*"All in Good Time: How do Infants Discover Distinct Types of Words and Map Them to Distinct Kinds of Meaning"?*

More than any other developmental achievement, word-learning occupies the crossroad between human conceptual and linguistic development. Facing the conceptual domain, we know that infants form core concepts that capture various relations among the objects and events that they encounter. Facing the linguistic domain, we know that they cull words and phrases from the melody of the human language in with they are immersed. In my research program, our overarching goal has been to discover when and how human language and conceptual organization become linked. It is now apparent that even before infants begin to produce words on their own, they make important advances in each of these domains. Even more remarkably, their early conceptual and linguistic advances are powerfully linked. My goal in this chapter is to outline recent theoretical and empirical approaches to studying these links in infancy, highlighting the methods that permit us to examine it in detail.

## 1. OVERVIEW AND THEORETICAL APPROACH

Infants live in an enormously rich environment. Each day, they encounter new objects and witness new events. An essential developmental task is to form concepts that capture commonalities and relations among the objects and events they encounter, and to learn words to express them.

I have proposed that even before infants begin to produce words on their own (at roughly 12 months), their conceptual and linguistic development are linked, in at least a rudimentary way. As infants begin the process of lexical acquisition, they harbor a broad, universal expectation linking novel content words to a broad range of commonalities among objects and events. This broad link sets the stage for the evolution of more specific expectations, linking particular *kinds* of words (e.g., noun, adjective, verb) to particular *kinds* of relations (e.g., object

categories, object properties, and relations among objects). These more specific expectations, which are shaped by the structure of the native language under acquisition, do not emerge all of a piece. Instead, infants first tease apart the nouns (from among the other grammatical forms) and map them specifically to object categories. With this noun-category link in place, the precise links between other grammatical forms and their associated meanings will follow.

This is a dynamic proposal that underscores the vital interaction between infants' expectations and the shaping role of the environment. Ultimately, both developmental and cross-linguistic evidence will be essential in discovering the origin of infants' early expectations if we are to identify which expectations (if any) are universal, and how these are shaped by infants' experience with the native language under acquisition.

We have employed two kinds of tasks to trace the relation between word-learning and conceptual organization in infancy. In the *live interactive tasks*, infants interact directly with a trained experimenter in a structured play session in which she offers them 3-dimensional objects to explore while she comments on them. In the *automated tasks*, infants view 2-dimensional video images presented on a screen, accompanied by auditory input consisting of pre-recorded comments of an individual talking about them. Each of these tasks brings with it strong advantages and disadvantages. Together, they converge to provide a window through to view infants' advances in word-learning over the first few years of life.

## 2. FOUNDATIONAL ISSUES AND EVIDENCE

Recent years have witnessed a decisive renewal of scientific interest in the relation between conceptual and linguistic development. A central focus has been to discover whether and how the categorization of objects -- a conceptual task -- is influenced by novel words (Bloom, 2000; Gelman, Coley, Rosengren, Hartman, & Pappas, 1998; Hollich et al., 2000; Smith, 1999; Waxman, 2002; Woodward & Markman, 1998). To illustrate, consider a typical

word-learning scenario. A mature speaker (e.g., a parent) points to an ongoing stream of activity (e.g., a flamingo disappearing behind a dune), and utters a novel word (e.g., “Did you see the flamingo?”). To learn a word from this (indeed from any) context, the infant must (a) parse the relevant word (*flamingo*) from running speech, (b) identify the relevant entity from the ongoing stream of activity (e.g.,the flamingo, not the dune or the act of disappearing) , and (c) establish a word-to-world mapping between them. By the end of their first year, infants are well on their way to solving each of these three elements.

Specifically, in the first year, infants become increasingly sensitive to perceptual cues (morphologic, phonetic, prosodic) and distributional regularities that mark word and phrase boundaries in their native language (Fernald, 1992; Jusczyk & Aslin, 1995; Kemler Nelson, Hirsh-Pasek, Jusczyk, & Cassidy, 1989; Marcus, Vijayan, Rao, & Vishton, 1999; Saffran, Aslin, & Newport, 1996). By 9-12 months, with the ability to successfully parse individual words from the speech stream established, they spontaneously begin to build a lexicon consisting primarily of *open class* words (or, *content* words, including nouns, adjectives, verbs) (Jusczyk & Kemler Nelson, 1996; Morgan & Demuth, 1996; Shi & Werker, 2003; Shi, Werker & Morgan, 1999; Werker, Lloyd, Pegg, & Polka, 1996).

During their first year, infants also acquire an impressive repertoire of core conceptual knowledge (Baillargeon, 2000; Spelke, 2000). Some of their pre-linguistic concepts are focused around richly-structured category-based relations (e.g., flamingo, animal); others are focused primarily on property-based relations (e.g., red, soft) (see Quinn & Eimas, 2000); still others concern physical relations among objects (e.g., support; containment). This rich conceptual repertoire sets the stage for what has been described as the 'induction problem' problem: in principle, the very richness of infants' conceptual abilities should complicate their efforts to map words to meaning (Quine, 1960; Waxman & Lidz, 2006). How do they so rapidly discover that a

given word applied to a particular whole object (e.g., *flamingo*), can be extended to other members of that object category (e.g., other flamingos), but not to salient parts or properties of the object (e.g., its long neck or unusual color), or to salient actions in which it is engaged (e.g., feeding its young), or to salient thematic relations (e.g., a flamingo and palm trees)?

The evidence indicates that infants are guided by constraints, or expectations, that help them home in on the relevant meaning (see Waxman & Lidz, 2006; Woodward & Markman, 1998 for thorough reviews of recent evidence in word learning). For instance, infants are guided by social, pragmatic and intentional contexts in which novel words are introduced (Baldwin & Baird, 1999; Guajardo & Woodward, 2000; Hollich et al., 2000; Tomasello & Olguin, 1993; Woodward, 2000). In addition, they consistently use the grammatical form of a novel word as a clue to its meaning. For example, by two years of age, English-speaking children can extend a count noun ("That is a *blicket*") to the named object and extend it spontaneously to other members of the same category (e.g., flamingo, animal); they map proper nouns ("That is *Blicket*") to the named individual, but do not extend them further to other category members; they extend adjectives (and other modifiers) ("That is a *blickish one*") to object properties (e.g., color, textures, size) (see Hall & Lavin, 2004; Waxman, 1998; Woodward & Markman, 1998 for reviews of recent evidence).

### 2.1. Linking Word Learning and Conceptual Organization in Infancy

Clearly, then, by two years of age, children have made significant headway into discovering the relevant linguistic units (words), the relevant conceptual units, and the links between them. But how do infants break into this system? To answer this question, we have conducted a series of parallel experiments using *live* and *automated* procedures. These experiments share several fundamental design features. Under either procedure, each experiment is essentially a categorization task in which we observe infants' ability to detect commonalities

among a series of familiarization events. To examine the influence of novel words on categorization, we compare performance in "neutral" conditions (involving no novel words to performance when novel words are present. To insure that the words themselves carry no *a priori* meaning, we introduce novel (e.g., *fauna*), rather than familiar (e.g., *animal*) words. To examine the influence of grammatical form, we vary the frame in which the novel words are embedded. We present short utterances that are typical of those found in infant-directed speech; these utterances are specifically designed to provide clear evidence of the grammatical category assignment of each word (see Gerken & McIntosh, 1993; Shi, Werker & Morgan, 1999; Waxman & Markow, 1995, 1998 for evidence that infants are sensitive to the frames used in our program). Performance in the "No Word" control condition is used to assess how readily infants notice the commonalities among the familiarization events; performance in the conditions involving novel words is used to measure (a) the contribution of words in this conceptual endeavor and (b) the specificity of this contribution.

*2.1.1. The First Step: Evidence from Live Tasks*

In an early series of experiments, we used an interactive novelty-preference task to reveal that at 12 to 13 months of age infants are sensitive to a broad initial link between word learning and conceptual development (Waxman & Markow, 1995). Infants were familiarized to members of an object category (e.g., 4 different animals; see Figure 1). At test, they saw (a) a new member of the now-familiar category (e.g., another animal) and (b) an object from a contrasting category (e.g., a fruit). Infants manipulated the toys freely, and we used their total accumulated manipulation time as our dependent measure. To examine the influence of words on categorization, infants participated in one of three conditions, which differed only in the experimenter's comments during familiarization (see Figure 1 for instructions in each condition). Notice that at test, all infants heard precisely the same phrase ("See what I have?").

| Familiarization Phase | | | | Test Phase | |
|---|---|---|---|---|---|
|  Pink duck |  Purple raccoon |  Blue dog |  Orange lion |  Yellow cat |  Red apple |
| **Noun:** See the *blicket*? | | See the *blicket*? | | See what I have? | |
| **Adjective:** See the *blickish* one? | | See the *blickish* one?. | | See what I have? | |
| **No Word:** See here? | | See here? | | See what I have? | |

*Figure 1*. A representative set of stimuli (Waxman & Markow, 1995).

The results revealed that by 12 months of age, naming supports the formation of object categories. Infants hearing novel words (either nouns or adjectives) during familiarization successfully formed object categories, as witnessed by their preference for the novel test objects; those in the No Word control condition failed to do so. This means that the novel words (presented only during familiarization) influenced infants' attention to the new – and as yet unnamed – objects that were presented at test.

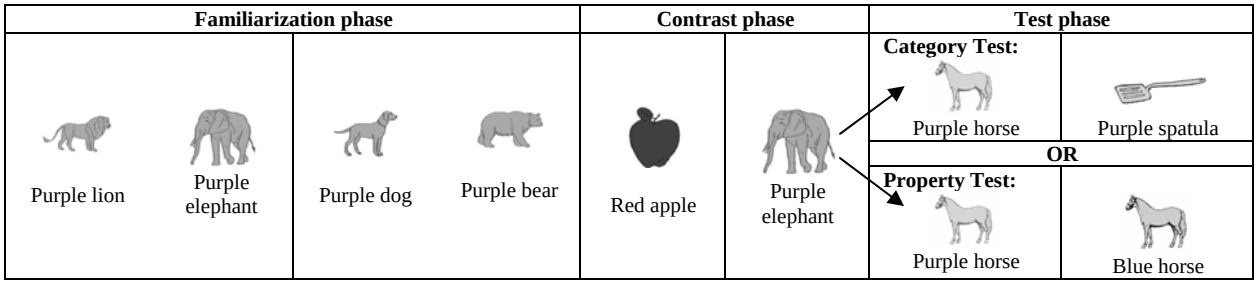
We interpreted this as evidence that words serve as *invitations* to form categories, and proposed that this simple invitation has dramatic consequences. Naming highlights commonalities among objects that might otherwise have gone undetected. Further evidence suggests that naming points infants toward deeper, sometimes non-perceptible commonalities as well (Booth & Waxman, 2002; Gelman & Markman, 1987; Welder & Graham, 2001). Moreover, the conceptual consequences of naming are evident specifically when the referential status of a novel word is made clear (Fennell, 2004; Fennell & Waxman, in press; Fennell, Waxman & Weisleder, 2006). Finally, this link between naming and categorization may be in place, in a rudimentary form, by 6 months of age (Fulkerson, Waxman, & Seymour, in press; Fulkerson & Waxman, 2006), and is certainly available early enough to support infants as they build their initial lexicon (Waxman & Lidz, 2006).

In a subsequent series involving the *live* task, we sought to specify the scope of infants' early expectations (see Waxman & Booth, 2001; Booth & Waxman, 2003 for details). We noted that in the natural course of word learning, infants encounter objects that share more than a single kind of commonality (e.g., furry dogs and orange pumpkins). We therefore asked whether infants link novel words specifically to commonalities underlying object categories (e.g., dog, animal), or whether they initially link words to a wider range of groupings including, for example, property-based commonalities (e.g., furry things, orange things)[1]?

In this series, we maintained the logic of our paradigm, but shifted the focus to include objects sharing *category-based* as well *property-based* commonalities (see Figure 2). This design permitted us to ask (a) whether infants could flexibly construe the very *same* set of objects (e.g., 4 purple animals) *either* as members of an object category (animal) *or* as embodying an object property (purple), and (b) whether their construals were systematically influenced by novel words. This task involved three phases. In the familiarization phase, the experimenter introduced infants in all conditions to four distinct objects, all drawn from the same object category (e.g., four animals) and all embodying the same object property (e.g., purple). These were presented in pairs, and infants manipulated them freely. In the contrast phase, the experimenter introduced an object from a different object category (e.g., not an animal) and embodied a different object property (e.g., not a purple thing). In the test phase, infants in all conditions saw a familiar object (e.g., a purple horse), and a novel object. For half of the infants (those assigned to the Category Test condition) the novel object was a member of a novel object category, but embodied the now-familiar property (e.g., a purple spatula). For the remaining infants (those assigned to the Property test condition) the novel object was a member of the now-familiar object category, but embodied a novel object property (e.g., a blue horse). At test, the experimenter presented a target

[1] See Waxman (1999) for a discussion of the psychological distinction between category- vs property-based commonalities.

object, drawn from the set of familiarization objects (e.g., a purple elephant), and drew attention to it by pointing and saying, "This one is a *blicket*" (Noun condition). She then presented the two test objects, placing them easily within the infant's reach, saying, "Can you give me the *blicket*?" Figure 2 presents the instructions in all conditions.




| | | | | |
|---|---|---|---|---|
| **Noun:** These are *blickets*. | These are *blickets*. | Uh-oh! This one is not a *blicket*! | Yay! This one is a *blicket*! | Look at these. Can you give me the *blicket*? |
| **Adjective:** These are *blickish*. | These are *blickish*. | Uh-oh! This one is not *blickish*! | Yay! This one is *blickish*! | Look at these. Can you give me the *blickish* one? |
| **No Word:** Look at these. | Look at these. | Uh-oh! Look at this one! | Yay! Look at this one! | Look at these. Can you give me one? |

*Figure 2*. A representative set of stimuli (Waxman & Booth, 2001). Note the test phase: Infants see either Category Tests or Property Tests.

We included infants at both 11 and 14 months of age, reasoning as follows. If infants harbor an initially general expectation linking novel content words (in general) to commonalities among objects (in general), then both nouns and adjectives should highlight both category-based (e.g., animal) and property-based (e.g., purple things) commonalities.. That is, infants hearing novel words (either nouns or adjectives) should be more likely to notice commonalities (either category- or property-based) than would infants in the No Word control condition. Moreover, if infants use this broad initial expectation as a basis upon which to discover the more precise links between particular grammatical forms and their associated meaning, then for older infants, more specific pattern should emerge.

The results were consistent with these predictions. At 11 months, infants treated nouns and adjectives similarly. They extended novel words (both nouns and adjectives) systematically

to the familiar test object (e.g., the purple horse) on both Category and Property test trials. Infants in the No Word condition performed differently, revealing no systematic preference for either test object on either type of trial. This suggests that by 11 months, novel words (both nouns and adjectives) direct infants' attention quite broadly to either category- or property-based commonalities.

We suspected that at 14 months (once word-learning was well underway and infants had established a modest lexicon), a more specific set of expectations would emerge. As predicted, 14-month-olds extended novel nouns *specifically* to category-based (and not property-based) commonalities. In contrast, their expectation for novel adjectives was still quite general, directing attention broadly to both kinds of commonalities.

We next designed a more challenging task. The familiarization and contrast phases were identical to those described above, but at test, we pitted the novel objects from the Category and Property test trials directly against each other (Booth & Waxman, 2003) (see Figure 3).

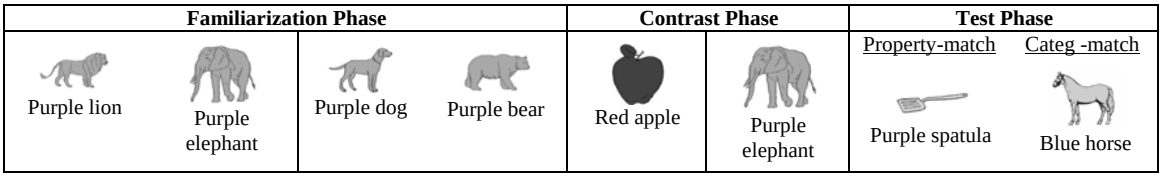



*Figure 3.* A representative set of stimuli (Booth & Waxman, 2003). Note the test phase.

We reasoned as follows: if infants focus specifically on the category-based commonalities among the familiarization objects, they should extend the novel word to the Category Match, despite the fact that it now embodied a novel property. If they attend specifically to the property-based commonalities, they should extend the novel word to the Property Match, despite the fact that it is from a novel category.

Even in this more stringent task, the results held up, suggesting that by 14 months, infants expect that nouns refer specifically to category-based, rather than to property-based,

commonalities, but that their expectations for adjectives is still rather fluid (see Booth & Waxman, 2003 for details).

In sum, evidence from these *live* tasks reveals that (a) infants begin the task of word-learning (at 11 months) with a broad initial expectation that links novel words (independent of their grammatical form) to commonalities among named objects, that (b) this initially broad expectation gives way (at around 14 months) to a more specific set of expectations, linking particular grammatical forms to particular types of meaning (Booth & Waxman, 2003; Waxman, 1999; Waxman & Booth, 2001, 2003; Waxman & Markow, 1995), and (c) that as infants begin to refine their expectations, they first tease apart the form *noun* from among the others, and map it specifically to category-based (and not property-based) commonalities. At this same point, infants' expectation for the grammatical form *adjective* remains general, highlighting both category- and property-based commonalities.

### *2.1.2. The Next Step: Moving to an Automated Task*

We went on to develop a task in which we could present the stimuli (both visual and auditory) entirely by computer, rather than with a live, interactive experimenter. We were motivated by (at least) three factors. First, we sought greater control over relevant features, including the duration of auditory and visual stimuli and acoustic features (e.g., rate of speech, pause length, stress, and other prosodic contours). In the *live* task it was difficult to control for such features, any of which (singly or in combination) could influence infants' ability to pick out novel words in fluent speech and map them to meaning. By automating the task, we were able to to modulate the stimuli to control for several of these factors. We were also able to time the onset of the linguistic stimuli precisely, to take advantage of advances in time-course analyses (Allopenna, Magnuson, & Tanenhaus, 1998; Swingley, Pinto, & Fernald, 1999) and develop

analytic tools for tracing the timed interplay between the introduction of a novel word and its consequence for infants' attention as they strive to map the word to meaning.

A second motivation for developing the automated method was to facilitate cross-linguistic investigation. Cross-linguistic evidence is essential if we are to discover how infants' expectations in word learning are shaped by the ambient language. At the same time, however, we know that across cultures and communities, there are significant differences in the ways in which adults interact with infants (Schieffelin, 1990). Because the *live* procedure, by definition, depends upon adult-infant interaction, it introduces potential confounds for cross-linguistic investigations. An automated task would offer clear advantages.

Third, the automated method opens the door for extending the paradigm to include a new grammatical form class, *verb*, and new candidate meanings, including actions and relations among objects. With an automated task, we can present objects in motion, while controlling the rate and salience of the motions.

Of course, this move to an automated task raises questions of its own. On the one hand, infants may perform better on automated than interactive tasks, particularly because the automated tasks introduce many fewer distractions. However, it is also possible that infants will perform less well in the automated procedure, either because their attention wanders when they are not actively engaged by an experimenter or because their representations of 2-dimensional video images are not as rich as their representations of 3-dimensional toy objects (DeLoache, Pierroutsakos, Uttal, Rosengren, & Gottlieb, 1998).

Faced with these questions, we first developed an automated procedure that was closely analogous to the live tasks, to provide a point of comparison. We began with the more challenging version of the live task in which two novel test objects are pitted directly against each other (see Figure 3). Our goals were to ascertain whether infants' expectations for novel

words were comparable in the live and automated versions, and to examine the ways in which infants deployed their visual attention over the time-course of an experimental trial**.** We created visual stimuli by making digital images of all of the objects used in Waxman and Booth (2001) and auditory stimuli by recording a female voice producing the instructions in each of the conditions. The visual and auditory stimuli were then coordinated using a commercially-available package that permitted precise control over their timing. For the experiment itself, the visual stimuli were presented on a large 61" screen, with sound emanating from a speaker at the center. Infants were seated in a highchair, 80" from the screen. Parents remained in the room during testing, but wore a visor to prevent them from seeing the images. Each session was videotaped for later off-line coding by a trained observer who identified for each frame (33 frames per sec), whether the infant looked to the left screen, the right screen, or neither.

We used this frame-by-frame coding to create two types of measures. First, we created a high-resolution 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 identified 'response windows' within the test phase. Within each window and for each condition, we calculated the mean proportion of attention devoted to the familiar test scene.

Figure 4 displays the continuous time-course of infants' looking behavior in each condition throughout the test phase. A glance at this timeline offers several impressions. Before the onset of the test question, infants in both conditions devoted their attention equally to the two test screens, but that after the onset of the novel word, infants in the two conditions pulled apart.

Those in the Noun condition begin to look toward the Category Match, while those in the Adjective condition continue to reveal no preference for either the Category or Property Match. To provide a point of contact with the *live* procedure, we compared mean performance during the selected response window. Infants in the Noun condition revealed a reliable preference for the Category match; those in the No Word and Adjective conditions did not.

Infants' performance in the *automated* task provides several insights. First, the result converges beautifully with the interactive task to suggest (a) that at 14 months, infants have a more precise expectation for nouns than for adjectives, and (b) that these effects are robust enough to hold up even under more rigorous experimental control and even in absence of direct interaction with engaging experimenter. Moreover, the frame-by-frame analysis of infant looking times in the automated procedure offers insights into the ways in which infants' deploy their attention over the course of the test trials, and permits us to examine how their interest is modulated by the linguistic input. Finally, the success of the automated method lays the foundation for moving beyond nouns and adjectives to examine infants' expectations for verbs.

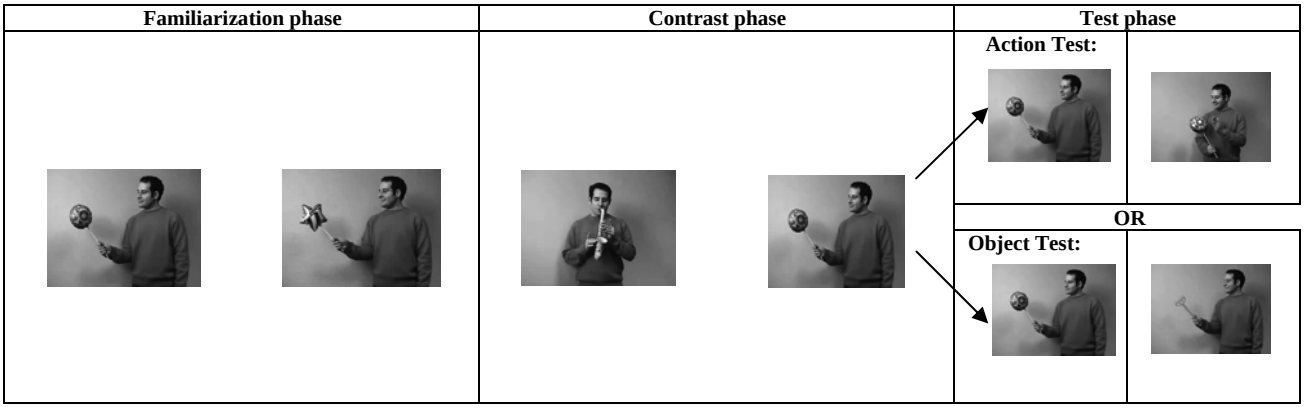
Our motivation for studying verbs stems not only from their pivotal role in theories of language, but also because evidence regarding infants' expectations for this grammatical form will help pinpoint the scope of infants' initial "cut". In other words, we can ask whether infants first tease out the nouns from among all predicate forms (including adjectives and verbs), or whether they tease out both nouns *and* verbs, in advance of adjectives and the remaining predicates.

There are several reasons to favor the former alternative. Most current language acquisition theories agree that the grammatical category *noun* may be established earlier than other grammatical categories (Dixon, 1982; Gleitman, 1990; Grimshaw, 1994; Maratsos, 1998; Snedeker & Gleitman, 1999; Talmy, 1985; Waxman, 1999). Indeed, the acquisition of the other

grammatical forms likely depends on the prior acquisition of nouns. The empirical evidence falls in line with this view, with verbs typically appearing later than nouns in the infant lexicon (Fisher, Hall, Rakowitz, & Gleitman, 1994; Gentner, 1982; Hollich et al., 2000; Huttenlocher & Smiley, 1987; Tomasello & Olguin, 1993; Valian, 1986; but see Choi & Bowerman, 1991; Choi & Gopnik, 1995; Tardif, Shatz, & Naigles, 1997). However, it is difficult to compare the acquisition of nouns, adjectives and verbs directly. This is because (a) there is comparatively little research on verbs (as compared to nouns) in the very earliest stages of lexical acquisition, and (b) what evidence there is comes from various experimental tasks, each of which presents infants with different kinds of task demands. Because we can now include verbs in our paradigm, we are in a good position to use a comparable task to tap into infants' expectations for these three major grammatical categories.

The logic and coding of our automated noun-verb task parallels the noun-adjective tasks described earlier. This time, however, infants observed a series of dynamic scenes (e.g., a man waving a balloon) during familiarization. We constructed the test trials to ask 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 would vary with the grammatical form of the novel word used to describe the scene (see Figure 5). We made several design decisions in selecting stimuli. First, to clarify the semantic roles of the event participants, all scenes involved animate agents acting upon inanimate patients. Second, to ensure that the actions would be present consistently throughout the entire trial, as were the objects, all actions were continuous (e.g., pet, wave) rather than fleeting (e.g., drop, slap). Third, to reduce the number of potential referents of each novel word, the same agent (e.g., the man) appeared in every scene within a given trial. Fourth, we presented infants with the less challenging test pairings. This meant that infants saw one of two kinds of test trials, and both the Action and

Object tests included a now-familiar scene (e.g. the man waving a balloon). In the Action test, the novel scene depicted a novel action (e.g., the man *tapping* a balloon); in the Object test, the novel scene depicted a novel object (e.g., the man waving a *rake*). Finally, to examine the influence of language on infants' construals, infants were randomly assigned to a Verb, Noun, or No Word (control) condition. We reasoned that if infants have specific expectations for both verbs and nouns, then they should map words from these grammatical categories differently, mapping verbs specifically to event categories and nouns specifically to object categories.




| | | | | | |
|---|---|---|---|---|---|
| **Noun:** The man is waving a *larp*. | … waving another *larp*. | Uh-oh!<br>That's not a *larp*! | Yay!<br>That is a *larp*! | Now look.<br>They're different | Which one is a larp? |
| **Verb:** The man is *larping* a balloon | … *larping* another balloon | Uh-oh!<br>He's not *larping* that! | Yay!<br>He is *larping* that! | Now look.<br>They're different | Which on eis he larping? |
| **No Word:** Look what's happening here. | Look at this. | Uh-oh!<br>Look there! | Yay!<br>Look at that! | Now look.<br>They're different | What do you see now? |

*Figure 4*. A representative stimulus set (Waxman et al., under review). Note that infants see either Action Tests or Object Tests.

The continuous time-course of infants' looking behavior for the Action test and Object test trials are depicted in Figures 6a and b, respectively[2]. Consider first infants' performance in the Action test. Before the onset of the test question, infants in both conditions were captivated by the novel test scene, suggesting that they detected the novel action. But with the onset of the

[2] In this task, infants' performance became more systematic over the course of the experiment. Therefore, in the interest of clarity, we present the results from infants' last three (out of six) trials

test question, performance began to diverge. Infants in the Noun condition maintained their focus on the novel test scene. This suggests that they interpreted the novel noun as referring to an object and not the action in which it was involved. Because both scenes on Action test trials involved the now-familiar object, infants hearing nouns had no motivation to redirect their attention from the novel test scene. Infants in the Verb condition deployed their attention differently. With the presentation of the test question, these infants moved away from the novel scene, increasingly directing their attention toward the familiar test scene – the only scene that depicted the now-familiar action.

An analysis of mean performance in the response windows echoed this impression. Infants in the Verb condition exhibited a reliable change in attention, devoting more attention to the familiar test scene after the test question than before it. This suggests that infants did in fact map novel verbs specifically to categories of events. Infants in the Noun condition maintained their preference for the novel scene. This is consistent with the prediction that infants do not consider event categories as possible meanings for nouns, and therefore have no motivation to direct their attention away from the novel test scene.

Consider next infants' attention in the Object test. A glance at Figure 6b reveals that before the onset of the test question, infants in both conditions prefer the novel test scene, suggesting that they detected the novel object. In response to the test question, performance between conditions began to diverge. Infants in the Verb condition maintained their focus on the novel test scene. This suggests that they interpreted the novel verb as referring to the action and not the objects involved in that action. After all, in the Category test, both test scenes involved the now-familiar action, and therefore infants hearing verbs had no motivation to direct their attention away from the novel test scene. In contrast, infants in the Noun condition began to

move away from the novel scene, directing increasingly more attention toward the familiar test scene – the only scene that depicted the now-familiar object.

An analysis of mean performance revealed that in the Verb condition, infants performed comparably both before and after the test question. This is consistent with the prediction that infants' representation of verb meaning is uncoupled from the objects involved in the event and that as a result, infants accept events involving new objects as candidates for verb meaning. In contrast, infants in the Noun condition devoted significantly more attention to the familiar test scene after the onset of the test question than before it. This suggests that infants in the Noun condition did indeed map novel nouns specifically to categories of object and not to the actions in which they are engaged.

Of course, we have only begun our explorations of infants' expectations for novel verbs, and have yet to examine younger infants. We speculate that infants' expectations for the grammatical form *verb* will emerge after the acquisition of the noun-category link.

## 3. CONCLUSIONS AND FURTHER DIRECTIONS

In these experiments, we have examined infants' expectations for *nouns, adjectives* and *verbs* in parallel procedures. Thus far, the results reveal that infants' construals of scenes they observe are influenced by the introduction of novel words. Moreover, their representations of word meaning are sufficiently abstract to permit them to extend novel words of each grammatical form appropriately beyond the precise scenes on which they had been taught.

Taken together, then, these results indicate that although infants' expectations may not be as refined as those of adults, they do share with mature language users an expectation that different kinds of words (e.g., nouns, adjectives, verbs) refer to different aspects of a scene (e.g., object categories, object properties, action categories). I have proposed that infants begin the task of word-learning equipped with a broad, universally-shared expectation that links novel

words (independent of their grammatical form) to a broad range of commonalities, and that this initially general expectation gives way to a more specific set of expectations, linking *particular* grammatical forms (e.g., nouns, adjectives, verbs) to *particular* types of meaning (object categories, object properties, actions). These more specific links are shaped by the structure of the native language under acquisition, and do not all emerge concurrently. Instead, infants appear to first tease apart the grammatical form *noun* and map this form specifically to category-based commonalities. With this noun-category link in place, other specific links follow, and these will be sensitive to the correlations between the particular grammatical forms represented in the native language and their associated meanings.

The results described above are intriguing, and they cry out for further investigation. Perhaps most pressingly, we are now poised to move to new populations, including younger infants and infants acquiring languages other than English. Crosslinguistic research is essential if we are to ascertain which links (if any) are universal and how these are shaped by the structure of the native language. It provides a fascinating opportunity to observe the rich interplay between expectations held by the infant and the shaping role of language input.

The work summarized in this chapter also sets the stage for more detailed developmental analysis. One interesting possibility will be to consider how the time-course changes with development. We suspect that as infants become more adept at identifying words in fluent speech, their responses to the introduction of novel words will become more streamlined (Fernald, Perfors, & Marchman, 2006). Furthermore, while the time-lines that we have produced are exciting, they are at this point primarily descriptive. A major goal is to develop the analytic tools necessary to more formally capture the timing and course of infants' performance in the context of mapping a novel word to meaning (e.g., Swingley, Pinto, & Fernald 1999; Suzuki & Goolsby, in press; Suzuki & Grabowecky, in press). In doing so, we look forward to making

more precise the time-course of children's word learning within the course of a task, and over the course of development.

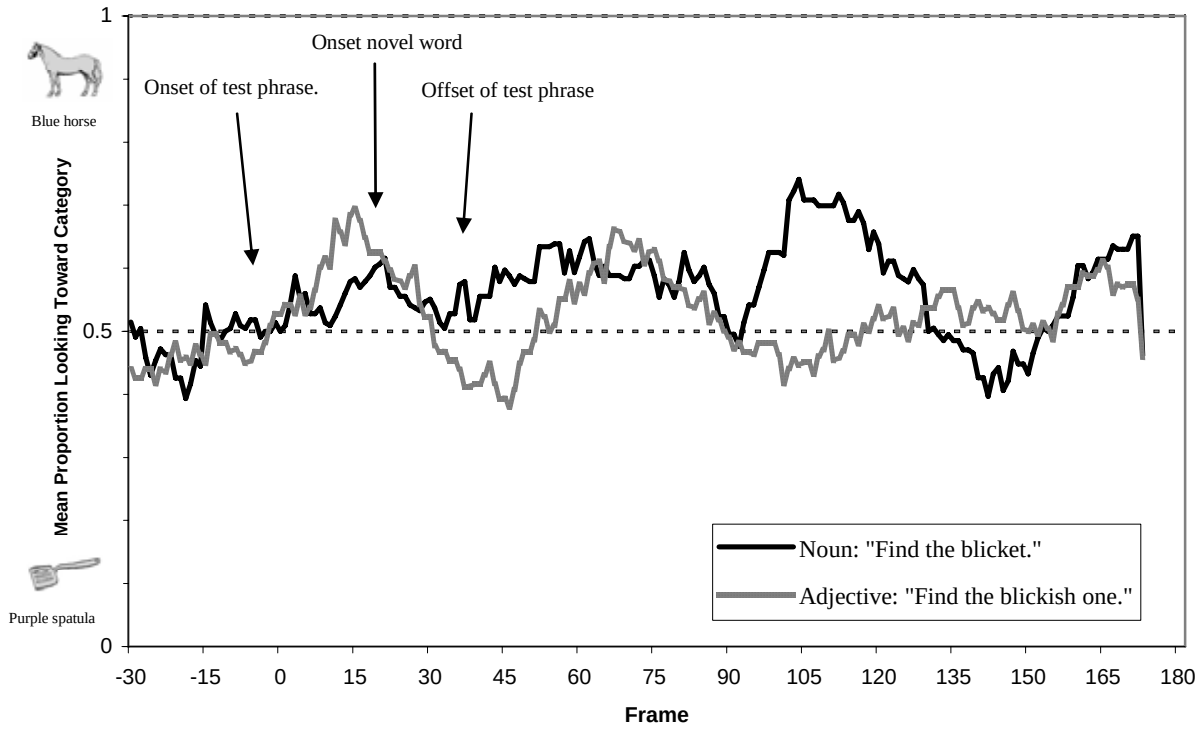
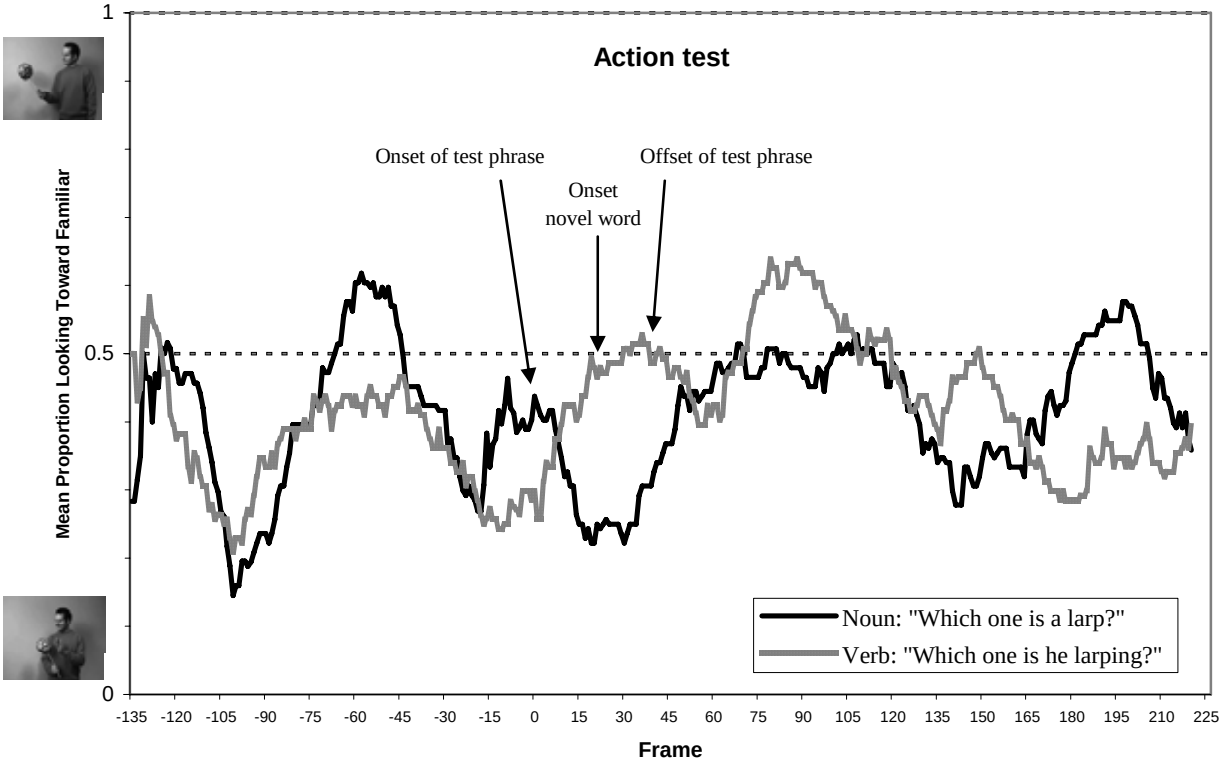
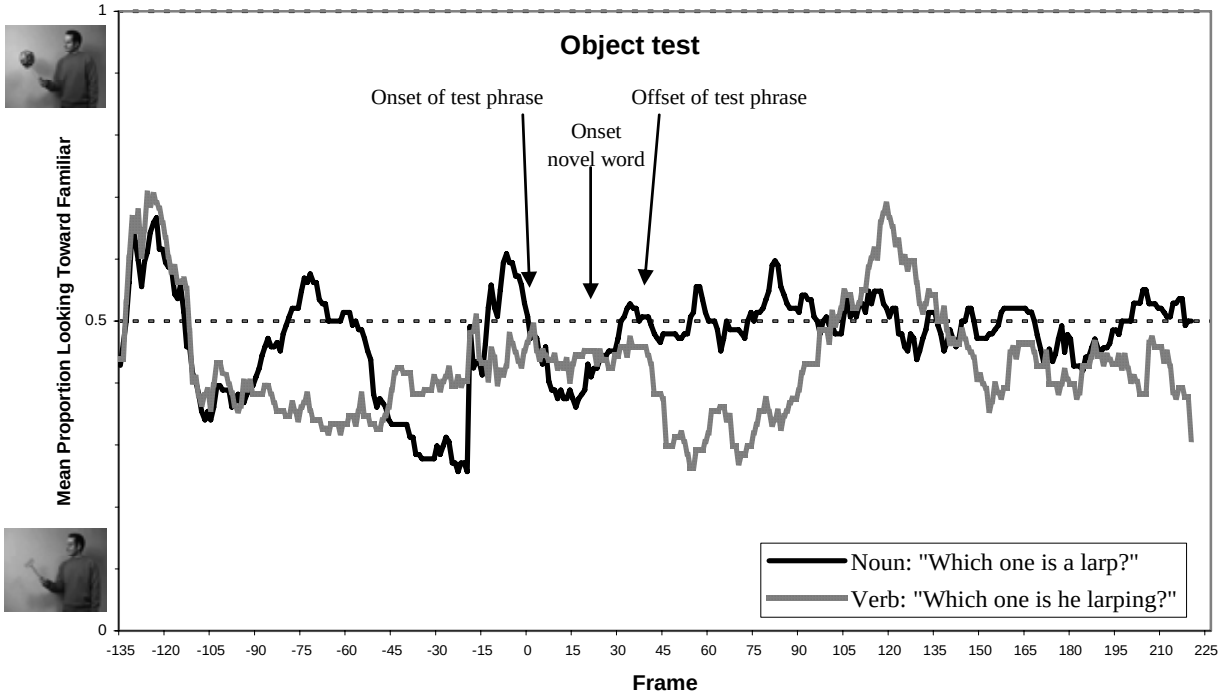



*Figure 5.* Time-course of looking behavior (Waxman & Braun, in prep.)




*Figures 6a.* Time-course of looking behavior (Waxman et al., under review).




*Figures 6b.* Time-course of looking behavior (Waxman et al., under review).

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