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CHAPTER 4

Constraining the Problem Space in Early Word Learning

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Quine's famous (1960) "gavagai" example—in which a linguist sees a native point to a rabbit and hears the native say, "Gavagai" just as the rabbit runs by—is well worn in discussions of word learning by now, but it is still apt. Given a new word produced by a speaker in a real-world context, even assuming that the word refers to something in the immediate environment, there are, in principle, indefinitely many ways in which the word could be interpreted. A challenge facing learners, then, is to limit the range of hypotheses to be considered. In this respect, word learning is not unique. Constraining the problem space is a ubiquitous need in acts of cognition. Given the rich array of information available in the world, thinkers need to select elements that are most relevant to the task at hand. This basic problem has been investigated for a wide range of cognitive abilities, including finding solutions to problems (e.g., Holyoak, 1995), deciding which features are central to members of a category (e.g., Medin & Wattenmaker, 1987), and making attributions about the causes of human behavior and other events (e.g., Ahn, Kalish, Medin, & Gelman, 1995; Schwarz, 1995). Multiple sources of constraint contribute to people's success at solving these problems. Knowledge within a domain, properties of human memory and learning, properties of the task, and heuristics are among the many factors that have been found to constrain reasoning.

Like other complex cognitive problems, word learning is multiply constrained. By the time children reach preschool age, they have a well-equipped arsenal to help them narrow the hypothesis space in word learning. For one, children bring to bear their knowledge about language, speakers, and the world. To narrow the range of hypotheses that they consider in word learning, they use the syntactic structure of the sentence surrounding a new word, morphological cues, the meanings of the other words in the sentence, their knowledge about pragmatics, and their knowledge about kinds of objects and events. In addition, children's word learning is constrained by a set of default assumptions that lead them to consider some possible word-referent mappings before they consider others. In preschool-aged children, these sources of constraint interact. No sin-

gle factor can account for the word-learning success of young children. It is much more likely that each act of learning reflects the interaction of multiple constraints (see chapter 1 in this volume and Woodward & Markman, 1998, for elaborations of this view).

Our goal in this book—to ask how word learning begins—leads us to focus on 1- and 2-year-olds. The 2nd year of life is a time of salient transitions in language development. Babies produce their first words at about 12 months of age, but they generally do not develop large productive repertoires until the vocabulary spurt that often occurs at 18 to 24 months of age. To illustrate, Fenson and his colleagues (1994) found that the productive vocabularies of babies from 12 to 16 months of age grew slowly, with median scores increasing from just under 10 words to 40 words. By 24 months of age, babies produced about 300 words. Based on this evidence it could be concluded that word learning begins in earnest in the second half of the 2nd year of life.

However, if comprehension instead of production is used as an index of learning, word learning seems to be progressing at a good clip long before this time. There are two kinds of evidence for this view: First, observations of babies in everyday contexts have long indicated that by 12 months of age, babies respond appropriately to many of the words they hear (Benedict, 1979; Fenson et al., 1994; Huttenlocher, 1974). Fenson and his colleagues report parental estimates showing that babies understand between 50 and 100 words at 12 months, an age when they produce fewer than 10 words. Second, by 13 months of age, babies can acquire a new word in comprehension based on relatively brief exposure. In an experiment investigating this ability, my collaborators and I introduced 13- and 18-month-old infants to a novel word as the name for a novel object (Woodward, Markman, & Fitzsimmons, 1994). We called the baby's attention to the object and then labeled it nine times. Following training, we tested comprehension of the word using a multiple-choice procedure. Because we embedded the training and testing procedures in naturalistic interaction, there was a concern that the experimenter could inadvertently influence the baby's performance—for example, by creating a preference for the labeled object during training or by giving subtle cues during testing. To guard against the first possibility, we introduced a distracter item during training and then assessed babies' preferences for the target versus the distracter item on preference control trials. These control trials never revealed a preference for the object that had been labeled during training. To guard against the second possibility, we used different experimenters to administer the training and testing procedures. The tester did not know which object had been assigned as the target for any given baby. The results of several studies indicated that when the testing conditions were not demanding, babies at both ages chose the correct object at rates greater than chance. We then tested another group of 13-month-olds, this time imposing a 24-hour delay between training and testing. Babies once again chose

the target object at above-chance rates. This early rapid word learning has been replicated using similar procedures (Woodward & Hoyne, 1999), and other researchers have reported similar findings using different procedures (Bird & Chapman, 1998; Schafer & Plunkett, 1998; Stager & Werker, 1997; Werker, Cohen, Lloyd, Casasolo, & Stager, 1998).

Thus, even the youngest word learners do not seem to ponder all of the possible interpretations of a new word. Instead, even in unfamiliar experimental contexts, babies arrive at an interpretation of a new word relatively quickly. In this chapter I will consider how this process occurs. Given the multiple constraints at work for older word learners, my goal is to explore the range of constraints that may be at work for babies. In the last 5–10 years, there has been an explosion in research on early word learning. Although the literature provides many pieces of the puzzle, important gaps remain. Several assumptions frame my review of the current literature. First, I assume that babies, like older children, are active learners who draw on the sources of constraint that are available to them in learning. These may include both knowledge-based constraints and default assumptions. Second, I assume that babies know less about people, language, and the world than older learners do. Thus, a critical question is how and when babies acquire the breadth of knowledge that constrains word learning in older children. Third, I assume that the default assumptions evident in older children have a developmental history and that these assumptions may therefore be undergoing change in the youngest word learners. Thus, it is also critical to ask when and how these constraints develop. In short, I consider the possible sources of constraint that babies have when they first learn words, how these differ from those of older learners, and where they come from. I begin with a review of the evidence for default assumptions in very early word learning.

DEFAULT ASSUMPTIONS

By the time children are in preschool, they have acquired a set of default assumptions that lead them to favor some interpretations of new words over others. In particular, children assume that new words name objects as wholes rather than as their parts or properties (this is the whole-object assumption or principle of object scope; see Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1989), that novel names extend to members of a kind (this is the taxonomic assumption, noun-category bias, or principle of categorical scope; see (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1989; Markman & Hutchinson, 1984; Waxman, 1991, 1994), and that objects have only one category label (this is the mutual-exclusivity assumption; see Markman, 1989; Markman & Wachtel, 1988; Merriman & Bowman, 1989; for related formulations, see E. V. Clark,

1987, 1993; Mervis & Bertrand, 1994; Mervis, Golinkoff, & Bertrand, 1994). These assumptions operate as defaults—given counterevidence, they can be overridden (Markman, 1989, 1992; Merriman & Bowman; Woodward & Markman, 1991). Strong evidence for these assumptions in children and adults comes from many different laboratories (for reviews, see Golinkoff, Mervis, & Hirsh-Pasek; Markman, 1989; Merriman & Bowman; Woodward & Markman, 1998).

That these constraints are distinct from other sources of constraint is evident in their interactions with them. To illustrate, the social context of sharing attention on a set of objects is not sufficient to lead children to focus on categories of objects rather than on other aspects of the situation. If the objects are pictures of two dogs and a bone, for example, young children are likely to focus on the thematic relation between the dogs and the bone. Introducing a new label shifts children's attention to object categories. Given a new label, such as "dax," in reference to one of the dogs, preschoolers extend "dax" to the other dog and not to the bone (Markman & Hutchinson, 1984). Even a seemingly clear pragmatic act, pointing at an object while uttering a novel word, is interpreted differently by children based on their default assumptions. To illustrate, Markman and Wachtel (1988) introduced children to novel substance terms, for example, pointing to an object and saying, "See this? It's chrome." When the referent object was unfamiliar, such as a pair of tongs, children ignored grammatical form class and interpreted "chrome" as the name for the object as a whole. When the object was familiar, such as a cup, children honored the mutual-exclusivity assumption, concluding that "chrome" was not a second name for the object as a whole. Hall, Waxman, and Hurwitz (1993) found that in the latter situation, preschool-aged children were likely to interpret "chrome" as a property term.

In recent years, there has been active debate about how best to characterize these assumptions. One level of argument concerns their exact definition. Is it more accurate to describe children's word learning as being guided by a taxonomic assumption (Markman, 1989; Markman & Hutchinson, 1984) or by a noun-category bias (Waxman, 1991, 1994)? Is mutual exclusivity (Markman, 1989; Markman & Wachtel, 1988; Merriman & Bowman, 1989) the correct formulation; or do children instead have a novel-name nameless-category assumption (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Mervis & Bertrand, 1994), a bias to fill lexical gaps (E. V. Clark, 1993; Merriman & Bowman, 1989), or the principle of contrast (E. V. Clark, 1987, 1993)? Clarifying these issues is important for understanding the nature of these constraints. To some extent, the correct formulation may be a function of the age of the learner. For example, the noun-category bias formulation seems to work well for preschool-aged children, who often (but not always) attend to form class when deciding how to extend a word, but it works less well for very young word learners who seem not

to distinguish between nouns and other classes of words (Waxman & Markow, 1995).

A second level of debate concerns the source of these assumptions. Some researchers have proposed that the assumptions emerge from basic properties of human cognition (Gentner, 1982; Gentner & Boroditsky, in press; Imai & Gentner, 1997; Markman, 1989, 1992). Other theorists have proposed that one or more of these assumptions are based on the child's knowledge about statistical regularities in parental speech. These issues come to the fore when considering word learning in its earliest stages. Are these default assumptions evident in very early word learning, and, if so, which account of their origins is most accurate?

Links between Words and Objects

Preschool-aged children have a well-documented propensity to interpret novel words as the name for an object as a whole rather than for one of its parts or properties (e.g., Golinkoff, Mervis, & Pasek, 1994; Hall, Waxman, & Hurwitz, 1993; Imai & Gentner, 1997; Landau, Smith, & Jones, 1988; Markman, 1989; Markman & Wachtel, 1988). This bias is strong enough that children often misinterpret property terms as object labels, even when there are syntactic cues indicating that the word is not a noun (Hall, 1991; Markman & Wachtel). Two-year-olds also have this propensity. When an experimenter shows 2-year-olds a new object and tells them, "This is my dax," for example, the children extend the name "dax" to objects of the same kind as the original but not to objects made of the same substance (Imai & Gentner, 1997; Soja, Carey, & Spelke, 1991) or to parts of the object (Kobayashi, 1998; Markman & Wasow, described in Woodward & Markman, 1998; Mervis, Golinkoff, & Bertrand, 1994). Like older children, 2-year-olds often interpret a novel word as an object label even when they are given form-class cues indicating that the word is a mass or property term—for example, when the experimenter says, "This is some dax" or "This is a daxish one" (Hall, Waxman, & Hurwitz, 1993; Soja, 1992). Markman (1989, 1992) proposed that the link between words and whole objects may be privileged because object categories are conceptually richer than are part or property categories and because children tend to process new stimuli holistically rather than analytically.

In addition to a bias to interpret names for entities at a particular level of analysis—objects as wholes rather than their parts or properties—there may be a second kind of object assumption at work in early word learning: the bias to interpret new words as object labels rather than as terms for other aspects of a situation, such as relations or actions. This possibility derives from observations made by Gentner (1982; Gentner & Boroditsky, in press), who proposed that object concepts are more cohesive than are relational concepts and objects

are more readily extracted as perceptual units than are actions. That is, object-sized units are "natural partitions" of information. As evidence for this proposal, Gentner has presented studies of adults' memory for nouns and verbs as well as crosslinguistic analyses of lexicalization patterns for object and action terms. The prediction that follows from these observations is that, because word learning requires mapping linguistic units onto conceptual units, this mapping should occur most easily when the conceptual units are readily extracted and conceptually cohesive—that is, for object terms.

This prediction has generated a lot of heat. Several researchers have been quick to point out that, from the first, babies acquire words for actions, properties, and routines as well as for objects (Bloom, Tinker, & Margulis, 1993; Nelson, Hampson, & Shaw, 1993; Tomasello, 1995). However, the product of learning, the end-state lexicon, may not perfectly reflect the processes by which learning occurred (Woodward & Markman, 1991, 1998). If the object bias is a default assumption, given additional evidence such as pragmatic or syntactic cues, babies may well acquire many nonobject terms. A better source of evidence for or against word-learning assumptions would come from studies of the process of learning. If they exist, default assumptions should be evident in babies' first approaches to new words.

Only a few studies have taken this approach in testing the natural-partitions hypothesis. In one, Schwartz and Leonard (1984) provided 1- to 1½-year-olds with extensive exposure to eight new object labels and eight new action words and then assessed how readily babies learned the words. Based on production, babies learned more object words than action words. A different approach is to tap babies' interpretations of new words in ambiguous contexts, in which the word might name an action or an object. Several researchers report anecdotes indicating that, in ambiguous labeling contexts, 1-year-olds sometimes misinterpret new words as object labels—for example, interpreting the word "hot" as the name for a coffee mug (e.g., Macnamara, 1982; Waxman, 1991). Two preliminary studies have taken an experimental approach to this question. Echols (1991) introduced 14-month-olds to novel objects undergoing distinct kinds of motion in a habituation paradigm. She found that when babies heard words, it drew their attention to the identity of the object rather than to the kind of motion that the object underwent. In a study with 18- and 24-month-olds, I tested whether hearing a new label would lead babies to attend more to objects or to salient entities that were not objects (Woodward, 1993). Babies saw two video displays presented simultaneously, one showing an object and the other showing a substance undergoing motion (e.g., blue dye diffusion through water). In order to test whether labels enhance attention to what babies are already interested in or promote attention specifically to objects, I designed the substance displays to be more interesting than the objects. Overall, infants preferred to watch the substance displays. When they heard a new label, however,

18-month-olds shifted attention to the object, looking for a longer time at the object on these trials than they did when there was speech but no new label. Twenty-four-month-olds did not show this time difference, but their production of the novel words suggested that they had linked them with the object displays.

In sum, there is evidence for two kinds of object assumption in the word learning of 1- and 2-year-olds. However, there are important gaps in the empirical record. The "objects as wholes" assumption has not been investigated in babies under age 2; on the other hand, evidence for the natural-partitions hypothesis has come mainly from babies under age 2. In addition, for each of these assumptions, the developmental process by which novel words come to draw attention to objects is not known. The findings of my (1993) study indicate that by the time babies reach 18 months of age, novel words per se focus infants' attention on objects. Echols's (1991) work with 14-month-olds contrasted labeling utterances with no speech. Thus, it is possible that, initially, any speech draws infants' attention to objects. Echols found a developmental difference in the effects of speech: For 9-month-olds, speech drew attention to elements that were constant across trials, for both objects and motions. For 14-month-olds, however, speech drew attention to objects even when motion was constant across trials and objects were not. Further research is required to confirm and extend these findings.

The question of developmental origins has been considered from another vantage point. As described so far, the object assumption has been conceptualized as being a product of basic aspects of human cognition: Babies interpret words as naming objects as wholes because this level of analysis is most readily apparent to them and because this level of analysis provides a rich packaging of information (Markman, 1989, 1992); babies interpret words as naming objects rather than actions or relations because objects are more coherent perceptual and conceptual units (Gentner, 1982). An alternative has been suggested: The whole-object assumption is a strategy acquired based on probabilistic regularities in parental speech, in particular in middle-class American parental speech that stresses nouns over other classes of words (Gathercole & Min, 1997; Gopnik & Choi, 1995; Tardif, 1996; cf. chapter 3 in this volume). This suggestion was the impetus behind a number of crosslinguistic studies of parents' speech and babies' early vocabulary growth. The studies explored languages such as Japanese and Korean, because these languages have several features that might lead to a lesser emphasis on nouns in parental speech. For one, these languages are verb final, and the final position in an utterance has been argued to be salient to language learners. In addition, these languages allow for nominal ellipsis—that is, leaving out nouns that are part of the shared communicative context. The first question is whether these linguistic differences lead to parental speech that stresses object terms less than does parental speech in middle-class American homes. The answer seems

to be yes (Au, Dapretto, & Song, 1994; Fernald & Morikawa, 1993; Gopnik & Choi, 1995; Tardif, 1996).

This observation leads to the question of whether these differences in parental speech lead to different kinds of word-learning biases in babies. The studies provide remarkably mixed answers to this question. As a proxy for measuring the object bias, most researchers have used babies' productive lexicons, asking how many nouns or object labels as compared to other word types babies produce. Some researchers report that babies from different language communities do not differ in the proportion of nouns in their productive lexicons and that babies are noun-dominant across languages (Au, Dapretto, & Song, 1994; Caselli et al., 1995; Fernald & Morikawa, 1993; Gentner & Boroditsky, in press). However, others report that babies acquiring languages such as Korean or Mandarin have fewer nouns or object labels in production than do babies acquiring English (Gopnik & Choi, 1995; Tardif, 1996). Gentner and Boroditsky note that this difference in findings corresponds to a difference in methodology: studies reporting a noun advantage across languages use checklists to assess vocabulary, whereas studies reporting fewer nouns in some languages sample babies' speech from taped naturalistic interactions. There are reasons to believe that both methods are biased (see Gentner & Boroditsky for a discussion).

This methodological problem aside, there is a deeper problem in interpreting these findings vis-à-vis the object bias. As I argued earlier, a child's end-state lexicon may be an unreliable index of the process by which learning occurred. For this reason, using babies' productive lexicons as a proxy for word-learning biases is a flawed approach. Clearer evidence would come from crosslinguistic studies in which babies' interpretations of ambiguous terms were assessed. Imai and Gentner (1997) conducted such a study with English and Japanese speakers ranging in age from 2 years to adulthood. They drew on Soja, Carey, & Spelke's (1991) methodology to ask whether people would interpret a new word as naming an object as a whole or naming the substance of which the object was made. For complex objects (e.g., a citrus reamer) and nonsolid substances (e.g., hand lotion), Japanese and English speakers agreed. Even the 2-year-olds construed the new words as naming objects for the former and substances for the latter. The two groups differed, however, in how they treated simple solid objects (e.g., a kidney-shaped piece of wax). For these, English speakers extended the new word to items with the same overall shape, that is to objects of like kind. Japanese speakers, in contrast, were agnostic—they interpreted the term as naming the substance half the time and the object half the time (see Gathercole & Min, 1997, for similar evidence from Korean-speaking children). Imai and Gentner proposed that there is a continuum of individuation. Some entities (people and complex objects) stand out as salient units, and others (nonsolid substances) do not. Items such as chunks of wax fall somewhere between these two. Thus, there is evidence for both crosslinguistic similarity in and language-specific influences on word learning. For highly individuable entities, speakers of dissimilar languages agree that names refer to objects as wholes. This evidence is consistent with the conclusion that the object bias derives from properties of cognition that do not vary across language groups. However, there is room for language experience to influence interpretations of new words, specifically for items in the middle of the continuum.

Extending Names to Members of a Kind

In many learning contexts, babies generalize to whole situations. After visiting the doctor for a vaccination, for example, a baby may fear anything that reminds him or her of that visit, including not only hypodermic needles but also waiting rooms, people wearing white clothing, and stethoscopes. Even in the realm of communication, generalization to thematic associates may occur. Petitto (1988) described infants' prelinguistic gestures as sometimes extending to thematically related items; for example, some babies used the same gesture to communicate about jars and the act of opening jars. Babies also notice taxonomic relations in and out of word-learning contexts (Mandler & McDonough, 1993; Oakes, Madole, & Cohen, 1991; Quinn, 1987; Waxman & Markow, 1995). For word learning, of course, it is critical to attend to taxonomic relations. Names for objects and actions extend to members of a kind, not to thematic associates.

Early theories of language acquisition proposed that babies' first words were "complexive" in nature—that they were associated with whole situations rather than with a particular class of referents (Piaget, 1962; Vygotsky, 1962). According to these accounts, a child's use of a word such as "cookie" might extend to cookies; objects shaped like cookies; and items associated with cookies, such as cookie jars, kitchens, and grandmothers. Huttenlocher and Smiley (1987) analyzed the spontaneous word use of 1- to 2-year-olds to see whether this was the case. They found that babies' use of object labels was almost always an extension to items within a basic level or superordinate category. When babies used a noun in the absence of an appropriate referent, there were clear indications that they were requesting absent objects or commenting on relationships between objects rather than extending the word thematically.

Waxman and Hall (1993) explored babies' novel-name extensions in an experimental context. They introduced 16-month-olds to triads in which two items were taxonomically related and two were thematically related—for example, a cup, another cup, and a doll. Babies were introduced to both the taxonomic relation (the two cups) and the thematic relation (that the doll could "drink" from the cup). After this introduction, in one condition, the experimenter labeled the first cup, saying, "This is a dax." Then the experimenter showed the baby the other cup and the doll and asked the baby to find another dax. In the control condition, the experimenter showed the baby the first cup

and then the other cup and the doll and instructed him or her to "find another one." Babies who heard a new label selected the taxonomic match most of the time. In contrast, in the absence of a label, babies selected the taxonomic match only about half of the time (see also Markman, 1994, for further evidence from 1-year-olds, and Waxman & Kosowski, 1990, for evidence from 2-year-olds). Thus, in a receptive word-learning task as well as in their uses of nouns, 1-year-olds, like older children, do not interpret new terms as extending to thematically related items. Moreover, Hall (1991) found that, as is the case for the whole-object assumption, 2-year-olds sometimes overlook form-class cues in interpreting a novel term as a category label. When babies were introduced to a novel stuffed animal and told, "This is Zav," they extended "Zav" to other animals, treating it as a common noun rather than as a proper noun. Babies even produced "zav" as a count noun, saying, for example, "There are two zavs."

Words highlight categorical relations for babies still earlier, at 12 months of age. Waxman and Markow (1995) found that novel words directed babies' attention to categorical relations that they would not otherwise notice. When experimenters gave babies members of a basic-level category to play with, one after the other (e.g., a red toy car, a blue toy car, etc.), babies habituated to the category, exploring later items for a shorter time than they explored prior ones. Then, when babies were shown an out-of-category member such as an airplane they dishabituated, attending to this object for a longer time. Waxman and Markow found that 12-month-olds did not habituate spontaneously for superordinate sets. However, when the experimenter labeled each object as she handed it to the baby, babies habituated to items of the same category and dishabituated to items from outside the category. This occurred only when the items were members of the same category. When infants were handed random objects (e.g., a dinosaur, a clown, and a pipe), labeling did not lead to "categorization." Moreover, it was the presence of a novel word per se that led babies to categorize. When there were no labels, the experimenter talked about the toys and engaged in joint attention with the baby, and these behaviors alone did not boost categorization.

By the time a child reaches 12 months of age, then, the effect of new words can be distinguished from general effects of speech and social engagement. The former, but not the latter, leads babies to pay special attention to categorical relations. Even so, speech sounds are affectively charged from the beginning of life, and speech may serve to regulate infants' attention (Baldwin & Markman, 1989; Fernald, 1992). The specific link between words and categories that is evident in 12-month-olds may emerge, in part, from this more general effect of speech on infants' attention. In keeping with this possibility, Balaban and Waxman (1997) reported that, for 9-month-olds, speech sounds in general, rather than novel words per se, enhance attention to stimuli in a categorization task. Balaban and Waxman familiarized infants with pictures of items from

within a basic-level kind (e.g., dinosaurs) and then showed them a new exemplar of that category or an item from another category (e.g., a bird). When the pictures were accompanied by recorded words or by recorded speech that had been low-pass filtered so that no individual words were identifiable, infants showed more attention to the item from the new category than they did when the pictures were accompanied by recorded tones (but see Roberts & Jacob, 1991).

Markman (1992) proposed that the specific link between words and taxonomic categories is related to using taxonomic relations as a basis for inductive inference. Just as babies assume that items of like kind share important properties (Baldwin, Markman, & Melartin, 1993; Gelman & Coley, 1991), they may also assume that items of like kind have the same name. Under this account, babies' appreciation of the link between words and categories would be dependent on their prelinguistic category knowledge. In contrast, Smith (see chapter 3 in this volume) has suggested that infants learn to extend labels to items with the same overall shape (and thus, generally, of the same kind) based on regularities in parents' speech. If this is correct, then babies bring little if any category knowledge to word learning. There are many unresolved questions about the state of category knowledge in infants. Nevertheless, it is clear that prelinguistic infants form categories for both unfamiliar and familiar objects (Mandler & McDonough, 1993; Quinn, 1987; Quinn, Eimas, & Rosenkrantz, 1993). Moreover, Mandler and her colleagues have argued that prelinguistic infants' categories are not based only on perceptual regularities; they also reflect knowledge about important conceptual distinctions (e.g., Mandler & McDonough, 1993, 1996). This knowledge provides a basis for inductive projection (Mandler & McDonough, 1996) and could also provide a basis for extending newly learned words.

Mutual Exclusivity

Preschool-aged children have the default assumption that items will have only one name (Markman, 1989; Markman & Wachtel, 1988; Merriman & Bowman, 1989). This mutual-exclusivity assumption could contribute to word learning in several ways. For one, it could make word learning harder when the child encounters a second name for an item with a known name. In this case, mutual exclusivity might lead children to reject the second label. Merriman and Bowman called this the "rejection effect." In other situations, mutual exclusivity could facilitate word learning. It could help the learner to rule out familiar objects in the case where a novel object is named. Merriman and Bowman called this the "disambiguation effect." It could also help to override the whole-object assumption in learning a part or property term. Moreover, if the child erroneously overextended a new term—for example, calling sheep "goats,"

mutual exclusivity could lead him or her to correct the extension of the term "goat" once "sheep" was learned. This is an example of two effects described by Merriman and Bowman: the "restriction" effect (the extension of "goat" has been restricted) and the "correction" effect (for sheep, the correct term has been substituted for "goat"). In different contexts, all of these effects appear in preschool-aged children (e.g., see Markman & Wachtel; Merriman & Bowman). Investigations of mutual exclusivity in 1- and 2-year-olds vary in terms of which of the effects they explore.

A number of studies provide evidence for disambiguation in 1½- and 2-year-olds. When experimenters present babies with a familiar object (e.g., a spoon) and an unfamiliar object (e.g., a honey dipper) and ask them about a novel label (e.g., "Can you get the dax?"), babies select the novel object (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Merriman & Marazita, 1995; Mervis & Bertrand, 1994). Several researchers have pointed out that the disambiguation effect could result from biases other than mutual exclusivity. If babies had a bias to fill lexical gaps (E. V. Clark, 1987, 1993; Merriman & Bowman, 1989), then they would also select the unfamiliar object as the referent of the new word. Another possible constraint on word learning, the novel-name nameless-category principle (Golinkoff, Mervis, & Hirsh-Pasek, 1994), which would lead children to link new names with object categories for which they have no name, could also explain the disambiguation effect. A different procedure, such as the one used in a study reported by Markman (1994; see also Woodward & Markman, 1998), is necessary to distinguish between these possibilities. Experimenters gave 16- and 19-month-olds a familiar object (e.g., a spoon). Then they asked babies to "Get the mido." Babies responded by looking around for another object, apparently not considering the spoon to be a possible "mido." Since there was no novel object in the situation, there was not a lexical gap or nameless category. Rather, babies assumed that the familiar item was not also called a "mido."

While this is an example of infants attempting to disambiguate, it is also an example of infants rejecting the spoon as a likely referent for "mido." Rejection of new labels given in reference to items with known names has also been tested by assessing babies' propensity to accept second labels. Two-year-olds can learn multiple category labels for the same item, seeming to interpret the words as synonyms, overlapping terms, or hierarchically related terms (Banigan & Mervis, 1988; E. V. Clark, 1997; Mervis, Golinkoff & Bertrand, 1994; Waxman & Senghas, 1992). This fact has been taken as evidence against mutual exclusivity (e.g., E. V. Clark, 1993, 1997; Golinkoff, Mervis, & Hirsh-Pasek, 1994; Mervis, Golinkoff, & Bertrand). However, Liittschwager and Markman (1994) pointed out that the critical question is whether second labels are harder to learn than first labels. Because mutual exclusivity is proposed to

be a default assumption, learners will be able to acquire terms that violate it. Like other default assumptions, mutual exclusivity should be evident in the process of word learning. Liittschwager and Markman tested this by attempting to teach 16- and 24-month-olds first versus second labels. In one condition, they introduced babies to a novel label for an object that was unfamiliar (e.g., a honey dipper). In this case the novel name was a first label. In a second condition, they introduced a novel label for an object for which babies would have a familiar name (e.g., a toy unicorn that babies would call a "horse"). In this case, the novel name was a second label. Babies' comprehension of the new labels was assessed by a multiple-choice procedure. The 16-month-olds learned the first labels but not the second labels. In contrast, the 24-month-olds learned both the first and the second labels. Liittschwager and Markman reasoned that the context of labeling provided evidence that might run counter to mutual exclusivity (the experimenter clearly indicated the toy while labeling) and that 24-month-olds might be able to draw on this evidence to override the default assumption. If so, then increasing the demands of the learning task might make it harder for 24-month-olds to override mutual exclusivity. With this in mind, Liittschwager and Markman next introduced 24-month-olds to two new first or second labels rather than to one. In this case, the 24-month-olds learned the first labels but not the second labels. Thus, although 24-month-olds were able to learn second labels when the task was not demanding, for both 16- and 24-month-olds, learning second labels was harder than learning first labels.

If babies had the mutual-exclusivity assumption, then they might respond to certain instances of second-label learning by restricting or correcting the meanings of previously learned words (see Merriman & Bowman, 1989, for a discussion of the conditions under which children will respond to a new word by restricting an old term versus by rejecting the new term). Merriman and Stevenson (1997) investigated this effect in 24-month-olds. They showed babies sets containing a typical familiar item (e.g., a car), two atypical items from the category, and one item from outside the category (e.g,. a bicycle). In the context of a storybook, one of the atypical items was given a novel name—for example, "jegger." Then Merriman and Stevenson showed babies the full set of items and asked them to identify all the cars and all the jeggers. The question was whether hearing the first atypical car called a "jegger" would decrease babies' likelihood of identifying that item as a "car." This is what Merriman and Stevenson found. Compared to the other atypical car, babies were less likely to select the jegger when asked to indicate all the cars. Thus, accepting the new word led babies to restrict the range of the familiar term "car."

In summary, recent studies provide evidence for several effects of mutual exclusivity in the word learning of babies 2 years of age and younger. As orig-

inally formulated by Markman (1989; Markman & Wachtel, 1988), mutual exclusivity pertains to object labels; however, other researchers have suggested that learners may assume mutual exclusivity within other semantic domains—for example, for verbs and spatial terms (Merriman, Evey-Burkey, Marazita, & Jarvis, 196; Regier, 1997; cf. Golinkoff, Hirsh-Pasek, Mervis, Frawley, & Parillo, 1995). Markman (1992) noted that mutual exclusivity is similar to a number of other phenomena including the one-to-one principle, the essentialist bias in categorization, and blocking and overshadowing in classical conditioning. Based on this observation, she suggested that mutual exclusivity may be a particular case of a more general tendency to systematize information in learning. In an alternative formulation, E. V. Clark (1987, 1993) has stressed the role of pragmatic and linguistic knowledge in children's resistance to multiple labels for the same object. In the section "Knowledge-Based Constraints," I consider these factors.

Conclusion

There is a good deal of evidence for the whole-object, taxonomic, and mutual-exclusivity assumptions in 2-year-old word learners. The evidence in children under age 2 is less plentiful. Nevertheless, there are strong indications that 1-year-olds' word learning is constrained by default assumptions such as those at work in older learners. Twelve- to 18-month-olds seek out object-sized units in word learning. Twelve-month-olds respond to new words by attending to taxonomic categories, and even the earliest words that babies produce seem to be category terms. A bit later, by 16 months of age, babies show evidence of mutual exclusivity by rejecting second labels for familiar objects.

Even so, as for older children, these default assumptions are insufficient to account for the full range of words that are learned from the start of vocabulary acquisition (Bloom, Tinker, & Margulis, 1993; Nelson, 1988; Nelson, Hampson, & Shaw, 1993). From the first, babies acquire words other than object labels (e.g., event terms, social greetings, and spatial terms), words that do not extend to members of a category (e.g., proper nouns and performatives such as "peekaboo," and multiple labels for the same object (Banigan & Mervis, 1988; E. V. Clark, 1997; Mervis, Golinkoff, & Bertrand, 1994; Waxman & Senghas, 1992). In older learners, the child's knowledge about language and language users provides a strong source of constraint in word learning. This knowledge can help to explain the breadth of older children's vocabularies (e.g., Anglin, 1993). One question, then, is what kinds of knowledge interact with default assumptions in very young word learners? To answer this question, I focus on knowledge that undergoes important developments during a baby's 2nd year of life: knowledge about acts of communication and the language system.

KNOWLEDGE-BASED CONSTRAINTS

Knowledge about Communication

Because, in the word of the infant, words are actions, infants most likely draw on their understanding of human action in making sense of words. For mature language users, interpreting utterances involves understanding intentional action and knowledge states in themselves and in their interlocutors. Adults use behavioral evidence to infer what conversational partners know and what their intentions in using language are; that is, we use folk "theories of mind" in making sense of language acts (E. V. Clark, 1997; H. Clark, 1992; but see Keysar, Barr, & Horton, 1998, for exceptions).

To what extent does this knowledge play a role in early word learning? The work of Akhtar, Tomasello, and Baldwin, among others (for reviews, see chapter 5 in this volume; Baldwin, 1995; Baldwin & Tomasello, 1998; Tomasello, 1995), has documented that, for 18- to 24-month-olds, behavioral cues to referential intent influence children's interpretations of new words. For example, 18-month-olds will learn the link between a new word and a toy when the person who utters the word looks toward the toy and indicates it by pointing but will not do so when such behaviors are absent or when the behaviors specify another object (e.g., Baldwin, 1991; Baldwin et al., 1996; Moore, Angelopoulos, & Bennett, 1999). One issue that has arisen is whether these effects are best characterized as based in the baby's knowledge or the adult's highlighting of objects (Moore, Angelopoulos, & Bennett; Samuelson & Smith, 1998). Much evidence from the work of Akhtar, Tomasello, Baldwin, and others indicates that, by the time babies reach 18 to 24 months of age, highlighting alone is insufficient to explain the role of communicative cues in word learning. Babies' interpretations of novel words seem to be a function neither of simply attending to an object while a word is uttered (Baldwin, 1991; Baldwin, et al.) nor seeing the object or action immediately after hearing a word (Baldwin, 1991; Tomasello & Barton, 1994), and babies can correctly interpret a new word even when they never see the referent during or after the time that word is uttered (Akhtar & Tomasello, 1996). The conclusion supported by these findings is that 18- to 24-month-old babies filter their word learning through their understanding of human action and, more specifically, communication.

It might be tempting to conclude from these findings that by 18–24 months, babies understand communication in much the same way that adults do. However, given the well-documented deficits in preschool-aged children's theories of mind (see, e.g., Astington, Harris, & Olson, 1988) and in the pragmatic skills of toddlers and young children (see Shatz, 1983, for a review), it seems very likely that the knowledge that 18- to 24-month-olds have about communication differs significantly from that of adults. Therefore, it is important to

specify the ways in which toddlers' reasoning is and is not like that of adults (see chapter 5 in this volume; Baldwin & Moses, 1996; Baldwin & Tomasello, 1998; and Moore, Angelopoulos, & Bennett, 1999, for preliminary considerations of this issue). Current evidence suggests two ways in which the knowledge of 18- to 24-month-olds is similar to later knowledge: by this age, babies seem to have precursors to later understandings of intention and attention, both of which are critical to reasoning about communication.

Evidence for the first of these similarities comes from a number of studies. Fourteen-month-olds distinguish between purposeful and apparently accidental actions when imitating: They are more likely to imitate the former than the latter (Carpenter, Akhtar, & Tomasello, 1998). Somewhat older babies, 18-month-olds, can use behavioral cues to infer the goal of a novel action: When they see an actor apparently fail to complete an intended action, babies at this age infer the intended act and imitate it rather than the actual motions of the actor's hands (Meltzoff, 1995). By age 18–24 months, babies use their notions of purposeful action in word learning. Tomasello and Barton (1994) found that 24-month-olds interpreted new verbs as naming acts that are done purposefully rather than those that are portrayed as accidental. Moreover, 18- and 24-month-olds use other behavioral indicators of a satisfied or frustrated intention to inform their interpretation of a new word (Akhtar & Tomasello, 1996; Tomasello & Barton).

Eighteen- to 24-month-olds also seem to understand some aspects of attention. Infants attend the direction of another person's gaze from quite early in life (Scaife & Bruner, 1975), but not until later, at 12–18 months, is there evidence that infants understand something about the role of eyes in perceptual experience (Lempers, Flavell, & Flavell, 1977). The work of Baldwin (1991, 1995) clearly indicates that 18-month-olds understand the relevance of this behavior for language use. Eighteen-month-olds interpret words as naming objects looked at by the speaker, even when baby and speaker attend to different objects. By 2 years of age, babies understand an additional aspect of attention: O'Neill (1996) reported evidence that 2-year-olds have a nascent understanding of the link between seeing and knowing. Babies in her study were more likely to give their mothers detailed information about a recent event if the mothers were out of the room or had their eyes covered during the event than if the mothers had observed it with them. In addition, a study by Akhtar, Carpenter, & Tomasello (1996) suggests that 2-year-olds can go one step further: They keep track of what others have and have not seen and infer that speakers will remark on items that are new to them. In the study, this inference enabled babies to determine which of several objects had been named by an experimenter (but see Samuelson & Smith, 1998, for an alternative interpretation).

A recent study by Moore, Angelopoulos, & Bennett (1999) indicates another

potential development in babies' reasoning about shared attention between the ages of 18 and 24 months. In their study, 18-month-old babies used a speaker's line of regard to determine which of two objects she was referring to. Even when one of the objects moved around and made noise, if the speaker looked at the baby but not at either of the objects, 18-month-olds did not think the new word named the object. In contrast, 24-month-olds assumed that the speaker was referring to the salient object. Older, but not younger babies, therefore, may reason that if there is a very salient item, people nearby will notice it and remark on it. Adults make a similar assumption. At a fireworks display, we do not need to monitor the gaze of our interlocutor to make an intelligent guess about the subject of his or her "oohs" and "aahs."

Does knowledge about communication play a role in word learning at the beginning—that is, for infants between 12 and 18 months of age? Although there has not been nearly as much research at this age as there has been at older ages, two preliminary findings indicate that some form of social knowledge is used by 12- to 13-month-olds when they encounter new words. First, Baldwin and Tomasello (1998) reported a study in which 12-month-olds were introduced to a new word under one of two conditions: In one condition, there was a single novel object in front of the baby. In the other, there were two novel objects. Infants were much more likely to check the speaker's line of regard in the latter condition than in the former. That is, when faced with a potentially ambiguous labeling event, 12-month-olds seemed to seek to resolve the ambiguity by checking the speaker's behavior.

A second study, recently completed in my laboratory, indicates that 13-month-olds not only seek out information about line of regard and pointing but also use this information in word learning. In this study, 13-month-olds were introduced to a new object label as they jointly attended to an object with an experimenter. The label was produced by a second experimenter. For half the babies, the second experimenter looked at and pointed toward the object that the baby was attending to (the joint-attention condition). For example, the experimenter would say, "Wow, the gombie!" For the other half, the experimenter looked at a video screen, never at the toy the baby attended to, and produced the same utterance (the discrepant-attention condition). The video screen showed the camera's view of the interaction, so that the speaker could time her utterances to coincide with the baby's attention to the object. Thus, in both conditions, babies had their attention directed to an object by the first experimenter, and then they heard a word. Only in the joint-attention condition, however, were there clear behavioral cues linking the speaker to the target object.

After training, my collaborators and I tested comprehension using a multiple-choice procedure. An experimenter showed babies a tray containing the target toy and a second novel object while asking them, "Get the gombie." This portion of the procedure was administered by a third experimenter who did not

know which object had been paired with the label or whether the baby was assigned to the joint- or discrepant-attention condition. In the joint-attention condition, babies selected the previously labeled object at above-chance rates. In the discrepant-attention condition, in contrast, babies chose randomly. Thus, hearing the label as they attended to the object was not sufficient for infants in this condition to learn the relation between the word and the object.

One possible explanation for this difference in learning is that the joint- and discrepant-attention training procedures manipulated babies' attention in different ways. Perhaps babies in the joint-attention condition had their attention focused more effectively on the object than did the infants in the discrepant-attention condition. To evaluate this possibility, we are currently coding babies' patterns of visual attention from the videotapes. This coding is partially completed (14 of the 20 babies in each group have been coded). The preliminary data indicate that babies in the two training conditions did not differ in terms of the amount of time they looked at the target object, the amount of time they looked at the speaker, or the number of times they looked at the target at the exact moment the label was produced. Thus, at this point, it does not seem that the differences in learning resulted from differences in attentional highlighting during training. Instead, it may be that infants' construal of the speaker's actions matters for word learning.

In sum, there is evidence that for 13-month-olds, as for older babies, behavioral cues to communicative intent impact on word learning and that this impact may not reduce to attentional highlighting. There are at least two possible explanations for this finding. The first is that the knowledge that has been demonstrated in 18- to 24-month-olds is present much earlier in life, by 13 months of age. The second possibility is that, in word learning, infants initially attend to behaviors such as gazing and pointing based on a less-elaborated understanding of the link between speaker and referent. The evidence favors the second possibility. Hirsch-Pasek, Golinkoff, and Hollich (chapter 6, this volume), for example, report that under more stringent testing conditions, 12-month-olds engaged in word learning seem not to attend to an adult's gaze. In addition, several studies have found that 12-month-olds are more limited than are 18- to 24-month-olds in their production and comprehension of nonverbal communicative behaviors (e.g., Butterworth & Grover, 1988; Lempers, Flavell, & Flavell, 1977). How, then, might younger 1-year-olds understand the connection between speaker and referent? By 6 months of age, infants construe some actions in terms of the relationship between actor and object (Woodward, 1998), and recent work in my laboratory indicates that, by 12 months of age, babies interpret pointing and gazing in this way. Early word learning could build on this understanding. Babies may use behaviors by adults, such as gazing, touching, and pointing, to interpret utterances—like other actions—in terms of the objects to which the speaker is connected, without yet understanding that words communicate mentally represented information. This would mean that, without having a full-fledged understanding of the way that words relate to ideas, babies understand something about reference—that words are "about" or directed toward objects. The relationship between knowledge about communication and word learning may well be bidirectional. Baldwin and Moses (1996) have proposed that learning words and interpreting the language behavior of others leads babies to acquire the insight that other people have knowledge states. If so, this insight would in turn have a powerful effect on babies' ability to make sense of language.

Knowledge about Word Forms

Beyond understanding that other people have intentions and attention, mature language users understand the particular way that linguistic symbols—words—are used to fulfill communicative intent. This is not a simple extension from general reasoning about intentional action; it requires understanding some facts about the linguistic system. Words are independent from their referents in form. Their meaning rests not in an inherent relationship between the form and its referent but rather in the fact that speakers of a language agree on their meanings; that is, words are conventionally set. Words function as symbols in a system in which a change in a single componential unit, a phoneme, signals difference in meaning. In these respects, words differ from nonverbal communicative acts such as gestures.

E. V. Clark (1987, 1993) has proposed that knowledge about these aspects of the language system provides a source of constraint in word learning. Specifically, she suggests that language learners are guided by the assumptions that people use particular word forms because they have agreed-upon meanings (the principle of conventionality) and that if someone uses a form that is not conventionally appropriate for a familiar item, he or she must intend to mean something else (the principle of contrast). These principles would result in learners' assuming that every difference in form indicated some difference in meaning. Given a new word—"carnivore" for a dog, for example—a child would reason that "carnivore" must mean something other than "dog." These assumptions could also contribute to children's learning about morphology and syntax; learners would be motivated to find the difference in meaning implied by different forms such as "dogs" versus "dog" or "walked" versus "walk." Thus, understanding the conventional and contrastive nature of linguistic symbols could serve as a powerful tool in language acquisition.

Whether this specific formulation is correct for young children has been debated. The evidence for these principles in babies is that they avoid having two labels for the same object (E. V. Clark, 1987, 1993). As discussed earlier, this evidence is also consistent with the stronger mutual-exclusivity assumption

(the assumption that objects have only one label). In fact—as several researchers have pointed out—by themselves, the principles of contrast and conventionality are insufficient to explain children's resistance to second labels (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1989). If children had the principle of contrast, then a second label (e.g., for a dog) could be readily accepted as a hierarchically related term ("animal"), overlapping term ("pet"), or less-formal term ("pooch"), among other possibilities, so long as the meaning of the second term differed in some way from that of "dog." To explain the observation that children resist second labels, E. V. Clark (1987, 1993) proposed that children have additional biases to favor terms at a single level of analysis and terms that do not overlap in meaning (but see E. V. Clark, 1997, for arguments against this view). This cluster of assumptions yields predictions similar to that of mutual exclusivity.

Setting aside for the moment the question of whether mutual exclusivity or contrast is the correct formulation, we can ask whether 1- and 2-year-olds have the kinds of knowledge just described—that is, do they understand the formal properties of linguistic symbols? Early in infancy, babies have the perceptual prerequisites to identify the class of forms that is conventionally used to name and to note differences between particular word forms. Infants distinguish speech from other kinds of sounds (Balaban & Waxman, 1997) and can discriminate phonetic contrasts between different speech sounds (for a review, see Goodman & Nusbaum, 1994). However, recent findings indicate that it takes babies some time to determine the relevance of these perceptual differences to word meaning.

The most basic convention is that we use some forms—spoken words—and not others as linguistic symbols. Long before babies learn what words mean, they respond to speech as a special kind of signal. Speech is salient and affectively charged for infants, and it serves to regulate infants' attention and mood (Balaban & Waxman, 1997; Baldwin & Markman, 1989; Fernald, 1992). Nevertheless, babies do not seem to begin word learning with the strong expectation that names will be in the form of spoken words. In several recent studies, younger 1-year-olds have been found to accept a range of signals in situations that older learners reserve for spoken words (Namy, 1998; Namy & Waxman, 1998; Woodward & Hoyne, 1999; chapter 3 in this volume). In our 1999 study, Hoyne and I introduced 13-month-old infants to novel signals that were embedded in labeling routines: A researcher would call the baby's attention and point to a toy saying, "Look" and would then produce a new sound (e.g., a siren whistle) while indicating the toy. That is, the experimenter accompanied the sound with behavioral cues to referential intent. We measured babies' learning of the relation between the sound and the toy by using a multiple-choice procedure. A second researcher placed the target object and another novel object in a tray and asked the baby to "get one," as the researcher produced the sound. For comparison, a second group of 13-month-olds was introduced to words. Thirteen-month-olds who heard sounds responded just as did those who heard words—that is, they chose the object that had been "labeled" with the sound during training. We found no evidence that babies were more resistant to the sounds than to the words. Babies responded to test questions as often and as quickly in the sound condition as in the word condition. Moreover, as was the case for words, babies generalized the sound labels to an item that differed in color from the training object. We next examined whether older babies, 20-month-olds, would accept the sound labels. Given the same training with sounds, 20-month-olds responded randomly on test trials. That is, the older babies did not seem to consider the novel sounds as potential labels, even though the sounds were accompanied by gazing and pointing.

Namy and Waxman (1998) reported a similar pattern of findings with somewhat older babies. In their studies, 18-month-olds but not 24-month-olds accepted novel gestural labels for objects. Moreover, 18-month-olds generalized these labels to items of like kind (see also Acredolo & Goodwyn, 1988). In subsequent work Namy (1998) found this pattern for sound and pictogram labels. In all of these studies, younger 1-year-olds treated novel signals as if they were labels. They readily learned the specific links between particular signals and particular objects, generalized the labels to an appropriate range of taxonomically related referents, and responded readily to the signal when it was embedded in communicative routines. In other words, babies seem to understand something about the functions of names before they have strong expectations about the forms that will serve these functions.

At the same time that babies are honing their expectations about the limits of the class of word forms, they are refining their expectations about meaningful differences between words. Even for a newborn, minimal pairs such as "bih"/"dih" are readily discriminable. However, Stager and Werker (1997) found that 14-month-olds do not exploit phonemic differences between minimal pairs when they are learning to link word forms with pictures. In their first study, Stager and Werker habituated infants to two word/picture pairings. One picture was shown as the babies heard "bih"; another was shown as they heard "dih." Then, in test, on some trials there was a mismatch—for example, "dih" was played with the picture that had been paired with "bih" during habituation. Fourteen-month-olds did not respond to this mismatch. Next, Stager and Werker administered a simpler test: They habituated infants to a single word/object pairing and then played a recording of a mismatching word in test. In this study, too, fourteen-month-olds failed to respond to the change in word (see Bird & Chapman, 1998, for further evidence). Strikingly, 8-month-old infants succeeded at this task, looking for a longer period of time on mismatch trials. Stager and Werker proposed that 8-month-olds solved the task by making a perceptual distinction and that 14-month-olds failed by approaching it as a

word-learning task. Fourteen-month-olds succeeded at noticing the difference between "bih" and "dih" when they were not learning a picture/word correspondence, and they succeeded at distinguishing words that differed globally ("lif" versus "neem") in a word-learning task (see Bird & Chapman; Schafer & Plunkett, 1998; Werker, Cohen, Lloyd, Casasolo, & Stager, for further evidence). Werker (1994) has reported unpublished findings indicating that, by 19 months of age, babies can learn that minimally different words have different referents. Thus, in the first half of the 2nd year, babies are homing in on the level of phonetic detail that is relevant for word meaning.

By 2 years of age, then, babies have the wherewithal to understand contrast between conventionally set linguistic symbols. They have the expectation that some forms—spoken words—serve as names for things, and other forms do not. Moreover, based on Werker's (1994) data, by this age, babies seem to have determined the level at which forms within the system differ from one another. Before age 2, babies' understanding of the formal properties of names is surprisingly limited. Nevertheless, babies as young as 16 months old note global differences between word forms and, based on these differences, reject second labels. This ability could result from the cognitive factors described by Markman (1992). Babies may seek to simplify the word-learning problem by assuming that each object has only one name—that is, via the mutual-exclusivity assumption. This kind of simplification assumption does not require that babies understand much about the linguistic system. Even so, mutual exclusivity would be limited in significant ways by babies' knowledge about word forms.

Knowledge about Syntax

Once children understand that linguistic forms constitute a special class of actions, they can learn about the combinatorial properties of this system. How children acquire syntax is strongly debated, but regardless of how they go about it, once they do, they have an important source of knowledge to bring to bear in word learning. By the time they reach elementary school, children can use a range of syntactic information in word learning, including count- versus mass-noun syntax, articles specifying count- versus proper-noun status, syntactic and morphological cues to adjective versus noun status, the argument structure of a sentence, and aspects of derivational morphology (e.g., Anglin, 1993; E. V. Clark, 1993; Fisher, Hall, Rakowitz, & Gleitman, 1994).

Children have access to some syntactic cues to meaning by the time they are 2 years old. Macnamara's (1982) pioneering work suggested that by 18 months of age, babies use the presence or absence of an article in front of a noun to inform their interpretations of common versus proper nouns. Subsequent studies, which included important controls absent in the original work, established this

ability in 2-year-olds (Gelman and Taylor, 1984; Hall, 1991). Two-year-olds also distinguish between novel count nouns (e.g., the "daxin") and novel adjectives (e.g., a "daxish" one) (Waxman & Kosowski, 1990; Waxman & Markow, 1998). In addition, E. V. Clark (1993) described evidence from children's coinage of new terms that indicates that, by 2 years of age, babies draw on another aspect of English morphology in vocabulary acquisition: They have learned the rules for compound formation.

Gleitman, Naigles, Fisher, and their colleagues (Fisher, Hall, Rakowitz, & Gleitman, 1994; Gleitman, 1990; Naigles, 1990, 1996) have argued that syntactic frames provide a particularly important source of constraint for verb learning. Because verbs have relational meanings, syntactic cues such as the number and arrangement of arguments in a sentence give information about a verb's meaning. Naigles (1990) established that 2-year-olds use this cue. Based on whether a novel verb occurred in a transitive or intransitive sentence frame, babies interpreted the verb as naming a causative or noncausative action (for further evidence, see Hirsh-Pasek & Golinkoff, 1996). Naigles (1996) found that 2-½-year-olds also attend to a verb's occurrence in multiple sentence contexts and use this information to make inferences about the verb's meaning.

There is little evidence about whether babies draw on syntactic information in word learning before 2 years of age, and the evidence that exists suggests that they do not. In one of the few studies addressing this question, Hirsh-Pasek and Golinkoff (1996) reported that unlike 24-month-olds, the 19-month-olds they tested showed no attention to argument structure in verb learning. Based on babies' spontaneous production of newly learned verbs, Olguin and Tomasello (1993) have argued that babies' first action terms are learned without an understanding of the grammatical aspects of verbs. Before babies use syntactic frames in learning verbs, they may be able to use form-class cues to distinguish between nouns and other kinds of words. Waxman and Markow (1998) recently reported that 21-month-old infants use syntactic cues to distinguish adjectives from nouns. Given a novel adjective (e.g., "This is a citron one"), babies extended the new word to items that shared a salient property—color or texture. Given a novel noun (e.g., "This is a citron"), babies extended the word to members of a kind, even if they differed in color or texture. The lower limit for this ability is not yet known, though it seems to be absent in 12-month-olds (Waxman & Markow, 1995).

Conclusion

The evidence confirms that, as is the case for older word learners, toddlers draw on multiple sources of evidence in making sense of new words. By the time babies are 2 years old, they understand some aspects of intention, knowledge, and communication; they know about the conventional forms of names and how

they vary; and they understand some aspects of syntax. Moreover, there is empirical confirmation that 2-year-olds use each of these kinds of knowledge in word learning. We know less about this type of knowledge in babies before this age. There is preliminary evidence that, by 12–13 months of age, babies understand words as being about their referents: Babies at this age attend to behaviors such as looking and pointing when interpreting new words. Other aspects of understanding reference—for example, knowing that words communicate ideas or information (mental entities)—may not emerge until 2 years of age or later. Moreover, although younger 1-year-olds understand something about the functions of names, the evidence suggests that they have strongly delimited neither the class of forms that serve this function nor the level of perceptual detail that signals a difference in meaning.

Because what babies know about acts of communication and language figures intimately into the process of word learning, this portion of the chapter has focused on that knowledge. In fact, understanding the referential, conventional, and syntactic nature of words is what makes a word/object mapping an act of word learning. Consideration of the development of these systems of knowledge provides a new look at a very old question. There has long been debate about whether the words learned by young 1-year-olds are "true" words or are, instead, learned without an understanding of their status as linguistic symbols (for various points of view on this question, see Huttenlocher & Smiley, 1987; Lock, 1980; McShane, 1979; Oviatt, 1980; Piaget, 1962; Vygotsky, 1962; Werker, Cohen, Lloyd, Casasolo, & Stager, 1998). Early theorists proposed that the transition from "proto" to "true" words occurred via a sudden insight or via radical qualitative changes in conceptual structure argued to occur at the time of the productive vocabulary spurt. However, based on the work just reviewed, my argument is, instead, that the difference between early and later word learning can be described in more quantitative terms: How much and what kind of knowledge does the baby bring to bear in word learning?

The findings reviewed in this section raise the question of how knowledge about language and communication interacts with default assumptions. On one hand, knowledge about the communicative nature of words seems to be a prerequisite for default assumptions about word meanings. In order for assumptions about the scope and extension of new words to make sense, babies must understand, in at least some limited way, that words are about objects and events (see Golinkoff, Mervis, & Hirsh-Pasek, 1994). On the other hand, when babies first start learning words, they seem to lack an understanding of some critical features of linguistic symbols, and the roots of default assumptions are evident at this early point in development. So, 12- to 18-month-olds have the whole-object and taxonomic assumptions, yet babies at this age do not have strong expectations about the forms of names. They are likely to accept other kinds of signals that are given in labeling contexts with behavioral cues to referential intent. Therefore, for younger 1-year-olds, gestural labels or other signals might elicit the same kinds of shifts in focus (to objects or to taxonomic relationships) as do words. There is preliminary evidence for this: Both Namy and Waxman (1998) and Hoyne and I (Woodward & Hoyne, 1999) found that younger 1-year-olds readily extend gesture or sound labels, like words, to members of like kind.

Changing knowledge about word forms would have a profound effect on mutual exclusivity. For one, to the extent that 1-year-olds have not delimited spoken words as a special class, gestural forms might interfere with word forms. Acredolo and Goodwyn's (1988) work on early gestural labels provides preliminary evidence on this question. They documented that 1-year-olds can learn a range of novel gestural labels. In this study, when babies acquired the words for these items, they stopped using the gestures. This is reminiscent of babies' correction or restriction of a known label in response to their learning a new word.

In addition, the level or detail of babies' representations of word forms imposes a limit on mutual exclusivity. If babies cannot determine that two word forms differ, they cannot use the difference in form to make inferences about meaning. The evidence for mutual exclusivity in 16-month-olds involves words that differ globally in form (e.g., "horse" and "mido"); thus, it is compatible with Stager and Werker's (1997) findings concerning the level of perceptual detail to which infants are sensitive in word-learning tasks. The prediction that mutual-exclusivity effects will vary as a function of increasing sensitivity to differences in form is yet to be tested. Keeping track of differences in form may continue to challenge older babies: Merriman and Marazita (1995) reported that manipulations that boost phonemic processing in 2-year-olds enhance the disambiguation effect. It is possible that vocabulary growth contributes to babies' increasing precision in distinguishing between word forms. Mervis and Bertrand (1994) reported that in a sample of 16- to 20-month-olds, the disambiguation effect varied as a function of productive vocabulary size. Babies with more words in production showed the disambiguation effect, whereas those with smaller vocabularies did not.

SUMMING UP

My goal in this chapter was to survey the word-learning landscape for 1- to 2-year-olds. When a very young learner hears a new word, how does he or she make sense of it? The first conclusion that emerges is that, even for young 1-year-olds, there are important features of the landscape. Twelve- to 18-month-old babies use aspects of a speaker's behavior to interpret new words. They seem to understand words not as undifferentiated associates of items in the

world but as actions that are directed at or "about" objects. Moreover, young 1-year-olds show evidence of the whole-object, taxonomic, and mutual-exclusivity assumptions. They favor object-label interpretations, extend new words readily to members of like kind but not to thematic associates, and avoid having two labels for the same object. This is a powerful set of tools to get language learning off the ground, and it helps to explain how 12- to 14-month-old infants readily learn words in brief laboratory sessions.

The second conclusion is that, as a result of (in large part) rapidly developing knowledge about language and communication, the landscape changes considerably by the time babies are 2 years old. By 2 to 2½ years of age, babies understand acts of communication as involving the transmission of information. They can make subtle inferences about shared experiences and shared information. These abilities provide the means for making inferences about new terms across a range of situations. By age 2, babies have honed their expectations about the forms of words and have an understanding of the combinatorial system that gives rise to different words. This knowledge adds power to the ability to use the form of a new word to make inferences about its meaning. Finally, by age 2 or just before, babies have begun to understand words as syntactic units and to use this information in interpreting new words.

From the beginning, then, word learning is multiply constrained. Even young 1-year-olds draw on both default assumptions and behavioral cues in word learning. The developing ability of babies to make sense of behaviors such as looking, pointing, and speaking plays a central role in their interpretations of new words, just as does their predisposition to interpret words as naming object-sized units and extending to members of a kind. Any account proposing that a single factor is responsible for early word learning will be lopsided at best. Because word learning in the wild most likely involves multiple constraints, it may not be a clear reflection of any one of them. Experiments are useful for clarifying the role of individual constraints on word learning, but they do not always shed light on the ways in which multiple constraints converge in natural contexts.

In this chapter I have distinguished between default assumptions, which are hypothesized to be based in aspects of the baby as learner and perceiver, and knowledge-based constraints, which are the product of learning in a particular domain. How well this distinction can be maintained is yet to be seen. Several proposals about default assumptions characterize them as knowledge based, deriving solely from knowledge about regularities in parental word use or about the pragmatics of communication. Although these accounts seem inaccurate in their strongest forms, Imai and Gentner's (1997) findings suggest that regularities in input can modulate cognitively based word-learning biases. Moreover, domain-specific knowledge contributes importantly to the deployment of word-learning constraints—for example, in informing understanding

of taxonomic categories or providing a basis for distinguishing between different word forms.

As I hope this chapter illustrates, understanding the development of word learning requires tracking several distinct streams that ultimately converge on the problem. Knowledge about human action, communication, and language are part of the story. Each of these systems of knowledge, though related, has its own developmental history. In addition, predispositions to see objects as salient units, to organize important information in terms of taxonomic categories, and to simplify complex learning problems contribute to the development of default assumptions. Accounts of how each of these sources of constraint develops and is recruited in word learning will, by necessity be different. All of these disparate factors come together in the minds of word-learning children and babies.

All of these sources of constraint in 1- and 2-year-olds may seem implausible. After all, babies know little and are limited in their cognitive abilities. Word learning must be quite special to recruit so many resources so early in life. But consider that 2-year-olds and younger babies are making progress at other kinds of complex cognitive tasks as well—for example, determining the bases for category membership (Gelman & Coley, 1991; Mandler & McDonough, 1993, 1996), solving increasingly complex means-ends problems (Diamond, 1991; Frye, 1991), and understanding the causes of events (Oakes & Cohen, 1990; Shultz, 1982). Like adults, 1- and 2-year-olds succeed at limiting the problem space across many contexts. In this respect, early word learning is not unique, but neither is it any less impressive.

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CHAPTER 5

The Social Nature of Words and Word Learning

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> Language is a social art. In acquiring it we have to depend entirely on intersubjectively available cues as to what to say and when. (Preface to W. V. O. Quine, *Word and Object,* p. ix)

Word learning has often been portrayed as a classic example of an induction problem: When faced with a novel word, how does a child (or an adult, for that matter) determine the meaning or referent of that word? Logically, there seem to be innumerable possibilities, even in the relatively straightforward case of ostension—the situation in which a speaker points to an object and utters a single word. Is the speaker labeling the entire object, commenting on one of its properties, or labeling the action that the object is engaged in? How does the listener decide? The scenario becomes even more complicated when we consider the fact that young children in the beginning stages of language acquisition are often faced with situations that involve *multiple* objects and actions for which they do not yet have names. How do they decide which of several possible referents the speaker intends to label with a new word that is used in the presence of several nameless objects, actions, and attributes?

There are currently three major approaches to these central questions in research on early word learning. One approach emphasizes the logical problem of referential indeterminacy and posits the existence of word-learning constraints or principles as a solution to the problem (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman, 1992; Woodward & Markman, 1998; chapters 4 and 6 in this volume). Another approach asserts that general processes of association and learning are sufficient to account for early lexical acquisition (Smith, Jones, & Landau, 1996; chapter 3 in this volume). What is common to these two approaches, however, is a relative neglect of the social dimensions of word learning.

In contrast, our approach—known as the social-pragmatic approach (Akhtar & Tomasello, 1998; Bruner, 1983; Nelson, 1985; Tomasello, 1992b; 1995)—