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Early word learning and conceptual development: Everything had a name, and each name gave birth to a new thought.[1]

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Synopsis

Perhaps more than any other developmental achievement, word-learning stands at the very intersection of language and cognition. Early word-learning represents infants' entrance into a truly symbolic system and brings with it a means to establish reference. To succeed, infants must identify the relevant linguistic units, identify their corresponding concepts, and establish a mapping between the two. But how do infants begin to map words to concepts, and thus establish their meaning? How do they discover that different types of words (e.g., "dog" (noun), "fluffy" (adjective), "begging" (verb) refer to different aspects of the same scene (e.g, a standard poodle, seated on its hind legs and holding its front paws in the air)? We have proposed that infants begin the task of word-learning with a broad, universal expectation linking novel words to a broad range of commonalities, and that this initial expectation is subsequently fine-tuned on the basis of their experience with the objects and events they encounter and the native language under acquisition. In this chapter, we examine this proposal, in light of recent evidence with infants and young children.

Introduction

Infants across the world's communities are exposed to vastly different experiences. Consider, for example, one infant being raised in a remote region of the Guatemalan rainforest, another growing up in the mountains of rural Switzerland, and a third being raised in Brooklyn, NY. Each infant will

live in a world that is unimaginable to the other, surrounded by objects and events that are foreign to the other, and immersed in a language that the other cannot begin to understand. Yet despite these vast differences in experience, infants across the world display striking similarities in the most fundamental aspects of their conceptual and language development.

Within the first year of life, each of these infants will begin to establish systematic links between words and the concepts to which they refer. On the conceptual side, they will begin to form categories of objects that capture both the similarities and differences among the objects they encounter. Most of these early object categories will be at the basic level (i.e., dog) and the more inclusive global level (i.e., animal). Infants will begin to use these early object categories as an inductive base to support inferences about new objects that they encounter. They will also begin to relate categories to one another, implicitly, on the basis of taxonomic (e.g., dogs are a kind of animal), thematic (e.g., dogs chase tennis balls), functional (e.g., dogs can pull children on sleds) and other relations. Infants' early object and event categories will provide a core of conceptual continuity from infancy through adulthood.

Concurrent with these conceptual advances, infants in each community will make remarkably rapid strides in language acquisition. Even before they begin to understand the words of their native language, infants show a special interest in the sounds of language. Newborns respond to the emotional tone carried by the melody of human speech (Fernald, 1992a, b), and prefer speech sounds to other forms of auditory input (Jusczyk & Kemler Nelson, 1996; Vouloumanos & Werker, 2004, 2007). Within the first six months, infants become perceptually attuned to the distinct prosodic, morphologic, and phonologic elements that characterize their native language (Jusczyk & Kemler Nelson, 1996; Kemler Nelson, Hirsh-Pasek, Jusczyk, & Cassidy, 1989; Morgan & Demuth, 1996; Shi, Werker, & Morgan, 1999; Werker, Lloyd, Pegg, & Polka, 1996; see Saffran, Werker, & Werner, 2006 for a review). By their first birthdays, infants begin to produce their first words. These early words tend to refer to salient individual objects (e.g., "Mama"), categories of objects (e.g., "cup", "doggie"), social

routines (e.g., "bye-bye"), and actions (e.g., "up"). Across languages, infants' earliest lexicons tend to show a "noun advantage", with nouns referring to basic-level object categories (e.g., cup, dog) being the predominant form (see Bornstein, Cote, Maital, Painter, Park, & Pascual, 2004 for an excellent cross-linguistic developmental review). By their second birthdays, most infants have mastered hundreds of words of various grammatical forms (e.g., nouns, verbs, adjectives) and have begun to combine these into short, well-formed phrases that conform broadly to the syntactic properties of their native language.

This brief sketch illustrates several early milestones along the road of language and conceptual development. Infants naturally form categories to capture commonalities among objects and events and learn words to express them. What is perhaps even more intriguing is that these two advances do not proceed independently. Instead, there are powerful implicit links between them.

Links between early language and conceptual development: A view through the lens of word-learning

The links between early language and conceptual development are most clearly viewed through the lens of early word-learning. Word learning supports infants' subsequent discovery of the fundamental syntactic properties of the native language (See Gillette, Gleitman, Gleitman, & Lederer, 1999; Snedeker & Gleitman, 1999; Pinker, 1984, 1989; Waxman, 1999a; Waxman, 1999b) as well as the evolution of increasingly abstract conceptual representations. Moreover, from the onset of acquisition, the process of word-learning involves powerful, implicit links between the linguistic and conceptual systems. Even before infants begin to speak, novel words guide their attention to objects, and highlight commonalities and differences among them (Balaban & Waxman, 1997; Booth & Waxman, 2002; Fulkerson & Haaf, 2003, 2006; Fulkerson & Waxman, 2007; Graham, Kilbreath, & Welder, 2004; Keates & Graham, 2008; Waxman & Markow, 1995; Welder & Graham, 2006; Xu, 1999). But these links are not as precise as those held by older children and adults. How does their development proceed?

We have proposed that 1) infants across the world's language communities begin the task of word learning equipped with an initially general and universal expectation, and 2) this early expectation is then shaped by the structure of the particular language under acquisition. In our most recent work, which will be reviewed here, we have sought to uncover the origin and unfolding of these links (Booth & Waxman, 2003; Waxman & Booth, in press; Fulkerson & Waxman, 2007; Klibanoff & Waxman, 2000; Waxman, 1998; Waxman & Booth, 2000a; Waxman & Booth, 2001b; Waxman, Lidz, Braun, & Lavin, in press; Waxman & Markow, 1995). To amplify this topic, we will discuss what it takes to learn a word, to establish a mapping between the linguistic entities that we call *words* and the corresponding entities and events in the *world*. We then go on to trace the origin and emergence of these links in infants.

What does it take to learn a word?

Perhaps the most celebrated example of word-learning comes from Helen Keller's autobiography. As Keller recounts, "...my teacher placed my hand under the spout. As the cool stream gushed over one hand she spelled into the other the word *water*, first slowly, then rapidly. I stood still, my whole attention fixed upon the motions of her fingers. Suddenly I felt a misty consciousness as of something forgotten – a thrill of returning thought; and somehow the mystery of language was revealed to me. I knew then that 'w-a-t-e-r' meant the wonderful cool something that was flowing over my hand. That living word awakened my soul, gave it light, hope, joy, and set it free! ... I left the well-house eager to learn. Everything had a name, and each name gave birth to a new thought." (Keller, 1904 p. 22-23)

This memorable passage poignantly conveys the obstacles in first establishing a correspondence between the abstract entities that we call *words* and their referents in the *world*. It also conveys the power of such *word-to-world* mappings, once they are attained. But the scenario in this passage differs in important ways from the more typical circumstances in which infants' first words are

acquired. One important difference is the age of acquisition. Infants tend to produce their first words at approximately one year of age. Keller, in contrast, learned *water* at approximately seven years of age.[2] A second difference is the extent to which names are deliberately "taught". Psycholinguists and anthropologists have conducted detailed observations of naming practices across cultures. In some cultures (c.f., Western, college-educated communities), caretakers do name objects deliberately for their infants, even before the infants themselves can speak. Yet in many other communities, (c.f., Kahluli, see Ochs and Schieffelin, 1984), caretakers refrain from speaking directly to infants until the infants themselves have begun to speak. Clearly, then, infants can discover the meaning of novel words even in the absence of direct tutoring.

A third relevant difference is in the presentation of the new word. In the typical course of events, words are seldom, if ever, presented in isolation, as Keller's tutor presented the word *w-a-t-e-r*. Instead, words tend to be embedded in a fluent stream of continuous speech (e.g., "Look at the water! Oooh…it's so cold. Isn't that cold water?"), leaving it to the infant to parse the novel word. How do they succeed in these cases? At a most general level, it helps that infants devote special attention to human speech, for this puts them in a good position to begin to single out the novel words (Jusczyk & Kemler Nelson, 1996). Moreover, in many cultures, caretakers use a special speech register (sometimes known as infant-directed speech or 'motherese') when addressing infants and young children. Two characteristic features of this speech register -- exaggerated pitch contours and phrase boundaries – help infants to identify words and phrases in the continuous speech stream (Gleitman & Wanner, 1988).

A fourth difference concerns the identification of the referent of the novel word. Unlike Keller, infants must identify the referent of a novel word amidst an ever-changing current of events. In many cases, the referent may be absent entirely (e.g., "Let's call Daddy", uttered as the caretaker picks up a phone), or may make only a fleeting appearance (e.g., "Look at the monkey", uttered as a monkey makes a brief appearance in its habitat at the zoo). And even if the referent is present throughout the

naming episode, there is no guarantee that the infant will be attending to it at the time that the novel word is introduced (e.g., "Go find your teddy-bear", uttered as a caretaker tries (in vain) to pull the infants' attention away from the sleeping family cat).

The puzzle of word-learning

Thus, in the natural course of word-learning, an infant is faced with a difficult three-part puzzle: (1) parsing the relevant word from the ongoing stream of speech, (2) identifying the relevant entity in the ongoing stream of activity in the world, and (3) establishing a word-to-world correspondence. To put matters more formally, successful word-learning rests on the infant's ability to discover the relevant linguistic units, the relevant conceptual units, and the mappings between them.

Notice also that each piece in the word-learning puzzle is itself dependent on infants' ability to recruit other perceptual and psychological capacities. Consider, for example, the ability to parse words. We know that newborns prefer to listen to human speech—and particularly infant-directed speech —as compared to other sources of auditory stimulation. However, the function of infant-directed speech appears to change during the first year of life (Fernald, 1992b). Initially, infant-directed speech serves primarily to engage and modulate the infant's attention. Toward the end of the first year, "…words begin to emerge from the melody" (Fernald, 1992a p. 403). By approximately 9 to 10 months, infants become increasingly sensitive to the cues (morphologic, phonetic and prosodic cues) that mark word and phrase boundaries (Jusczyk & Aslin, 1995; Kemler Nelson et al., 1989).

Infants' growing sensitivity to these perceptual cues permit them to distinguish two very broad classes of words: *open class* words (or, *content* words, including nouns, adjectives, verbs) and *closed class* words (or, *function* words, including determiners and prepositions). Research using a preferential listening task reveals that even 6-month-old infants prefer to listen to open class words (Gomez, 2002; Shi & Werker, 2003). This preference is likely related to the fact that such words are perceptually more salient: they receive greater stress and more interesting melodic contours than closed class words. Since this preference exists well before infants begin to map words systematically to meaning, it is

reasonable to assume that it is perceptually based and independent of meaning. Yet this perceptually-based preference represents an important step on the way to word-learning, for it insures that infants attend to just those words (the open class, content words) that are required if they are to anchor their first word-to-world mappings. (Jusczyk & Kemler Nelson, 1996; Morgan & Demuth, 1996; Werker et al., 1996).

Early word-learning also draws upon the infants' perceptual and conceptual ability to identify objects and events in their environment, and to notice commonalities among them. During the first year, infants demonstrate a great deal of core knowledge about objects (Baillargeon, 2000; Spelke, 2000). They also form a repertoire of pre-linguistic concepts, including category-based (e.g., dog, bottle) and property-based (e.g., red, soft) commonalities. Since many of these concepts are formed before the advent of word-learning, it is reasonable to assume that they are independent of language and are universally available. Each object and concept is, in essence, a candidate for a word's meaning. The infants' task is to discover which candidate meaning maps to the word that they have parsed.

The third piece of the word-learning puzzle—grasping the symbolic and referential power of words—further requires infants to draw upon fundamental notions related to human behavior: inferring the goals and intentions of others (Waxman & Gelman, in press). For example, the ability to establish a mapping between a word and its referent is predicated upon infants' capacity to infer that the speaker *intended to name* the designated object. By the end of the first year of life, infants have begun to make such connections (Ahktar & Tomasello, 2000); for example, they spontaneously follow a speaker's line of regard to identify the object to which an adult speaker is attending (Baldwin & Baird, 1999; Guajardo & Woodward, 2000).

In addition to these three central elements, successful word-learning requires infants to go beyond a word-to-object mapping. To use a word consistently over time, infants must be able to store in memory the correspondence between a word and its intended referent. They must also be able to generalize a newly learned word appropriately beyond the individual on which it was taught. For

example, to be able to apply the word *dog* to a new, and (as yet) unlabeled object, that child must make an inference regarding its extension. Infants' spontaneous extensions indicate that they do not merely map words to the objects on which they were introduced. Infants go beyond word-to-object mappings to establish word-to-category mappings (Gelman, 2006; Waxman & Lidz, 2006).

Different kinds of words highlight different aspects of a scene

To complicate matters further, many different words -- indeed many different *types* of words – may be offered in a single naming episode. Importantly, each type of word highlights a different aspect of the same observed scene and supports a unique pattern of extension. For example, in English, count nouns ("Look, it's a *dog*") typically refer to the named object itself and are extended spontaneously to other members of the same object kind (other dogs); proper nouns ("Look, it's *Zeus*") also refer to the named individual, but these are not extended further. Adjectives can also be applied correctly to that individual ("Look, it's *furry*"); they refer to a property of the individual, and are extended to other objects sharing that property. Verbs, in contrast, are used to describe the event, or the relation in which the individual(s) are participating ("Look, it's running"), and are extended to other relations of the same type.

Considerable research has documented that by two-and-a-half to three years of age, children are sensitive to many of these links between kinds of words and kinds of relations among objects, and recruit these links in the process of word learning (For a review, see Waxman & Lidz, 2006). This establishes that preschool-aged children have the *linguistic* capacity to distinguish among the relevant syntactic forms (e.g., count noun vs. adjective) and the *conceptual* or *perceptual* ability to appreciate many different kinds of relations among objects, and a tacit expectation that these linguistic and conceptual abilities are interwoven.

The proposal: The acquisition of word-to world links

But how do infants acquire these specific word-to-world links? Which, if any, are available at the very onset of lexical acquisition, and how are these shaped over the course of development? The

evidence discussed above suggests that infants begin with a perceptual preference for listening to open class words, with a repertoire of accessible perceptual and conceptual categories, and with a broad expectation that novel (open class) words, independent of their grammatical form, highlight commonalities among named objects. This initial link serves (at least) three essential functions. First, with words directing attention to commonalities, this link facilitates the formation of an expanding repertoire of concepts, concepts that may not have been detected in the absence of a novel word. Second, this initial expectation supports infants' first efforts to establish symbolic reference, to form a set of stable 'word-to-world' mappings. Finally, and perhaps most radically, this initial expectation sets the stage for the evolution of the more specific expectations linking particular types of words (nouns, adjectives, verbs) to particular types of relations among objects (object categories, object properties, event categories) in the native language under acquisition (Waxman, 1999b).

How might this evolution come about? Infants' early expectation (that words refer to commonalities) supports the establishment of a rudimentary lexicon. This lexicon serves as a base upon which infants a) begin to tease apart the various grammatical forms presented in the language under acquisition, and b) begin to detect the correlations between these emerging forms and their meanings. We argue that infants' initial expectation (linking words in general) to commonalities (in general) will direct their attention to just the sorts of regularities in the input that will promote the rapid discovery of the distinct grammatical forms present in the language under acquisition, and will support the induction of more specific expectations.

The evidence: The evolution of infants' word-to world expectations

To test this proposal, we must identify the expectation(s) of infants on the threshold of word-learning, and observe how these are shaped in the course of acquiring their native language. The sections that follow describe the influence of language on categorization in infants and young children. The focus is on how infants and young children begin to map words to meaning, and how their

expectations vary according to the word's grammatical category, be it noun, adjective, or verb. We examine the acquisition of words in each of these grammatical categories, considering evidence from a variety of measures, including time-course analyses of children's responses to a novel word. We conclude with a discussion of new avenues for research on word learning.

Unifying features of the experiments

The experiments described in this section all share several important features. Each is essentially a categorization task, tailored to suit the very different behavioral repertoires of infants vs. young children. In each, the goal is to observe the influence of language on categorization. To do so, we compare subjects' performance in "neutral" conditions (involving no novel words), with their performance when they are introduced to novel words. Because our goal is to examine an abstract linkage between particular grammatical forms and particular types of relations, we introduce novel words (e.g., *blicket*), rather than familiar (e.g., *animal*) words. This insures that the words themselves carry no *a priori* meaning for the child. To examine the influence of grammatical form, we vary the frame in which the novel word is embedded. We use short, simple syntactic constructions that 1) are typical in infant- and child-directed speech, and that 2) provide unambiguous contextual evidence that the novel word is either a count noun, an adjective, or a verb. In all conditions, these constructions are presented to infants in a speech register known as "motherese" or infant-directed speech because infants find it especially engaging. In the Novel Noun conditions, we introduce the novel word, saying, for example, "This is a *blicket*." In the Novel Adjective and Novel Verb conditions, we present the same word using a different frame, saying, for example, "This is a *blick-ish* one," or "She is *blicking* the cup." In the No Word control conditions, we engage the infants with infant-directed speech, bur offer no novel word, simply saying, for example, "Do you like this?" or "Look at this". Performance in this No Word control condition assesses how readily subjects form the various categories presented in our tasks (e.g., dog, animal, purple, running). Performance in the Noun, Adjective and Verb conditions assesses the role of naming in this important endeavor, and permit us to test the specificity

of the relation between form and meaning. Because nouns, adjectives, and verbs alike can be used to describe different aspects of the very same scene, this is an important control.

Naming and categorization

Prelinguistic infants: Cognitive consequences of naming. Recent research suggests that naming has several cognitive consequences, even for infants who have not yet begun to produce words on their own. For example, by 10 months, infants devote more attention to objects that have been named than to objects that have been presented in silence (Baldwin & Markman, 1989). This raises two further questions: First, does the increased attention stem from the general attention-engaging functions of auditory stimuli, or does it reflect something special about words? Second, does naming promote attention to a named individual only, or does it exert an influence beyond the named individual?

Several recent studies have compared the effect of novel words versus tone sequences on infants' categorization behavior, and these suggest that words are indeed special (Balaban & Waxman, 1997; Fulkerson & Haaf, 2003, 2006; Fulkerson & Waxman, 2007). In one study, Fulkerson and Waxman (2007) assessed 6-month-old infants' performance when presented with words versus tones in a novelty-preference task. During a familiarization phase, infants saw a sequence of colorful slides, each depicting a different member of a basic-level category (e.g., dinosaurs). To examine the influence of words, they randomly assigned infants to either a Word or a Tone condition. For infants in the Word condition, a naming phrase (e.g., "Oh look, it's a *toma*! Do you see the *toma*?") accompanied the familiarization trials. For infants in the Tone condition, a sine-wave tone (matched to the naming phrase in amplitude, duration, and pause length) accompanied the familiarization trials. Next, infants were presented with a test trial, including a) a new member of the now-familiar category (e.g., another dinosaur) and b) an object from a novel category (e.g., a fish). Test trials were presented in silence.

The authors reasoned that if words focus attention on commonalities among objects, then infants hearing words during familiarization should notice the commonalities among the familiarization objects. In that case, the infants should reveal a preference for the novel test object

(e.g., the fish). If this effect is specific to words, and not to auditory stimulation more generally, then infants hearing tones during familiarization should be less likely to notice these commonalities and less likely to reveal a novelty preference at test. This is precisely the pattern of results obtained. We can therefore conclude that for infants as young as 6 months of age, there is indeed something special about words, and that providing a shared name for distinct individuals highlights commonalities among them.

In addition to supporting object categories, naming supports the process of object individuation. Evidence suggests that 10-month-olds find it difficult to keep track of the unique identities of two distinct objects (e.g., a ball and a duck), especially if these objects are presented in constant motion, with one appearing and disappearing from one side of a screen, and the other appearing and disappearing from the other side of the same screen (Xu & Carey, 1996). However, infants' difficulty tracking these distinct objects diminishes dramatically if each is labeled with a distinct name as it emerges from behind the screen.

Together, these results reveal that naming has powerful cognitive consequences, even in pre-linguistic infants. Naming supports the establishment of a repertoire of object categories and provides infants with a means of tracing the identity of individuals within these categories throughout development. These links appear before the advent of productive language.

Infants on the threshold of word learning: Changing expectations of word-to-world mappings. In the previous section, we established that words have a unique influence on prelinguistic infants' construals of individual objects and object categories. In this section, we trace the evolution of infants' expectations regarding word-to-world mappings as they cross the important developmental threshold of producing words on their own. At this developmental point, how do words influence infants' attention to individual objects and object categories?

Words as invitations to form categories. One series of experiments examined the influence of novel words on object categorization in 12- to 14-month old infants (see Waxman & Markow, 1995 for

a complete description). We used a novelty-preference task (See Figure 1 for a sample set of stimuli and introductory phrases). During a familiarization phase, an experimenter offered an infant four different toys from a given category (e.g., four animals) one at a time, in random order. This was immediately followed by a test phase, in which the experimenter simultaneously presented both a) a new member of the now-familiar category (e.g., another animal) and b) an object from a novel category (e.g., a fruit). Each infant completed this task with four different sets of objects. Two involved basic level categories (e.g., horses vs. cats); two involved more abstract superordinate level categories (e.g., animals vs. fruit). Infants manipulated the toys freely. Their manipulation served as the dependent measure.

To test the influence of novel words, we randomly assigned infants to one of three conditions. All infants heard infant-directed speech; what varied was the experimenter's comments during familiarization. See Figure 1.

Insert Figure 1 here

We reasoned as follows: If infants detect the presence of the novel word, and if novel words direct infants' attention to object categories, then infants who hear novel words during familiarization should be more likely than those in the No Word condition to form object categories. Including both a Novel Noun and Novel Adjective condition permitted us to test the specificity of infants' initial expectation. If the expectation is initially general, as we have proposed, then infants hearing either novel nouns or adjectives should be more likely than those hearing no novel words to form object categories.

For infants who had begun to produce words on their own, the data were entirely consistent with this prediction. Interestingly, the facilitative influence of novel words was most powerful on superordinate level trials. On basic level trials, all infants successfully formed categories. But on

superordinate trials, infants in the No Word condition did not detect the commonalities. This difficulty is likely due to the fact that there is considerable variation among category members at superordinate levels, and as a result, the commonalities among them can be difficult to trace. However, infants who heard novel words during familiarization (either count nouns or adjectives) detected the commonalities among objects and successfully formed superordinate level object categories.

These results reveal that infants on the threshold of producing language can reliably detect novel words presented in fluent speech, and that these novel words (both adjectives and nouns) direct infants' attention to commonalities among objects. We have interpreted this finding as evidence that words serve as “invitations to form categories” and have pointed out that this invitation has several consequences. First, novel words invite infants to assemble together objects that might otherwise be perceived as disparate entities. We suggest that words promote comparison among objects, and that this process of comparison supports the discovery of other commonalities that might otherwise have gone unnoticed (Booth, 2006; Chambers, Graham, & Turner, 2008; Gelman, 2006; Gentner & Namy, 1999; Keates & Graham, 2008; Welder & Graham, 2006).

Naming may also have dramatic consequences in situations in which infants have already formed groupings and noticed (some of) the commonalities among objects. For example, although infants in this series successfully formed basic level object categories (whether or not they were introduced to novel words), their knowledge about these categories is not on a par with the knowledge of an older child or adult. Even preschool-aged children lack detailed knowledge about most categories (Gelman, 1996; Keil, 1994). Nonetheless, despite their relative lack of information, children seem to expect that members of object categories share deep, non-obvious commonalities. Indeed, children depend upon these to support inference and induction. We suspect that novel words are instrumental in motivating infants and young children to discover the deeper commonalities that underlie our richly-structured object categories (Ahn & Luhmann, 2004; Barsalou, 1983; Barsalou, Santos, Simmons, & Wilson, 2008; Gelman, 1996; Gelman, Coley, & Gottfried, 1994; Gelman & Kalish, 2006; Gelman &

Medin, 1993; Kalish & Gelman, 1992; Keil, 1994; Landau, 1994; Landau, Smith, & Jones, 1988; Lassaline & Murphy, 1996; Macnamara, 1994; Markman, 1989; Medin & Heit, 1999; Murphy 2004). Most importantly, the results of this series of experiments document that a link between word-learning and conceptual organization is in place early enough to guide infants in their very first efforts to establish word-to-world mappings.

Specifying the scope of infants' word-to-world mappings. Having shown that words promote the formation of object categories, our next goal was to capture more precisely the scope, power and evolution of infants' expectations in word-learning (Booth & Waxman, 2003; Waxman & Booth, 2001b, 2003). To do so, we extended the work described in the previous section in four ways. First, we included a developmental component, comparing the performance of 11-month-old infants on the very threshold of producing words with that of 14-month-olds whose lexicons already include a modest set of entries. Second, we expanded the range of commonalities under investigation. In the previously-described studies (Waxman & Markow, 1995), the only commonality among objects was category-based (e.g., four animals, all of a different color). Here, we ask whether infants link novel words specifically to category-based commonalities (e.g., animal), or whether they also link words to a wider range of groupings including, for example, property-based commonalities (e.g., pink things, lumpy things) (Waxman, 1999).[3] Third, we considered the influence not only of nouns, but also of adjectives, on infants' categorization behavior.

A fourth goal in this series was methodological. All of the evidence reviewed thus far has been based entirely on infants' performance in novelty-preference tasks. In the current series, we asked whether infants' expectations would influence performance in a word extension task. Our goal here was to bridge a methodological gap between research with infants and preschoolers. Novelty-preference tasks have been successful with infants, but beyond 18 months of age, infants lose interest in such tasks. Word-extension tasks have been successful with toddlers and preschoolers, but lack

sensitivity with infants under 18-months, who have difficulty choosing systematically among objects in forced-choice tasks.

To bridge this methodological gap, we developed a new method, which weds features of the novelty-preference procedure with those of the word-extension paradigms. See Figure 2 for a schematic description of the procedure and a summary of the instructions presented in each condition.

Insert Figure 2 here

In the Familiarization phase, an experimenter introduced infants in all conditions to four objects, all drawn from the **same object category** (e.g., horses or animals) and embodying the **same object property** (e.g., purple). These were presented in pairs, and infants manipulated them freely. During the Contrast phase, the experimenter presented a new object (e.g., a brown rolling-pin), drawn from a contrastive object category and embodying a contrastive object property. In the Test phase, infants were presented with one familiar object (e.g., a purple horse), and one novel object. For half of the infants in each condition (see below), this novel object was a member of a novel object category, but embodied the same property (e.g., a purple plate). This constituted a Category test. For the remaining infants, the novel object was a member of the same category as the familiarization objects, but embodied a novel property (e.g., a blue horse). This constituted a Property test. Infants were first permitted to play freely with the two test objects. Then, to assess word-extension, the experimenter removed the test objects. At this point, she introduced a target object, drawn from the familiarization set (e.g., a purple horse) and then re-presented the two test objects, asking the infant to give her one. (See Figure 2). This word-extension task was presented a second time for each set of familiarization objects. This permitted us to observe the consistency of infants' responses. Infants completed this entire procedure four times, with four different sets of objects, two representing basic level object categories and two representing superordinate level categories.

To trace the proposed developmental trajectory from an initially general expectation linking open class words (either count nouns or adjectives) to commonalities among objects (either category-based or property-based) to a more specific set of expectations, we compared the influence of novel nouns and adjectives in the performance of infants at 11 and 14 months of age. If infants begin the process of lexical acquisition with a broad expectation linking words (in general) to commonalities among objects (in general), then for 11-month-olds, both nouns and adjectives should highlight both category-based (e.g., animal) and property-based (e.g., purple things) commonalities. If this initial expectation is refined once the process of lexical acquisition is under way, then for more advanced learners, a different pattern should emerge: Different kinds of words should direct older infants' attention to different aspects of the same experience: naming objects (with either a count noun or adjective) should systematically influence infants' construals of the very **same** set of objects (e.g., purple animals) either as members of an **object category** (animals) or as embodying an **object property** (purple). Based on our previous work (Waxman, 1999b; Waxman & Booth, 2000a), we expected that at 14 months, infants would have begun to distinguish count nouns (from among the other grammatical forms) and to map these specifically to category-based, but not property-based, commonalities. We expected that at this same developmental moment, infants' expectations for adjectives would still be quite general, directing their attention more broadly toward commonalities (be they category- or property-based).

The results were consistent with these predictions. At 11 months, infants hearing novel words (both nouns and adjectives) performed differently than those in the No Word condition. Infants extended both novel nouns and adjectives consistently to the familiar test object (e.g., the purple horse) on both Category and Property trials. This confirms that at the very onset of building a lexicon, (a) novel (open class) words direct infants' attention broadly to both category- and property-based commonalities among named objects, and (b) this link is sufficiently strong to support the extension of novel words. This outcome provides strong support for our proposal that infants on the very threshold

of word-learning harbor a general expectation linking words (both nouns and adjectives) to commonalities (both category- and property-based) among objects.

We also proposed that once word-learning is underway, a more specific pattern should emerge. Evidence from 14-month-olds offers support for this developmental prediction. By 14 months, infants were sensitive to the distinction between novel words presented as nouns as compared to adjectives, and they recruited this distinction in mapping words to their meaning. They mapped nouns to category-based, rather than to property-based, commonalities. However, their expectations regarding the extension of novel adjectives were more general. Infants hearing adjectives were equally likely to select the familiar object on both types of test trials (see Waxman, 1999b; Waxman & Booth, 2000a for replications and extensions using various properties (e.g., color, texture)). Clearly, by 14 months, infants have begun to distinguish among different kinds of words (nouns vs. adjectives) and recruit this distinction in the service of mapping words to their meaning.

Additional support for this developmental trajectory comes from a recent study using a precisely controlled automated method (Booth & Waxman, 2009). This method offers two advantages over the studies described above, which all involved direct interaction between an infant and experimenter: 1) it allows for tight control over the presentation of stimuli, and 2) it permits us to trace the time course of children's mapping of novel words to meaning (Fernald, Swingley, & Pinto, 2001; Fernald, Pinto, Swingley, Weinberg, & McRoberts, 1998; Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Swingley, Pinto, & Fernald, 1999). In this study, 14- and 18-month-olds watched a video that mirrored the structure of the earlier studies. Their response was measured by examining the infants' eye movements during the test period. Examining which of two images the infant paid more attention to during this period provided an indirect measure of how they extended the novel noun or adjective.

Once again, infants at both ages in this study extended novel nouns to other members of the same category, as opposed to items sharing the same property. Moreover, the time-course of their extension was swift, occurring within two seconds of hearing the novel word. When the same words

were presented as adjectives, infants revealed no preference for either category- or property-based extensions. This finding lines up with the results of previous studies, which suggest the adjective-property link may begin to emerge just after 18 months, or during the 18- to 21-month time frame (Waxman & Markow, 1998).

The convergence between performance in this automated procedure and in the live tasks is striking. Taken together, they show that clearly, 14-month-olds are sensitive to (at least some of) the relevant cues (e.g., prosody, morphology, structural position within a phrase) that distinguish count nouns from adjectives. Cues like these are sufficiently rich to support an emerging distinction among major grammatical forms (Morgan & Demuth, 1996). Although infants' grammatical distinctions are certainly not as well-honed as those of adults, and although their knowledge of categories and properties of objects is certainly not as rich, 14-month-olds do appear to share with adults an expectation that different types of words (count nouns versus adjectives) refer to different types of relations among objects.

Talking two-year-olds: beyond nouns and adjectives. Having examined the trajectory of infants' mapping of novel nouns and adjectives, we turn our attention now to the acquisition of verbs. Verbs do not appear in appreciable number in infants' productive lexicons until several months after the appearance of nouns (between roughly 20 - 24 months) (For recent reviews, see Gleitman, Cassidy, Nappa, Papafragou and Trueswell, 2005; Waxman and Lidz, 2006). This developmental phenomenon, favoring the acquisition of nouns over verbs, suggests that these distinct grammatical forms differ not only in the kinds of meanings they convey, but also in their underlying course of acquisition. In the next series, we look at what it takes to learn a verb.

The conceptual underpinnings of verbs seem to be in place, at least in rudimentary ways, by the end of the first year of life. By 8 – 12 months, infants are sensitive to certain fundamental components of events, including animacy, agency, and cause (Buresh, Wilson-Brune & Woodward, 2006; Casasola & Cohen, 2000; Gergely & Csibra, 2003; Gergely, Nádasdy, Csibra, & Bíró,1995; Gertner, Fisher, &

Eisengart, 2006; Golinkoff & Hirsch-Pasek, 2006; Leslie & Keeble, 1987; Meltzoff, 2007; Muentener & Carey, 2006; Sommerville, Woodward, & Needham 2005; Wagner & Carey, 2005). Between 12 and 24 months, infants demonstrate sensitivity to other key elements of events, including changes of state, result, manner and path of motion (Bunger, 2007; Bunger & Lidz, 2004; Pruden, Hirsh-Pasek, Maguire, & Meyer, 2004; Pulverman, Hirsh-Pasek, Pruden, & Golinkoff, 2006).

What this means is that infants' relatively delayed acquisition of verbs must not be due to an inability to represent the kinds of concepts that underlie verb meaning, but rather to other factors. What might these factors be?

One possibility is that infants' relative delay in acquiring verbs reflects the fact that the meaning of a verb depends upon the arguments that it takes (and the relation among them). Simply put, to identify the event labeled by a verb, learners 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, et al., 2005; Landau & Gleitman, 1985; Lidz, Gleitman & Gleitman, 2003; 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 to identify the event labeled by the verb in that context. The acquisition of verbs must therefore follow the acquisition of nouns.

This trajectory is supported by studies of toddlers' vocabularies. Productive use of verbs to refer to actions, mental states, and relations is often not established until 24 months, well after the productive use of nouns (Fenson, Bates, Dale, Goodman, Reznick, & Thal, 2000). Around this age, not only do toddlers produce verbs, but they seem to map novel verbs onto categories of events, taking 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, 2004; Fernandes, Marcus, DiNubila, & Vouloumanos, 2006; Fisher, 2002; Gertner, Fisher, & Eisengart, 2006; Gleitman, 1990;

Gleitman et al., 2005; Hirsch-Pasek, Golinkoff, & Naigles, 1996; Landau & Gleitman, 1985; Naigles, 1990, 1996; Naigles & Kako, 1993).

Nonetheless, the verb learning literature also reveals some astonishing failures, many of which persist throughout the preschool years (Imai, Haryu, & Okada, 2005; Imai, et al., 2008; see also Behrend, 1990; Kersten & Smith, 2002; Meyer et al., 2003). A review of the evidence suggests 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. This suggests that infants and even young children are essentially "captured" by the participant objects and have difficulty extending verbs beyond them.

Interestingly, infants appear to be captured by participant objects in laboratory tasks, but not in real-world acquisition. Children are often observed extending verbs like "drink" to different beverages (e.g., milk, water), "run" to different actors (e.g., dogs, people), etc. outside of the laboratory. How can we account for this mismatch? What information is missing from laboratory tasks that hampers children's ability to learn novel verbs?

We examined infant verb-learning using the automated procedure described above (Waxman, Lidz, Braun, & Lavin, 2009). Videos of dynamic scenes (e.g., a man waving a balloon) were presented to 24-month-old infants. The study examined 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 were presented with the scenes in a Familiarization phase, where the accompanying audio varied as function of condition. Afterward, during the Test phase, 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 <u>familiar</u> 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). See Figure 3 for the audio presented in each phase of each condition.

Infants' visual attention during each frame of the Test phase was analyzed, measuring attention to the novel event (e.g. a man *tapping* a balloon) versus the familiar event (e.g. a man *waving* a balloon). These time-course results revealed that infants were sensitive to the consistent events shown during familiarization, as they exhibited a strong novelty preference (directing their attention to the novel event) before hearing the test sentence that varied by condition. Once the infants heard the test sentence (e.g., "Where's larping?), their attention began to diverge. Children in the Verb condition reliably directed their attention back toward the familiar event, or the event labeled with the novel verb during familiarization (e.g. waving a balloon). Children in the Noun and No Word conditions maintained their visual attention on the novel event. Note that both the novel and familiar events included a balloon, making them both appropriate responses for the Noun condition. However, a subsequent experiment using the same Familiarizaton phase, but changing the Test phase to include events with the same action but different objects (e.g., waving a *balloon* versus waving a *rake*) revealed that children could indeed appropriately extend a novel noun and direct their attention back to the familiar object.

These results suggest that 24-month-olds' representations of novel words are sufficiently precise to permit them to map novel verbs to event categories (e.g., waving events) and novel nouns to object categories (e.g., balloons). Once again the time-course of their mapping is swift, occurring within about a second of hearing the novel word. These results beckon us to move beyond asking whether or not infants can represent verb meanings, and to consider instead the conditions that support their successful acquisition.

Avenues for future research

The evidence discussed above has significantly advanced our understanding of children's early word learning, while simultaneously prompting myriad avenues for future research. Among them are questions concerning how word learning proceeds in bilingual children, and what neuropsychological studies can contribute to theories of word learning. We consider each of these in turn below.

Word-learning in bilingual environments. The previous sections highlight the many challenges word-learning presents to infants and young children. The task for bilingual children is even more complex, as they grapple with solving the puzzle of word-learning in more than one language. Nevertheless, the time-course of bilingual children's acquisition is similar to that of monolinguals (Holowka, Brosseau-Lapre, & Petitto, 2002; Oller, Eilers, Urbano, & Cobo-Lewis, 1997; Pearson, Fernandez, & Oller, 1993), and their early words and sentences closely resemble those of monolingual infants (Yip & Matthews, 2007).

Monolingual and bilingual word learning nonetheless differs in important ways (see Fernald, 2006; Werker & Byers-Heinlein, 2008 for recent reviews). Bilingual infants must separate the linguistic input that they receive from their two languages, forming two distinct phonological systems and two lexicons. An active area of research is the way the two languages might be represented and processed in the brain. A recent neuropsychological study examined brain responses in 19- and 22-month-old bilingual infants as they listened to known and unknown words in both of their languages (Conboy & Mills, 2006). Differences were found not only the infant brain responses to known and unknown words, but also in the infant brain responses to the two languages. Moreover, the timing and distribution of brain activity linked to word-meaning differed for children's dominant vs. non-dominant language. These differences most likely reflect differences in the infants' experience with the two languages, rather than a general brain maturational mechanism.

The neuroscience of word-learning. Other recent neuropsychological studies contribute to our understanding of the neural processes underlying word-learning in both bilingual and monolingual environments, and support the behavioral findings detailed above in two main ways. First, neuropsychological evidence shows that the infant brain responds to speech in a special way, distinct

from other auditory signals. This dovetails well with evidence that infants map words (but not non-speech stimuli like tones) to meaning (Fulkerson & Waxman, 2007). Second, there is evidence that the infant brain responds in a specific way not only to speech sounds in general, but also to words in particular. This specific response to the presentation of words provides the first neurological correlates of word learning.

The evidence that even newborn infants process speech stimuli in a way that is distinct from non-speech stimuli suggests that the human brain comes prepared to process human speech. In particular, areas of activation observed in the newborn brain bear a striking resemblance to those for adults. Two recent studies examined areas of brain activation in neonates (Pena, et al, 2003) and 3-month-olds (Dehaene-Lambertz et al, 2002). These studies revealed that even in neonates there is a left hemisphere bias when listening to language, a bias that is not observed when listening to backwards speech or silence. Moreover, this left hemisphere bias was shown to emerge even when subjects were presented with a language other than their own (Hespos, Ferry, Cannistraci, Gore, & Park, 2009; Hespos, Park, Ferry, Lane, & Gore, 2009).

Recent work also shows that infants go beyond merely processing speech sounds in speech-specific ways, but that they can also detect speech patterns, like the repetition of syllables (Gervain, et al, 2008). Different patterns of brain responses emerged when neonates were presented with blocks of syllables with immediate repetition (e.g., ABB) vs. no repetition. This indicates that the infant brain is sensitive to speech structure, and suggests at least one way in which neuropsychological capacities support the acquisition of words.

Beyond speech processing, neurospsychological research on word-learning primarily consists of ERP studies that use the N400 as a method of testing children's knowledge. The N400 is an ERP response that is associated, in adults, with semantic integration. It is consistently observed after an unexpected stimulus, as when a picture is paired with a mismatching names (e.g., pairing the word

"dog" with a picture of a banana). (See Werker & Yeung, 2005 for a terrific overview of ERP correlates to word learning)

The N400 response has been observed in several studies of infants and toddlers. In one study, 19-month-olds were presented with known words that either matched or did not match a sequentially presented picture (Friedrich & Friederici, 2004). The words referred to the basic level name of the object or an incongruent basic level name. As expected, the N400 emerged when the object names did not match the object pictures. A later study obtained this same result with 14-month-olds (Friedrich & Friederici, 2005). Studies featuring novel words have also revealed the N400 in infants and young children (Mills, Plunkett, Prat, & Schafer 2005; von Koss Torkildsen et al., 2008).

In conclusion, the neuropsychological evidence converges well with the behavioral evidence on word-learning. Recall that behavioral studies reveal that by 14 months, infants have mapped several nouns to objects and object kinds. Correspondingly, neuropsychological studies show that when a mismatch occurs between a known noun and picture of an object, the 14-month-old infant brain 'notices' the mismatch. As research in this field progresses, it will be interesting to see if neuropsychological correlates are also evident in the infant brain's response to words from other grammatical categories, including adjectives and verbs.

Conclusions

In this chapter, we have focused on word-learning, asking what expectations, if any, infants recruit in the process of establishing their first word-to-world mappings, and how these evolve over development. We suggested that infants begin the task of word-learning equipped with a broad, initial, and universally-available expectation that links novel open class words (independent of their grammatical form) to a wide range of commonalities among named objects. We suggested that this initially general expectation sets the stage for the evolution of more specific expectations, calibrated in

accordance with the correlations between particular grammatical forms and their associated meanings in the language under acquisition.

Infants' performance provided clear support for this proposal. At 11 months, infants revealed a broad initial expectation, linking words (count nouns and adjectives) to commonalities (both category- and property-based) among named objects. By 14 months, infants' expectations have indeed become more fine-tuned. They distinguish nouns from adjectives, and treat this distinction as relevant when mapping words to their meaning (mapping count nouns specifically to category-based, but not property-based, commonalities among objects). Specific links between adjectives and properties of objects continue to emerge toward the end of the second year of life. By this age, infants also begin to map verbs to commonalities among events as well.

These results point to substantial continuity across development in the types of concepts we form, and in the influence of naming in their acquisition. We see this line of work as providing evidence that words are powerful engines for conceptual development: words advance us beyond our initial groupings, fueling the acquisition of the rich relations that characterize our most powerful concepts.

Finally, this developmental account has several distinct strengths. First, it embraces both the importance of the expectations imposed by the learner, as well as the shaping role of the environment. In the case of word-learning, this interplay between factors inherent in the child and factors within the environment is essential. Infants across the world will encounter different objects, will acquire different languages, and will be provided with different types of language input (Cole, Gay, Glick, & Sharp, 1971; Laboratory of Comparitive Human Cognition, 1983).

Moreover, under our proposal, early acquisition is sufficiently constrained to permit infants to form fundamental categories of objects and to learn the words to express them, and sufficiently flexible to accommodate the systematic variations in the word-to-world mappings that occur across languages. Notice that our view of constraints on acquisition is not an argument based entirely on assumptions of

innate knowledge. Neither is it a polarized argument that locates the engine of acquisition solely within the mind of the child. Rather, the idea is that in the process of word learning, infants direct their attention toward precisely the sort of information and precisely the kinds of regularities in the environment that will support foundational concepts and the acquisition of words to describe them. Our proposal is flexible enough to account for the fact that infants naturally acquire a wide range of human languages, and that these differ in the ways in which they recruit the particular grammatical forms to convey particular types of meaning. We have suggested that the specific links between particular grammatical forms and their associated meanings are calibrated on the basis of correlations or regularities that are present in the language under acquisition. It therefore stands to reason that these more specific links would not be available at the onset of word-learning, but instead would emerge later, once the process of lexical acquisition is underway.

Finally**,** our proposal is a dynamic one: The initial expectations that we observe in infants at the outset of acquisition are not rigidly fixed, exerting a uniform influence throughout development. On the contrary, these expectations are shaped over the course of development in accordance with the observed regularities in the language under acquisition.

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Figures

Figure 1. A schematic presentation of introductory phrases from Waxman & Markow (1995) and an example of a single stimulus set

	Familiarization Phase				Test Phase	
	Trial 1	Trial 2	Trial 3	Trial 4		
Animal Set:						
	yellow duck	green raccoon	blue dog	orange lion	red cat	red apple
Noun	This one is. a(n) X	This one is a(n) X	See what I have?	This one is a(n)X	See what I have?	
Adjective	This one is X-ish	This one is X-ish	See what I have?	This one is X-ish	See what I have?	
No Word	Look at this.	Look at this.	See what I have?	Look at this.	See what I have?	

Figure 2. A schematic presentation of introductory phrases from Waxman & Booth (2001) and an example of a single

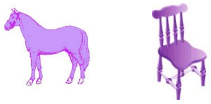
	Familiarization		Contrast	Test	
	Trial 1	Trial 2		Category	Prope
Purple Animal Set:	 bear lion	 dog	 red apple	 purple horse vs. purple chair	 purple horse vs.
Noun	These are blickets. This one is a blicket & This one is a blicket	These are blickets. This one is a blicket & This one is a blicket	Uh-oh, this one is not a blicket!	Can you give me the blicket?	Can you give m
Adjective	These are blickish. This one is blickish & This one is a blickish	These are blickish. This one is blickish & This one is a blickish	Uh-oh, this one is not blickish!	Can you give me the blickish one?	Can you give m one
No Word	Look at these. Look at this one & Look at this one	Look at these. Look at this one & Look at this one	Uh-oh, look at this one!	Can you give one?	Can you giv

Figure 3. A schematic presentation of introductory phrases from Waxman, Lidz, Braun, & Lavin (in press) and exam

Familiarization	Contrast		Fami
			
Man waving balloon (4 consecutive exemplars)	Man playing toy saxophone	Man waving balloon	Man
Verb: "Look, the man is *larping* a balloon!"	Verb: Uh-oh! He's not *larping* that.	Verb: Yay! He is *larping* that.	Verb: "N "W
Noun: "Look, the man is waving a *larp*!"	Noun: Uh-oh! That's not a *larp*!	Noun: Yay! That is a *larp*!	Noun: "N "W
No Word: "Look at this!"	No Word: Uh-oh! Look at that.	No Word: Yay! Look at this.	No Word:

[1] From Keller (1904).

[2] Note, that this was, in fact, Keller's second language. She had begun to acquire English before becoming de

[3] This question itself hinges on there being a psychological distinction between object categories and object p approaches in cognitive psychology distinguish object categories (sometimes known as *kinds* or *sortals*) from other ty pink things, things to pull from a burning house) on at least 3 (related) grounds: Object categories (1) are richly-struc commonalities, including deep, non-obvious relations among properties (as opposed to isolated properties), and (3) s induction (Barsalou, 1983; Gelman & Medin, 1993; Kalish & Gelman, 1992; Macnamara, 1994)**(Medin & Heit, in p** 1985). Although infants and children lack detailed knowledge about most object categories, they clearly expect name serve these functions (Gelman, 1996; Keil, 1994). In addition, there is now evidence for a psychological distinction b properties and relations among properties in infancy (Bhatt & Rovee-Collier, 1997; Younger & Cohen, 1986). We se because these properties are perceptually salient to infants, and because these property-based commonalities typically categories. We suspect that an object's shape is more centrally related to category membership, particularly for simpl objects (Waxman & Braig, 1996).