; Naigles, 1990; Naigles & Kako 1993). In closely related work, infants have also demonstrated their sensitivity to subparts of events, like manner, path, and result (Bunger, 2007; Bunger & Lidz, 2004; Pruden, Hirsh-Pasek, Maguire, & Meyer, 2004; Pulverman, Sootsman, Golinkoff, Hirsh-Pasek, 2003), and to other verb-relevant characteristics like intentionality and telicity (Wagner, 2002; 2006).

These studies reveal that once verb learning is underway at roughly 24 months, the process appears to be exquisitely tuned. Infants reveal a sensitivity to apparently abstract relations between syntactic frames and meaning, relations that are evident in all human languages (Geyer, 1998; Lee & Naigles, 2005; Li, 1994; Lidz, Gleitman & Gleitman, 2003, 2004), and recruit these relations in settling on the meaning of a novel verb. In short, these studies underscore considerable success in verb learning both in and out of the laboratory, and a finely-calibrated use of syntactic information in doing so.

Nonetheless, the verb learning literature also reveals some astonishing failures, many of which persist throughout the preschool years. A recent series of studies comparing noun- and verb-learning serves to illustrate this point (Imai, Haryu, & Okada, 2002, 2004, 2005; Kersten & Smith, 2002; Meyer et al., 2003). Here, adults and children (3- and 5-year-olds) viewed a standard event, in which an actor performed a novel action with a novel object. This event was labeled with either a novel noun ("Look! There is an X!") or a novel verb ("Look! There is Xing!"). At test, participants viewed two different events, one depicting the familiar action performed on a new object, and the other depicting a new action performed on the familiar object. Participants were instructed either to "Find the X" (noun condition) or "Find X'ing" (verb condition). Perhaps not surprisingly, adults extended novel nouns to the 'same object' test event (successfully generalizing beyond the particular event in which the noun had been introduced) and extended novel verbs to the 'same action' test event (successfully generalizing beyond the particular event participant in which the verb had been introduced). Five-year-olds did the same. However, 3-year-olds revealed a different pattern: like their elders, they extended novel nouns to the 'same object' test event but unlike their elders, they performed at chance when asked to extend the novel verbs. This is a robust finding, and one that has been observed in a range of languages, including English, Mandarin, and Japanese (Imai, et al., in press).

How can we reconcile this striking failure in verb learning in preschool-aged children with the finely-calibrated successes of infants (reviewed above)? A review of the evidence offers an intriguing observation: that infants and young children succeed in verb-learning when the

very same participant objects are present in all the events, but encounter difficulty when there is a change in the event participants. Recall, for example, that in Naigles (1990), where infants saw the same two participant objects (a duck and a bunny) in every scene, infants mapped novel verbs successfully and used syntactic information (the number of noun phrases and relations among them) as a guide in homing in on meaning. But a very different picture of verb-learning emerges when young learners are required to extend the novel verb to a token of the same event category, but with different participant objects, as in Imai, Haryu, and Okada (2005). When this was the case, 3-year-olds were essentially 'captured' by the participant objects as witnessed by their difficulty generalizing the verb to an event that preserved the action but involved a different participant object.

There is, in fact, considerable support for this interpretation. For example, in his classic work on parts of speech, Brown (1957) introduced children to scenes (e.g., a boy scooping a novel substance (resembling sand) with a novel instrument (resembling a scoop)), and described this event with a novel word. Three- to five-year-old children overwhelmingly pointed to the novel object (scoop) when the novel word was presented as a noun (e.g., "Can you show me a sib?"). They also revealed a strong tendency to point to the novel action when it was presented as a verb (e.g., Can you show me sibbing?). Nonetheless, on 25% of the trials involving verbs, children pointed to the novel object. Behrend (1990, 1995) reported that 3- to 5-year-olds had difficulty generalizing a verb if it involved the same agent performing the same action, but with a different instrument (also see Forbes and Farrar, 1995; Forbes and Poulin-Dubois, 1997). Moreover, children appear to be 'captured' by the participant object not only when the object assumes the role of instrument, but also when it assumes the role of agent. Kersten and Smith (2002) reported that when children are asked to extend a novel verb to a scene involving a new agent, they focus on the agent, rather than on the action itself. In one of the most striking findings in this field, Maguire and her colleagues (Maguire, Hennon, Hirsh-Pasek, Golinkoff, Slutzky, & Sootsman, 2002) demonstrated that infants successfully extended novel verbs over a change in agents, but only when the actions were presented as point-light displays, a manipulation that rendered the agent essentially invisible.

This review offers a new perspective on the developmental decalage between nouns and verbs. Infants and young children have apparently mastered the principles governing the generalization of nouns: they understand that a novel noun picks out an object or category of objects, and can be extended to other objects of the same kind, whether or not they are engaged in the same action. But mastering the principles governing the generalization of verbs seems to be a different, and more difficult matter: even 3-year-olds seem to have difficulty extending a novel verb to other actions of the same kind if the participant objects involved in the action have changed. Put differently, infants and even young children are essentially captured by the participant objects and have difficulty extending verbs beyond them.

This analysis of the literature offers an intriguing account for infants' resounding success in some experimental verb learning tasks and preschoolers' striking failures in others. But another tension remains: We know that when infants produce verbs spontaneously, they abstract them away from particular participant objects. For example, they extend verbs like *run* to events involving dogs, children and horses, and verbs like *eat* to events involving ice cream, raisins and cheerios. Why then do they encounter such difficulties extending verbs in just this way in experimental tasks? Put differently, the question is whether infants have indeed mastered the principles governing the generalization of verbs.

In the current experiments, we address this question, focusing on 24-month-old infants' generalizations of novel verbs and nouns. We took as our starting point a recently-developed

paradigm that has been successful in unveiling word-learning capacities in infants from 12- to 18-months (Booth & Waxman, 2003; Waxman & Booth, 2001) and that lends itself especially well to questions concerning noun- and verb-learning capacities in 24-month-old infants.

A brief overview of the task illustrates some of its key features. Infants were first engaged in a familiarization phase, in which they observed a series of videotaped dynamic scenes (e.g., a man waving a balloon). At test, we *either* modified the action while preserving the very same participant (e.g., a man *tapping* a balloon; Experiment 1) *or* modified the participant while preserving to the very same action (e.g., a man waving a *rake*; Experiment 2). This design permitted us to consider first, whether infants were sensitive to a change in either the action (e.g., waving) or the participants (e.g., the balloon) in these simple dynamic scenes, and second, whether infants were sensitive to the principles governing the generalization of nouns and verbs. More specifically, we asked whether infants would map a novel verb to an event category (e.g., wave), generalizing beyond the original participant objects with which it was introduced (e.g., waving a rake) (Experiment 1), and whether infants would map a noun to an object category (e.g., balloon), generalizing beyond the original action with which it was introduced (e.g., hitting a balloon) (Experiment 2).

We made several decisions in designing the stimuli. First, to ensure that the actions (like the objects) would be available for inspection throughout the entire scene, we portrayed events in which the actions were continuous (e.g., *wave*) rather than fleeting (e.g., *drop*). Second, based on evidence that infants are especially interested in casual events, we presented them with canonically causal scenes, in which an animate agent (e.g., a man) performed a continuous action (e.g., waving) on an inanimate patient (e.g., a balloon). To reduce the number of potential referents of each novel word, the same agent (e.g., the same man) appeared in every scene within a given trial (see below). To examine the influence of grammatical form on infants' construals of these scenes, we assigned infants randomly to a Verb, Noun, or No Word condition. Based on evidence that infants have a strong tendency to align causal events with transitive frames (Abbot-Smith, Lieven, & Tomasello, 2004; Bunger, 2007; Fisher, 1996; Lidz, Gleitman & Gleitman, 2003), we chose to present the novel words in transitive frames (e.g., in the verb condition," The man is *larping* the balloon"; in the noun condition, "The man is waving the *larp".*)

One last methodological issue bears mention. Using infants' looking time as a dependent measure, we derived two sets of analyses, both of which are based on the well-documented assumption that infants prefer to look at a test image that matches the auditory input that they receive, than one that does not match (Kuhl & Meltzoff, 1982; Hirsh-Pasek & Golinkoff, 1996; Spelke, 1976). We designed one set of analyses, based on infants' average looking times in the test period, to ascertain whether infants' looking times were influenced by the grammatical form of the novel word they heard. But we also developed a more precise frame-by-frame analysis that would depict the time-course underlying infants' responses to the novel words during the test period.

Time-course analyses have been the topic of considerable attention in recent years, but in the infant literature they have been based almost exclusively on infants' responses to familiar words (but see Shafer, 2005). Typically in these studies infants view two simultaneous images (e.g., a dog and a baby) while hearing, for example, 'Find the baby!' Fine-grained analyses of infants' eye movements reveals when they orient their visual attention toward the image that matches the spoken word. In general, 15- to 18-month-old infants initiate a visual response within 300 msec after the familiar word has been uttered in its entirety (Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998), but by 18 to 24 months, infants respond more rapidly, in some cases initiating a response even before the entire word has

been uttered (Fernald, Swingley, & Pinto, 2001; Swingley, Pinto, & Fernald, 1999). This suggests that over the second year of life, infants become increasingly efficient in processing familiar words in continuous speech and mapping them to appropriate referents. What remains unanswered is the time-course underlying infants' responses to newly-learned words, and to more complex tests of mapping.

The current experiments are considerably more challenging than most involving time-course data. To succeed, infants must recognize that the novel word presented at test is the same word that was previously presented during familiarization and must map that word to one of two alternatives (both of which share important components with the familiarization images). Our hope was that a fine-grained depiction of infants' looking behavior over the test phase would offer insights in the time-course underlying their response to both novel nouns and verbs in this complex word-learning task.

Experiment 1: Mapping Words to Event Categories

The primary goal of this experiment was to discover whether 24-month-old infants are able to focus their attention specifically on an event category (and not an object category), whether they are able to map a novel word to an event category, generalizing beyond the particular participants involved, and whether this type of mapping is reserved for novel verbs (and not nouns). To address these questions, 24-month-old infants were familiarized to a series of dynamic event scenes. In these familiarization scenes, an animate agent (e.g., a man) performing a continuous action (e.g., waving) on an inanimate patient (e.g., a balloon). At test, infants were presented with two scenes simultaneously: a familiar test scene (e.g., the man *waving* a balloon) and a novel test scene involving a novel action (e.g., the man *tapping* a balloon). Notice that both test scenes involved the same two objects (e.g., man; balloon); what varied was the action in which these were involved (e.g., waving vs. hitting). Infants were randomly assigned to either a verb, noun, or no word (control) condition. Infants in all conditions saw precisely the same events; what varied was the auditory information that accompanied them.[2]

We asked (a) whether 24-month-olds focused sufficiently on the consistent action depicted during familiarization to detect the novel action presented at test, and (b) whether infants' interpretation of a novel word applied to these scenes was influenced by the grammatical form of the novel word to which they had been exposed.

Participants

Seventy-two 24-month-olds (32 males) with a mean age of 23.84 months (range: 22.14 to 26.05) were included in the final sample. All were recruited from Evanston, IL and its surrounding communities and were acquiring English as their native language. Infants were from primarily Caucasian middle- and upper-middle-class families. Parents completed the MacArthur Short Form Vocabulary Checklist: Level II - Form A (Fenson et al., 2000) and the infants' mean production vocabulary was 57 words (ranging from 22 to 99); there were no differences in vocabulary among the conditions. We analyzed the data of infants that completed all six test trials. An additional 21 infants were excluded due to: fussiness (n = 7), parental interference (n = 3), failure to complete all test trials (8) and experimenter error or technical difficulty (n = 3).

[2]In the design of this experiment, novel words were embedded within two different sentence frames. In the Verb condition: "Which one is he/she Xing?" and "Where is he/she Xing something?" In the Noun condition: "Which one is a X?" and "Where is a X?" Within each condition, infants heard half of the novel words presented in one frame, and the other half in the other frame. The frames were counterbalanced over trials and presented in alternation. Preliminary analyses revealed no differences in performance in either condition as a function of these constructions. We therefore collapse across them in reporting the results of Experiment 1 and 2.

Materials

Visual stimuli—We began by creating digitized video recordings of live actors performing a series of continuous actions on objects. These were edited to create the series of action sequences described in Table 1. These action sequences were approximately 1 min in duration and were presented to infants against a black background, on either side of a 61 in. (155 cm) screen.

Auditory stimuli—A female native speaker of American English adopted an infant-directed speech register to produce the speech stimuli described in Table 1. We recorded her utterances in a sound-attenuated booth. These utterances were edited to control timing, duration, peaks, etc. and were then synchronized with the visual stimuli. The auditory stimuli, which varied as a function of condition (see below) were presented on a speaker that was centered on the visual display. See Appendix B for full set of stimuli and Table 1 for a representative sample.

Apparatus and Procedure

Infants and caretakers were welcomed into a laboratory playroom. While the infant played freely with toys, the caretaker signed a consent form and completed the MCDI. Next, the experimenter escorted the infant and caretaker into an adjoining test room (14 ft × 10 ft (4.3 m × 3.0 m)) where the infant was seated in an infant-seat, 6 ft (1.8 m) directly in front of the screen. The caretaker, seated either behind or beside the infant, was instructed not to talk or to influence the infant's attention in any way. The experimenter then moved behind the screen to control the experimental procedure (described below). Throughout the procedure, infants' looking behavior was recorded (for subsequent coding) with a video camera that was centered above the screen. Sessions lasted approximately 15 min.

The procedure itself included three distinct phases: a familiarization, contrast, and test phase (see Table 1). Each infant completed this three-phase procedure six different times. Each trial involved a different sequence of scenes (e.g., a man waving a balloon, a girl petting a dog). See Appendix A for a complete description of the scenes in each trial. To capture infants' attention at the beginning of each trial, a still photo of a smiling infant appeared at the center of the video screen for 4 s, accompanied by an audio track of an infant giggling. Trials were presented in one of two random orders, balanced across conditions. The left-right position of the familiar and novel test scenes was counterbalanced across trials.

Infants were randomly assigned to either the Verb, Noun, or No Word condition. Infants in all conditions saw exactly the same video scenes. What varied across conditions was the audio stimulus. See Table 1.

Familiarization phase. (26 s)—Infants saw four different examples of a given same event category, presented one at a time on alternating sides of the screen. In each scene, the same actor (e.g., a man) performed the same action (e.g., waving) on one of four different objects of the same kind (e.g., four different balloons). The accompanying audio varied as function of condition. For example, in the Verb condition, infants heard, "Look! The man is *larping* a balloon"; in the Noun condition, they heard, "Look! The man is waving a *larp*"; in the No Word condition, they heard "Wow! Look what's happening here."

Contrast Phase. (14 s)—Next, infants saw two scenes, presented one at a time in the center of the screen. Both scenes involved the now-familiar actor (e.g., the man). In the first contrast scene, this actor performed a novel action on a novel object (e.g., the man *played* a *saxophone*). On the accompanying audio, the female speaker projected a distinctly disappointed tone, but her comments varied as function of condition. In the Verb condition,

she referred to the novel action saying, e.g., "Uh oh. He's not *larping* that". In the Noun condition, she referred to the novel object saying, e.g., "Uh oh. That's not a *larp*". In the No Word condition, she offered a general comment ("Uh-oh. Look at that"). In the second contrast scene, infants saw a familiar scene, selected randomly from the original familiarization phase (e.g., the man *waving* a balloon). On the accompanying audio, the female speaker adopted a cheerful tone, exclaiming, for example, "Yay, he is *larping* that" (Verb condition), "Yay, that is a *larp*" (Noun condition), or "Yay, look at this!" (No Word condition).

Notice that the first contrast scene differed from the familiarization scenes in two ways: it depicted a different participant object and a different action. This was a deliberate decision on our part; we wanted to insure that the contrast scene itself could not bias infants' construal toward either an object or action interpretation. We made this decision because the purpose of the contrast phase was not to bias infants toward one interpretation or another, but rather to indicate to infants that not all scenes constituted an appropriate generalization. By (disappointedly) introducing a contrast scene and then (cheerfully) re-introducing a familiarization scene, our hope was to demonstrate that there were limits to the correct application of the novel words. For example, by making it explicit that *larp* could not be applied to a scene in which the man played a saxophone, an infant could reasonably surmise that the word *larp* has a meaning more specific than either TOY or THING or LIKE or HOLD. The (cheerful) re-introduction of the familiar scene gave infants an opportunity to reinterpret the meaning of the novel word in light of the information provided in the contrast scene.

Test Phase. (12 s)—Finally, infants saw two test scenes, presented simultaneously on either side of the screen. Both scenes featured the same actor (e.g., the man) and the same object (e.g., the balloon) as in familiarization; what varied was the event in which these two were involved. In the familiar test scene, the man performed the now-familiar action (e.g., man *waving* a balloon); in the novel test scene, he performed a novel action (e.g., man *tapping* a balloon).

The test phase was divided into two distinct periods.(also see Booth & Waxman, under review; Waxman & Booth, 2001), each designed to address a different aspect of our research question. First, in a baseline period, we examined infants' baseline preference for the two test scenes. Second, in a response period, we examined infants' response in each condition to an explicit probe.[3]

Baseline period (4 sec): Infants in all conditions saw the two test scenes accompanied by the same audio ("Now look. They're different"). At the close of the baseline period, the screen went blank (.33 s).

Response period (8 sec): The two test scenes then reappeared, but at this point, the accompanying audio varied as a function of condition. In the Verb condition, the test questions probed infants' mapping of the novel verb that had been introduced during familiarization (e.g., "Which one is he *larping*?"); In the Noun condition, the test question probed infants' mapping of the novel noun that had been introduced during familiarization (e.g., "Which one is a *larp*?").[1] In the No Word condition, the test question contained no

[3]Within the response period, the response window opened with the onset of the novel word because our interest is in infants' response to the presentation of novel words. The response window closed 3 sec later because at precisely this point, a new test question was initiated. We did not analyze infants' response to this second test question because our impression, confirmed by initial analyses, revealed that by this point in a trial, infants' interest had waned considerably in all three conditions, and that as a result, their responses to the 2nd test question offered no discriminative value.

novel word (e.g., "What do you see now?"). This served as a control, providing a metric against which to compare performance in the Noun and Verb conditions.

Coding

The videotaped sessions were coded off-line with sound removed to ensure that coders, who were blind to the experimental hypotheses and 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, and another from the response period. The response window began with the onset of the novel word and ended three seconds later.[3] The baseline window included the last 3 seconds of the baseline period.[4] 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 9 infants, 3 per condition. Consistency between coders in both the baseline and response windows (computed for each trial and then averaged across trials) was excellent (91.4% agreement; Cohen's kappa = .85).

Predictions

Baseline Period—If infants are sensitive to the consistent action portrayed in the familiarization scenes, then they should detect the novel action portrayed in the novel test scene, and should therefore reveal a strong baseline preference for the novel test scene.

Response Period—If infants distinguish between novel words presented as verbs versus nouns, and if they recruit this distinction in establishing word meaning, then performance in the response period should vary systematically as a function of condition:

If infants expect that verbs refer to categories of events, then during familiarization they should map the novel verb (e.g., larping) to the event category (e.g., waving) and not to the objects undergoing the action (e.g., balloons). If this is the case, then in the response to the test question, they should search for the familiar event, directing their attention away from the novel test scene (which depicts a novel event) and toward the familiar test scene (which depicts the familiar event).

If infants expect that nouns refer to categories of objects, then during familiarization they should map the novel noun (e.g., larp) to the object category (e.g., balloon) and not to the

[4]Within the baseline period, we selected the last three seconds arbitrarily as our window. In fact, the results of all analyses are identical, whether we selected the first or three seconds, the last three seconds, or the full four seconds of the baseline period as our 'window.'

action in which it was engaged (e.g., waving). If this is the case, then in response to the test question (e.g., "Which one is a *larp*?"), they should search for the familiar object. Note that because the familiar object appears in both the novel and familiar test scenes, the novel noun can be correctly applied to either. Therefore, infants could reasonably maintain their focus on the (favored) novel test scene.

Finally, because in the No Word condition, the response question contains no novel word (e.g., "What do you see now?"), performance in this condition should not change from the baseline to the response period.

Results

Figure 1 displays the continuous time-course of infants' looking behavior in each condition throughout the test phase. A glance at this timeline offers several impressions. First, during the baseline period, infants in all conditions reveal a strong preference for the novel test scene. This suggests that 24-month-olds in all conditions were sensitive to the actions portrayed throughout the dynamic familiarization scenes, and therefore detected a change in the event, even when the very same objects are involved. Second, during the response period, performance among the conditions began to diverge, with infants in the Noun and No Word control conditions maintaining their strong preference for the novel test scene, but those in the Verb condition directing increasingly more visual attention toward the familiar test scene. This suggests that infants' construals of these dynamic scenes were indeed influenced by the novel words with which they were described. Moreover, Figure 1 indicates that infants direct their attention efficiently, with performance among the conditions pulling apart in the response window, just after the onset of the novel word.

To further consider whether and how the introduction of novel words affected infants' construals, we conducted an analysis of variance with condition (3: Verb, Noun, No Word) as a between-participants factor and window (2: baseline, response) as a within-participants factor. We used the proportion of looking time that infants devoted to the familiar test scene as the dependent measure. We used this analysis to test our predictions. First, a simple effects test revealed that during the baseline window, there were no reliable differences among the conditions, $F(2, 69) = .47$, $p > .05$; $\eta^2 = .12$. As predicted, infants in all conditions exhibited a strong preference for the novel test scene, all t's > 6.1, all p's < .0001. However, during the response window, the predicted differences among the conditions emerged, $F(2, 69) = 11.31$, $p < .0001$; $\eta^2 = .99$. Post hoc analyses of this effect revealed that infants in the Verb condition devoted a larger proportion of looking time to the familiar test scene than did infants in either the Noun or the No Word conditions, Tukey test, both p's < .05. Infants in the latter two conditions maintained their preference for the novel test scene, both p's < .001, but those in the Verb condition showed no such preference. It is important to notice that although performance in the Verb 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. There are two reasons for this assertion. First, in the current experiment, 50% does not constitute baseline performance. Instead, there is a strong baseline preference for the novel scene. Second, the theoretical issue under investigation is whether infants' performance changes as a result of the introduction of a novel verb or noun.

We therefore used planned comparisons to compare infants' performance in the baseline and response windows in each condition. As predicted, infants in the No Word condition performed comparably in the baseline and response windows ($M = .38$ and .38, respectively), $F(1, 69) = 0.01$, $p > .05$; $\eta^2 = .05$. This is an important finding because it indicates that when no novel word is presented, infants' preference for the novel test scene persists throughout the response window. Infants in the Noun condition performed similarly ($M = .37$ and .39, respectively), $F(1, 69) = 1.27$, $p > .05$; $\eta^2 = .20$, documenting that infants

do not shift their attention in response to any novel word. Instead, and as predicted, this shift in attention from the baseline to the response window was evident *only* with the presentation of a novel verb, (M = .49 and .37, respectively), $F(1, 69) = 30.12$, $p < .0001$; $\eta^2 = .99$.

Finally, we asked whether the distinct patterns of performance observed within each condition were reflected in the behavior of most infants within that condition. We tallied the number of infants in each condition whose mean looking time to the familiar scene in the response window (averaged over all trials) exceeded that in the baseline window. In the Verb condition, 79% of the infants (19 out of 24) looked longer at the familiar test scene in the response than the baseline window, a distribution that differed from chance, $\chi^2(1) = 8.167$, $p < .005$. In contrast, the number of infants displaying this pattern in the Noun (13 out of 24) and No Word (12 out of 24) conditions did not differ from chance, both p's > .50. Thus, non-parametric analyses echo analyses based on group means, suggesting that the mean patterns within each condition characterize well the behavior of its individual participants.

Discussion

The results of this experiment offer three insights into the word-learning capacities of 24-month-old infants. First, infants' strong novelty preferences in the baseline period reveals that infants in all conditions were quite sensitive to the consistent events that were portrayed in the dynamic familiarization scenes and readily detected a change in event category at test. Second, infants' performance in the response period reveals that they distinguish between novel words presented as verbs versus nouns, and recruit this distinction in mapping words to meaning. They consider that verbs, but not nouns, map to event categories. Third, the time-course underlying infants' response to novel words is swift. Performance among the conditions begins to diverge just after the offset of the novel word.

The results also raise some intriguing questions. For example, we have demonstrated that 24-month-olds map novel verbs specifically to categories of event, and not to categories of object, but the breadth of their representation of verb meaning remains unclear. Does their representation of verb meaning include information about the particular object(s) involved in the event? On this view, infants may have taken the novel verb *larp* to refer to the specific category of *balloon-waving events*. Or does their representation abstract over the participant objects? On this view, infants may have taken the novel verb *larp* to refer to the more general category of *waving events*. At issue is whether infants map novel verbs like *larping* narrowly (e.g., to *balloon-waving events)* or more abstractly (e.g., to *waving events)*. The evidence from Experiment 1 cannot address this issue because although infants in the Verb condition alone directed their attention toward the test scene in which the familiar action was portrayed, that scene involved the familiar object as well. Therefore, in Experiment 2, we go on to ask whether 24-month-old infants are able to extend a novel verb beyond the action-object pairing on which it was introduced.

The current results also offer insights into infants' interpretation of novel nouns. Previous work has documented that infants as young as 14 months of age interpret novel count nouns as referring specifically to categories of objects, and not to their surface properties (e.g., color, texture) (Booth & Waxman, 2003; Waxman, 1999; Waxman & Booth, 2001). The results of the current experiment take us one step further: Although infants in the current experiment noticed the categories of action depicted during familiarization (as witnessed by their novelty preferences in the baseline window), they did not consider these actions to be candidates for noun meaning.

Performance in the Noun condition also sheds light on the breadth of infants' representations of noun meaning. We have argued that because both the novel and familiar test scenes

depicted a member of the familiar object category (e.g., balloon), either could constitute a correct extension of the novel noun. But notice that this argument goes through *only* if infants successfully uncouple the participant object from the action in which it is engaged when assigning meaning to a novel noun. If they had failed to do so, then in the response window, infants in the Noun condition would have shifted their attention toward the familiar test scene, seeking to preserve the same object-action pairing that they observed in familiarization. The fact that infants did not do so, but instead maintained their focus on the novel test scene, suggests that their representation of noun meaning is sufficiently abstract to include instances of an object category, independent of the action in which it is engaged. However, it is also possible that infants had difficulty resolving the meaning of the novel nouns in this task, and as a result, simply maintained their baseline preference for the novel test scene. Experiment 2 permits us to distinguish between these alternatives.

Experiment 2: Mapping Words to Object Categories

Experiment 2 was designed to clarify further the breadth and precision of 24-month-old infants' interpretations of novel words presented as verbs and nouns. The design was identical to that of Experiment 1, except for one crucial modification in the test scenes. Infants in the current experiment saw the very same familiarization scenes as in Experiment 1 (e.g., a man waving a balloon), the very same contrast scene (e.g., a man playing a saxophone) and the very same familiar test scene (e.g., a man waving a balloon); what differed was the novel test scene. In Experiment 2, the novel feature of the novel test scene was the object (e.g., the man waving a *rake*), whereas in Experiment 1, the novel feature had been the action (e.g., the man *tapping* the balloon). Infants were assigned randomly to a Verb, Noun, or No Word condition.

Following the same logic as in Experiment 1, we asked (a) whether 24-month-olds focused sufficiently on the consistent object depicted during familiarization to detect the novel object presented at test, and (b) whether infants' interpretation of a novel word applied to these scenes was influenced by the grammatical form of the novel word to which they had been exposed.

Method

Participants—Seventy-two 24-month-olds (37 males) with a mean age of 24.08 months (range: 21.64 to 26.25) were included in the final sample. All participants were recruited from Evanston, IL and its surrounding communities and were acquiring English as their native language. Infants were from primarily Caucasian middle- and upper-middle-class families. Parents completed the MacArthur Checklist: Level II - Form A (Fenson et al., 2000) and infants' mean production vocabulary was 52 words (ranging from 4 to 98) and did not differ among the three conditions. We analyzed the data of infants that completed all six test trials. An additional 25 infants were excluded due to: fussiness (n = 13), parental interference (n = 3), failure to complete all test trials (6), or experimenter error/technical difficulty (n = 3).

Materials—The audio and visual materials were identical to those in Experiment 1, with one exception. In Experiment 1, the novel test scene had depicted a novel action (e.g., the man *tapping* the balloon); in contrast, in Experiment 2, the novel test scene depicted a novel object (e.g., the man waving a *rake*). As in Experiment 1, participants in all conditions viewed the same video sequences; the accompanying audio input varied as a function of their condition assignment. See Table 2 for a sample representation of the sequence and Appendix A & B for a complete set of stimuli.

Apparatus and Procedure—This was identical to Experiment 1.

Coding—This was identical to Experiment 1. Agreement between coders for the selected windows, calculated for 3 infants in each condition, was excellent (93.5% agreement; Cohen's kappa = .88).

Predictions—The predictions follow the same logic as those in Experiment 1.

Baseline period: If infants are sensitive to the participant objects involved in these dynamic action scenes, then they should detect the novel object presented in the novel test scene and as a result, infants in all conditions should reveal a baseline preference for the novel test scene.

Response period: We predicted that performance in the response period would vary systematically as a function of condition. Recall that in this experiment, the familiar object (e.g., balloon) appears only in the familiar test scene, and the familiar action (e.g., waving) now appears in both the novel and familiar test scenes.

If infants expect that nouns map onto categories of objects, independent of the actions in which the objects are engaged, then in response to the test question, infants in the Noun condition should direct their attention toward the familiar test scene because it is only here that the infant will find a member of the object category presented during familiarization (e.g., the balloon).

If in their representations of verb meaning, infants fuse an action with its participant objects, then they should map novel verbs narrowly (e.g., taking *larp* to refer to balloon-waving events) and as a result, in response to the test question ("Which one is he *larping*?") infants should move their attention reliably away from the novel test scene (which depicts a novel participant object) and toward the familiar test scene (which depicts the familiar participant object). Yet if in their representation of verb meaning, infants uncouple the action from its participant objects, then they should map novel verbs more broadly, abstracting to other instances of the same action, despite a change in participant objects. (e.g., taking *larp* to refer to waving events). As a result infants in the Verb condition could reasonably maintain their focus on the novel test scene in response to the test question.

Finally, because in the No Word control condition, the response question contains no novel word (e.g., "What do you see now?"), infants in this condition should exhibit no change from the baseline to the response window.

Results

An examination of Figure 3 indicates that during the baseline period, infants in all three conditions reveal a strong preference for the novel test scene, suggesting that they detected the novel object presented at test in the current experiment, just as they had detected the novel action in Experiment 1. Also as in Experiment 1, performance among the conditions began to diverge in the response period with the onset of the novel word. However, in this experiment, it was infants in the Noun condition that shifted their attention toward the familiar test scene.

As in Experiment 1, 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 (3: Verb, Noun, No Word) as a between-participants factor and window (2: baseline, response) as a within-participants factor, and used this to test our predictions. See Figure 4. First, a simple effects test revealed that during the baseline window, there were no reliable differences among the conditions, $F(2,69) = 1.12$, $p > .05$; $\eta^2 = .24$. As predicted, infants in all three conditions exhibited clear preferences for the novel test scene, all t's > 5.0, all p's

< .0001. Also as predicted, in the response window, reliable differences among the conditions emerged, $F(2,69) = 8.04$, $p < .01$; $\eta^2 = .95$. Infants in the Noun condition devoting a greater proportion of looking time to the familiar test scene than did infants in either the Verb or No Word conditions, Tukey tests, both p's < 05. There was no difference between performance in these latter two conditions. Moreover, infants in these two conditions maintained their preference for the novel test scene, both p's < .001, but those in the Noun condition did not.

We therefore used planned comparisons to compare infants' performance in the baseline and response windows in each condition. As predicted, infants in the No Word condition performed comparably in the baseline and response windows ($M = .36$ and .39, respectively), $F(1,69) = 1.70$, $p > .05$; $\eta^2 = .25$, suggesting that in the absence of a novel word, infants' preference for this novel scene persists through the response window. The same was true of infants in the Verb condition ($M = .38$ and .42, respectively), $F(1,69) = 2.67$, $p > .05$; $\eta^2 = .36$. This suggests that in their representations of verb meaning, infants were indeed able to uncouple the action from the participant objects and as a result, accepted events involving new participant objects as candidates for verb meaning. Performance in this condition also reveals that a shift away from the novel scene is not motivated by the presentation of any novel word; instead, this shift is observed only in infants hearing a novel noun. Instead, and as predicted, this shift in attention from the baseline to the response window was evident *only* in the Noun condition, ($M = .40$ and .51, respectively), $F(1,69) = 16.28$, $p < .0001$; $\eta^2 = .98$.

A nonparametric analysis of individual infants' patterns of performance revealed that the distinct patterns observed within each condition were reflected in most infants within that condition. As in Experiment 1, we tallied the number of infants in each condition whose mean looking time to the familiar scene in the response window exceeded that in the baseline window. In the Noun condition, 75% of the infants (18 out of 24) looked longer at the familiar test scene in the response than the baseline window, $\chi^2(1) = 6.304$, $p < .05$. In contrast, in both the Verb and No Word conditions, 54% of the infants (13 out of 24) displayed this pattern, both p's > .50.

Discussion

The results of this second experiment bolster the results of the first, but also offer new information concerning the breadth of infants' representations of novel words. Infants in all conditions were sensitive to the participant objects portrayed in the dynamic scenes presented during familiarization and readily detected a change in participants when it was presented in the baseline test period, just as they had detected the change in action in Experiment 1. In addition, infants' differential performance in the response period offers insights into their representations of both novel verbs and nouns.

Consider first the evidence concerning verbs. Recall that in this experiment, the familiar and novel test scenes portrayed the very same events, differing only in event participants. We found that infants in the verb condition maintained their focus on the novel test scene, even though it involved a novel participant. This suggests that their representation of verb meaning was sufficiently abstract to permit them to generalize a novel verb broadly, to instances of an event category that includes different participants than the ones with which the verb was introduced. This outcome is at variance with the claim that such abstraction in verb learning is unavailable even in more advanced word learners (Imai, Haryu, & Okada, 2002, 2004, 2005; Kersten & Smith, 2002; Meyer et al., 2003), and we turn to this issue in the General Discussion. The current results also clarify the breadth of infants' representations of novel nouns. We found that infants in the noun condition shifted their visual attention reliably from the novel test scene during the baseline window toward the

familiar test scene in the response window, suggesting that their representation of noun meaning was sufficiently abstract to permit them to map novel nouns specifically to object categories, and not to the actions in which they are engaged.

General Discussion

The results of these two experiments make three strong contributions which, taken together, begin to resolve several concerns, both empirical and theoretical in nature, that have surfaced within the verb-learning literature. First, when 24-month-old infants view a series of dynamic scenes, they rather readily detect a change in that scene, whether the change involves a novel action (Experiment 1) or a novel object (Experiment 2). Clearly, then, infants are not captivated so thoroughly by the participant objects that the actions in which they are involved go unnoticed. Infants' sensitivity to both actions and objects suggests that in principle, both are available as potential referents for novel words. Second, infants' performance in the response window reveals that this is, in fact the case: In the context of hearing a novel verb, they direct their attention to events (and not to the participant objects involved, or even to a specific object-action pair); in the context of hearing a novel noun, they direct their attention to categories of objects (and not to the particular actions in which they were engaged, or even to a specific object-action pair). Thus, 24-month-old infants are able to (a) distinguish events from their participant objects in dynamic scenes, (b) distinguish novel verbs from nouns, and (c) treat these conceptual and linguistic distinctions as relevant to establishing the meaning of novel words.

These experiments shed light on several outstanding issues in word learning. Focusing first on the verbs, we have shown that after having heard a novel verb in conjunction with only one set of participants (e.g., man, balloon), 24-month-old infants extended that verb to a novel scene involving the same action, but a different participant (e.g., man, rake). This reveals that when seeking to establish the meaning of a novel verb, infants focus on the event category (waving events), abstracting away from the particular participants involved in the event (balloons), and identifying the *relations* among the participants as definitional of the event category. This suggests that infants are indeed sensitive to the principles governing the generalization of verb meaning. What remains to be seen is whether they can invoke these principles under more challenging conditions, an issue we address below.

Focusing next on the nouns, we have shown that 24-month-old infants successfully map novel nouns (but not verbs) onto object categories (e.g., balloons), independent of the actions in which they are engaged. This in itself is not surprising: it is entirely consistent with evidence that by 14 months of age, infants map nouns specifically to object categories (Waxman, 1999). But the current results take us one step further, offering the first evidence that at 24 months, infants' focus on object categories in noun-learning is sufficiently strong to persist even in the presence of dynamic action scenes, and even when a salient action is available as a candidate meaning.

Reconciling infants' success with preschoolers' failures

How can we reconcile 24-month-old infants' success in mapping verbs onto event-categories, abstracting over the particular event participants, when 3- and even 5-year-old children have encountered such difficulty making this very same abstraction in similar experimental tasks (Behrend, 1990, 1995; Brown, 1957; Forbes & Farrar, 1995; Imai, Haryu, & Okada, 2002, 2004, 2005; Kersten & Smith, 2002)? Could it be that infants' success in verb learning is tied rather closely to contexts, like those presented here, in which transitive frames accompany clearly causal events? After all, our decision to present transitive frames and causal events was based on evidence that infants tend to align these (Bunger, 2007; Fisher, 1996; Lidz, Gleitman & Gleitman, 2003). Notice, however, that this

particular pairing of frames and events does not, in and of itself, guarantee successful verb learning, as witnessed by 3-year-old children's difficulty mapping (transitive) verbs to causal events in Imai (2005). In addition, infants' success in verb learning does not appear to be limited to such pairings. In a task modeled closely after the one used here, 23-month-old infants successfully mapped intransitive verbs to non-causal one-participant actions (Bernal, Lidz, Millotte & Christophe, 2007). Apparently, infants' success is neither guaranteed by, nor restricted to, transitive-causal pairings.

We suspect that 24-month-olds' success in the current experiments may be related, at least in part, to issues of experimental design. In our view, these design issues are more than mere methodological niceties. Instead, they reflect the distinct informational requirements underlying the acquisition verbs (Gleitman, 1990). There is considerable evidence that successful verb learning requires different, and more extensive, information than that required for noun learning (Gillette, et al., 1999; Snedeker & Gleitman, 2004; Piccin & Waxman, 2007). Infants' success in the current experiments suggests that there is something present in the current design, but absent in others, that provides infants with just the sort of information that they require for verb learning. But what might that something be? To answer this question, we consider design features of both the familiarization/contrast and the test phase.

Notice two sources of information are embedded within the familiarization/contrast phase. In the familiarization phase, infants viewed multiple versions of a given scene (e.g., a man waving different balloons), accompanied by multiple presentations of the novel word within its relevant grammatical context. In the contrast phase, they received explicit evidence concerning the limits on the application of the novel word. Each of these factors -- multiple exemplars and contrast -- has a facilitative effect in word learning (Au & Markman, 1987; Bradlow & Bent, 2008; Brown & Hanlon, 1970; Clark, 1988, 1997; Hall & Belanger, 2005; Klibanoff & Waxman, 2000; Namy & Gentner, 2002; Waxman & Booth, 2003; Waxman & Markow, 1995). We included these factors in our design because our goal was to uncover infants' early representations of verb meaning. The fact that 24-month-old infants were successful in verb learning suggests that these factors, jointly present in the current experiments but absent in others (Behrend, 1990, 1995; Forbes & Farrar, 1995; Imai, Haryu, & Okada, 2002, 2004, 2005; Kersten & Smith, 2002), may have been instrumental.

In future work, it will be important to test the contribution of *each* of these factors directly. Although investigations with infant learners are currently underway (Lidz, Waxman, Bunger & Leddon, 2006), recent work with 3-year-old children indicates that each of these factors contributes to successful verb learning (Piccin & Waxman, 2007; Waxman, in press). These results are instructive because, as we have pointed out, 3-year-olds often encounter difficulty when they are required to extend the verb beyond the particular participants with which the verb had been introduced. Piccin and Waxman (2007) replicated this oft-reported effect: when 3-year-olds were provided with *neither* multiple exemplars nor explicit contrast, they learned nouns but failed to learn verbs. Notice that this condition parallels the design of Imai and her colleagues and produces results that echo their with children at the very same age. This pattern – success with nouns and difficulty with verbs -- fits well with the argument that the requirements underlying verb learning are steeper than those underlying noun learning (Gleitman et al., 2005). However, Piccin and Waxman showed that when 3-year-olds were offered *both* multiple exemplars and explicit contrast, they successfully learned verbs as well as nouns. Notice that this condition parallels the design of the experiments reported here and produces results in 3-year-olds that echo precisely our results with 24-month-olds. Moreover, when 3-year-olds were offered only one these source of support (*either* multiple exemplars *or* contrast), it became clear that each factor exerted an independent contribution toward success in verb-learning. Taken together, these findings

reveal the impact of experimental design on the acquisition verbs in particular, and underscore the empirical and theoretical importance of considering how various sources of information, independently or in concert, contribute to the acquisition of word meaning.

It is also worth noting another design difference – the structure of the test trials -- that distinguishes current and previous investigations. In the experiments reported here, the test trials included one familiar scene and one novel scene. The novel scene portrayed either a novel action (Experiment 1) or a novel participant object (Experiment 2). In previous investigations, the structure of the test trials was more demanding; both test trials included novel scenes and children were required to choose between one novel scene (portraying a familiar action but a novel object) and another (portraying a familiar object but a novel action) (Imai et al., 2002; 2004; 2005; Kersten & Smith, 2002; Piccin & Waxman, 2007). Our decision to simplify the test trials was motivated by our goal of uncovering infants' early capacities in verb learning. Infants' success in this task, important in its own right, also raises the question of whether 24-month-olds might also succeed in the more demanding testing events. For example, after being familiarized to scenes in which a man is waving a balloon, are infants able to choose between two novel scenes, either a man waving a rake (novel object) *or* a man tapping a balloon (novel action)? Preliminary results suggest that even in this more stringent task, 24-month-olds' representations of verb meaning are sufficiently abstract to permit them to extend a novel verb to an action, generalizing beyond the particular participants with which it has been introduced (Waxman, in press).

It will also be important to identify which other syntactic environments (e.g., intransitive frames; verbs appearing with pronouns) and which other kinds of events (e.g., punctate rather than continuous events; events with different numbers of participants and different temporal or causal characteristics) also enable infant verb learning (Bunger & Lidz, 2008; Childers & Tomasello, 2001; Echols & Marti, 2004; Lidz, Bunger, Leddon, & Waxman, 2006; Fisher, Hall, Rakowitz, & Gleitman, 1994; Wagner & Carey, 2003; Viau 2007).

In closing, the current experiments address several concerns, both empirical and theoretical in nature, that have surfaced within the verb-learning literature. They begin to reconcile what, until now, has been a large and largely unexplained gap between infants' well-documented ability to acquire verbs in the natural course of their lives and their rather surprising failures to do so in many laboratory-based tasks. At a descriptive level, we document that at 24 months, a point at which many infants naturally begin to add new verbs in increasing number to their lexicons, they also successfully learn new verbs in a laboratory-based task. At a more theoretical level, we document that 24-month-olds' representations are sufficiently abstract to permit them to extend novel verbs appropriately beyond the precise scenes on which they have been introduced. Together, these findings suggest that it is time to move beyond asking whether infants can or cannot represent verb meanings, and to consider instead the conditions that support the acquisition of verb learning in infants and young children.

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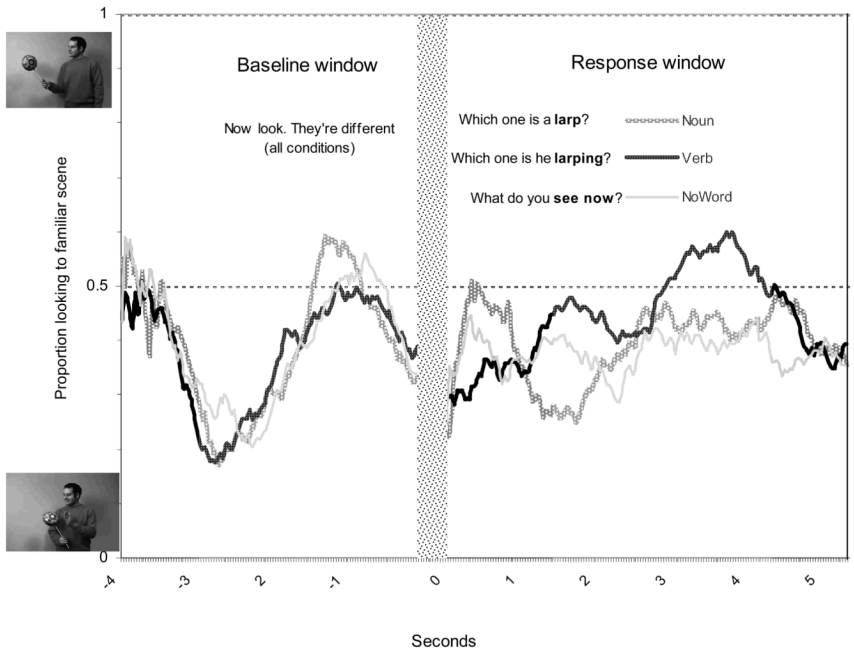

Figure 1.
Experiment 1. Time-course of infants' looking behavior in the baseline and response windows in each condition, aggregated over all trials.

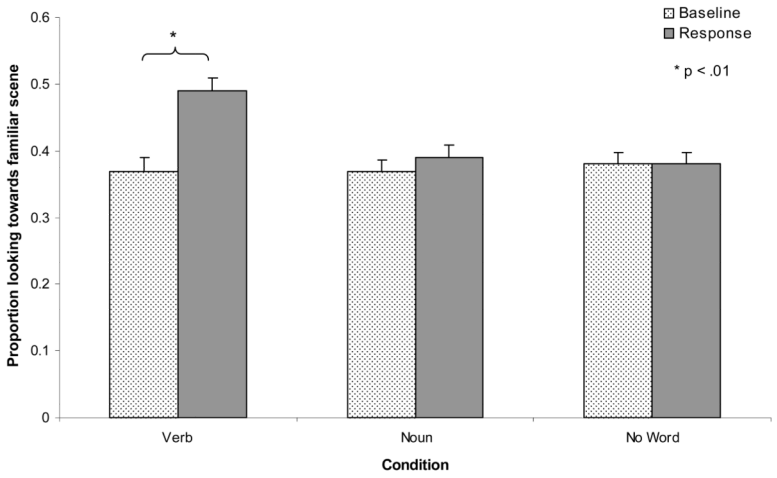

Figure 2.
Experiment 1. Mean proportion of looking time towards the familiar test scene in the baseline and response windows, expressed as a function of condition.

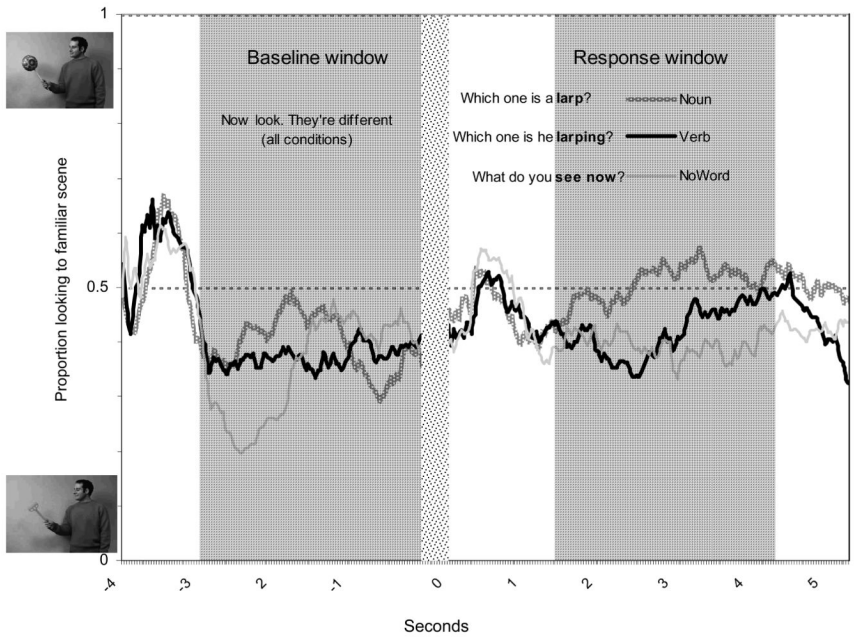

Figure 3.
Experiment 2. Time-course of infants' looking behavior in each condition, aggregated over all trials.

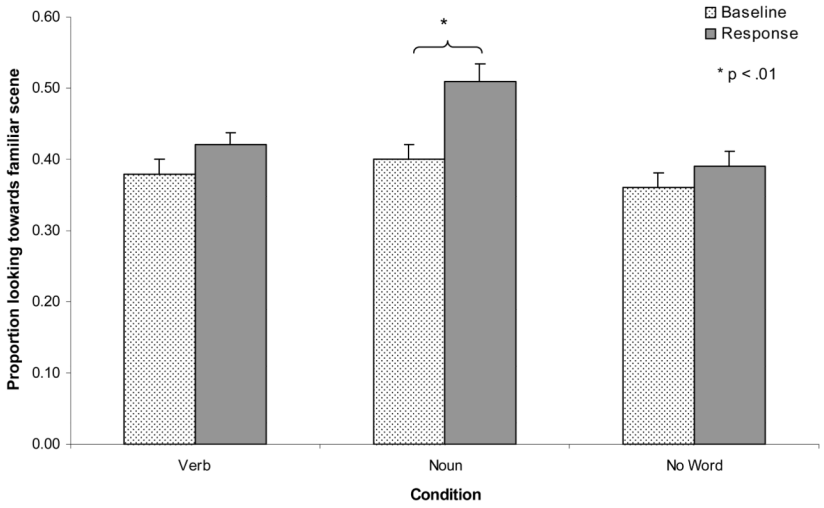

Figure 4.
Experiment 2. Mean proportion of looking time towards the familiar test scene in the baseline and response windows, expressed as a function of condition.

TABLE 1

Representative set of the stimuli presented in Experiment 1

	Familiarization	**Contrast**		**Test**	
				Familiar Scene	Novel Scene
Exp. 1: Action Test					
	Man waving balloon (4 consecutive exemplars)	Man playing toy saxophone	Man waving balloon	Man waving balloon	Man tapping balloon
	Verb: "Look, the man is *larping* a balloon!"	Verb: Uh-oh! He's not *larping* that.	Verb: Yay! He is *larping* that.	Verb: "Now look, they're different! (Baseline) "Which one is he *larping* ?" (Response)	
	Noun: "Look, the man is waving a *larp*!"	Noun: Uh-oh! That's not a *larp*!	Noun: Yay! That is a *larp*!	Noun: "Now look, they're different! (Baseline) "Which one is a *larp*?" (Response)	
	No Word: "Look at this!"	No Word: Uh-oh! Look at that.	No Word: Yay! Look at this.	No Word: "Now look, they're different! (Baseline) "What do you see now?" (Response)	

TABLE 2

Representative set of the stimuli presented in Experiment 2

	Familiarization	**Contrast**		**Test**	
				Familiar Scene	Novel Scene
Exp. 2: Object Test					
	Man waving balloon (4 consecutive exemplars)	Man playing toy saxophone	Man waving balloon	Man waving balloon	Man waving rake
	Verb: "Look, the man is *larping* a balloon!"	Verb: Uh-oh! He's not *larping* that.	Verb: Yay! He is *larping* that.	Verb: "Now look, they're different! (Baseline) "Which one is he *larping*?" (Response)	
	Noun: "Look, the man is waving a *larp*!"	Noun: Uh-oh! That's not a *larp*!	Noun: Yay! That is a *larp*!	Noun: "Now look, they're different! (Baseline) "Which one is a *larp*?" (Response)	
	No Word: "Look at this!"	No Word: Uh-oh! Look at that.	No Word: Yay! Look at this.	No Word: "Now look, they're different! (Baseline) "What do you see now?" (Response)	

APPENDIX A

Complete Sets of Stimuli for Experiments 1 and 2

Familiarization (four consecutive scenes)	Contrast	Test			
			Familiar scene	Novel scene	
Man waving balloon	Playing toy saxophone	Waving balloon	Waving balloon	Tapping balloon *or* Waving rake	Exp. 1: Action Test Exp. 2: Object Test
Woman washing cup	Playing guitar	Washing cup	Washing cup	Drinking from cup *or* Washing plate	Exp. 1: Action Test Exp. 2: Object Test
Man pushing chair	Bouncing ball	Pushing chair	Pushing chair	Lifting chair *or* Pushing box	Exp. 1: Action Test Exp. 2: Object Test
Woman twirling umbrella	Lifting hat on head	Twirling umbrella	Twirling umbrella	Spinning umbrella *or* Twirling pillow	Exp. 1: Action Test Exp. 2: Object Test

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Familiarization (four consecutive scenes)	Contrast	Test		
		Familiar scene	Novel scene	
Boy pulling bunny	Sweeping floor with broom	Pulling bunny	Pulling bunny	Tossing bunny *or* Pulling bucket	Exp. 1: Action Test Exp. 2: Object Test
Girl petting dog	Drinking from cup	Petting dog	Petting dog	Kissing dog *or* Petting Frisbee	Exp. 1: Action Test Exp. 2: Object Test

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APPENDIX B

Complete Sets of Introductory phrases used in Experiments 1 and 2

Trial		Familiarization		Contrast		Test	
						Baseline	Response[1]
Waving Balloon	Verb	**1**	Look, the man is *larping* a balloon.	Uh oh! He's not *larping* that!	Yay! He is *larping* that!	Now look. They're different.	Which one is he *larping*? *or* Where is he *larping* something?
		2	The man is *larping* another balloon.				
		3	Do you see the man *larping* a balloon?				
		4	Look, the man is *larping* a balloon!				
	Noun	**1**	Look, the man is waving a *larp*.	Uh oh! That's not a *larp*!	Yay! That is a *larp*!	Now look. They're different.	Which one is a *larp*? *or* Where is a *larp*?
		2	The man is waving another *larp*.				
		3	Do you see the man waving a *larp*?				
		4	Look, the man is waving a *larp*!				
	No Word	**1**	Wow, look what's happening here.	Uh oh! Look at that!	Yay! Look at this!	Now look. They're different.	What do you see now?
		2	Look at this.				
		3	Do you see that?				
		4	Hey, look there!				
Washing Cup	Verb	**1**	Look, the girl is *semming* a cup.	Uh oh! She's not *semming* that!	Yay! She is *semming* that!	Now look. They're different.	Which one is she *semming*? *or* Where is she *semming* something?
		2	The girl is *semming* another cup.				
		3	Do you see the girl *semming* a cup?				
		4	Look, the girl is *semming* a cup!				
	Noun	**1**	Look, the girl is washing a *sem*.	Uh oh! That's not a *sem*!	Yay! That is a *sem*!	Now look. They're different.	Which one is a *sem*? *or* Where is a *sem*?
		2	The girl is washing another *sem*.				
		3	Do you see the girl washing a *sem*?				
		4	Look, the girl is washing a *sem*!				
	No Word	**1**	Wow, look what's happening here.	Uh oh! Look at that!	Yay! Look at this!	Now look. They're different.	What do you see now?
		2	Look at this.				
		3	Do you see that?				

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Trial		Familiarization		Contrast		Test	
						Baseline	Response[1]
		4	Hey, look there!				
Pushing Chair	Verb	**1**	Look, the man is *dacking* a chair.	Uh oh! He's not *dacking* that!	Yay! He is *dacking* that!	Now look. They're different.	Which one is he *dacking*? *or* Where is he *dacking* something?
		2	The man is *dacking* another chair.				
		3	Do you see the man *dacking* a chair?				
		4	Look, the man is *dacking* a chair!				
	Noun	**1**	Look, the man is pushing a *dacket*.	Uh oh! That's not a *dacket*!	Yay! That is a *dacket*!	Now look. They're different.	Which one is a *dacket*? *or* Where is a *dacket*?
		2	The man is pushing another *dacket*.				
		3	Do you see the man pushing a *dacket*?				
		4	Look, the man is pushing a *dacket*!				
	No Word	**1**	Wow, look what's happening here.	Uh oh! Look at that!	Yay! Look at this!	Now look. They're different.	What do you see now?
		2	Look at this.				
		3	Do you see that?				
		4	Hey, look there!				
Twirling Umbrella	Verb	**1**	Look, the girl is *wugging* an umbrella.	Uh oh! He's not *wugging* that!	Yay! He is *wugging* that!	Now look. They're different.	Which one is he *wugging*? *or* Where is he *wugging* something?
		2	The girl is *wugging* another umbrella.				
		3	Do you see the girl *wugging* an umbrella?				
		4	Look, the girl is *wugging* an umbrella!				
	Noun	**1**	Look, the girl is twirling a *wuggit*.	Uh oh! That's not a *wuggit*!	Yay! That is a *wuggit*!	Now look. They're different.	Which one is a *wuggit*? *or* Where is a *wuggit*?
		2	The girl is twirling another *wuggit*.				
		3	Do you see the girl twirling a *wuggit*?				
		4	Look, the girl is twirling a *wuggit*!				
	No Word	**1**	Wow, look what's happening here.	Uh oh!	Yay! Look at this!	Now look. They're different.	What do you see now?
		2	Look at this.				
		3	Do you see that?				

Trial		Familiarization		Contrast		Test	
						Baseline	Response[1]
		4	Hey, look there!	Look at that!			
Pulling Bunny	Verb	**1**	Look, the man is *toping* a bunny.	Uh oh! She's not *toping* that!	Yay! She is *toping* that!	Now look. They're different.	Which one is she *toping*? *or* Where is she *toping* something?
		2	The man is *toping* another bunny.				
		3	Do you see the man *toping* a bunny?				
		4	Look, the man is *toping* a bunny!				
	Noun	**1**	Look, the man is pulling a *topin*.	Uh oh! That's not a *topin*!	Yay! That is a *topin*!	Now look. They're different.	Which one is a *topin*? *or* Where is a *topin*?
		2	The man is pulling another *topin*.				
		3	Do you see the man pulling a *topin*?				
		4	Look, the man is pulling a *topin*!				
	No Word	**1**	Wow, look what's happening here.	Uh oh! Look at that!	Yay! Look at this!	Now look. They're different.	What do you see now?
		2	Look at this.				
		3	Do you see that?				
		4	Hey, look there!				
Petting Dog	Verb	**1**	Look, the girl is *pilking* a dog.	Uh oh! He's not *pilking* that!	Yay! He is *pilking* that!	Now look. They're different.	Which one is he *pilking*? *or* Where is he *pilking* something?
		2	The girl is *pilking* another dog.				
		3	Do you see the girl *pilking* a dog?				
		4	Look, the girl is *pilking* a dog!				
	Noun	**1**	Look, the girl is petting a *pilker*.	Uh oh! That's not a *pilker*!	Yay! That is a *pilker*!	Now look. They're different.	Which one is a *pilker*? *or* Where is a *pilker*?
		2	The girl is petting another *pilker*.				
		3	Do you see the girl petting a *pilker*?				
		4	Look, the girl is petting a *pilker*!				
	No Word	**1**	Wow, look what's happening here.	Uh oh!	Yay! Look at this!	Now look. They're different.	What do you see now?
		2	Look at this.				
		3	Do you see that?				

Trial	Familiarization	Contrast	Test	
			Baseline	Response[1]
4	Hey, look there!	Look at that!		

[1]Each infant heard the following construction “Which one is he/she Xing?” (Verb condition) or “Which one is a X?” (Noun condition) on three of their six trials. On the remaining three trials, the infants heard “Where is he/she Xing something?” (Verb condition) or “Where is a X?” (Noun condition).