24 Names for Things… and Actions and Events: Following in the Footsteps of Roger Brown

DANI LEVINE[1], KRISTINA STROTHER-GARCIA[2], KATHY HIRSH-PASEK[1] AND ROBERTA MICHNICK GOLINKOFF[2]

[1] Temple University
[2] University of Delaware

> *I cannot convince myself that there is any principle of correctness in names other than convention and agreement; any name which you give, in my opinion, is the right one, and if you change that and give another, the new name is as correct as the old.*
>
> *–Plato, Cratylus*

Debates about how we learn names have occupied philosophers for centuries and psychologists for decades. Plato proposed two ways we might acquire names for things. The first possibility is that naming is a social convention derived from the culture of use. The other is that names are intrinsically linked to that which they represent. This discussion continued in the Confucian Xunzi (ca. 310–ca. 210 BCE) with the publication of the *Right Use of Names* and enjoyed a resurgence of interest in the Chomskian period of the mid-twentieth century. It was then that Roger Brown (1958) wrote his now classic book, *Words and Things*. Brown not only offered a theoretical treatment of how words map onto world, but also provided substantial diary data in *A First Language* (1973), which still serves as a foundation for research in word learning today. This chapter reviews this vibrant empirical enterprise and demonstrates just how far we have come in understanding how children learn words. Brown's work represented the first modern day treatment of this topic in psychology, and we think he would be pleased with what our field has

The Handbook of Psycholinguistics, First Edition. Edited by Eva M. Fernández and Helen Smith Cairns.

accomplished since. We offer but a portion of the research on word learning over the past 50 years. Interestingly, most of the current debate still sits with the age-old questions of how children learn to link words to world and how word learning processes change with development and experience (~~Hollich, Hirsh-Pasek, & Golinkoff, 2000~~).

Introduction

As Paul Bloom (2002) noted in *How Children Learn the Meanings of Words*, word learning seems like it should be strikingly simple. Say the word *dog* in the presence of a dog and a child is sure to associate the word with its referent. Pilley and Reid (2011) demonstrated that their border collie, Chaser, could do precisely the same thing. Chaser correctly identified 1,022 objects by name. If a dog can learn over 1,000 words in three years, why is it any surprise that human children learn 14,000 words by the age of six (O'Grady & Archibald, 2010)? Obviously, children—and dogs—associate words they hear with the objects, actions, or events that are most salient at the time. Or is it so obvious?

As it turns out, *associationistic* learning supports the beginnings of word learning (Pruden *et al*., 2006), but this mechanism alone cannot cleanly explain lexical development (Hollich *et al*., 2000; Quine, 1960). Even a seasoned linguist could be thrown by the ambiguity in the *dog* scene. Might the word refer to the dog's ears or the dog's panting rather than the whole dog? Quine (1960) suggested that, given the vast number of options, there must be some way to resolve the indeterminacy of reference. Indeed, the problem is even more staggering: children do not merely learn perceptually salient object names—they also learn words for categories like *furniture*, abstract concepts like *truth*, relations like *connection*, and actions like *poking*. Words like *savage* are rooted in a cultural context of social and linguistic information above and beyond simple associative cues. The resulting variety in word types is necessary to achieve the level of complexity found in human language, but it makes the task of discovering a word's meaning that much harder for the child. Might word learning be influenced by constraints that bias the child toward certain interpretations (e.g., assuming a novel label refers to a *whole object* rather than a part or property of it), or perhaps a set of guiding social cues, or even the use of statistical computations that support the kinds of cross-situational learning that enables lexical acquisition? All of these possibilities have been posited in the literature.

This chapter explores a variety of theories and endeavors to explain how young children ultimately converge on lexical acquisition. We present the current research in five sections. In the first, we tackle the thorny question of what counts as a word. Using this definition, the second section identifies the processes children use to learn new words, and how these processes change over time. The required inputs for word learning—both linguistic and nonlinguistic—are discussed in Section 3. The fourth section offers readers a timeline of lexical acquisition and reveals some near-universal patterns observed in word learning across many of the world's languages. Finally, Section 5 revisits Plato's and Brown's questions by focusing on contemporary models of word learning and the ways in which they solve the mapping problem.

What does it mean to know a word?

Word knowledge is defined, broadly, in two important ways. One definition focuses on the sound patterns, semantics, pragmatics, and syntax that specify adult linguistic knowledge (Brandone *et al*., 2006). The second definition reflects the real-time processes (i.e., perception, action, learning, attention, and memory) required for understanding or producing a word in the particular context (e.g., social cues, task demands) of a given moment (Bates & MacWhinney, 1989; Colunga & Smith, 2008; Regier, 2005). Modern theories affirm that word knowledge and the processing necessary for that knowledge are indistinguishable; that is, "knowledge is an abstraction over many underlying processes," (Smith, Colunga, & Yoshida, 2010). We begin here by outlining the various components of that abstract knowledge, as a lead-in to understanding the motley of processes that, together, ground lexical acquisition.

Certainly, a prerequisite to word knowledge involves recognition of a patterned string of sounds, for example, "dawg," (or handshapes and movements, in the case of signed languages). Beyond identifying a consistent phonological shape, however, there are additional criteria that must be met for a sound sequence to count as a word.

Knowing a word requires at least some *semantic information*. Children must minimally know that the sound unit "dawg" is associated with the particular dog that is present when they first hear the word. Many writers (Bloom, 2002; Golinkoff, Mervis, & Hirsh-Pasek, 1994; Golinkoff & Hirsh-Pasek, 1999) contend that a sound unit does not achieve word status until the child can extend the label to other members of the same category (e.g., to other dogs). Expanding on the basic referential meaning of a word, children later make connections between a given word and other related ones, forming a *semantic network*. For example, a *ball* is part of a category of objects called *toys*, and may be used to *play* a *game*. It is also part of a category of objects that are *round*, along with *oranges* and *marbles*. Thus the word *ball* is part of a network (including words like *toy, play, game, round, orange*, and *marble*) based on semantic relations.

Pragmatics, which includes social and cultural information about how to use a word in a given context, is another building block for word knowledge. Relatively early in the course of lexical development, words begin to take on communicative functions, being understood as a means to socially and intentionally share information. As word learning progresses, the pragmatics of a word become more intricate. This includes understanding how a word can influence other people's actions; for example, knowing that the simple word *stop* conveys the desire that another person halt their behavior. Additionally, pragmatics encompasses knowledge of what Tomasello (2008) called *common ground*—that is, the information shared between people in a conversation based on past experiences, cultural knowledge, and topics discussed earlier. In these ways, pragmatic information connects the literal meaning of a word to its real-world implications, as when "bad" paradoxically means good to members of a given subculture.

Finally, *syntactic information* dictates how a word combines structurally with other words in a phrase or sentence. Although children's earliest word representations likely lack this information, it is essential for complete word knowledge. Once children have acquired even a partial understanding of abstract syntactic structures, they use syntactic contexts to learn new words and to solidify the meanings of old words. One of the first demonstrations of how children do this was provided by Roger Brown (1957). He showed children a drawing of a person manipulating a substance in a bowl. When he asked children to point to "some sib" they pointed to the substance, but when he asked where the person was "sibbing" they pointed to the kneading action. This process is called *syntactic bootstrapping* (Gertner & Fisher, 2012; Gleitman *et al*., 2005) and entails using the argument structure a word appears in to glean something of its meaning. As children's linguistic knowledge matures, the syntactic representation of a word comes to include specific information about part of speech (noun, verb, adjective, adverb, preposition, etc.) and about the types of *syntactic arguments* the word requires. The verb *kiss*, for instance, requires two arguments: an *agent* to perform the action of kissing and a *recipient* of the kiss. A sentence with the verb *kiss* will be ungrammatical if one of the arguments is missing, as illustrated in (1) below.

(1) a. Sally kissed the baby
    b. *Sally kissed.
    c. *Kissed the baby.

Note that the semantics dictates what types of things can be the arguments of a given verb; part of the meaning of *kiss* also includes the fact that only people (and perhaps certain animals) can be the *agent*. This semantic requirement of *kiss* explains why sentence (1a) is understandable while sentence (2) is not, except perhaps in a poetic sense. In many theories, semantic and syntactic information are thought to be stored with the word's lexical representation (Bresnan, 1978).

(2) The door kissed John.

The information that constitutes word meaning is complex, even during the first few years of life. The earliest words may enter the lexicon with only their phonology and a basic understanding of their semantics. That is, first words may initially be "things heard most often in the presence of a particular object," acquired via cross-situational learning mechanisms (see below, Models of Word Learning). These words might therefore constitute partial or incomplete lexical entries, not yet representing the entire reach of the word's meaning (Yurovsky *et al*., 2014). For instance, Seston and colleagues (2009) found that 6 year olds evince protracted word development when extending words to odd, metaphorical uses as in, "He *vacuumed* with his mouth." Later on, lexical entries for earlier learned words will be expanded to include more semantic, pragmatic, and syntactic information. What it means to know a word, and the processes that support that burgeoning knowledge, develop gradually, alongside the growing lexicon.

The process of word learning

With all these component pieces, it is little wonder that linking the word *dog* with its referent is far from a simple process. Children must first segment units of speech from strings of *sounds*, which are not well punctuated with stops and starts. That is, they have to isolate the phrases and individual words. Second, they have to segment a continuous stream of *events* into the objects, actions and event units that will be labeled by those words and phrases. Third, children must map linguistic units onto the objects, actions and events they refer to—often called the *mapping problem*. This latter challenge has turned out to be somewhat intractable and is the subject of most theoretical debates on word learning today.

Speech segmentation

Before children can begin to learn what words mean, they must first recognize where one word ends and another begins. Though this segmentation seems obvious to adults, there are actually no pauses or reliable acoustic signals to indicate word boundaries in natural speech. So how do infants begin to parse the speech stream? Shortly after birth, sleeping neonates' brain responses to speech reveal a precocious sensitivity to the statistical structure underlying language (Teinonen *et al.*, 2009). Statistical cues, such as the likelihood of certain syllables being adjacent, are crucial for early word segmentation. For example, "bee" may be heard more often after "bay" (as in *baby*) than after "go" (as in *go before*), indicating that "bay-bee" is a word while "go-bee" is not. Newborns are also sensitive to the *prosody* or rhythmic patterns of language, as evidenced by changes in their sucking rate in response to hearing alternations between stress-timed languages (e.g., English) and mora-timed languages (e.g., Japanese; Nazzi, Bertoncini, and Mehler, 1998).

As infants gain experience with the language(s) they are exposed to, they develop language-specific biases that facilitate a more fine-tuned approach to word segmentation. Given the consistency of prosodic changes at clause boundaries in English (e.g., rises and falls in fundamental frequency; see Jusczyk, 1986 for a review), infants rapidly develop a sensitivity to phrase boundaries (Hirsh-Pasek *et al.*, 1987). By seven to nine months, infants show a listening preference for speech with pauses inserted at clausal boundaries relative to speech containing pauses within syntactic units (Hirsh-Pasek *et al.*, 1987). This demonstrates infants' remarkable ability to home in on important linguistic structures before they can understand what the words that form these structures actually mean. In this way, infants identify linguistic patterns early on that will help them learn words later in development.

Similarly, infants quickly acquire a parsing heuristic based on the lexical stress patterns of their language. By 7.5 months, English-learning infants segment strong/weak bisyllabic units (e.g., "*cray*on") but not weak/strong units (e.g., "sur*prise*"; Jusczyk, Houston, & Newsome, 1999), and are only able to extract trisyllabic words when the first syllable is stressed ("*par*achute" versus "tambou*rine*"; Houston, Santelmann, & Jusczyk, 2004). The ability to identify likely words from the speech stream before those words carry meaning is critical for ultimately mapping those word segments onto referents. Indeed, stress-based segmentation abilities at seven months predict vocabulary size at age three (Kooijman *et al.*, 2013).

Statistical segmentation of speech also matures with language experience. As early as eight months, infants use statistical regularities to distinguish coherent syllabic units from non-units in a monotone, nonsense speech sample (Saffran, Aslin, & Newport 1996). Seventeen month olds capitalize on this ability for word learning; they learn a word-referent mapping if the label was previously presented in fluid speech, but not if the label is a novel syllabic sequence (Graf Estes *et al.*, 2007).

In addition to these developments in bottom-up speech segmentation, stored knowledge of words becomes a tool for infants who use these words to conduct top-down analyses of the speech stream. This begins with the child's own name, which infants recognize at 4.5 months of age (Mandel, Jusczyk, & Pisoni, 1995). They then can use their name to isolate a novel word appearing after their name (but not someone else's name) by six months of age (Bortfeld *et al.*, 2005). Speech segmentation, via developing bottom-up and top-down mechanisms, is clearly a critical step in word learning.

Segmentation of events

Just as children must segment the sound stream, they must also segment events into meaningful units. Imagine a parent picking up a toy and putting it on a shelf. This sounds like two events as written here, but it also could be viewed as one ("putting the toy away") or even three ("grabbing the toy, moving it to the shelf, and placing it"). Infants are faced with the challenge of unitizing the rich, continuous stream of nonlinguistic events into meaningful categorical units that will be labeled by language.

This area of research is in its infancy, but it suggests a developmental trajectory similar to that of word segmentation. Newborns evince a very limited sensitivity to statistical event structure (Bulf, Johnson, & Valenza, 2011), maturing into more sophisticated visual statistical learners by seven to nine months of age (Roseberry *et al.*, 2011; Stahl *et al.*, 2014). Infants' detection of event goals (Lakusta *et al.*, 2007) may also be crucial for the parsing of continuous events (Levine *et al.*, 2017). Experience identifying event goals early in life may facilitate identification of actor intent in events later on, which in turn simplifies and aids in the process of segmenting events (Baldwin *et al.*, 2001). Critically, segmentation of events is a foundational prerequisite for learning verbs, which map onto transient units of events (Friend & Pace, 2011; Golinkoff & Hirsh-Pasek, 2008).

Language is special

Mapping word to world requires the understanding that words (and *not* other types of sounds) carry meaning as symbols; this understanding is gradually fine-tuned with language experience. By three months, infants can use a novel speech segment paired with a series of objects (e.g., fish exemplars), to form a category of those objects (i.e., *fish*; Ferry, Hespos, & Waxman, 2010). When this speech is replaced by a matched sequence of sine-wave tones, infants fail to form the object category (Ferry, Hespos, & Waxman, 2010). However, lemur vocalizations succeed at facilitating categorization similar to human speech at this age, and it is not until six months that the effect of nonhuman primate vocalizations disappears (Ferry, Hespos, & Waxman, 2013).

By 12 months, infants demonstrate their understanding that non-linguistic human noises (e.g., coughing), unlike words, do not communicate information about a target object (Martin, Onishi, & Vouloumanos, 2012). Infants at this age can learn a word-object pairing following habituation to the coupling, but given the same procedure, are unable to learn pairings of objects with nonlinguistic communicative sounds (e.g., "oooh") or consonantal sounds (e.g., "/l/"; MacKenzie, Graham, & Curtin, 2011). Twelve month olds also recognize that different languages use different labels for a given object, and do not expect a speaker of another language to use the same label for a given object as a speaker of their native language (Scott & Henderson, 2013). Still, given sufficient attentional cues, infants aged 12–18 months will map almost any symbol to an object—from non-native language sounds (e.g., "tsk-tsk"; May & Werker, 2014) to gestures (Namy & Waxman, 1998) to whistles and digitized sounds (Woodward & Hoyne, 1999; Hollich *et al.*, 2000). By 20–26 months, however, infants fail to map anything but native-sounding words to objects, even with referential cues (May & Werker, 2014; Namy & Waxman, 1998; Woodward & Hoyne, 1999). Thus, the selectivity of words as symbols becomes greater over the first two years of life, leading children to develop more specialized means of language learning, beyond the general associative mechanisms they start out with (Namy, 2012).

What it takes to learn a word: Quantity and quality of input

On a fundamental level, infants must receive input to learn, through their exposure to a language (i.e., perceptual input that is symbolic and communicative) and non-linguistic information (i.e., all other perceptual input as well as action experiences). This section explores the input children require (and that which they do not require) in order to acquire a lexicon.

Language input

Receiving some type of language input is a guarantee for almost every infant (but see Fromkin *et al.*, 1974). Thus, the vast majority of children become competent users of their native language. Despite the near universality of lexical acquisition, there is a great deal of variation in language input that is reflected in children's vocabulary outcomes. While a child from a family on welfare hears 616 words per hour, a child brought up by a professional family hears more than three times that amount (Hart & Risley, 1995). Considering the fact that 86% to 98% of the words in children's vocabularies at age three are words used by their parents, language input stands as a major determinant of children's lexical store (Hart & Risley, 1995). Hurtado, Marchman, and Fernald (2008) extended this research, demonstrating that the amount of language input at 18 months predicts vocabulary size and lexical processing efficiency at 24 months. This suggests that input quantity affects not only which words children acquire, but also how rapidly they understand the words they hear.

If lexical development was simply determined by the quantity of input, we could set infants up with books on tape and walk away. To assess the potential importance of input *quality*, one study asked a sample of adults to watch muted vignettes of a variety of parent-child interactions and to guess what the parents were saying at select moments in the videos. The children of parents whose words could be readily guessed by naive adult viewers had significantly larger vocabularies three years later, as compared to children of parents whose words were more difficult to infer from the socio-visual context (Cartmill *et al.*, 2013). Providing disambiguating social and visual cues during speech may therefore be critical to vocabulary acquisition.

The importance of unambiguous word learning situations for lexical development is also evidenced by situations in which children are unable to learn words. For example, Weisleder and Fernald (2013) demonstrated that language input that is not specifically directed toward the child (i.e., overheard words) does not contribute to vocabulary outcomes. Although laboratory experiments have suggested children could learn word mappings by overhearing speech (Akhtar, 2005; Floor & Akhtar, 2006; Yuan & Fisher, 2009), more naturalistic studies indicate that this is only possible with experimental constraints narrowing children's attentional focus (Shneidman *et al.*, 2013; Shneidman & Goldin-Meadow, 2012; Weisleder & Fernald, 2013). Children are also typically unable to learn words from video prior to age three (e.g., Zimmerman, Christakis, & Meltzoff, 2007). However, when video is live (e.g., over Skype) and involves socially contingent interactions, even verbs—harder to learn than nouns—can be learned from video as early as age two (Roseberry, Hirsh-Pasek, & Golinkoff, 2014). A growing literature emphasizes that adult talk must not only be directed toward the child, but must also be appropriate to the specific interaction in terms of timing, content, and intensity in order to resolve ambiguity in word learning situations (Bornstein *et al.*, 2008; Roseberry *et al.*, 2014; Tamis-LeMonda, Kuchirko, & Song, 2014).

In addition to these overall effects of linguistic quantity and quality, the importance of different aspects of linguistic input changes (or should change) as the child becomes a more sophisticated user of language. After assessing parental language in parent-child interactions, Rowe (2012) found that the most critical aspect of input contributing to vocabulary growth at 18 months was the quantity of parental speech; at 30 months, diversity and sophistication of vocabulary were the largest contributors to children's vocabulary development; and at 42 months, it was parents' use of decontextualized language (i.e., language removed from the immediate environment) that most significantly contributed to vocabulary advancement. Thus, children rely on different aspects of language input over the course of development, from building a foundational vocabulary of common words, to adding uncommon words, to practicing the language necessary for extended narratives (Rowe, 2012).

Infant-directed speech

The acoustic properties of language input also make a difference for vocabulary development (Ma *et al.*, 2011; Yurovsky, Yu, and Smith, 2012). Originally called *motherese*, infant-directed speech (IDS), describes a particular register used by adults (Newport, 1975) and even by children without siblings of their own (Shatz & Gelman, 1973) when addressing infants and younger children (Broesch & Bryant, ~~2013~~; Fernald *et al.*, 1989). This register involves slower rates of speaking, longer vowels and pauses, shorter phrases, and higher and more variable pitches as compared to adult-directed speech (ADS; Andruski & Kuhl, 1996; Fernald & Simon, 1984; Graf Estes & Hurley, 2013; McRoberts & Best, 1997). IDS is also characterized by certain sentence structures: in English, the label of a referent often occurs in the final position of the sentence and that label is typically preceded by a frequently used article (e.g., "Look at *the balloon*"; Yurovsky, Yu, & Smith, 2012).

Although IDS has not always been extolled (Dougherty, 2000), research has demonstrated its value for word learning in children (Graf Estes & Hurley, 2013; Ma *et al.*, 2011; Ramirez-Esparza, Garcia-Sierra, & Kuhl, 2014; Singh *et al.*, 2009) and even in adults (Golinkoff & Alioto, 1995). In one study, seven and eight month olds were familiarized with words delivered either in IDS or ADS (Singh *et al.*, 2009). Twenty-four hours later, infants recognized words presented in ADS that were originally heard in IDS, but did not recognize words originally heard in ADS (Singh *et al.*, 2009). A second study presented 17 month olds with novel label-object pairs using IDS or ADS (Graf Estes & Hurley, 2013). Infants learned the labels only in the IDS condition, and only when prosody was varied rather than constant (Graf Estes & Hurley, 2013).

Despite the early advantage of IDS over ADS for word learning, children do not rely on IDS forever. At 21 months, infants with larger vocabularies than their peers learn novel words from ADS, and by 27 months even those with below-average vocabularies can do the same (Ma *et al.*, 2011). These findings suggest a developmental progression in which IDS is crucial for word learning early on, when much of the speech stream is unfamiliar to the infant, but becomes less critical as the lexicon grows.

Nonlinguistic input

Perhaps less intuitively, nonlinguistic information is also critical for lexical development. One important clue to word meaning is where the speaker is looking—their *eye gaze*. As early as 12 months, infants attend to a speaker's eye gaze for substantially longer periods of time when the word learning situation is ambiguous than when it is unambiguous (Baldwin, Bill, & Ontai, 1996). Infants at this stage also show a developing sensitivity to gestural cues; dynamic gestures synchronized with object labeling promote greater attention to the labeled object than asynchronous dynamic gestures or static gestures (Rader & Zukow-Goldring, 2012).

Beginning in the second year of life, visually available social cues affect the success of word-referent mapping. For example, 18- to 20-month-old infants can map a label to an object only if the adult labeling the referent is observed attending to the object; if the adult is out of sight, the mapping fails (~~Baldwin, Bill, & Ontai, 1996~~). This illustrates the importance of *joint attention*—or the situation in which a child and her caretaker are both focused on the same object or event. Mothers and children speak more during episodes of joint attention, and mothers' frequency of object labeling during these episodes predicts later vocabulary (Tomasello & Farrar, 1986). Additionally, more novel words are learned if parents simultaneously look at and label the object their child is focused on rather than looking at other objects during labeling (Akhtar, Dunham, & Dunham, 1991). The redundancy of visual socio-pragmatic cues also increases the probability that a child will correctly map a word to its referent. Toddlers are more likely to learn a word when pointing accompanies eye gaze than when gaze cues are provided alone (Booth, McGregor, & Rohlfing, 2008; Hollich *et al*., 2000).

Infant-directed action

Just as adults modify their speech when addressing infants, they also modify their actions. This more salient form of nonlinguistic input is called *infant-directed action* (IDA) or *motionese*. When labeling objects for infants, adults use more exaggerated and repeated actions, less complex combinations of actions, and more attempts to elicit interaction than in adult-directed action (ADA; Brand, Baldwin, & Ashburn, 2002). Speech is often synchronized with IDA, such that when a mother moves an object in the presence of her infant, she is more likely to label it than to use other non-labeling words (Gogate, Bahrick, & Watson, 2000). Moreover, six to eight month olds are more likely to map a word onto a referent when mothers make use of this label-movement synchrony (Gogate, Bolzani, & Betancourt, 2006).

Even the type of object motion concurrent with labeling makes a difference in the success of the object-label mapping. Mothers use looming or shaking object motions more often than upward or sideways motions when teaching novel object labels to their six- to eight-month-old infants (Matatyaho & Gogate, 2008). Word learning is facilitated when infants view looming or shaking object motions relative to other types of motions, likely because these particular adult gestures highlight the object, bringing it into the foreground of the child's attention (Matatyaho & Gogate, 2008; Matatyaho-Bullaro *et al*., 2014).

Over time, at least in the Western families studied in this research, adults tailor their actions to the developmental level of the infant, similar to their changing use of IDS. Synchronizing object movement with labeling is extremely common at the earliest stages of word learning, when infants lack alternative tools for detecting word-to-world relations. As children progress from the prelexical (5 to 8 months) to early-lexical period (9 to 17 months) and from the early-lexical to advanced-lexical stage (21 to 30 months), mothers use this method less and less (Gogate, Bahrick, & Watson, 2000). By the advanced-lexical stage, toddlers use subtle social cues (e.g., eye gaze) as well as more sophisticated (and less infant-directed) pragmatic cues. For example, 27 month olds will differentially map a speaker's novel label to an action or to an object depending on the prior (rather than concurrent) actions of the speaker (Tomasello & Akhtar, 1995). Thus non-linguistic input plays a critical, albeit shifting role in word meaning disambiguation across development.

What is not *required for word learning?*

Despite a wealth of research supporting the role of eye gaze and IDA in language development (Baldwin, Bill, & Ontai, 1996; Carpenter *et al.*, 1998; Tomasello & Akhtar, 1995), vision is clearly not a prerequisite for lexical acquisition. Blind children learn words much the same as their sighted counterparts, including visual terms like *look* and *see* (Landau & Gleitman, 1985), even if the meanings they store for these lexical items are somewhat distinct from the meanings acquired by sighted children.

Lexical acquisition is most often discussed in terms of spoken language, but speech and hearing are not necessary for language development, either. Stromswold (1994) tested an anarthric child who could not produce speech and showed that he, too, comprehended many words and sentences. Furthermore, children learn signed languages just as easily as spoken languages (with the right input), regardless of whether they can hear or not. Indeed, hearing infants of hearing parents come prepared to find the "phonemes" in infant-directed *sign* at four months of age, an ability they lose by 14 months of age (Palmer *et al.*, 2012). Remarkably, the milestones for lexical acquisition are very similar for children learning signed languages and spoken languages (Bonvillian, Orlansky, & Novack, 1983; Schick, 2010). In the following section, we describe these milestones and discuss the implication, that certain aspects of word learning are universal.

The timeline of lexical acquisition

Across the globe, children reach major vocabulary milestones at the same time and show similar patterns in learning words. Whether children are learning French or Chinese, they tend to comprehend more words than they can produce. Furthermore, children show a tendency to learn nouns before they learn verbs—even in what are termed *verb-friendly* languages (Bornstein *et al.*, ~~2008~~; Waxman *et al.*, 2013), in which verbs can appear alone or at the ends of sentences.

Major milestones

Although there is some variation among individuals and among languages, children typically experience a remarkably similar trajectory of lexical growth (Bleses *et al.*, 2008). It takes about 12 months for children to produce their first word, but from then onward, their expressive vocabulary grows to approximately 50 words in the following six months (O'Grady & Archibald, 2010). The lexicon rapidly expands after this point, during a period often referred to as the *vocabulary spurt* (Fernández & Cairns, 2010). Some research suggests this spurt may simply be a by-product of learning words, of varying difficulty, in parallel (McMurray, 2007). However, specialized learning processes do emerge, and a large body of evidence suggests that word learning accelerates across development because children discover regularities in referential mappings (e.g., the shape bias, Landau, Smith, & Jones, 1988) and increasingly make use of a variety of information when learning new words (Hollich *et al*., 2000). This growth continues into adulthood, by which point most people know about 60,000 words. Table 24.1 summarizes some well-established milestones in lexical acquisition (Bornstein & Hendricks, 2012; Hollich *et al*., 2000; O'Grady & Archibald, 2010).

Comprehension before and greater than production

As Table 24.1 suggests, comprehension precedes and exceeds production throughout the early years of lexical development (Hirsh-Pasek & Golinkoff, 1996; O'Grady & Archibald, 2010). Some words are understood as early as six months, before any words can be produced (Bergelson & Swingley, 2012; Tincoff & Jusczyk, 2012). Even once production begins, the rate of word learning for comprehension is nearly twice that of production (Benedict, 1979). Bornstein and Hendricks (2012) found that comprehension consistently exceeds production among two to nine year olds in 16 under-researched developing nations, indicating that this developmental pattern continues throughout childhood and may be universal.

The asymmetry between receptive and expressive vocabulary has sparked controversy over the potential independence of these two aspects of language. To explore this possibility, Gershkoff-Stowe and Hahn (2013) studied incremental changes in word knowledge for 12 novel objects over three weeks, in both two-year-old children and adults. The authors found a comprehension advantage in both age groups, but there was no clear pattern as children progressed from

Table 24.1 Milestones of lexical acquisition

Age	*Milestone*
6–9 months	Understand first words
12 months	Produce first words, understand 50 words
	Learn to produce 2 new words per week
18 months	Produce 50 words, understand 150 words
	Learn to produce 10 new words per day
6 years	Produce and understand 14,000 words
	Learn up to 20 new words per day
17 years	Produce and understand 60,000 words

comprehension to production. In other words, any given word need not be part of the child's receptive vocabulary *before* entering the expressive vocabulary (Gershkoff-Stowe & Hahn, 2013). Rather, comprehension and production are distinct processes with different requirements. Comprehension involves recognizing the target word, but the meaning of a recognized word can sometimes be inferred from context without retrieval from memory. Word production, on the other hand, requires the active generation (i.e., retrieval) of words to match a communicative intention, as well as the motivation to speak (Bock, 1995; Woodward, Markman, & Fitzsimmons, 1994). These processes likely share an overlapping knowledge store (Gershkoff-Stowe & Hahn 2013), but word production seems to develop on its own timescale, somewhat independent of the earlier-developing comprehension. Mayor and Plunkett (2014) found that toddlers learning English, Dutch, Norwegian, and German all tend to understand the same set of words, but expressive vocabulary is highly variable among children (after the first 100 words), supporting the view that these two types of word knowledge progress differently during development.

The noun bias

Children have been observed to learn more nouns than other types of words (Gentner, 1982; Goldin-Meadow, Seligman, & Gelman, 1976; Waxman *et al*., 2013), but there has been some debate about the potential universality of this tendency (Tardif, Gelman, & Xu, 1999). Bornstein and colleagues (2004) found that children learning Spanish, Dutch, French, Hebrew, Italian, and Korean tend to exhibit a noun bias in expressive vocabulary. Still, certain environmental factors that vary substantially around the world may affect the strength of the noun bias in different linguistic communities. Goldfield (2000) reports, for example, that parents in New England elicit more nouns from their children than verbs and use verbs to elicit actions rather than speech. This suggests that children may understand many more verbs than they produce, and that the way parents use speech to interact with their children influences what types of words children tend to produce (Benedict, 1979; Goldfield, 2000; Waxman *et al*., 2013). Korean (Choi & Gopnik, 1995) and Mandarin (Tardif, 1996) use verbs more frequently and in more prominent sentence locations than in English. Despite these differences, the noun bias is retained in these so-called *verb-friendly* languages (Waxman *et al*., 2013; Bornstein *et al*., 2004; Imai *et al*., 2008), suggesting that nouns have a universally privileged status in lexical acquisition.

What causes nouns to be learned earlier and more easily? Gentner (1982) suggested that nouns are learned first because their meanings are easier to carve from the ever-changing world. Maguire, Hirsh-Pasek, and Golinkoff (2006) augmented this explanation, suggesting that all words lie on a continuum of abstractness, termed the SICI (shape, individuation, concreteness, and imageability) continuum (see Figure 24.1). SICI scores reflect the difficulty of learning a word based on four factors that have been discussed in the literature: the consistency of the referent's *shape*, the ease with which the referent concept can be *individuated*, the extent to

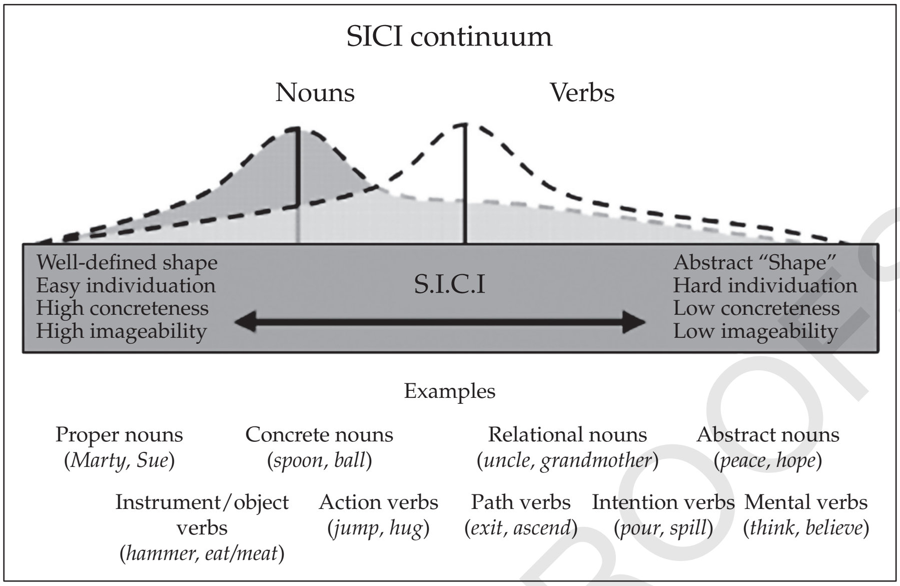

Figure 24.1 The SICI Continuum. 'SICI' is an acronym for four factors (shape, individuation, concreteness, and imageability) that contribute to the ease or difficulty of learning nouns and verbs. The concepts that these words represent lie on a continuum defined by the reliability of the concept's shape, the ease with which the concept can be individuated from other items, the concreteness of the concept to sensory systems, and the degree to which the word elicits a mental image. Although nouns typically precede verbs in vocabulary acquisition, this pattern is a by-product of the SICI continuum. Reproduced, with permission, from Maguire, Hirsh-Pasek, and Golinkoff (2006) and Oxford University Press, USA.

which the referent is *concrete* to the senses, and the facility with which the word evokes a mental *image*. Although some verbs, such as *jump*, involve a consistent "shape" of motion and are easily imageable, and although some nouns are extremely opaque (e.g., *peace*), the average verb is more abstract (i.e., has a higher SICI score) than the average noun.

A number of sources support the accuracy of the SICI criteria in describing word difficulty. Shape consistency determines whether children will learn and extend both nouns (Landau, Smith, & Jones, 1988) and verbs (Golinkoff *et al*., 2002) to other category members. Landau, Smith and Jones (1988) demonstrated a *shape bias* for extending count nouns: children easily extended a novel label to objects that had the same shape as the established referent (regardless of size or texture differences), but tended not to use the same label for objects of different shapes that had the same size or texture. For example, golf balls and tennis balls differ in size and texture, but both belong to the category of *ball* because of their spherical shape. This is untrue of things like tennis balls and ducklings, which have a similar size and a soft texture, but do not share a common label.

Additionally, concreteness of words predicts learnability: although infants cannot identify videos depicting abstract words like *wet* and *all-gone* until 10 to 14 months, six-month-old infants are already capable of recognizing pictures of several concrete words (e.g., *hand, banana*) in a similar task (Bergelson & Swingley, 2012, 2013). Further, imageability is one of the best predictors of age of acquisition for both nouns and verbs among English-learning children (Bird, Franklin, & Howard, 2001), and Ma and colleagues (2009) found that the increased imageability of Chinese compared to English verbs contributes to their being learned earlier. Thus, accruing evidence suggests that the noun bias may be an epiphenomenal by-product of the learnability of words, based on multiple dimensions of abstractness.

Individual differences

Although there are some general milestones and patterns in word learning, well-known individual differences abound. Children who receive less input generally learn fewer words and tend to learn these words more slowly (Hart & Risley, 1995). Bilingual children might trail slightly behind in reaching milestones in either of their two languages (Hoff *et al*., 2012), but combining the number of words known in both languages reveals that their overall vocabularies are as large as their monolingual peers' (Hoff *et al*., 2012; see also Byers-Heinlein and Lew-Williams in this volume for a more detailed review of bilingual vocabulary development). Bilingualism is also associated with certain advantages in cognitive flexibility, even in infants (Bialystok & Viswanathan, 2009; Kovács & Mehler, 2009, but see Paap & Greenberg, 2013).

Nelson (1973) noted that individual variation may also result from children following one of two possible paths as they begin learning words. One group, the *referential learners*, fill their early lexicon with names for objects, such as *ball* and *milk*. More socially attuned children, called *expressive learners*, instead master non-referential, communicative words early on, such as *hi* and *want*. The expressive learners tend to reach the 50-word milestone slightly later than the referential learners (Nelson, 1973).

Models of word learning: Solving the mapping problem

A heated debate surrounds the mechanisms behind word learning across development. In early word learning, theorists ask whether lexical acquisition is purely associationistic or whether it involves true referential learning via *fast mapping*—making a snap decision about the meaning of a novel word based on whatever information is available at the time of first exposure. Models of word learning after this initial "novice" phase diverge even further, with different researchers pointing to either perceptual, social, or linguistic information as the dominant force behind later lexical acquisition. In the last three decades, the field seems to have converged on a hybrid view, suggesting that all three types of cues are in play during advanced word learning. Hybrid models take a broader perspective, examining how the processes supporting lexical development change over the first few years of life (Hollich *et al*., 2000).

Early word learning

Although children eventually make use of complex social and linguistic cues to disambiguate word meaning, research suggests that they might not be able to recruit all these types of input from the outset. At first, they focus on perceptual salience as the main source of word meaning (Hollich *et al*., 2000; Brandone *et al*., 2007). Even with this narrow focus, two competing theoretical models propose distinct mechanisms for the acquisition of first words: cross-situational models and single-hypothesis models.

Cross-situational models propose that infants are robust statistical word learners, using similar methods to learn word meanings as they do to segment and identify words in the speech stream. To do this, infants must keep track of all the possible referents for a word, gleaned from experience within and across situations. At any given time, a child's representation of a word is considered to be manifold: first, the representation includes a mapping of the word to a single referent based on which referent co-occurs with the word most frequently; second, the representation requires partial knowledge of how frequently other referents have co-occurred with that word (Smith & Yu, 2008; Yu & Smith, 2007; Yurovsky *et al*., 2014).

The single-meaning hypothesis offers an alternative to cross-situational models. According to this hypothesis, children fast map one and only one hypothetical meaning in any given word learning situation (Golinkoff *et al*., 1992; Medina *et al*., 2011; ~~Stevens *et al*., 2014;~~ Trueswell *et al*., 2013); no other possible meanings are stored, even when the word learning occurs in a highly ambiguous situation. Early instantiations of single-meaning hypothesis models postulated that a word meaning hypothesis was maintained until it was disconfirmed by experience, at which point a new hypothesis was posited and the old discarded (Medina *et al*., 2011; Trueswell *et al*., 2013).

However, behavioral evidence and computational modeling have led researchers to alter the single-meaning hypothesis. The revised version, termed *Pursuit*, proposes that disconfirmed hypotheses are maintained alongside new hypotheses for some time (Stevens *et al*., ~~2014~~). After all, some words (i.e., ~~homonyms~~) can have multiple meanings (e.g., *bear*, *date*), and there must be a way for children to learn these. The Pursuit model takes a step toward acknowledging the infant's statistical learning abilities (Stevens *et al*., ~~2014~~). Repeated encounters with a word that support the original (fast-mapped) meaning are thought to increase the child's confidence in this hypothesis. If new encounters suggest a different meaning instead, a new hypothesis is created and assigned its own confidence level (based on how informative the learning situation is), while confidence in the original hypothesis decreases. Thus, at any given time, the child's representation of a word includes the most probable hypothesis as well as hypotheses formed during prior exposures to the word.

The key difference between cross-situational and single hypothesis models is whether multiple possible meanings of a word (based on word-object co-occurrences) are retained, or whether the child maintains only a limited set of hypothetical word meanings (one from each experience with the word). Although cross-situational models seem to avoid errors by maintaining all competing possibilities, they crowd the hypothesis space for each word, requiring an enormous amount of memory for each entry in the lexicon (Stevens *et al.*, 2014). Single-meaning or Pursuit models, on the other hand, may be more prone to error due to mistakes in fast mapping.

So which theory is supported by the data? Co-occurrence statistics can be used to determine the meanings of novel words in constrained experimental settings, as proposed by cross-situational models (Vouloumanos & Werker, 2009; Yu & Smith, 2011), but more naturalistic studies are necessary to test whether this method of word learning works in real-life situations (Smith, Suanda, & Yu, 2014). For example, the human simulation paradigm tests adults' ability to learn a novel object label by watching videos of parent-child interactions that are muted. This simulates the vast ambiguity of natural labeling events to determine whether or not cross-situational experience with a word is sufficient for everyday word learning (Medina *et al.*, 2011; Yurovsky, Smith, & Yu, 2013). Yurovsky, Smith, and Yu (2013) found that adults perform significantly better on every subsequent trial, even if their hypothesized meaning on the preceding trial was incorrect, indicating an effect of other object co-occurrences. However, each trial in this study was only compared to the trial immediately before it, not to all prior trials. It is therefore possible that only participants who developed the correct meaning hypothesis at some earlier point (not necessarily the trial immediately prior) were eventually successful on a later trial. Indeed, Koehne, Trueswell, and Gleitman (2013) found this to be true, suggesting that participants must have retained the correct hypothesis from a previous mapping and did not simply happen upon it with repeated exposure to the word. This finding lends support to the Pursuit hypothesis as a more accurate model of perceptual word learning.

The growing acceptance that word meanings are learned probabilistically and gradually (i.e., partially; see Yurovsky *et al.*, 2014) across situations rather than instantaneously originates in these early word learning models and signifies a critical step in understanding the word learning process. It is also vital that word learning models take memory into account, as recent evidence demonstrates that the retention of fast mapped labels is remarkably poor (Bion, Borovsky, & Fernald, 2013; Horst & Samuelson, 2008; Twomey, Ranson, & Horst, 2013, but see Zosh, Brinster, & Halberda, 2013). Further, memory for newly learned words follows a curvilinear pattern, with rapid forgetting early on, and slower rates of forgetting as time passes (Vlach & Sandhofer, 2012). Perhaps counterintuitively, forgetting is crucial for successful word learning. Lexical representations for frequently experienced words are reactivated and strengthened with each subsequent experience of the word (Wojcik, 2013), but if a word-object pairing is not re-experienced, as might happen for erroneous mappings or rare words, the pairing is never retrieved (i.e., reactivated) from memory and is forgotten over time (Vlach & Sandhofer, 2012). Thus forgetting is necessary to weed out incorrect mappings and to extend object mappings to more general object categories (Vlach & Sandhofer, 2012). Importantly, the ability to retain fast mapped word meanings increases with language experience (Bion *et al*., 2013), perhaps in part because later mappings are based on more than just perceptual information.

Word learning beyond the novice phase

While early word learning relies on perceptual cues as the main source of information about word meaning, there are differing views on the role of these and other types of cues in *later* lexical acquisition. In addition to perceptual information, social and linguistic cues have been identified as potential indicators of meaning. Word learning models based on all three of these types of cues have found supporting evidence in experimental and observational research.

Evidence shows that perceptual cues remain important beyond the first year of life, with 18 month olds learning a novel object label more easily when the object has a consistent location than when its location varies (Benitez & Smith, 2012). Perceptual models of later word learning assume that social and linguistic cues simply function to increase or decrease the perceptual salience of possible word referents (~~Frank, Tenenbaum, & Fernald, 2013;~~ Smith, 2000). In support of this view, Yoshida and Smith (2005) found that two year olds are more likely to learn a novel (i.e., non-native) semantic category when the linguistic information provided is redundant with perceptual cues. At this age, children can even learn a novel word when labeling occurs in the absence of the object referent, as long as labeling coincides with visual cues to the object's previous location (Baldwin, 1993; Smith, 2005). Three to four year olds and adults alike may learn new words through Bayesian inference, a type of statistical learning that requires general knowledge of word-to-world mapping and the ability to reweight the likelihood that fast-mapped hypotheses are correct, based on new experiences (Xu & Tenenbaum, 2007). In this way, Bayesian models of word learning straddle the cross-situational and Pursuit hypotheses, but still rely primarily on perceptual cues.

One major criticism of these perceptual models is that they seem to assume a nearly infinite number of tracked associations between words and their possible referents, as well as an infinite number of probabilistic calculations that must be computed to determine the correct referent of a given word. Arguing against this view, Yu and Smith (2012) suggest that word learning events are not as ambiguous as we (adults) believe, because children are visually selective in ways that adults are not. Not only do children move an object of interest so that it dominates their visual field, but they are more likely to learn the name for this object if their parents label it during a moment of visual focus (Yu & Smith, 2012). Still, perceptual models cannot easily explain how children map words to referents that are more abstract and lack perceptual salience (e.g., most verbs). The current evidence for these models comes from studies of noun learning, which generally involve mapping words to concrete, highly imageable referents (see Figure 24.1), for which perceptual cues are highly informative.

Another category of word learning models take a social-pragmatic approach. These models emphasize the importance of social-cognitive skills and socially contingent parent-child interactions (Tamis-LeMonda, Kuchirko, & Song, 2014; Tomasello, 2000). Word learning is thought to be facilitated by the child's understanding that language is used to exchange socially contextualized meanings, in conjunction with nonverbal communicative interaction. Additionally, these models suggest that social influences *gate*, or restrict, word learning processes, thus circumventing the unlimited number of calculations implicit in perceptual models (Kuhl, 2007). Studies have shown that even when a novel object is visually available at the time of labeling, this word-object mapping is learned more easily if the speaker and infant are jointly attending to the object (Baldwin, Bill, & Ontai, 1996; Bannard & Tomasello, 2012; Tomasello & Farrar, 1986). Booth, McGregor, and Rohlfing (2008) further demonstrated that word learning in 2.5 year olds could be enhanced by providing redundant socio-pragmatic cues, and this improvement resulted from increased attention to the communicative context rather than increased attention to the target referent.

Despite these findings, socio-pragmatic word learning models cannot explain the whole of lexical acquisition. Frank, Tenenbaum, and Fernald (2013) showed that socio-pragmatic cues alone are not reliable indicators of word meaning. Rather, these cues must be probabilistically combined to inform word reference (Frank, Tenenbaum, & Fernald, 2013). Moreover, socio-pragmatic approaches do not explain how infants who lack a repertoire of socio-cognitive skills (such as children who fall on the autistic spectrum) are able to learn words (e.g., Parish-Morris *et al*., 2007), nor do they account for later word learning in the absence of social cues (e.g., when reading a text).

A third and final class of word learning models are the linguistic models, which attribute the child's later lexical acquisition to the developing knowledge of her native language's structure. Once a foundational vocabulary (of mostly basic-level nouns) is acquired, young children begin to use these "easy" words to learn new "hard" (i.e., less perceptually available) ones through syntactic bootstrapping (Gleitman *et al*., 2005). For example two year olds infer that a novel verb in a two-argument (transitive) construction (e.g., "Look! The *duck* is gorping the *rabbit*!") is causal while a novel verb in a single-argument (intransitive) structure (e.g., "Look! *They* are gorping!") must refer to a self-caused act (Naigles, 1990; Hirsh-Pasek & Golinkoff, 1996). Similarly, Syrett and Lidz (2010) revealed that by 30 months, children even use syntactic bootstrapping to determine the meanings of novel adjectives, based on the type of adverbial modifier they appear with. Children used intensifiers (e.g., *too*) as a cue to *relative* adjective meaning (e.g., *small*) and proportional modifiers (e.g., *totally*) as a cue to *absolute* adjective meaning (e.g., *dry*).

Of course, linguistic models are also limited by their specificity. No single sentence is a reliable source for word meaning, and structural context alone is not enough to form an accurate mapping. Rather, children must experience a word in multiple sentential contexts and receive additional non-linguistic cues to a novel word's meaning (Rispoli, 1995; Yuan, Fisher, & Snedeker, 2012). Similar to socio-pragmatic word learning models, linguistic models fail to explain how word learning occurs prior to extensive language experience.

Modeling word learning as a complex developmental process

With evidence supporting the importance of perceptual, social, *and* linguistic information, word learning may be better explained by hybrid models that emphasize the weighting of multiple cues. These multifaceted models are empirically testable and have the added advantage of allowing the field to examine the changing nature of word learning over time.

The first hybrid theory of lexical acquisition to acknowledge the complexity of the word learning task was the Emergentist Coalition Model (ECM; Golinkoff & Hirsh-Pasek, 2006; Hollich *et al.*, 2000). Initially proposed in response to competing theories that posited a single word learning mechanism, the ECM changed the question from what process underlies word learning to how the processes underlying word learning change and interact across development. Hybrid theories of lexical development have now become the norm, with many adopting the same basic views as the ECM (Booth & Waxman, 2008; Caza & Knott, 2012; Namy, 2012).

The ECM is founded on three tenets: 1) children are sensitive to multiple cues, including perceptual, social, and linguistic sources of information from the outset 2) there is a differential weighting of these cues over time such that perceptual cues are more salient at the start of word learning, and 3) children construct word learning principles from the combination of internal biases and attention to these interactive and weighted cues (Hollich *et al.*, 2000). These claims have been experimentally tested by using eye gaze, pointing, and enthusiastic speech to label only one of two novel objects in children's immediate view—one interesting (e.g., brightly colored) and the other boring (e.g., dull in appearance). When the interesting object is labeled (the *coincident* condition), perceptual and social cues converge. However, when the boring object is labeled (the *conflict* condition), children must override their natural preference for the interesting (perceptually salient) object to map the label correctly—that is, children must weight social cues over perceptual ones (Pruden *et al.*, 2006). While 10 month olds map the novel word to the interesting object regardless of condition, 12 month olds do not; they map successfully in the coincident condition, but fail to form any mapping in the conflict condition (Hollich *et al.*, 2000). Finally, by 19–24 months, children are successful at mapping in both conditions. These results implicate a gradual shift in the weighting of social cues with respect to perceptual ones. This shift may be explained, in part, by infants' accrual of multifaceted experiences with adults who respond contingently and appropriately to their pre-linguistic object-directed behaviors (e.g., vocalizing, pointing, eye gaze), reflecting the infants' perceptual interest (Goldstein & Schwade, 2009; Wu & Gros-Louis, 2014; Yu & Smith, 2012).

In addition to the transition toward socially cued mapping, the ECM posits a shift in the use of linguistic cues. This is reflected both in infants' increasing selectivity of using words (and not other sounds) as symbolic representations for objects (see discussion above on how language is special) and in the developmental changes in how linguistic information is utilized for learning words. The ECM argues that syntactic bootstrapping is available early, but not dominant when faced with competing cues to word meaning. Further, social and linguistic sources of information are sometimes leveraged against one another. Social cues such as eye gaze seem to be more critical for learning nouns than other word classes (Bergelson & Swingley, 2013), while linguistic cues are especially useful for verb learning, likely because verb referents are more abstract or fleeting (Gleitman *et al*., 2005; Maguire, Hirsh-Pasek, & Golinkoff, 2006). Relatedly, social cues may be weighted more heavily earlier in the word learning process than linguistic cues (Caza & Knott, 2012; Hollich *et al*., 2000).

In some cases, social and linguistic cues are integrated in a single word-learning situation, with neither type of information necessarily dominating over the other. Grassmann, Stracke, and Tomasello (2009) tested whether two year old's use of the *mutual exclusivity bias*, the tendency to map novel words onto referents lacking a known label, was influenced by social information. When an experimenter excitedly uttered a novel word in reference to an object she had never seen before, children, as expected, mapped the label to the object. However, if the adult and child jointly played with the object first, the subsequent excited labeling event was much less likely to lead children to this mapping. This indicates that children make use of common ground (social-pragmatic information) to determine whether the mutual exclusivity bias (a linguistic cue) will be useful in a given situation. In this way, social and linguistic cues may be especially useful in concert with one another during later word learning. The next wave of research in this area will involve testing hybrid models longitudinally to tease apart children's progressive reweighting of different cues to word meaning.

Conclusion

Since Roger Brown's *Names for Things*, we have come to understand a great deal about the word learning process. We know that children, as master statisticians, can segment the fluid stream of sounds and events into coherent units. We even have some purchase on the mapping problem, which is compounded in the case of verbs and other relational and abstract words. Future research will surely continue to explore the mapping problem, but must do so in a way that nests the problem in a developmental and ecological framework. Gone are the days when researchers could seek simplistic single-mechanism answers to the "how" of lexical development. Any future solutions must embrace the complexity of the problem, including multiple inputs (i.e., linguistic and nonlinguistic), as well as the child's contribution in segmentation, symbolization, and the changes to mapping processes that occur over time. In short, the problems that plagued Plato remain contentious today; and P. Bloom was right—word learning is not a simple matching of word to world, but rather a window onto a multipronged cognitive problem.

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