

CHAPTER FIVE

Early Word-Learning and Conceptual Development: Everything had a Name, and Each Name Gave Birth to a New Thought

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How do infants begin to map words to their meaning? How do they discover that different types of words (e.g., noun, adjective) refer to different aspects of the same objects (e.g., object category, object property)? I have proposed that (1) infants begin the task of word-learning with a broad, universal expectation linking novel words to commonalities among objects, and that (2) this initial expectation is subsequently fine-tuned on the basis of infants' experience with 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 rain-forest, 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 others, surrounded by objects and events that are foreign to the others, and immersed in a language that the others cannot begin to understand. Yet in spite of such vast differences, 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 form categories 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*) (see Quinn, ch. 4 this volume). 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 among them. Infants' early 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, 1992b), and prefer speech sounds to other forms of auditory input. 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). 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. 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 learn *words* to express them. Together with my colleagues, I have argued 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

These links between early language and conceptual development are most clearly viewed through the lens of early word-learning. Perhaps more than any other developmental achievement, word-learning stands at the very intersection of language and cognition, and serves as the gateway to subsequent development in both domains. Early word-learning represents infants' entrance into a truly symbolic system and brings with it a means to establish reference. It supports infants' subsequent discovery of the fundamental syntactic properties of the native language (see Gillette, Gleitman, Gleitman, & Lederer, 1999; Snedeker & Gleitman, 1999; Waxman, 1999a, 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; Waxman & Markow, 1995; Xu, 1999).

My colleagues and I have made a developmental proposal regarding these links. We have proposed (1) that infants across the world's language communities begin the task of word learning equipped with an initially general and universal expectation, and (2) that 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 (Klibanoff & Waxman, 2000; Waxman, 1998; Waxman & Booth, 2000a; Waxman & Booth, in press; Waxman & Markow, 1995). To amplify this topic, I 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 in the *world*. This exploration will underscore infants' implicit expectations, as well as their ability to recruit fundamental perceptual and conceptual capacities in the service of word-learning. The second section will be devoted to illustrating some of these links between word-learning and conceptual development in preschool-aged children. In the third section, the goal is 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, pp. 22–3)

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 1 year of age. Keller, in contrast, learned *water* at approximately 7 years of age.¹ 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 (e.g., Western, college-educated communities), caretakers do name objects deliberately for their infants, even before the infants themselves can speak. Yet in many other communities

(e.g., Kahluli, see Ochs & 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. Infants' preference for human speech over other sources of auditory input has been documented in studies using a variety of techniques, including the head-turn procedure (Jusczyk & Kemler Nelson, 1996). Another advantage is that 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). In addition, whether or not words are presented in "motherese", infants as young as 8 months of age are especially attentive to words that come at the end of a sentence or phrase boundary (e.g., "See the *water*?") (Fernald, 1992b; Jusczyk & Aslin, 1995; Newsome & Jusczyk, 1994). In many languages (e.g., English, Spanish, French), nouns tend to occupy this privileged phrase-final position. However, in other languages (e.g., Mandarin Chinese (Tardif, 1996), Korean (Au, Dapretto, & Song, 1994; Choi & Gopnik, 1995), and apparently Tzeltal and Itzaj) this is less often the case. Yet, despite these variations, infants across the world's language communities begin to produce their first words at roughly the same age, and the composition of their early lexicons is roughly comparable, with nouns (that is, words that are classified as nouns in the adult language) being the predominant early form (Au et al., 1994; for a different interpretation see Bloom, 1993; Choi & Gopnik, 1995; Gentner, 1982; Gentner & Boroditsky, in press; Gleitman, 1990; Goldin-Meadow, Seligman, & Gelman, 1976; Huttenlocher & Smiley, 1987; Nelson, Hampson, & Shaw, 1993; Saah, Waxman, & Johnson, 1996; Tardif, 1996). Information regarding the composition of the early lexicon has been gleaned primarily from two types of survey-based research. In the first, researchers present a list of words and caretakers indicate which of these the infant comprehends and/or produces. The most commonly used list (the MacArthur Communicative Developmental Inventory) has been translated into several languages (Fenson, Dale, Reznick, Bates, et al., 1994). The second method involves direct observations of conversations between infants and their caretakers (Bloom, 1993; Braun, Balaban, Booth, & Waxman, 2001; Gelman, Coley, Rosengren, Hartman, & Pappas, 1998).

A fourth difference concerns the identification of the referent of the novel word. The referent is seldom available for inspection throughout the duration of the naming episode. Therefore, 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 cordless telephone). In other cases, the referent may make only a fleeting appearance (e.g., "Look at the monkey," uttered as

a monkey makes a fleeting 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. Typically, one individual (say, an adult) points to an object (say, a tapir) and provides its name ("Ila' a' tzimin~che' je'lo'" (in Itzaj Maya) or "Look, a tapir" (in English)). To succeed, the infant must (1) parse the relevant word (*tzimin~che* or *tapir*) from the ongoing stream of speech, (2) identify the relevant entity (the tapir) in the ongoing stream of activity in the world, and (3) establish 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 even 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, which are available in the speech stream, 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) (Shi et al., 1999). Research using a preferential listening task reveals that 9- to 10-month old infants prefer to listen to open class words. This preference is likely related to the fact that these 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 is dependent upon the infants' perceptual and conceptual ability to identify objects in their environment, and to notice commonalities among them.

During the first year, infants demonstrate a great deal of core knowledge about objects (Baillargeon, 2000a, and ch. 3 this volume; 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 (see Quinn, ch. 4 this volume). 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 (see Gergely, ch. 2 this volume). 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. Recent research reveals that by 10 months, infants have begun to make such connections (Baldwin & Baird, 1999; Guajardo & Woodward, 2000); they spontaneously follow a speaker's line of regard to identify the object to which an adult speaker is attending.

In addition to these three central elements, successful word-learning requires infants to go beyond a word-to-object mapping. For 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. Infants are exceptional word-learners (see Carey, 1978; Goldfield & Reznick, 1990; Heibeck & Markman, 1987; Waxman & Booth, 2000b; Waxman & Booth, 2001; Waxman & Hall, 1993; Woodward, Markman, & Fitzsimmons, 1994). For example, when a child applies the word *tapir* to a new, and (as yet) unlabeled object, that child has made 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 (Waxman & Booth, 2000b).

Different kinds of words highlight different aspects of a scene

To complicate matters further, even if an infant happens to be attending to the same scene as a speaker, and even if the infant takes notice of the novel word introduced in this context, there is no guarantee that the infant will successfully map the word correctly. In large part, this is because many different words – indeed many different *types* of words – may be offered in a 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 *tapir*") typically refer to the named object itself and are extended spontaneously to other members of the same object kind (other tapirs); proper nouns ("Look, it's *Zeus*") also refer to the named individual, but these are not extended further; although adjectives can also be applied correctly to that individual ("Look, it's *furry*"), they do not refer to the individual itself, but to a property of the named individual, and are extended to other objects sharing that property.

An important feature of human language is that different kinds of words bring to the foreground different aspects of the very same observed scene. Considerable research has documented that by 2.5 to 3 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, 1998). This establishes that preschool-aged children have the *linguistic* capacity to distinguish among the relevant syntactic forms (count noun vs. adjective) and the *conceptual* or *perceptual* ability to appreciate many different kinds of relations among objects (see Goswami, ch. 13 this volume), and a tacit expectation that these linguistic and conceptual abilities are interwoven.

Acquisition of word-to-world links: three theoretical possibilities

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? There are three logically possible classes of answer.

Possibility 1. One possibility is that early acquisition is guided by an a priori set of expectations, linking each type of word (e.g., noun, adjective, verb) to a particular type of meaning (e.g., object categories, object properties, actions). A review of the cross-linguistic literature casts serious doubt on this possibility, because the links between particular types of words (or grammatical forms) and meaning are not universal. Across languages, the grammatical form *noun* tends to refer to individual objects (Zeus) and to categories of objects (e.g., tapir). In contrast, there is considerable cross-linguistic variability in the mappings for most other grammatical forms, including adjectives, verbs, prepositions, and spatial terms (Bowerman, 1996b; Haryu & Imai, 1999; Imai & Gentner, 1993; Regier & Carlson, in press; Waxman, Senghas, & Benveniste, 1997). This cross-linguistic variability is directly related to the question at hand, for it reveals that infants' expectations linking particular grammatical forms to their meaning cannot be fixed from the outset. Instead, infants must discover how the various grammatical forms are mapped to meaning in the language under acquisition.

Possibility 2. Perhaps, then, infants begin the task of word-learning as something of a *tabula rasa* (blank slate), equipped with no expectations to guide the acquisition of their first word-to-world mappings. On this view, any expectation regarding a word and its meaning must be acquired inductively, as infants notice the precise correlations between particular grammatical forms and particular types of meaning. Implicit in this account is the assumption that at the onset of lexical acquisition, word-learning is qualitatively different in nature than word-learning in older children, for only older children could have induced the appropriate correlations between types of words and types of meaning. Although this position has been argued forcefully (Smith, 1999), a review of the developmental literature casts serious doubt on its plausibility. There is now ample evidence that infants begin the task of word-learning with certain powerful, albeit general, expectations linking words with concepts (Balaban & Waxman, 1997; Waxman & Markow, 1995; Xu, 1999). The fact that these nascent expectations are in place in advance

of word-learning makes it unlikely that they could have been induced from infants' own lexicons.

Possibility 3. The shortcomings of possibilities 1 and 2 lead us to argue for a third possibility, one that represents an interaction between a universally available expectation inherent in infants, and the shaping role of the environment (here, the structure of the native language). We propose that infants across the world's languages embark upon the task of word-learning equipped with a broad, universally shared expectation, and that this expectation is itself subsequently shaped by the structure of the particular language under acquisition. 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, actions) 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 meaning. Recall that infants' earliest lexicons include words that refer to a range of relations, including category-based commonalities (dog), property-based commonalities (hot), and common social routines and actions (bye-bye; up). Recall also that across languages, nouns are by far the most prevalent type of word represented in the early lexicon, and that these tend to refer to salient basic-level categories of objects (e.g., dog, horse, cup). Because the pairing between nouns and object categories are the most prevalent and most consistently represented in the early lexicon, infants are likely to first tease apart the nouns (from among the other open class grammatical forms)² and to notice that words from this grammatical category tend to refer to object categories (as opposed to other types of commonalities, including property-based or action-based commonalities). In other words, 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. Infants will first tease apart the nouns and map them to categories of objects. Subsequent linkages will build upon this referential base, and will be fine-tuned as a function of experience with the specific correlations between particular grammatical forms and their associated meanings in the native language.

The Evidence: The Evolution of Infants' Word-to-World Expectations

To test these possibilities, 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. In this section, I offer the evidence. I first describe a series of experiments demonstrating the precise expectations held by preschool-aged English-speaking children. I then go on to consider the origin and evolution of these expectations in infants ranging from 9 to 15 months of age.

Unifying features of the experiments

The experiments that I will describe utilize an array of methods and subject populations, but share several important features. Each is essentially an object categorization task, tailored to suit the very different behavioral repertoires of infants versus young children. In each, the goal is to observe the relation between object naming and categorization. To do so, we compare subjects' categorization of objects 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., *fauna*), rather than familiar words (e.g., *animal*). 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 (2) provide unambiguous contextual evidence that the novel word is either a count noun or an adjective. In the *Novel Noun* conditions, we introduce objects saying, for example, "This is a *blicket*." In the *Novel Adjective* conditions, we present the same word using a different frame, saying, for example, "This is a *blick-ish* one" (see Gerken & McIntosh, 1993; Waxman & Markow, 1995; Waxman & Markow, 1998 for evidence that infants are sensitive to these distinct frames). In the *No Word* control conditions, we introduce no novel words, but point out the objects, 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 things). Performance in the *Noun* condition assesses the role of naming in this important endeavor. Performance in the *Adjective* condition permits a strong test of the specificity of the relation between form and meaning. Because both count nouns ("That is a *dog*") and adjectives ("That is *purple*") can be applied ostensibly to objects, this is an important control.

Evidence from preschool-aged children

By the time they are 3 years of age, children reveal very specific expectations linking particular types of words with their meaning. The cross-linguistic evidence reveals that these

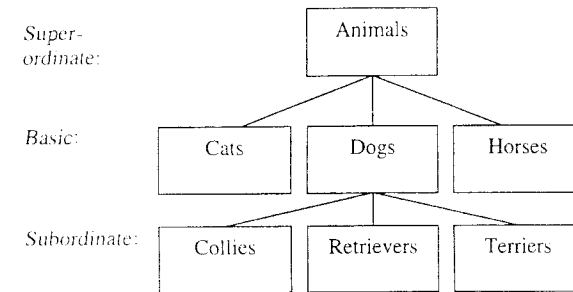


Figure 5.1 Representation of an object hierarchy

links are shaped by the structure of the native language (Waxman & Guasti, in preparation; Waxman et al., 1997). For English-speaking children, novel nouns direct attention specifically to categories of objects (e.g., dog, animal), and novel adjectives direct attention specifically to properties of objects (e.g., color, texture). These links have been documented in a highly structured object-classification task (Waxman, 1990; Waxman & Gelman, 1986). An experimenter introduced children to some "very picky" puppets, explaining that they "only want(ed) a certain kind of thing." To indicate the "kind of thing" that each puppet wanted, the experimenter displayed three typical instances of a familiar object category (e.g., a dog, a horse, a duck to indicate the category *animal*). Children were then asked to categorize additional items for the puppets.

To identify an influence of novel words on categorization, we compared performance in three conditions. In the *No Word* (control) condition, the experimenter introduced the three instances by saying, "Look at these." In the *Novel Noun* condition, children saw the same instances, but these were labeled with a count noun (e.g., "These are *dobutsus*"). In the *Novel Adjective* condition, children heard, e.g., "These are *dob-ish* ones." The only difference between these latter two conditions was the grammatical form in which the novel word was presented. We examined children's categorization at three different hierarchical levels (subordinate, basic, and superordinate) within two different natural kind hierarchies (animals and food) (see figure 5.1).

Children in all three conditions formed the basic-level categories very successfully. It was at the non-basic levels that the specific influence of novel words became apparent. In the absence of a novel word, children in the *No Word* condition had difficulty forming both subordinate- and superordinate-level categories. Novel nouns directed children's attention specifically to the category-based commonalities among objects. As a result, novel nouns facilitated the formation of superordinate-level categories, but had no effect at the subordinate level (see Markman & Hutchinson, 1984; Waxman & Gelman, 1986). Children hearing novel adjectives displayed a very different pattern: Novel adjectives directed children's attention specifically to property-based commonalities among objects (e.g., color), and therefore facilitated categorization at the subordinate, but not superordinate, level. These results, coupled with converging evidence from other paradigms (Bloom, 2000; Hall & Graham, 1999; Landau, 1994; Waxman & Hall, 1993) document

clearly that preschool-aged children have the *linguistic* capacity to distinguish among the relevant grammatical forms (count noun vs. adjective), the *conceptual* or *perceptual* ability to appreciate different kinds of relations among objects (category- vs. property-based), and a tacit expectation that these linguistic and conceptual abilities are interwoven. To discover which linkages (if any) guide acquisition from the outset, and how these are shaped by experience, we must go on to consider infants on the very threshold of language acquisition.

Evidence from infants

What capacities do infants recruit at the very onset of acquisition? How do they begin to map words to the objects and events they perceive in the world? We know that by the end of their first year, infants have a remarkable ability to identify novel words, to notice perceptual and conceptual similarities among objects, and to interpret the rich social and pragmatic cues in which novel words are introduced. These major accomplishments certainly provide a foundation for infants' entry into the process of word learning. However, these accomplishments are not, in themselves, sufficient to guarantee that word-learning will proceed smoothly. What remains to be seen is whether naming has any consequences on conceptual organization. Is there a relation between naming and conceptual organization before the onset of productive language?

Prelinguistic infants: cognitive consequences of naming. Recent research suggests that naming does have 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 confirms that even before infants begin to talk, naming directs their attention to an object. This raises two further questions: Does the increased attention stem from the salience of words or from the attention-engaging functions of auditory stimulation in general? And does naming promote attention to a named individual only, or does it exert an influence beyond the named individual?

To answer these questions, Marie Balaban and I (Balaban & Waxman, 1997) compared the effect of novel words versus tone sequences on 9-month-old infants. We used a novelty-preference task to assess infants' attention to individual objects and categories of objects. During a *familiarization* phase, infants saw a sequence of slides, each depicting a different member of a basic-level category (e.g., rabbits). To examine the influence of words, we randomly assigned infants to either a *Word* or a *Tone* condition. For infants in the *Word* condition, a naming phrase (e.g., "a rabbit!") 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. This familiarization phase was immediately followed by a *test* trial, in which infants in both conditions saw (a) a new member of the now-familiar category (e.g., another rabbit) and (b) an object from a novel category (e.g., a pig). Test trials were presented in silence.

We reasoned as follows: If words focus attention on commonalities among objects, then infants hearing words during familiarization should notice the commonalities among

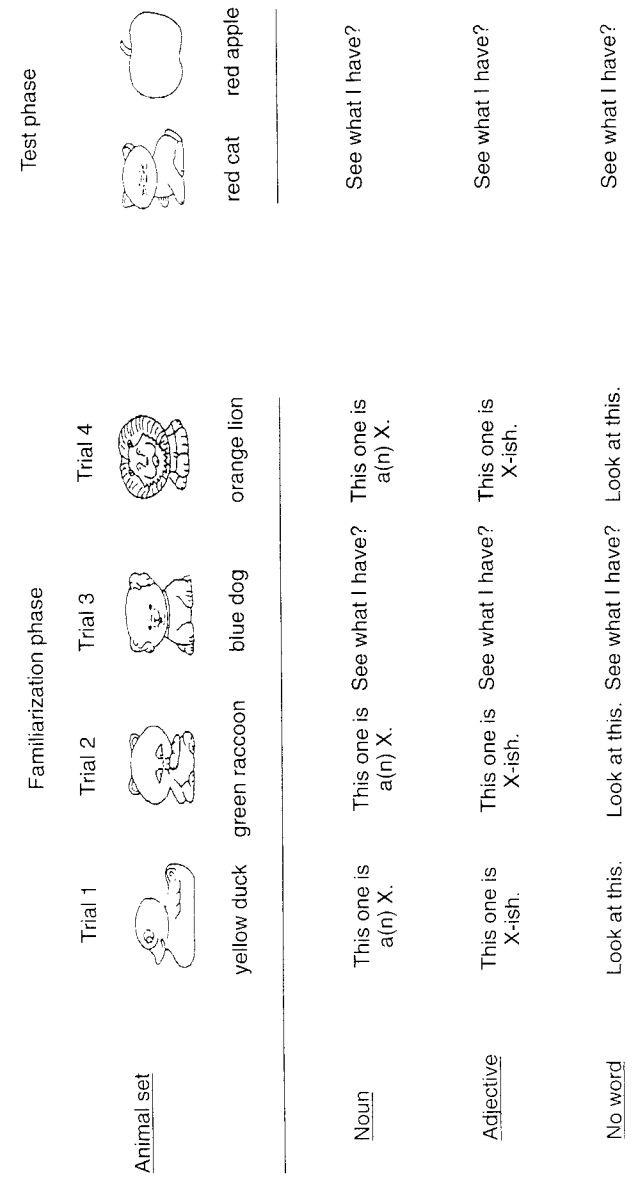


Figure 5.2 A schematic presentation of introductory phrases from Waxman & Markow (1995) and an example of a single stimulus set

the familiarization objects. If this is the case, then these infants should reveal a preference for the novel test object (e.g., the pig). 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 that we obtained. We can therefore conclude that for infants as young as 9 months of age, there is indeed something special about words, as opposed to a more general facilitative effect of auditory input, and that the cognitive consequence of naming extends beyond the named individual(s) to highlight commonalities among named individuals and to promote the formation of object categories.

Naming has other cognitive consequences as well. Recent 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 distinct objects with the *same* name highlights their commonalities and promotes the formation of object categories (Balaban & Waxman, 1997). Naming distinct objects with *distinct* names (e.g., *ball*, *duck*) highlights their differences and promotes the process of individuation (Xu, 1999). Thus, naming supports the establishment of a repertoire of object categories and provides infants with a means of tracing the identity of individuals 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 this section, we go on to trace the evolution of infants' expectations regarding word-to-world mappings as they cross the important developmental threshold of producing words on their own.

In one series of experiments, Dana Markow and I examined the influence of novel words on object categorization in 12- to 14-month-old infants (see Waxman & Markow, 1995 for a complete description). Once again, we used a novelty-preference task (see figure 5.2 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 in this procedure 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. In all conditions, the infants heard infant-directed speech. The conditions differed only in the experimenter's comments during *familiarization*. In the *No Word* condition (control), she said, "See here?" as she introduced each object; in the *Novel Noun* condition, she said, "See the *blicket*:" In the *Novel Adjective* condition, she said, "See the *blick-ish* one?" In the test phase, infants in all conditions heard precisely the same phrase ("See what I have?").

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 in conjunction with the objects presented 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. In this way, words facilitate the acquisition of object categories. We have interpreted this finding as evidence that words serve as "invitations to form categories" and have pointed out that this invitation has several dramatic 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 (Gentner & Namy, 1999; Gentner & Waxman, 1994).

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 (Gelman & Opfer ch. 7 this volume). Indeed, children depend upon these to support inference and induction. I suspect that novel words are instrumental in motivating infants and young










Familiarization		Contrast	Test	
Trial 1	Trial 2		Category	Property
 bear  lion  elephant  dog	 red apple  purple horse vs.  purple chair  purple horse vs.	 blue horse	purple horse vs. purple chair	purple horse vs. blue horse
Noun	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 me the blicket?
Adjective	These are blickish. This one is blickish & this one is blickish.	Uh-oh, this one is not blickish!	Can you give me the blickish one?	Can you give me the blickish one?
No word	Look at these. Look at this one & look at this one.	Uh-oh, look at this one!	Can you give me one?	Can you give me one?

Figure 5.3 A schematic presentation of introductory phrases from Waxman & Booth (1999) and an example of a single stimulus set

children to discover the deeper commonalities that underlie our richly structured object categories (Barsalou, 1983; Gelman, 1996; Gelman, Coley, & Gottfried, 1994; Gelman & Medin, 1993; Kalish & Gelman, 1992; Keil, 1994; Landau, 1994; Landau, Smith, & Jones, 1988; Lassaline & Murphy, 1996; Macnamara, 1994; Markman, 1989; Medin & Heit, in press). Most importantly, the results of this series of experiments documents 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. (See Smith, 1999, for arguments to the contrary.)

In a more recent series of experiments, our goal was to capture more precisely the scope, power, and evolution of infants' expectations in word-learning. We extend the work described in the previous section in three ways. First, we include 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 expand 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). In the next series, 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*).³ We also considered the conditions under which naming objects (with either a count noun or adjective) would 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).

A third goal of the current series is methodological. The evidence reviewed thus far regarding infants' expectations in word-learning has been based entirely on the novelty-preference task. It remains to be seen whether infants' expectations are sufficiently strong to support performance beyond this task. 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. From the onset of word-learning, infants advance from producing single word utterances (at approximately 9 to 12 months) to creating rich multi-word expressions (at approximately 24 months). We have proposed that in the intervening period, infants fine-tune their initially general expectation (that content words, in general, highlight commonalities among objects, in general) to develop the more specific expectations characteristic of their native language (that nouns refer to category-based commonalities, adjectives refer to property-based commonalities, etc.).

Unfortunately, however, our view of this critical transition has been clouded, at least in part, by the difficulties of accommodating the very different behavioral capacities of individuals at either end. *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 wedds features of the novelty-preference procedure with those of the word-extension paradigms. See figure 5.3 for a

schematic description of the procedure and a summary of the instructions presented in each condition.

In the *Familiarization phase*, the 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 5.3 for the instructions used in each condition. 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. To answer this question, we present infants in all conditions with objects that are members of the *same object category* and share the *same object property* (e.g., four purple animals). We have proposed that infants begin the process of lexical acquisition with a general expectation linking words (in general) to commonalities among objects (in general). If this is the case, then for infants of 11 months, both nouns and adjectives should highlight both category-based (e.g., animal) and property-based (e.g., purple things) commonalities. We further proposed that this initial expectation is refined once the process of lexical acquisition is under way, using the early lexicon as a basis for discovering the more precise links between kinds of words and their associated meaning. If this is the case, then for more advanced learners, a more specific pattern should emerge. Different kinds of words should direct 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 and infants have established a modest lexicon, a more specific pattern should emerge. In support of this aspect of our proposal, we have found that by 14 months, infants begin to distinguish between novel words presented as nouns as compared to adjectives, and this distinction is recruited in word learning. Fourteen-month-old infants were more likely to extend novel nouns to the familiar object (e.g., purple horse) on Category trials (e.g., purple horse vs. purple plate) than on Property trials (e.g., purple horse vs. blue horse). This suggests that they expect nouns to refer to category-based, rather than to property-based, commonalities among objects. However, infants' 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. This result has been replicated in our laboratory (Waxman, 1999b; Waxman & Booth, 2000a), using various properties (e.g., color, texture). Clearly, by 14 months, infants have begun to distinguish among the various grammatical forms and these distinctions are recruited in the service of mapping words to their meaning. As this process of refinement unfolds, infants first tease apart the nouns from among the other grammatical forms, and map them specifically to category-based commonalities. At the same time, however, infants' expectations for novel adjectives are less precise; adjectives appear to highlight the commonalities underlying object categories as well as object properties. This suggests that the more specific expectations linking adjectives to their meaning is a subsequent developmental accomplishment, one that appears to depend upon infants' prior establishment of the link between count nouns and object categories, and one that is shaped by the semantic and syntactic properties of adjectives in the language under acquisition. Thus, at 14 months, infants' expectation for count nouns is more precise than their expectations for adjectives (table 5.1).

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. Recent work confirms that cues like these are sufficiently rich to support an emerging distinction among major grammatical forms (e.g., noun, adjective, verb) (Morgan & Demuth, 1996). The current results go one step further to reveal that these cues are detected reliably in fluent speech, that they support an emerging distinction between count nouns and adjectives, and that this distinction may be recruited in the process of word learning. Although infants' grammatical distinctions are certainly not as well honed as those of adults, and although their knowledge of categories and properties

Table 5.1 Means and standard deviations of the proportion of word-extension test trials on which the familiar object was chosen

	14-month-olds (Waxman & Booth, in press)		11-month-olds (current data)	
	M	SD	M	SD
NOUN				
Category	.68*	.13	.57	.24
Property	.44	.15	.55	.14
ADJECTIVE				
Category	.50	.18	.59	.24
Property	.52	.17	.58	.15
NO WORD				
Category	X	X	.46	.15
Property	X	X	.49	.09

* $p < .05$ versus chance of .50.

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.

The Evidence in Review

The experiments described in this chapter were designed to discover what expectations, if any, infants recruit in the process of establishing their first word-to-world mappings, and how these evolve over development. We offered a developmental proposal, in which infants begin the task of word-learning equipped with a broad, initial, and universally available expectation linking novel open class words (independent of their grammatical form) to a wide range of commonalities among named objects. Infants' performance provided clear support for this aspect of the proposal. At 11 months, infants revealed a broad initial expectation, linking words (both count nouns and adjectives) to commonalities (both category- and property-based) among named objects. We have suggested that this initially general expectation, which appears before the advent of word learning, is universally available and provides the foundation for infants' early establishment of symbolic reference and lexical acquisition. It also sets the stage for the evolution of the more specific expectations, which are calibrated in accordance with the observed correlations between particular grammatical forms and their associated meanings in the language under acquisition (Waxman, 1999b; Waxman & Booth, 2000a; Waxman & Markow, 1995). Infants' performance at 14 months offered clear support for this aspect of the

proposal. At this point in development, infants' expectations have indeed become more fine-tuned. They distinguish among the various grammatical forms and treat these distinctions as relevant when mapping words to their meaning. At 14 months, infants have begun to distinguish the count nouns and map them specifically to category-based, but not property-based, commonalities among objects. They have yet to acquire the specific links between adjectives and object properties that are characteristic of more mature speakers of English.

These results provide substantial support for our developmental proposal. More generally, they point to substantial continuity across development in the types of concepts we tend to form, in the influence of naming in their acquisition. I 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 essential, rich relations that characterize our most powerful concepts.

Two other developmental proposals have recently been offered, and each of these is committed to a very different set of assumptions than those I have argued for in this chapter.

Entry points for categorization: acquiring global versus basic-level object categories. One issue concerns the breadth of infants' earliest categories, and the bases upon which they are formed. My colleagues and I have argued that basic-level object categories (e.g., dog, cup) serve as an important entry point in object categorization, naming, and inductive inference (Gelman et al., 1994; Hall & Waxman, 1993; Waxman, 1999b; Waxman & Booth, in press; Waxman & Markow, 1995). There is strong evidence for the developmental primacy of basic-level object categories in cognitive and lexical development (Brown, 1958; Fenson, Cameron, & Kennedy, 1988; Mervis & Crisafi, 1982; Quinn, Eimas, & Rosenkrantz, 1993; Rosch & et al., 1976; Waxman, 1990). However, this position has been challenged. Mandler and her colleagues (Mandler, 1992; Mandler & Bauer, 1988; Mandler, Bauer, & McDonough, 1991; Mandler & McDonough, 1993; Mandler & McDonough, 1996) have argued that (1) conceptual development begins at a more abstract, global (e.g., animate vs. inanimate objects) level, (2) the basic-level groupings formed by infants and toddlers are entirely perceptually based, lacking in any conceptual grounding or inductive strength, and (3) the acquisition of global concepts *precedes* the acquisition of basic-level concepts.

Let us examine these claims in turn (see also Quinn, ch. 4 this volume). First, there is no doubt that basic-level object categories enjoy considerable perceptual support. But this does not, in itself, mean that they lack conceptual force, for perceptual and conceptual information are not mutually exclusive. In fact, we find no logical or empirical basis to the claim that perceptual and conceptual information or processes are as distinct as Mandler's theory suggests, either in infancy or in adulthood. Second, we take no issue with the possibility that both global (e.g., animate vs. inanimate objects; land vs. sea animals) and basic-level (e.g., dog vs. cow; cup vs. plate) conceptual categories are acquired early in development. We suspect that infants can, under certain circumstances, form object categories at various levels of abstraction, and that in doing so, they attend to several different kinds of perceptual and conceptual information, including an object's form, function, and type of movement (Baldwin, Markman, & Melartin, 1993; Nelson,

1995; Smith & Heise, 1992). The early acquisition of global, as well as basic, categories also ensures considerable continuity in conceptual development.

However, we strongly doubt that the acquisition of global concepts *precedes* the acquisition of basic-level concepts, with the latter being strictly derivative of the former. We also doubt that there is a frank dissociation between perceptual and conceptual factors, in which infants' basic-level object categories are entirely perceptually based, while their global categories are conceptual (Gelman & Medin, 1993; Gibson, 2000; Quinn & Eimas, 2000). These doubts are based on both logical and empirical grounds. First, the claim that global categories are conceptual, rather than perceptual, lacks empirical grounding. There are indeed perceptual cues to the distinction between animate and inanimate objects. For example, we know that infants are quite sensitive to the perceptual distinction between the types of motion displayed by animate versus inanimate objects early in development (Bertenthal, Proffitt, Kramer, & Spetner, 1987).

Second, the empirical evidence provides insufficient support for the precedence of global over basic-level concepts (see Waxman, 1998 for a full discussion). If the global-to-basic-level developmental progression were correct, then the *conceptual* commonalities among objects in our superordinate-level sets (e.g., animal vs. vehicle) should have been readily detected by infants. If this were the case, then infants in the *No Word* control conditions should have categorized at least as well on superordinate- as on basic-level sets. However, this was not the case. Despite their successful categorization on basic-level sets, infants in the *No Word* conditions evidenced no appreciation of the more abstract, superordinate-level categories. Infants' facility forming (or recognizing) commonalities at the basic level, as opposed to those at a more abstract global level, calls into question the global-to-basic progression. And the facilitative effect of naming that we observe on the superordinate-level sets is consistent with our claim that words serve as conceptual invitations, highlighting these more abstract object categories.

The evidence from early lexical acquisition also calls into serious question the assertion of a global-to-basic progression. Early in lexical development, words for basic-level categories are readily acquired (Gentner, 1982; Nelson, 1973; Nelson et al., 1993; Saah et al., 1996) while words for global categories are extremely rare (Fenson et al., 1994). In fact, infants' and young children's tendency to extend novel words, applied to novel objects, to other members of the same *basic*-level object category is so strong that it can override the use of syntactic form as a cue to word meaning (Au & Markman, 1987; Hall & Waxman, 1993; Hall, Waxman, & Hurwitz, 1993; see Waxman, 1998 for a review). How can the global-to-basic position be reconciled with the evidence for the central role of basic-level categories and the early acquisition of their names? On Mandler's account, infants' basic-level categories are purely perceptual. Could it be, then, that infants map their first words to perceptual, rather than to conceptual, groupings? This is unlikely. Why would abstract symbols (words) be tethered so tightly to perceptual groupings (basic-level categories, in Mandler's view), but not extended to groupings with an abstract conceptual base (global categories, in Mandler's view)? Second, even if we accepted the argument that basic-level categories are purely perceptually based, why would infants reveal such a strong talent for mapping words to only some perceptual groupings (namely, basic-level categories), to the exclusion of others (namely, perceptual properties like color and texture)? In fact, property terms like these enter the lexicon close to one year after the

appearance of basic-level names, and their acquisition appears to depend upon the prior acquisition of basic-level categories and their names (Klibanoff & Waxman, 2000; Waxman & Markow, 1998).

Object categories versus object shapes. There has also been debate concerning the types of meaning that children (and adults) associate with novel count nouns. This debate centers around whether count nouns direct word learners' attention to *categories* of objects (e.g., Gelman & Medin, 1993; Markman, 1994; Soja, Carey, & Spelke, 1991; Soja, Carey, & Spelke, 1992; Waxman, 1990; Waxman, 1994) or to *shapes* of objects (e.g., Landau, Jones, & Smith, 1992). There are several points of convergence between the noun-category and noun-shape positions. Most importantly, both document a powerful role for count nouns in object categorization. Moreover, both assume that perceptual properties play a role in our judgments of category membership and noun extension. Both assume that an object's shape and its category membership often covary, and that this is particularly true for basic-level categories (see also Gelman & Opfer, ch. 7 this volume). However, these positions also have fundamental differences, including (1) the role ascribed to development, and (2) the underlying model of word extension.

Role of development. According to the noun-shape position, infants come to the task of word learning with no a priori expectations (as in possibility 2, above). On this view, sometime after age 2, children *develop* an expectation, one that is based on their already acquired words. They infer from their own lexicons that count nouns refer to objects with the same shape (Landau et al., 1988; Landau et al., 1992; Smith, Jones, & Landau, 1992). There are two serious problems with this view. First, it cannot account for the evidence (reviewed in this chapter) that even in advance of word-learning, words have dramatic cognitive consequences, focusing infants' attention on commonalities as well as distinctions among objects (Balaban & Waxman, 1997; Waxman & Booth, in press; Xu, 1999). Second, it cannot account for the fact that shape-based similarities do not fully represent the commonalities underlying noun extension. On the contrary, if two objects look alike (say, by virtue of shape), then adults and children expect these will also share other, perhaps deeper, perhaps non-perceptual commonalities as well (Baldwin et al., 1993; Gelman, 1996; Gentner & Namy, 1999). In addition, even when objects are perceptually dissimilar (also see Gelman, 1988; Waxman & Booth, in press; as in superordinate-level sets in Waxman & Markow, 1995), if these objects share a common label, then children and adults expect that these objects also share other, perhaps deeper, non-perceptual commonalities. It is clear that for both adults and children, the extension of novel nouns rests upon more than shape-based similarities alone (Gelman & Medin, 1993; Gentner & Waxman, 1994; Soja et al., 1991; Soja et al., 1992; Waxman & Braig, 1996; Waxman & Markow, 1995). Yet the noun-shape account cannot specify how the learner moves from primarily shape-based extensions to those that capture additional, perhaps deeper, properties.

In contrast, the noun-category position ascribes a more central role to development. The central claim is that words serve as a catalyst for object categorization and for change. On this account, grouping objects together on the basis of shape can serve as one entry point (and perhaps an especially important entry point for simple artifacts in particular,

see below). Naming promotes the discovery of additional, perhaps deeper, commonalities than those that might have formed the initial basis of the word's extension. Thus, the noun-category position incorporates a developmental mechanism that motivates learners to discover these powerful, additional commonalities among objects (Gelman & Medin, 1993; Gentner & Waxman, 1994; Waxman & Braig, 1996; Waxman & Markow, 1995). Another advantage is that this mechanism provides for continuity over development, with infants and adults attending to both perceptual and conceptual relations among objects in the context of word learning.

Models of word extension. The noun-shape and noun-category positions instantiate different models of word extension. The noun-shape position is essentially a univariate model. Univariate models can pit one predictor (e.g., shape) against another (e.g., texture, size, function, animacy cues). And indeed, most work on the shape bias follows just this strategy: pitting object shape, texture, and size against each another in a binary fashion. But it is clear that the interactions among these predictors are crucial. A univariate model cannot capture these interactions or the complexity underlying word meaning and its evolution.

The noun-category position takes into account multiple indices, including (but not limited to) shape. It can accommodate the fact that the relative weights associated with each predictor will vary as a function of ontological kind. For example, although shape may be weighed heavily in some categorization judgments (e.g., judgments of simple artifacts), it carries less weight in others (e.g., judgments of animate objects). This position can also accommodate the fact that shape may receive greater emphasis early in development, but its relative importance may wane as infants and young children discover the additional commonalities underlying categorization and word extension (Imai, Gentner, & Uchida, 1994). A multivariate approach articulates well with current work documenting the contribution of many perceptual and conceptual factors in object categorization, naming, and induction (Medin & Heit, in press).

In sum, the noun-category position offers a more comprehensive account. It ensures that categorization in humans is a flexible and ongoing process. We continually incorporate new, perhaps deeper, information about commonalities within our existing categories; we also admit new instances into existing categories. These evolutions are, at least in part, an effect of naming. The complexities of objects (artifacts and natural kinds) and languages in the real world require that we attend to more than shape alone if we are to develop words and categories for the objects with which we daily do commerce.

Conclusions

The goal of this chapter has been to articulate a developmental account of the powerful relation between word-learning and conceptual organization. We proposed that (1) infants begin the task of word-learning equipped with a broad, initial, and universally available expectation linking novel words (independent of their grammatical form) to a wide range of commonalities among named objects, and that (2) 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 (Waxman, 1999b; Waxman & Booth, 2000a; Waxman & Markow, 1995).

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. The power of adopting this integrative approach to questions of acquisition has been recognized across disciplines. It can be seen in the elegant work of Marler (1991) on the acquisition of birdsong, of Held and Hein (1963) on the acquisition of depth perception in kittens, of Baillargeon (1993) and Spelke (1993) on the acquisition of physical knowledge about objects in human infants, and of R. Gelman (1991) on the acquisition of number concepts. Although each of these research programs considers very different domains of knowledge, they are all committed to considering carefully the relative contributions of both (a) the amount and type of information present in the environment, and (b) the structure or constraints imposed by the learner when characterizing the rapid acquisition of complex, sophisticated systems. (See Gallistel, Brown, Carey, Gelman, & Keil, 1991 for an extended discussion of this topic.)

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 and training (Cole, Gay, Glick, & Sharp, 1971; Laboratory of Comparative Human Cognition, 1983).

We have offered a proposal in which 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 for innate knowledge. Neither is it a polarized argument that locates the engine of acquisition solely within the mind of the child. Rather, these are constraints (Gelman & Williams, 1999) that direct the infant's attention toward precisely the sort of information and regularities in the environment that will make possible the rapid acquisition of complex systems of knowledge, including the acquisition of word-meaning and object categories. In our view, infants across the world's languages begin the process of word-learning equipped with the same, initially general expectation linking words to commonalities among named objects. At the same time, 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.

Notice also that our proposal is a dynamic one: We have argued that 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, the infants'

expectations regarding the specific relations between word meaning and conceptual organization themselves evolve over the course of development in accordance with the observed regularities in the language under acquisition.

Notes

1. Note, that this was, in fact, Keller's second language. She had begun to acquire English before becoming deaf and blind.
2. We suspect that infants' discovery of grammatical form is aided by cues that are perceptually available in the input. For instance, we suspect that infants will notice which words tend to be stressed or inflected, which tend to be preceded consistently by (unstressed) closed class words, which tend to occur in particular positions (initial, final) within phrases, etc. These cues, which are perceptually available in the input, are also integral cues to grammatical form.
3. This question itself hinges on there being a psychological distinction between object categories and object properties. Recent approaches in cognitive psychology distinguish object categories (sometimes known as *kinds* or *sortals*) from other types of groupings (e.g., *pink things*, *things to pull from a burning house*) on at least three (related) grounds: object categories (1) are richly structured, (2) capture many commonalities, including deep, non-obvious relations among properties (as opposed to isolated properties), and (3) serve as the basis for induction (Barsalou, 1983; Gelman & Medin, 1993; Kalish & Gelman, 1992; Macnamara, 1994; Medin & Heit, in press; Murphy & Medin, 1985). Although infants and children lack detailed knowledge about most object categories, they clearly expect named object categories to serve these functions (Gelman, 1996; Keil, 1994). In addition, there is now evidence for a psychological distinction between individual properties and relations among properties in infancy (Bhatt & Rovee-Collier, 1997; Younger & Cohen, 1986). We selected color and texture because these properties are perceptually salient to infants, and because these property-based commonalities typically do not underlie object categories. We suspect that an object's shape is more centrally related to category membership, particularly for simple artifacts and for animate objects (Waxman & Braig, 1996).