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LANGUAGE DEVELOPMENT

Brian MacWhinney
Carnegie Mellon University

INTRODUCTION

Every normal human child succeeds at learning language. As a result, people often tend to take the process of language learning for granted. To many, language seems like a basic instinct, as simple as breathing or blinking. But, in fact, language is the most complex skill that a human being will ever master. We come to realize the complexity of language when, as adults, we try to learn a very different foreign language, such as an English-speaker learning Chinese or Arabic. Suddenly, we are confronted with a vastly different set of articulations and sounds, a new orthography, radically different word meanings, and new rules of grammar and word formation. The fact that all people succeed in learning to use language, whereas not all people learn to swim or sing very well, demonstrates how fully language conforms to our human nature. Languages avoid sounds that people cannot produce, words they cannot learn, or sentence patterns they cannot parse. Moreover, the things we choose to talk about and the expressions we select provide a full compendium of the scope of human life and society. It is the complexity of our nature and our society that leads directly to the complexity of language. Language learning seems like an effortless process because all this structure emerges so directly from the shape of human nature, the human body, and human society.

Unlike the communication systems of other species, language allows humans to create complete and open-ended descriptions of all manner of objects and activities outside of the here and now. These obvious differences between human language and animal communication have led philosophers from Plato to Descartes to think of language as a species-specific ability, something like a "Special Gift." But this gift does not depend on some single ability that arose suddenly in modern *Homo sapiens*. Instead, growing evidence from the study of **language development**, language evolution, and neurophysiology paints a complex and increasingly dynamic view of the emergence of this Special Gift. We now know that language learning depends on the acquisition of abilities across the six dimensions given in Table 8.1, namely audition, articulation, words, grammar, **communication**, and literacy. In this chapter, we will examine recent models and accounts of each of these six dimensions of language learning with an eye toward understanding what they have to tell us about the modern notion of a Special Gift for language development. As indicated in Table 8.1, the functioning of each of these dimensions depends on processing in particular brain areas. However, each of these

TABLE 8.1
Levels of Linguistic Processing

Dimension	*Brain area*	*Theory*
1. Audition	Auditory cortex	Statistical learning
2. Articulation	IFG, motor cortex	Resonance, gating
3. Words	Wernicke's area	Self-organizing maps
4. Grammar	Inferior frontal gyrus	Item-based patterns
5. Communication	Dorsolateral prefrontal cortex	Turn-taking, perspective
6. Literacy	Dorsal cortex	Schema theory

brain areas functions in synchrony with many other areas, so we cannot think in terms of a simple set of modules for language processing. Researchers have proposed theories that account for the learning of skills on these six dimensions. Some of the relevant theories, which we will examine later, are indicated in the third column of Table 8.1.

Before beginning, let us take a brief look at the contents of these six dimensions, beginning with auditory and articulatory learning. Auditory development involves learning how to distinguish the basic sounds of the language and using them to chop up or segment the flow of speech into distinguishable words. This learning involves the receptive or perceptual side of language use. In contrast, children's articulatory development involves learning to control the mouth, tongue, and larynx to produce sounds that imitate those produced by adults. This learning involves the productive or expressive use of language. Auditory learning and articulatory learning are the two sides of phonological development. We cannot acquire control over articulation until we have learned the correct auditory contrasts. Thus, audition logically precedes articulation.

The third dimension of language development is lexical development, or the learning of words. In order to serve as a means of communication between people, words must have a shared or conventional meaning. Picking out the correct meaning for each new word is a major learning task for the child. But it is not enough for children just to recognize words produced by their parents. To express their own intentions, they have to be able to recall the names for things on their own and convert these forms into actual articulations. Thus, lexical development, like phonological development, includes both receptive and expressive components.

Having acquired a collection of words, children can then put them into combinations. Grammar—the fourth dimension of language—is the system of rules by which words and phrases are arranged to make meaningful statements. Children need to learn how to use the ordering of words to mark grammatical functions such as subject or direct object.

The fifth dimension of language is pragmatics. This is the system of patterns that determines how we can use language in particular social settings for particular communicative purposes. Because pragmatics refers primarily to the skills needed to maintain conversation and communication, child language researchers find it easiest to refer to pragmatic development as the acquisition of communicative competence and conversational competence (Ochs & Schieffelin, 1983). A major component of communicative competence involves knowing that conversations customarily begin with a greeting, require turn-taking, and concern a shared topic. Children must also learn that they need to adjust the content of their communications to match their listener's interests, knowledge, and language ability. Finally, children need to acquire literate control of language to use printed material and formal spoken dialog to express increasingly complex social, cognitive, and linguistic structures or schemas. Literacy is the sixth and final dimension of the language acquired by the child.

As we progress through our study of the learning of these six dimensions of language, we will find three recurring themes. First, to study each dimension, researchers have devised a unique set of methods that we will want to understand. Second, for each dimension, we can present a set of standard age-linked milestones in acquisition for normal development, as long as we understand that, even within normal children, there is immense variation in the age of attainment of these milestones. Third, for each dimension, we can examine specific mental and physical processes that the child can use to acquire systematic control of language. If we can specify in detail the exact steps that produce a particular increase in the child's linguistic abilities, then we can say that we have provided a mechanistic account for this aspect of language development. In the best of all cases, we would be able to link this type of detailed mechanistic account to actual changes in the brain structures that support language. In practice, explanations at this detailed neurological level are still largely outside our grasp (MacWhinney, 2009).

AUDITORY DEVELOPMENT

William James (1890) described the world of the newborn as a "blooming, buzzing confusion." However, we now know that, at the auditory level at least, the newborn's world is remarkably well structured (Bornstein, Arterberry, & Mash, Chapter 6, this volume). The cochlea and auditory nerve provide extensive preprocessing of signals for frequency and intensity. By the time the signal reaches the auditory cortex, it has already been processed and categorized. In the 1970s, researchers (Eimas, Siqueland, Jusczyk, & Vigorito, 1971) discovered that human infants were specifically adapted at birth to perceive contrasts such as that between /b/ and /p/, as in *bit* and *pit*, in a categorical fashion. Figure 8.1 illustrates that listeners make a sharp crossover from perceiving /b/ to perceiving /p/ when voicing begins at about 20 ms after the release of the labial closure. Remarkably, we then learned (Kuhl & Miller, 1978) that even chinchillas were capable of making this distinction. This result indicates that the basic structure of the infant's auditory world arises from fundamental processes in the mammalian ear and cochlear nucleus, rather than from some specifically human adaptation. Beyond this basic level of auditory processing, it appears that infants have a remarkable capacity to record and store sequences of auditory events. It is as if the infant's auditory cortex has a tape recorder that stores and replays input sounds. In this way, the ear accustoms itself to the general sound patterns of the language, as well as the specific forms of some highly frequent words, long before learning the actual meanings of particular words.

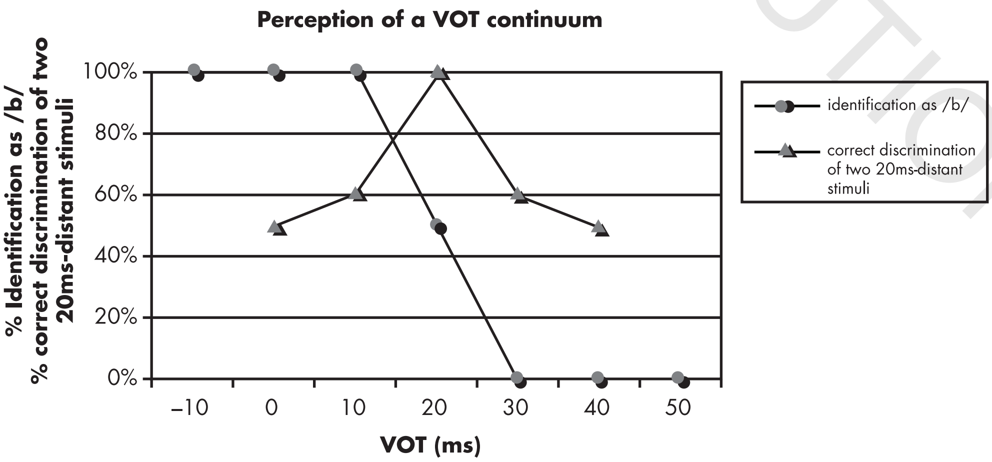

FIGURE 8.1 Perception of a VOT continuum (from Wikipedia).

One method (Aslin, Saffran, & Newport, 1999) for studying early audition relies on the fact that babies tend to habituate to repeated stimuli from the same perceptual class. If the perceptual class of the stimulus suddenly changes, the baby will brighten up and turn to look at the new stimulus. To take advantage of this, experimenters can play back auditory stimuli through speakers placed either to the left or to the right of the baby. If the experimenter constructs a set of words that share a certain property and then shifts to words that have a different property, the infant may demonstrate awareness of the distinction by turning away from the old stimulus and orienting to the more interesting, new stimulus. For example, when the sequence */badigudibagadigudigagidu/* is repeated many times, the parts that are repeated come to stand out perceptually and in the infant's memory. In this example, the repeated string is */digudi/*. If 6-month-olds are trained on this string, they will grow tired of the repeated sound and will come to prefer to listen to new sound strings, rather than to one with the old */digudi/* string. This habituation effect is strongest for stressed syllables and syllables immediately following stressed syllables (Jusczyk, 1997). This memory for sequences of syllables suggests that we are born with an ability to store and recall the sounds of human language. During the first year, the child is exposed to several thousand hours of human language. By continually attending to the auditory patterns of the language, the child builds up a rich repertoire of expectations about the forms of words. However, during this early period, the child still has no idea about the link between sounds and meanings.

In addition to demonstrating early abilities to store sequences of sounds, babies also demonstrate preferences for the language that resembles the speech of their mothers. Thus, a French infant will prefer to listen to French, whereas a Polish infant will prefer to listen to Polish (Jusczyk, 1997). In addition, babies demonstrate a preference for their own mother's voice, as opposed to that of other women. Together, these abilities and preferences suggest that, during the first 8 months, the child is remarkably attentive to language. In fact, this learning seems to begin even before birth. DeCasper and Fifer (1980) tape-recorded mothers reading a Dr Seuss book and then played back these tapes to babies before they were 3 days old. Making the playback of the tapes contingent on the sucking of a pacifier, they found that babies sucked harder for recordings from their own mothers than for those from other mothers. Moreover, newborns preferred stories their mothers had read out loud even before they were born over stories that were new (DeCasper, Lecanuet, & Busnel, 1994). Thus, it appears that their prenatal auditory experience shaped their postnatal preferences.

Although infants are not yet learning words, they are acquiring the basic auditory and intonational patterns of their native language. As they sharpen their ability to hear the contrasts of their native language, they begin to lose the ability to hear contrasts not represented in their native language (Kuhl, Conboy, Padden, Nelson, & Pruitt, 2005; Werker, 1995). If the infant is growing up in a bilingual world, full perceptual flexibility is maintained. Moreover, within the first year, bilingual children become increasingly able to distinguish the two different languages they are learning (Bosch & Sebastián-Galles, 1997). However, if the infant is growing up monolingual, flexibility in processing is gradually traded off for quickness and automaticity. As adults, bilinguals continue this trade-off of flexibility for automaticity, showing slightly slower reaction times in speeded lexical decision tasks than monolinguals (Kilborn, 1989).

ARTICULATORY DEVELOPMENT

Running in parallel with these growths in auditory ability, children display continual advances in vocal production. At birth, or shortly thereafter, the child is capable of four distinct types of cries (Wäsz-Hockert, Lind, Vuorenkoski, Partanen, & Valanne, 1968): the birth cry, the pain cry, the hunger cry, and the pleasure cry. The birth cry occurs only at birth and involves the infant trying to clear out the embryonic fluid that has accumulated in the lungs and trachea. The pain cry can be elicited by pricking the baby with a pin. The hunger cry is a reliable indicator of the infant's need to be fed. The pleasure cry, which is softer and not too frequent at first, seems to be the cry from which later language develops. Moreover, using spectrographic analysis, one can distinguish children with genetic abnormalities such as *cri du chat* or Lesch-Nyan syndrome at this age through their cries (Wäsz-Hockert, et al., 1968).

Infant cry patterns can be understood from the framework of the study of animal behavior or ethology (Tinbergen, 1951). In that framework, animals are viewed as capable of producing certain fixed action patterns. For example, bucks have fixed action patterns for locking horns in combat. Birds have fixed action patterns for seed pecking and flying. In humans, fixed action patterns include sucking, crying, eye fixation, and crawling. These various fixed action patterns are typically elicited by what ethologists call innate releasing mechanisms. For example, the sight of the nipple of the mother's breast elicits sucking. Mothers respond to an infant's hunger cry by lactating. If baby feels like it is falling, it will throw its arm outwards with the fingers out. A pinprick on a baby's foot elicits the pain cry, and parents respond to this cry by picking up and cuddling the child. On this level, we can think of the origins of language as relatively phylogenetically ancient and stable.

Articulatory development progresses through a fairly clear set of milestones, although with much individual variation. During the first 3 months, a baby's vocalizations involve nothing more than cries and vegetative adaptations, such as sucking, chewing, and coughing. However, just before 3 months (Lewis, 1936; McCarthy, 1954), at the time of the first social smiles, babies begin to make the delightful little sounds that we call "cooing." These sounds have no particular linguistic structure, but their well-integrated intonation makes them sure parent pleasers. During this time, the number and variety of vowel-like sounds the infant produces shows a marked increase. Unlike the vowels of crying, these vowels are produced from pleasure. Irwin (1936) noted that, up to 6 months, the infant's sounds are 90% consonants produced with closures in the back of the mouth like /*g*/ and /*k*/ and mid-vowels like /□/ and /ə/.

Babbling

At around 6 months there is shift from back consonants, such as /g/ and /k/, to front consonants, such as /p/ and /t/. This shift in consonants is accompanied by an increase in front vowels like /e/ and /i/. This shift may be a result of the shift from the dominance of spinal control of grosser synergisms such as swallowing to cortical control of finer movements (Berry & Eisenson, 1956; Tucker, 2002). This shift allows the baby to produce structured vocalizations, including a larger diversity of individual vowels and consonants, mostly in the shape of the consonant–vowel (CV) syllables like /*ta*/ or /*pe*/. As the frequency of these structured syllable-like vocalizations increases, we begin to say that the infant is **babbling**. Neural control of early babbling is built on top of patterns of noisy lip-smacking that are present in many primates (MacNeilage, 1998). These CV vocal gestures (Hoyer & Hoyer, 1924) have two pieces. The first part is a consonantal vocal closure that allows for a build-up of subglottalic pressure. Once this consonantal closure is released, the second part of the CV gestures begins. During this part, the vocal cords can vibrate freely, producing the resonant sound of the following vowel.

Until the sixth month, deaf infants babble much like hearing children (Oller & Eilers, 1988). However, well before 9 months, deaf infants lose their interest in vocal babbling, diverging more and more from the normal pathway (Mavilya, 1970; Wallace, Menn, & Yoshinaga-Itano, 1998). This suggests that their earlier babbling is sustained largely through proprioceptive and somaesthetic feedback, as babies explore the various ways in which they can play with their mouth. After 6 months, babbling relies increasingly on auditory feedback.

During this period, the infant tries to produce specific sounds to match up with specific auditory impressions. It is at this point that the deaf child no longer finds babbling entertaining, because it is not linked to auditory feedback. Instead, deaf children begin at this time to engage in forms of manual babbling. These facts suggest that, from the infant's point of view, babbling is essentially a process of exploring the coordinated use of the mouth, lungs, and larynx (Oller, 2000; Thelen & Smith, 1994).

In the heyday of behaviorism (Lerner, Lewin-Bizan, & Warren, Chapter 1, this volume), researchers viewed the development of babbling in terms of reinforcement theory. For example, Mowrer (1960) thought that babbling was driven by the infant's attempt to create sounds like those made by their mothers. In behaviorist terms, this involves secondary goal reinforcement. Other behaviorists thought that parents differentially reinforce or shape babbling through smiles or other rewards. They thought that these reinforcements would lead a Chinese baby to babble the sounds of Chinese, whereas a Quechua baby would babble the sounds of Quechua. This was the theory of "babbling drift." However, closer observation has indicated that this drift toward the native language does not occur clearly until after 10 months (Boysson-Bardies & Vihman, 1991). After 12 months, we see a strong drift in the direction of the native language, as the infant begins to acquire the **first words**. Opponents of behaviorism (Jakobson, 1968) stressed the universal nature of babbling, suggesting that, during babbling, all children produce all the sounds of all the world's language. However, this position also seems to be too strong. Although it is certainly true that some English-learning infants will produce Bantu clicks and Quechua implosives, not all children produce all of these sounds (Cruttenden, 1970).

Although vowels can be acquired directly as whole stable units in production, consonants can only be articulated in combinations with vowels, as pieces of whole syllables. The information regarding the place of articulation for all consonants except fricatives, such as /s/ or /z/, is concentrated in the transition that occurs between the release of the consonant and the steady state of the vowel (Cole & Scott, 1974). During this transition between the consonant and the vowel, the identity of the preceding consonant can be detected in a sound spectrograph by looking at deflections in the bands of energy that are unique to each vowel. Each vowel has three such formants or bands of sound energy concentrated at certain frequencies. In CV syllables like /*pa*/ or /*ko*/, each different consonant will be marked by different patterns of transitions in these formants before and after different vowels. Thus, in /*di*/, the second format rises in frequency before the steady state of the vowel, whereas in /*du*/ the second formant falls before the vowel. Massaro (1975) argued that this blending makes the syllable the natural unit of perception, as well as the likely initial unit of acquisition. By learning syllables as complete packages, the child avoids the problem of finding acoustic invariance for specific phonemes. If the syllable is, in fact, the basic unit of perception, we would expect to find that auditory storage would last at least 200 ms, or about as long as the syllable. In fact, it appears that auditory storage lasts about 250 ms (Massaro, 1975), indicating that it may be designed to encode and process syllables.

Ongoing practice with whole syllables occurs throughout the babbling period that extends from around 4 months to the end of the first year. In languages like Japanese, which has only 77 syllable types, this learning may allow the child to control some significant part of adult phonology. In English, with over 7,000 possible syllables, learning of the language through the acquisition of syllables seems to be a less realistic goal.

Infants commonly produce syllables sounding like /*ba*/ and /*di*/, but are relatively less likely to produce /*bi*/, probably because making a /*b*/ results in a tongue position well suited to following with /*a*/ but not /*i*/ (Massaro, 1975). Vihman (1996) studied infants and toddlers learning Japanese, French, Swedish, and English. A very small number of syllables accounted for half of those produced in all the groups, and the two most frequent syllables, /*da*/ and /*ba*/, were used by all language groups. These patterns suggest that infants use a basic motor template to produce syllables. These same constraints also affect the composition of the first words (Oller, 2000). For example, instead of pronouncing *mother* as /m□ðər/, the child will produce it as /mada/ or /mama/.

Between 6 and 10 months, there seems to be a tight linkage between babbling and general motoric arousal. The child will move arms, head, and legs while babbling, as if babbling is just another way of getting exercise while aroused. During the last months of the first year, the structure of babbling becomes clearer, more controlled, and more organized. Some children produce repetitive syllable strings, such as /*badibadibadibadigu*/; others seem to be playing around with intonation and the features of particular articulations.

Piaget's (1952) theory of sensorimotor learning provides an interesting account of many of these developments. Piaget viewed much of early learning as based on circular reactions in which the child learned to coordinate the movements of one process with another. In the case of babbling, the child is coordinating the movements of the mouth with their proprioceptive and auditory effects. In these circular reactions, the child functions as a "little scientist" who is observing and retracing the relations between one schema and another. For example, in the first month the infant will assimilate the schema of hand motion to the sucking schema. In babbling, the child assimilates the schema of mouth motions to the perceptual schema of audition, proprioception, and oral somaesthesia. There is much to support this view. It seems to be particularly on the mark for those periods of late babbling when the child is experimenting with sounds that are found in other languages. Also, the fact that deaf babies continue to babble normally until about 6 months tends to support this view.

Phonological Processes

The child's first words can be viewed as renditions or imitations of adult forms that have gone through a series of simplifications and transformations. Some of these simplifications lead to the dropping of difficult sounds. For example, the word *stone* is produced as *tone*. In other cases, the simplifications involve making one sound similar to those around it. For example, *top* may be produced as *pop* through regressive assimilation. Assimilation is a process that results in the features of one sound being adapted or assimilated to resemble those of another sound. In this case, the labial quality of the final /*p*/ is assimilated backwards to the initial /*t*/, replacing its dental articulation with a labial articulation. We can refer to these various types of assimilations and simplifications as "phonological processes" (Menn & Stoel-Gammon, 1995; Stampe, 1973). Many of these processes or predispositions seem to be based on something like the principle of "least effort" (Ponori, 1871). A proper theory of least effort has to be grounded on an independent phonetic account of effort expenditure. Ohala (1974, 1981, 1994) explored many of the components of this theory. However, most child phonologists have not yet made use of phonetically grounded principles, preferring to construct more abstract descriptive accounts (Bernhardt & Stemberger, 1998; Kager, 1999).

The child's problems with phonological form are very much focused on production rather than on perception. An illustration of this comes from the anecdote in which a father and his son are watching boats in the harbor. The child says, *look at the big sip*. Echoing his son's pronunciation, the father says, *yes, it's quite a big sip*. To this, the child protests, saying *no, Daddy say "sip," not "sip."* Such anecdotes underscore the extent to which the child's auditory forms for words line up with the adult standard, even if their actual productions are far from perfect. Table 8.2 presents some of the common types of phonological processes.

It is important to realize that many of these processes are also operative in adult language. For example, in Spanish, the dental /n/ in the word combination *digan paja* "say nice" becomes assimilated in normal speech to the labial sound /m/ under the influence of the

TABLE 8.2
Examples of Phonological Processes

Process	*Target*	*Actual*
final devoicing	bed	bet
final deletion	home	hoe
depalatalization	show	so
consonant harmony	dog	gog
syllable deletion	telephone	teffone
cluster reduction	bracket	backet
gliding	real	weal
stopping	funny	punny
stopping /z/	zoo	do
stopping /th/	them	dem
deaffrication	chip	ship
affrication	some	thumb
spirantization	thumb	fun
reduplication	baby	baybay
place assimilation	mad	mab

following labial sound. Assimilations and changes of this type are fundamental to the changes that languages undergo over the centuries.

Detailed observations of the course of phonological development have shown that the development of individual word forms does not follow a simple course toward the correct adult standard. Sometimes there are detours and regressions from the standard. For example, a child may start by producing *step* accurately. Later, under the influence of pressures for simplification of the initial consonant cluster, the child will regress to production of *step* as *tep*. Finally, *step* will reassert itself. This pattern of good performance, followed by poorer performance, and then finally good performance again is known as "U-shaped learning," because a graph of changes in accuracy across time resembles the letter "U." The same forces that induce U-shaped learning can also lead to patterns in which a word is systematically pronounced incorrectly, even though the child is capable of the correct pronunciation. For example, Smith (1973) reported that his son systematically produced the word *puddle* as *puggle*. However, he was also able to produce *puzzle* as *puddle*. Smith's account of this pattern assumes that the production of *puggle* for *puddle* is based on a consistent and deterministic rule. Another possible interpretation is that the child produces *puggle* in an attempt to distinguish it from *puddle* as the pronunciation of *puzzle*. Here, as elsewhere in language development, the child's desire to mark clear linguistic contrasts may occasionally lead to errors.

THE FIRST WORDS

The emergence of the first word is based on three earlier developments. The first is the infant's growing ability to record the sounds of words. The second is the development of an ability to control vocal productions, which occurs in the late stages of babbling. The third is the general growth of the symbolic function, as represented in play, imitation, and object manipulation. Piaget (1954) characterized the infant's cognitive development in terms of the growth of representation or the "object concept." In the first 6 months of life, the child is unable to think about objects that are not physically present. However, a 12-month-old will see a dog's tail sticking out from behind a chair and realize that the rest of the dog is hiding behind the chair. This understanding of how parts relate to wholes supports the child's first major use of the symbolic function. When playing with toys, the 12-month-old will begin to produce sounds such as *vroom* or *bam-bam* that represent properties of these toys and actions. Often these phonologically consistent forms appear before the first real words. Because they have no clear conventional status, parents may tend to ignore these first symbolic attempts as nothing more than spurious productions or babbling.

Even before producing the first conventional word, the 12-month-old has already acquired an ability to comprehend as many as 10 conventional forms. The infant learns these forms through frequent associations among actions, objects, and words. Parents often realize that prelinguistic infants are beginning to understand what they say. However, it is difficult for parents to provide evidence that demonstrates this ability convincingly. Researchers deal with this problem by bringing infants into the laboratory, placing them into comfortable high-chairs, and asking them to look at pictures, using the technique of visually reinforced preferential looking. A word such as *dog* is broadcast across loudspeakers. Pictures of two objects or actions are then displayed in two computer monitors, as illustrated in Figure 8.2. For example, a dog may be on the screen to the right of the baby and a car may be on the screen to the left. If the child looks at the picture that matches the word, a toy bunny pops up and does an amusing drum roll. This convinces babies that they have chosen correctly, and they then do the best they can to look at the correct picture on each trial. Some children get fussy after only a few trials, but others last for 10 trials or more at one sitting and provide reliable evidence that they know a few basic words. Many children show this level of understanding by the 10th month—2 or 3 months before the child has produced a recognizable first word (Oviatt, 1980).

Given the fact that the 10-month-old is already able to comprehend several words, why is the first recognizable conventional word not produced until several months later? Undoubtedly, many of the child's first attempts to match an articulation with an auditory target fall on deaf ears. Many are so far away from the correct target that even the most supportive parent cannot divine the relation. Eventually, the child produces a clear articulation that makes clear sense in context. The parent is amazed and smiles. The child is reinforced and the first word is officially christened.

But all is still not smooth sailing. The child still has no systematic method for going from auditory forms for words to the corresponding articulatory forms. Earlier experience with

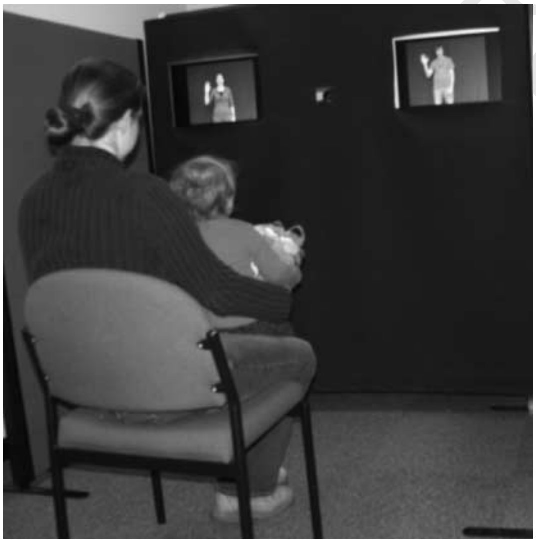

FIGURE 8.2 The preferential looking paradigm.

babbling provides some guide, but now the linkage requires increased precision and control over difficult articulators such as the tongue and the lips. The many simplifications that the 1-year-old introduces to adult phonology are well known to students of phonological development. Children tend to drop unstressed syllables, producing *Cinderella* as *rella*. They repeat consonants, producing *water* as *wawa*. And they simplify and reduce consonant clusters, producing *tree* as *pee*. All of these phonological processes echo similar processes found in the historical development and dialectal variation of adult languages (Stampe, 1973). What is different in child language is the fact that so many simplifications occur at once, making so many words difficult to recognize. Rather than repeating this experience, children may spend a month or two consolidating their conceptual and phonological systems in preparation for an attack on the adult target. However, most children do not go through this silent period. Instead, late babbling tends to coexist with the first words in most cases.

One way of understanding the challenge presented by the first words looks at the problem from the viewpoint of the infant. When babbling, the only constraints infants face are those arising from their own playfulness and interest. There are no socially defined constraints on the range of variation of those sounds. Some babies may try to get each sound "just right," but they do this to match their own goals and not ones imposed from outside.

It is easy to assume that children have some innate knowledge that tells them that words will always involve some spoken verbal form. However, an innate constraint of this type would severely limit the learning of sign language by deaf children. It would also inhibit gestural learning by hearing children. Rather than obeying some narrow view of the possible shape of a word, children are willing to learn all sorts of meaningful relations between signs and the objects that they represent. For example, Namy and Waxman (1998) found that normal 18-month-olds were happy to learn gestures as object labels. Similarly, Woodward and Hoyne (1999) found that 13-month-olds were happy to pick up a sound, such as clapping or banging, as if it was the name of an object.

Word Meanings

From Plato to Quine, philosophers have considered the task of figuring out word meaning to be a core intellectual challenge. Quine (1960) illustrated the problem by imagining a scenario in which a hunter is out on safari with a native guide. Suddenly, the guide shouts *Gavagai* and the hunter, who does not know the native language, has to quickly infer the meaning of the word. Does it mean *shoot now!* or *there's a rhino* or *it got away*, or maybe something else? If the word refers to the rhino, does it point to the horn, the hooves, the skin, or the whole animal? Worse still, the word could refer to the horn of a rhino if it is before noon and the tail of a jackal after noon. Without some additional cues regarding the likely meaning of the word, how can the poor hunter figure this out?

Fortunately, the toddler has more cues to rely on than does the hunter. The first person to recognize the importance of these additional cues was Augustine, the great Church Father, who wrote this in his *Confessions* (Augustine, 1952):

> This I remember; and have since observed how I learned to speak. It was not that my elders taught me words (as, soon after, other learning) in any set method; but I, longing by cries and broken accents and various motions of my limbs to express my thoughts, that so I might have my will, and yet unable to express all I willed or to whom I willed, did myself, by the understanding which Thou, my God, gavest me, practice the sounds in my memory. When they named anything, and as they spoke turned towards it, I saw and remembered that they called what they would point out by the name they uttered. And that they meant this thing, and no other, was plain from the motion of their body, the natural language, as it were, of all nations, expressed by the countenance, glances

> of the eye, gestures of the limbs, and tones of the voice, indicating the affections of the mind as it pursues, possesses, rejects, or shuns. And thus by constantly hearing words, as they occurred in various sentences, I collected gradually for what they stood; and, having broken in my mouth to these signs, I thereby gave utterance to my will. Thus I exchanged with those about me these current signs of our wills, and so launched deeper into the stormy intercourse of human life, yet depending on parental authority and the beck of elders.

The important point here is not whether Augustine could actually recall these memories, but rather how he conceptualized language learning. In this regard, his observations are remarkably astute. First, he emphasized the natural, emergent nature of **word learning** situated directly in situational contexts. Second, he understood the importance of a preliminary period of auditory learning, as discussed earlier. Third, he characterized the learning of words as occurring in the direct presence of the referent. Fourth, he understood the guiding role of eye gaze in establishing shared attention. Fifth, he recognized the importance of gestural and postural cues from the child's elders. Sixth, he recognized the difficulties involved in word production, as children have to "break in" their mouths to the pronunciation of words. Finally, he understood the central role of imitation in word learning.

Recent research has supported and elaborated Augustine's intuitions. One group of studies has supported the importance of gesture as a cue to meaning assignment. For example, Bates, Benigni, Bretherton, Camaioni, and Volterra (1979) showed how 10-month-olds would reliably follow eye gazes, pointing, and gesturing. More recent studies (Baldwin, 1993; Tomasello & Haberl, 2003) have further clarified the role of the cues of gesture, posture, intonation, and gaze (Pelphrey, Morris, & McCarthy, 2005) in establishing shared attention for word learning. For example, Gogate, Bahrick, and Watson (2000) showed that mothers, when they teach infants a name for a novel toy, tend to move the toy as they name it, much as Augustine suggested.

One hardly needs to conduct studies to demonstrate the role of gaze, intonation, and pointing, because these cues are so obvious to all of us. However, another aspect of Augustine's analysis is subtler and less fully appreciated. This is the extent to which children seek to divine the intention of the adult as a way of understanding a word's meaning (Bloom, 2000; Tomasello, 2003). They want to make sure that the adult is directly attending to an object before they decide to learn a new word (Baldwin et al., 1996). If the adult is speaking from behind a screen, children are uncertain about the adult's intentions and fail to learn the new word. Tomasello and Ahktar (1995) illustrated this by teaching 2-year-olds a new verb such as *hoisting*. In some of the trials, the toy character would inadvertently swing away and the experimenter would say "whoops." In those trials, the children would not associate *hoisting* with the failed demonstration. Autistic children have problems picking up on both gestural and intentional cues, possibly because of the fact that they have incompletely constructed models of the goals and intentions of other people (Baron-Cohen, Baldwin, & Crowson, 1997; Frith & Frith, 1999).

Augustine briefly alludes to one further way in which adults often simplify the word-learning task. This is by deciding to present words in a simplified, bare form outside of a complex sentential context. Corpus studies of adult input to children who are learning their first words have shown that as much as 20% of early utterances involve single words (Cartwright & Brent, 1997; Huttenlocher, 1974). By presenting single words in isolation, adults remove the problem of word segmentation, thereby further simplifying and facilitating the learning of the first words. This presentation of words in isolation occurs not only for common nouns, but also for words linked to social activities and games such as *bath*, *byebye*, *hi*, *uppie*, *no*, *yes*, *peekaboo*, and *yummy* (Ninio & Snow, 1988). It appears that some children focus learning on social rituals, whereas others are more oriented toward learning the names of objects (Ninio & Snow, 1988). However, in both cases, the initial referent for the word is a very rich encoding that is highly specific to the initial context of exposure.

Undergeneralization and Overgeneralization

The fact that words are picked up in specific contexts suggests that meanings may begin with a great deal of detail, much of it eventually irrelevant, which is then pruned off over time. These activities of refinement and pruning are reflected in the twin developmental patterns of **undergeneralization** and **overgeneralization** of early word meanings (see Figure 8.3).

Because they are initially acquired in very concrete situations, early word meanings are often highly *undergeneralized* (Dromi, 1987; Kay & Anglin, 1982). For example, a child may think that *dog* is the name for the family pet or that *car* refers only to vehicles parked at a specific point outside a particular balcony (Bloom, 1973). It is sometimes difficult to detect undergeneralization because it never leads to errors. Instead, it simply leads to a pattern of idiosyncratic limitations on word usage. Early undergeneralizations are gradually corrected as the child hears the words used in a variety of contexts. Each new context is compared with the current meaning. Those features that match are strengthened (MacWhinney, 1989), and those that do not match are weakened. When a feature becomes sufficiently weak, it drops out altogether.

This process of generalization is guided by the same cues that led to initial attention to the word. For example, it could be the case that every time the child hears the word *apple*, some light is on in the room. However, in none of these cases do the adults focus their attention on the light. Thus, the presence or absence of a light is not a central element of the meaning of *apple*. The child may also occasionally hear the word *apple* used even when the object is not present. If, at that time, attention is focused on some other object that was accidentally associated with *apple*, the process of generalization could derail. However, cases of this type are rare. The more common case involves use of *apple* in a context that totally mismatches the earlier uses. In that case, the child simply assumes nothing and ignores the new exemplar (Stager & Werker, 1997).

This process of initial undergeneralization and gradual generalization is the primary stream of semantic development. However, often children need to go outside this primary stream to find ways of expressing meanings that they do not yet fully control. When they do this, they produce *overgeneralizations*. For example, children may overgeneralize (and alarm their parents) by referring to tigers as *kitties*. Although overgeneralizations are not as frequent as undergeneralizations, they are easier to spot because they always produce errors. Overgeneralization errors arise because children have not yet learned the words they need to

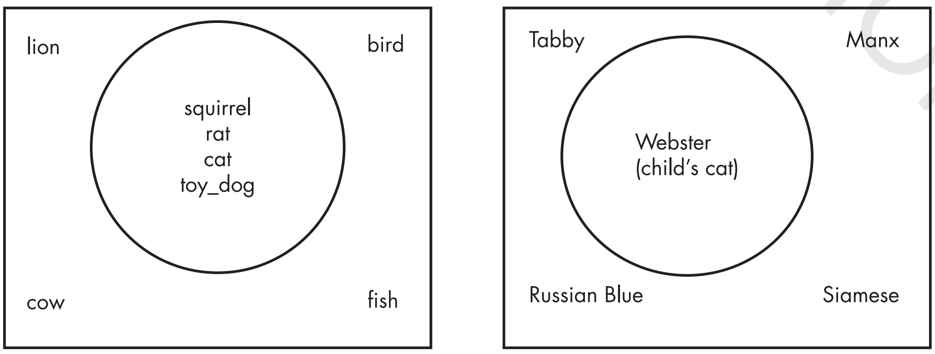

FIGURE 8.3 Overextension of CAT; underextension of CAT.

express their intentions. It is not that the child actually thinks that the tiger is a kitty. It is just that the child has not yet learned the word *tiger* and would still like to be able to draw the parent's attention to this interesting catlike animal.

The smaller the child's vocabulary, the more impressionistic and global will be the nature of these overgeneralizations. For example, Ament (1899) reported that his son learned the word "duck" when seeing some birds on a lake. Later he used the word to refer to other ponds and streams, other birds, and coins with birds on them. Bowerman (1978b) reported that her daughter Eve used "moon" to talk about a lemon slice, the moon, the dial of a dishwasher, pieces of toenail on a rug, and a bright street light. But this does not necessarily mean that the child actually thinks that *duck* refers to both lakes and birds or that *moon* refers to both lemon slices and hangnails. Rather, the child is using one of the few words available to describe features of new objects. As the child's vocabulary grows in size, overgeneralization patterns of this type disappear, although more restricted forms of overgeneralization continue throughout childhood.

This model of overgeneralization assumes that the child understands the difference between a *confirmed core* of features for a word and the area of potential further generalization. The confirmed core (see Figure 8.4) extends to referents that have been repeatedly named with the relevant word. The area of extension is an area outside this core where no other word directly competes and where extension is at least a possibility.

Constraints

The Augustinian vision of attunement between children and their parents provides a set of clear solutions to Quine's *Gavagai* problem. However, researchers have also explored a second major class of solutions to Quine's problem. This is the idea that children may come preprogrammed with fixed ideas that sharply limit the possible hypotheses for the meanings of words. In the 1980s, this approach to the challenge of word learning was characterized as constraint-based learning. The task of the developmental theorist was conceived in terms of discovering the shapes of these various **constraints**. One prominent proposal regarding a major constraint on word learning was the principle of mutual exclusivity formulated by Markman (1989). This principle held that a child would assume that a given referent could be named by one and only one word. However, it was soon noted that bilingual children are not constrained by this principle (Au & Glusman, 1990) and that monolingual children violate the principle when naming plurals, classes, and collections. To deal with these problems and additional experimental evidence, the principle was revised to emphasize the idea that alternative names for the same object tend to compete with each other. The revised constraint was

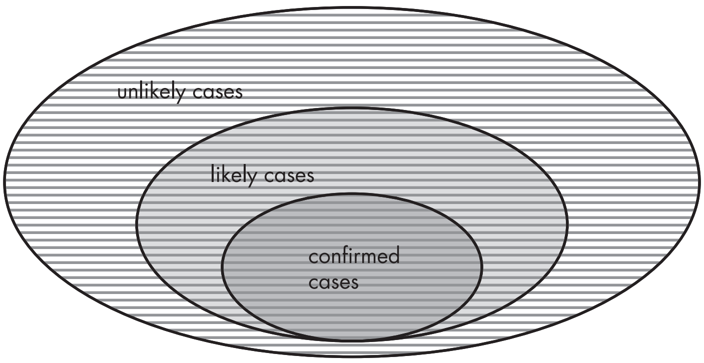

FIGURE 8.4 The confirmed core and its periphery.

characterized in terms of the competition (MacWhinney, 1991; Merriman, 1999), contrast (Clark, 1987), or the tendency to associate a new name with a novel object (Golinkoff, Hirsh-Pasek, & Hollich, 1999).

In addition to the principle of mutual exclusivity and its reformulations in terms of competition and contrast, researchers have proposed several other constraints or principles as partial solutions to Quine's *Gavagai* problem. As the child begins to learn new words, the process of learning itself produces new generalizations (Smith, 1999). For example, children soon come to realize that new words almost always refer to whole objects. There is no reason to think that this is some genetically determined, species-specific constraint. Within the first three months, children have come to realize that objects typically function as perceptual wholes (Bower, 1974). However, a cautious child will also realize that this assumption can sometimes be wrong. For example, one evening, I was sitting on a Victorian couch in our living room with my son Ross, aged 2, when he pointed to the arm of the couch, asking "couch?" He then pointed at the back and then the legs, again asking if they were also "couch." Each time, I assured him that the part to which he was attending was indeed a part of a *couch*. After verifying each component, he seemed satisfied. In retrospect, it is possible that he was asking me to provide names for the subparts of the couch. However, like most parents, I tried to focus his attention on the whole object, rather than on the parts. Perhaps I should have first taught him that all of the parts were pieces of couch and then gone on to provide additional names for the subparts, such as *arm*, *seat*, *back*, and *edge*, ending with a reaffirmation of the fact that all of these parts composed a *couch*.

It is clear that nature does not need to build in any language-specific machinery to enforce the whole object constraint. Rather, this constraint emerges from earlier developments in perception and cognition. However, there are other plausible constraints that one could frame in more purely linguistic terms. One such constraint is against the idea that words meanings can never include the notion of a disjunction. Consider the hypothetical example of the word *grue* that would mean "green in the morning, but blue at night." If the possible search space for word meanings included disjunctive concepts of this type, then the *Gavagai* problem might indeed be nearly impossible to solve. The unlikeliness of this constraint indicates that the view of word learning as unsituated hypothesis testing is itself a bit wide of the mark. It is true that children form hypotheses or guesses about word meanings, but these guesses are rooted deeply in the current situation. Thus, the constraint against disjunctives could be reformulated in terms of the observations that concrete situations themselves never involve disjunctions.

Flexible Learning

A third general approach to *Gavagai* problem focuses not just on the recharacterization of constraints, but rather on the idea that children are flexible word learners. One important aspect of this view is the idea that children can use their experiences with the meanings of the first few words they learn to sharpen their ideas about word meanings in general. As we noted earlier, Woodward and Hoyne (1998) found that 13-month-olds were happy to pick up a sound, such as clapping or banging, as if it were the name of an object. At this early point, children seem to be quite catholic in their views of what might be a word. We also noted the report from Ament (1899) showing that some of the meanings of early words take on rather unconventional shapes. However, as MacWhinney (1989) has argued, these various unconventional ideas are quickly rejected because they are not supported by later word learning. Children soon come to realize that clapping and banging are not used as the names for things. Similarly, they soon come to learn that words are most likely to refer to whole objects, rather than their parts.

Learning to learn can also induce the child to treat early word meanings in terms of common object functions. For example, Brown (1958) noted that parents typically label objects at the level of their most common function. Thus, parents will refer to *chairs*, but avoid *furniture* or *stool*, because *chair* best captures the level of prototypical usage of a class of objects (Adams & Bullock, 1986). As a result, children also come to realize that the names for artificial objects refer to their functions and not to their shape, texture, or size.

Children are also quick to pick up on a variety of other obvious correlations. They learn that the color of artificial objects such as cars and dresses can vary widely, but that many animals have unique colorings and patterns. They learn that any new word for an object can also refer to a toy characterizing that object or a picture of the object. They learn that people can have multiple names, including titles and nicknames. They learn that actions are mapped onto the human perspective (MacWhinney, 2008b), that objects can vary in qualities such as size, color, and texture, and that objects also produce a wide variety of pleasurable experiences through their qualities. Eventually, they use these facts and other data to govern their learning of nouns, verbs, adjectives, and other words. Generally speaking, children must adopt a highly flexible, bottom-up approach to the learning of word meanings (Maratsos & Deak, 1995), attending to all available cues, because words themselves are such flexible things.

This flexibility also shows up in the child's handling of cues to object word naming. Because shape is a powerful defining characteristic for so many objects, children learn to attend closely to this attribute. However, children can easily be induced to attend instead to substance, size, or texture, rather than to shape. For example, Smith (1999) was able to show how children could be induced, through repeated experiences with substance, to classify new words not in terms of their shape, but in terms of their substance.

Children's Agenda

The view of the child as a flexible word learner has to be balanced against the view of the child as having some definite personal agenda. Like Augustine, children often see language as a way of expressing their own desires, interests, and opinions. This then suggests a fourth major type of solution to Quine's problem. If the child's agenda aligned well with the words that adults are presenting to the child, then there would be little need for the child to confront the *Gavagai* problem. It is likely that this type of close alignment does occur for some words, but it is unlikely that it occurs for all words. Moreover, there is a danger inherent in sticking too closely to a self-determined agenda for learning word. In the extreme case, children might adopt the position espoused by Humpty Dumpty in *Alice in Wonderland*, when he chastises Alice for failing to take charge over the meanings of words. As Humpty Dumpty (see Figure 8.5) puts it, "When I use a word, it means just what I choose it to mean—neither more nor less." Unfortunately, the word meanings that Humpty Dumpty had selected failed to align properly with those that Alice had expected, confusing her badly.

In other cases, the ideas that children seek to express through early words match up closely with what their parents expect them to express. During the months before the first words, the child may use certain gestures and intonational patterns to express core agenda items such as desire, question, and attention focusing (Halliday, 1975). These non-conventional patterns may still possess a certain iconic basis that allows parents to guess at the meanings their children intend. Later, children seem to seek out words for talking about fingers, hands, balls, animals, bottles, parents, siblings, and food. Many of these early agenda items appear to focus on nouns, rather than on verbs or other parts of speech. Gentner (1982) argues that this is because it is easier to map a noun to a constant referent. Gentner referred to this tendency as the nominal bias, arguing that this bias is a cognitive universal. A variant of Gentner's position holds that nouns are learned more readily because it is easier for children to figure

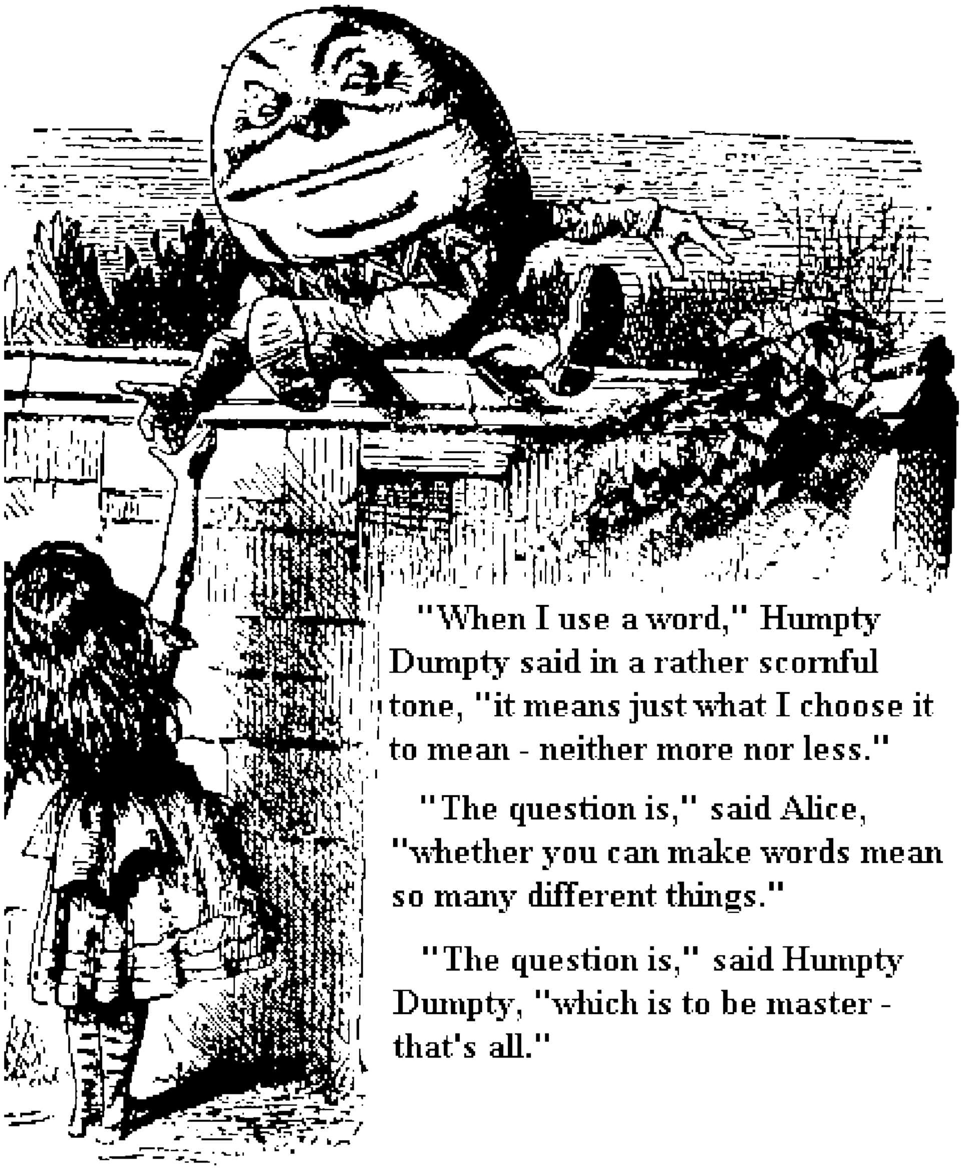

FIGURE 8.5 Humpty Dumpty's theory of word meaning. Illustration by John Tenniel from *Through the Looking Glass*, 1871.

out what people are talking about when they use nouns than when they use verbs. Moreover, nouns tend to be used in the same categorical and taxonomic ways (Sandhofer, Smith, & Luo, 2000), whereas verbs refer to a wider range of conceptual structures, include wishes, movements, states, transitions, and beliefs.

Input factors play a role as well. Studies of languages other than English show that sometimes children do not produce more nouns than verbs, at least during the first stages. For example, children learning Korean (Gopnik & Choi, 1995) and Mandarin Chinese (Tardif, 1996) may produce more verbs than nouns under certain conditions of elicitation. Two plausible explanations for this phenomenon have been offered. First, in both Korean and Mandarin verbs are much more likely to appear at the ends of utterances than in English, where the last word in input sentences tends to be a noun (Nicoladis, 2001). Perceptual studies (Jusczyk, 1997) have shown that it is easier for children to recognize familiar words at the ends of sentences, suggesting that this structural feature of languages influences rates of word learning as well. Second, Korean and Mandarin mothers tend to talk about actions more than do English-speaking mothers, who tend to focus on labeling things. Goldfield (1993) showed that American mothers who used more nouns tended to have infants with a higher proportion of nouns in their vocabularies.

The study of part of speech distribution within and between languages is probably highly sensitive to variations in the mode of data collection. In this regard, Sugárné (1970) showed that, in Hungarian preschoolers, verbs exceeded nouns when recordings were taken during playground interactions, but that nouns exceeded verbs under all other conditions of elicitation. Using comparable parental report measures in Spanish, Dutch, French, Hebrew, Italian, Korean, and American English, Bornstein et al. (2004) found that nouns dominated consistently over the other parts of speech by 20 months. These results seem to lend strong support to the idea that the nominal bias is universal. However, to fully evaluate this issue, we will eventually need actual child speech samples from across a wider variety of languages and activity types using maximally comparable data collection and analysis methods.

Whorf versus Humpty Dumpty

As learning progresses, the child's agenda become less important than the shape of the resources provided by the language. For example, languages like Salish or Navajo expect the child to learn verbs instead of nouns. Moreover, the verbs children will learn focus more on position, shape, and containment than do verbs in English. For example, the verb *áhéénìshtiih* in Navajo refers to "carrying around in a circle any long straight object such as a gun." The presence of obligatory grammatical markings in languages for concepts such as tense, aspect, number, gender, and definiteness can orient the child's thinking in certain paths at the expense of others. Whorf (1967) proposed that the forms of language end up shaping the structure of thought. Such effects are directly opposed to the Humpty Dumpty agenda-based approach to language. Probably the truth involves a dynamic interaction between Whorf and Humpty Dumpty. Important though language-specific effects may be, all children end up being able to express basic ideas equally well, no matter what language they learn.

Learning from Syntactic Contexts

Shared reference is not the only cue toddlers can use to delineate the meanings of words. They can also use the form of utterances to pick out the correct referents for new words. Consider these contexts:

Here is a pum. – count noun
Here is Pum. – proper noun
I am pumming. – intransitive verb
I pummed the duck. – transitive (causative) verb
I need some pum. – mass noun
This is the pum one. – adjective

Each of these sentential contexts provides clear evidence that *pum* is a particular part of speech. Other sentential frames can give an even more precise meaning. If the child hears, *this is not green, it is pum*, it is clear that *pum* is a color. If the child hears, *please don't cover it, just* *pum it lightly*, then the child knows that *pum* is a verb of the same general class as *cover*. The use of cues of this type leads to a fast, but shallow, mapping of new words to new meanings. Learning of this type was first identified in 3-year-olds by Brown (1957, 1973) and later in children younger than 2 by Katz, Baker, and Macnamara (1974). Carey (1978) later used the term *fast mapping* to refer to this induction of word meaning from syntactic context. The idea here is that the child can quickly pick up a general idea of the meaning of a new word in this way, although it may take additional time to acquire the fuller meaning of the word. Fast learning has also been identified in much younger children (Schafer & Plunkett, 1998). However, before age 2, fast mapping depends only on memory for the referent itself and not on induction from syntactic frames.

Words as Invitations

In a very real sense, words function as invitations for the construction of new categories. The child soon realizes that each new word is a pointer into a whole set of related objects or events that share some discoverable similarity. The more words the child learns, the clearer this effect becomes. New words for animals, like *hedgehog* and *dolphin*, invite an exploration of the habits, shapes, colors, and activities of that animal. New words for physical actions, like *gallop* and *knit*, invite an exploration of the ways in which the body can use these motions to act on other objects. Research has shown that the mere presence of a word can induce sharper and more consistent concept formation. For example, Waxman and Kosowski (1990) gave children two stories. In the first, they used the word *dobutsu* as a label, saying, "There's a being from another planet who wants some dobutsus. I don't know what dobutsus means, but he likes things like a dog, a duck, or a horse. Can you find him something he wants?" In the second story, they provided no label, saying, "This puppet only likes things like dogs, ducks, and horses. Can you find him something he likes?" Children were much more likely to point to another animal when the label *dobutsu* was used than when no label was provided. This effect has also been demonstrated for infants (Waxman & Markow, 1995) and echoed in several further studies, all of which emphasize the role that words play as invitations to categorization and cognition (Gentner, 2005; Lupyan, Rakison, & McClelland, 2007).

Competition and Mutual Exclusivity

Even the most complete set of syntactic cues and the fullest level of shared attention cannot completely preclude the occasional confusion about word meanings. Some of the most difficult conflicts among words involve the use of multiple words for the same object. For example, a child may know the word *hippo* and hear a hippopotamus toy referred to as a *toy*. But this does not lead the child to stop calling the toy a *hippo* and start calling it a *toy*. Some have suggested that children are prevented from making this type of error by the presence of a universal constraint called *mutual exclusivity*. This constraint holds that each object can only have one name. If children hear a second name for the old object, they can either reject the new name as wrong or else find some distinction that disambiguates the new name from the old. If mutual exclusivity were an important constraint on word meaning, we would expect children to show a strong tendency toward the first solution—rejection. However, few children illustrate such a preference. The fact is that objects almost always have more than one name. For example, a *fork* is also *silverware*, and a *dog* is also an *animal*. Linguistic structures expressing a wide variety of taxonomic and metonymic relations represent a fundamental and principled violation of the proposed mutual exclusivity constraint. The most consistent violations occur for bilingual children, who learn that everything in their world must, by necessity, have at least two names. Mutual exclusivity is clearly not a basic property of natural language.

One reason why researchers have devoted so much attention to mutual exclusivity stems from the shape of the laboratory situation in which word learning is studied. The child is presented with a series of objects, some old and some new, given a word that is either old or new, and then asked to match up the word with an object. For example, the child may be given a teacup, a glass, and a demitasse. She already knows the words *cup* and *glass*. The experimenter asks her to *give me the demitasse*. She will then correctly infer that *demitasse* refers to the object for which she does not have a well-established name. In this context, it makes sense to use the new name as the label for some new object.

Instead of thinking in terms of mutual exclusivity, the child appears to be thinking in terms of competition among words, with each word vying for a particular semantic niche. At the same time, the child is thinking in terms of the pragmatics of mutual cooperation (Clark, 1987). When two words are in head-on conflict and no additional disambiguating cues are provided, it makes sense for the child to assume that the adult is being reasonable and using the new name for the new object (Golinkoff, et al., 1999). The child assumes that the cooperative experimenter knows that the child has words for cups and glasses, so it only makes sense that the new word is for the new object.

In the real world, competition forces the child to move meanings around so that they occupy the correct semantic niche. When the parent calls the toy hippo a *toy*, the child searches for something to disambiguate the two words. For example, the parent may say, "Can you give me another toy?" or even "Please clean up your toys." In each case, *toy* refers not only to the hippo but also potentially to many other toys. This allows the child to shift perspective and to understand the word *toy* in the framework of the shifted perspective. Consider the case of a rocking horse. This object may be called *toy*, *horsie*, or even *chair* depending on how it is being used at the moment (Clark, 1997). This flexible use of labeling is an important ingredient in language learning. By learning how to shift perspectives, children develop powerful tools for dealing with the competitions among words. In this way conflicts among meanings give rise to complex structures and cognitive flexibility.

Building Theories

As children learn more and more words, they begin to develop clearer ideas about the ways in which words can refer to objects, properties, and events. The meanings of organized groups of words come to represent many aspects of the cognitive structure of the child's world. Children begin to realize that certain properties of objects are more fundamental and inherent than others. For example, Keil and Batterman (1984) talked to children about a cat that had been given a skunk's tail, nose, and fur. Before the age of 5, children believed that this animal would now actually be a skunk. After age 5, children began to realize that mere addition of these features would not change the fact that the animal was still inherently a cat. In effect, children are beginning to develop belief in a scientific theory that holds that animals cannot change their genetic status through simple transformations. Theories also provide children with conceptual structures they can use to infer the properties of new words. For example, if children are told that a *dobro* is a fish, then they can also infer that the *dobro* swims and has gills (Gelman, 1998).

Milestones in Vocabulary Growth

Typically, the child demonstrates new language abilities first in comprehension and only later in production. For example, children comprehend their first words by 9 months or even earlier, but only produce the first word after 12 months. Children are able to comprehend 50 words by about 15 months, but do not produce 50 words in their own speech until about

20 months. More generally, children acquire words into their receptive vocabulary more than twice as fast as into their productive vocabulary.

Children tend to produce their first words sometime between 9 and 12 months. One-year-olds have about 5 words in their vocabulary on average, although individual children may have none or as many as 30; by 2 years, average vocabulary size is more than 150 words, with a range among individual children from as few as 10 to as many as 450 words. Children possess a vocabulary of about 14,000 words by 6 years of age (Templin, 1957); adults have an estimated average of 40,000 words in their working vocabulary at age 40 (McCarthy, 1954). In order to achieve such a vocabulary, a child must learn to say at least three new words each day from birth.

GRAMMATICAL DEVELOPMENT

In terms of **grammatical development**, the transition from the first words to the first sentences is nearly imperceptible. After learning the first words, children begin to produce more and more single-word utterances. As their vocabulary grows, children begin saying words in close approximation, separated only by short pauses (Branigan, 1979). For example, they may say *wanna*, followed by a short pause and then *cookie*. If the intonational contour of *wanna* is not closely integrated with that of *cookie*, adults tend to perceive this as two successive single-word utterances. However, the child may already have in mind a clear syntactic relation between the two words.

As the clarity of the relations between single words strengthens, the temporal gap between the words will decrease. However, the transition from successive single-word utterances to true word combinations requires more than just faster timing. Two other achievements must occur. First, the child has to figure out how to join words together into a single intonational package or breath group. Second, the child also has to figure out which words can meaningfully be combined and in what order.

The level of successive single-word utterances is one that chimpanzees also reach when they learn signed language. Domesticated chimps like Sarah, Washoe, or Kanzi can learn about 100 conventional signs or tokens. They can then combine these words to produce meaningful communication. However, the combinations that chimpanzees produce never really get beyond the stage of successive single-word utterances. For example, the chimpanzee Washoe, who was raised by the Gardners (Allen & Gardner, 1969), produced strings such as "Open, now, me, now, open, door, please, open, please, me" to express the request to have a door opened. In a sequence like this, the chimp is basically using every item in her lexicon that might apply to the current scene without paying much attention to particular binary combinations of items (Terrace, Petitto, Sanders, & Bever, 1980). Human children take a very different approach to word **combination**.

When looking at children's first clumsy attempts to combine words, it is important to realize that they have already spent several months listening to words in combination during comprehension. Consider the case of the child's first use of the word *want* in combination with a noun like *cup* at 18 months. Before using the operator *want* for the first time, the child may well have heard it in combination dozens of times. During these exposures, the child comes to expect that certain words will follow directly after *want*. MacWhinney (1982) called such combinations **item-based patterns** because they specify the ways in which particular lexical items can combine with other words. In an item-based grammar of this type, lexical items produce syntactic combinations by combining with words that complete their argument structure (Bresnan, 1982; Tesniére, 1959).

In the case of the item-based pattern for *want* there are two terms that can complete its argument structure. First, there must be a nominal that serves as a direct object, as in *want cookie*. Second, there must be a nominal that serves as the subject, as in *I want cookie*. Because *want* expects these two additional words, we call it a two-argument predicate. Other predicates, such as *under* or *my*, take only one argument, and a few such as *give* take three *(John gave Bill a dollar)*. The only words that take no obligatory additional arguments are nouns. Unlike verbs, adjectives, prepositions, and other words that require additional arguments, nouns can express a full meaning without attaching additional arguments. Nouns that are derived from verbs, such as *destruction* or *remission*, can take optional arguments *(the destruction of the city* or *a decline in the dollar)*, but basic nouns such as *chair* and *goat* do not even have these expectations.

During the period of the first words, children are able to listen to speech and occasionally pick out verbs, adjectives, adverbs, and prepositions that they are starting to learn. However, to make sense of these words, they must link them to item-based patterns. Thus, some use of item-based patterns must be present in comprehension, well before we see it in production. Unfortunately, it is difficult to derive solid evidence regarding the exact shape of children's early abilities to comprehend syntactic patterns. As in the case of studies of early word comprehension, we have to assess children's early syntactic comprehension by controlled experiments in the laboratory. To do this, researchers have often relied on the preferential looking paradigm (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987). To the right of the child, there is a TV monitor with a movie of Big Bird tickling Cookie Monster. To the child's left, there is a TV monitor with a movie of Cookie Monster tickling Big Bird. The experimenter produces the sentence "Big Bird is tickling Cookie Monster." If the child looks at the matching TV monitor on the right, a toy makes a "success" noise and a correct look is scored. Using this technique, researchers have found that 17-month-olds already have a good idea about the correct word order for English sentences. This is about 3 months before they begin to use word order systematically in production.

Item-Based Patterns

Braine (1976) and Schlesinger (1974, 1975) made a close study of the exact semantic composition of early word combinations in several languages. These positional patterns involved combinations of predicates such as *want*, *more*, or *go* with arguments such as *cookie* or *flower*. Braine found that a small set of semantic combination types could be used to account for nearly all of the early sentences in the fairly small corpora that he studied. In some cases, the positional occurrence of the words involved was quite fixed. For example, children always said *my* + *X* and never *X* + *my* to express the possession relation. However, in other cases, the order was more variable. When the order became variable and applied inconsistently to various predicates, Braine referred to the ordering as indicating a "groping pattern." Braine thought that patterns of this type expressed high-level semantic relational features such as recurrence *(another doll)*, possession *(my doll)*, agency *(doll runs)*, or object *(want doll)*.

MacWhinney (1975) took a related, but somewhat different, approach to early word combination. Instead of assuming descriptions based on feature-based rules, he emphasized children's learning of low-level, item-based rules. Rather than viewing the combination of *more* and *milk* as expressing a pattern such as *recurrence* + *object*, MacWhinney interpreted the combination as evidence of the pattern *more* + *X*, where the italicization of the word *more* indicates that it is a particular lexical item and not a general concept. This analysis stresses the extent to which the item-based pattern first emerges as a highly limited construction based on the single lexical item *more*.

In MacWhinney's (1975) account, the grammar of the child's first word combinations is extremely concrete. The child learns that each predicate should appear in a constant position with respect to the arguments it requires. For example, in English, the word *more* appears before the noun it modifies, and the verb *run* appears after the subject with which it combines. The combination is based on a slot-filler relation. Consider the combination *more milk* which is generated from the item-based pattern *more* + *X*. In this combination, *milk* is a filler of the slot represented by the *X*.

Later, the child may generalize above the level of *more* and *milk* to acquire the higher-level pattern *want* + *object desired*. Once this pattern is learned, the child can then treat the whole unit or cluster *more milk* as an argument to the verb *want* producing *want more milk*. Finally, the child can express the second argument of the verb *want*, and the result is *I want more milk*. Thus, the child gradually builds up longer sentences and a more complex grammar. This recursive operation of item-based patterns uses basic mammalian cognitive mechanisms for structure building that have been further elaborated in the human species (Hauser, Chomsky, & Fitch, 2002; MacWhinney, 2008a).

Item-based patterns can be used equally well to characterize the positioning of affixes or inflections in words. For example, English marks the plural with the suffix –*s*, using the pattern: *object* + *s* to express the plural. Because affix-based patterns are so frequent and consistent, children find them very easy to learn. We know that in English (Braine, 1963), Garo (Burling, 1959), Hungarian (MacWhinney, 1976), Japanese (Clancy, 1985), and Turkish (Slobin, 1973), the ordering of affixes in words is almost always correct, even at the youngest ages. Together, item-based patterns coded on affixes like –*s* and stems like *wanna* can be used to describe and generate all of the basic aspects of grammar (MacWhinney, 1987; Sagae, Davis, Lavie, MacWhinney, & Wintner, 2007).

Applying the notion of item-based patterns to a corpus of Hungarian, MacWhinney (1975) examined the word order of 11,077 utterances produced by two Hungarian children between the ages of 17 and 29 months. He found that between 85% and 100% of the utterances in these samples could be generated by a set of 42 item-based patterns. Some examples of these patterns in English translation are: *X* + *too*, *no* + *X*, *where* + *X*, *dirty* + *X*, and *see* + *X*. The item-based pattern model was able to achieve a remarkably close match to the child's output, because it postulates an extremely concrete set of abilities that are directly evidenced in the child's output.

Children learn item-based patterns by listening to sentences. For example, if the child's older sister says *this is my dollie*, the child may only store the last two words as *my dollie*. Within this sequence, the child will then recognize the word *dollie* from previous experience and associate that word with the actual doll. This then leaves the segment *my* as uninterpreted (MacWhinney, 1978). At this point, the child can compare the phrase *my dollie* with the single word *dollie*, noticing the differences. The first difference is the presence of *my* before *dollie*. At this point, the child can establish a new lexical entry for *my* and associate it with the meaning of being possessed by the speaker (the older sister). While setting up this new form, the child also extracts the item-based positional pattern *my* + *X*. In this case, the older sister may be asserting her control over the doll and wresting it from the younger sister's possession. Thus, the younger child can pick up not only the meaning of *my* and the positional pattern but also the notion of a relation of possession and control between the two words. Thus, it is more accurate to speak of this item-based pattern as combining *my* + *object possessed*, rather than just *my* + *X*. By specifying a particular semantic role for the filler, we are emphasizing the fact that the pattern encodes both syntax and semantics.

Initially, this pattern is restricted to the words *my* and *dollie* and the relation of possession that occurs between them. However, if the older sister then says "and this is my horsie," the child can begin to realize that the open slot for the item-based pattern linked to *my* refers potentially to any manner of toy. Subsequent input will teach the child that any object can fill the slot opened up by the operator *my*. Each item-based pattern goes through this type of generalization (MacWhinney, 1975; Tomasello, Akhtar, Dodson, & Rekau, 1997)

Early child syntax is replete with examples of errors produced by the simple application of item-based patterns (Brown, Cazden, & Bellugi, 1968; Klima & Bellugi, 1966; Menyuk, 1969). Examples include *where Mama boot, no Rusty hat*, and *that no fish school*. These combinations arise from the application of item-based patterns such as *where* + *object located*, or *no* + *object denied*. In these patterns, the open slot can hold single nouns, noun phrases, or simple sentences. Errors arise because children are omitting articles and auxiliaries, but over time they will learn to add these through additional item-based patterns. Soon, children learn to use *where's* rather than *where* for interrogatives, producing correct combinations, such as *where's the wheel?* Some children form an overgeneralized *no* + *X* negation pattern in which X is not restricted to an object. Errors illustrating this incorrect overextension include *no do this*, *no wipe finger*, *no sit there*, *no play that*, *he no bite you*, and *I no taste them*. Parallel interrogative combination errors include *where go*, *what happen*, *where put him on a chair*, *what happen me*, and *why need them more*. Interrogative errors with missing auxiliaries of the shape *what they are doing* and *where he's going* are extremely common. There are also errors, such as *where the wheel do go* and *what you did eat*, in which the auxiliary is misplaced after the subject. These errors are further evidence for patterns such as *where* + *S*. Later, children replace *where* + *S* with *where* + *tense*. However, they fail to restrict the *where* + *tense* pattern to exclude main verbs. Overgeneralization errors attesting to the **productivity** of this later pattern include *where goes the wheel*, *where could be the shopping place*, *where's going to be the school*. After the first few months of word combination, there are no reports of errors that go against the basic item-based interrogative patterns. For example, there are no reports of errors such as *he can't do it why* (Labov & Labov, 1978).

The fact that grammatical patterns are often acquired word by word provides further evidence for the operation of item-based patterns. For example, Kuczaj and Brannick (1979) showed that children are quicker to show placement of the tensed auxiliary after the interrogatives *what* and *where* than after *how long* or *when*. Thus, children will produce *what is he doing?* at the same time they produce *when he coming?* Similarly, Bowerman (1978a) noted that, at 17 months, her daughter Eva used the patterns *want* + *X* and *more* + *X* productively. However, these patterns did not generalize to other words like *open*, *close*, *bite*, *no more*, or *all gone*.

One could argue that sentences of the type I have discussed are produced not through word combination but through **analogy**. Accounts based on analogy can be used to account for virtually any particular form. However, accounts based on analogy also typically predict many error types that never occur. For example, Kuczaj and Brannick (1979) noted that questions like *gonna he go?* have never been reported, although children say *he's gonna go*, *he will go*, and *will he go?* If analogy were operating here, we would expect to find *gonna he go?* on analogy with *will he go?* However, item-based patterns account for these data correctly. The auxiliary *will* is combined with *he go* using the item-based pattern *will* + *action*. This pattern does not generalize to *gonna*, because, by definition, the item-based pattern *will* + *action* is restricted to the auxiliary *will*. The item *gonna* never appears in initial position without a preceding nominal, so there is no evidence or form in support of an error such as *gonna he go?*.

Consider another example of how lexical classes help the child avoid overgeneralization. Children may notice that *big* and *red* pattern together in forms such as *big barn* and *red barn*. This might induce them to produce forms such as *I painted the barn big* on analogy with *I painted the barn red*. A conservative learner would stick close to facts about the verb *paint* and the arguments that it permits. If the child has heard a form like *I painted the barn white*, it would make sense to extend this frame to include the resultative predicate *red*. However, to extend from the word *white* to semantically unrelated words like *happy* or *difficult* would be to go far beyond the attested construction. As a result, this type of category-leaping overgeneralization is extremely infrequent.

Item-based patterns support gradual, but conservative productivity. We can also demonstrate the productivity of item-based patterns by teaching children novel words that serve as slot fillers. For example, we can show a child a picture of a birdlike creature that we call a *wug*. The positioning of the nonce word *wug* after the article *the* induces the child to treat the word as a common noun. We can show the child two pictures of the strange creature and ask them, "What are these?" By responding with the answer *wugs*, children show productivity of the item-based pattern based on the plural suffix. Similarly, we can set up a game in which each person names some toys. This will lead the child to produce the combination *my wug*, thereby showing the productivity of the pattern *my + object possessed*. Similarly, a German-speaking child can be taught the nonce name *der Gann* (nominative, masculine, and singular) for a toy. The experimenter can then pick up the toy and ask the child what he is holding. By the age of 3, children will correctly produce the accusative form *den Gann* (accusative, masculine, and singular).

Although it is easy to convince children to accept new slot fillers, it is far more difficult to teach them to accept new operators. This is because new operators must establish their own new item-based patterns. As a result, it is difficult to convince children to use novel verbs in a fully productive fashion. Instead, children tend to be conservative and unsure about how to use verbs productively until about age 5 (Tomasello, 2000). By then, they start to show productive use of constructions such as the double object, the passive, or the causative (Bowerman, 1988). For example, an experimenter can introduce a new verb like *griff* in the frame *Tim griffed the ball to Frank*, and the child will productively generalize to *Tim griffed Frank the ball*.

Combining Patterns

To understand how children learn complex syntactic structures, we need to see how a syntactic processor can combine words using item-based and feature-based patterns operating in real time. Most current accounts of real-time syntactic processors use the logic of the competition model of MacWhinney (1987). That model specifies a series of steps for the competition between constructions.

1. Sounds are processed as they are heard in speech.
2. Competition during sound processing controls activation of a current word.
3. Each new word activates its own item-based patterns along with related feature-based patterns (see following).
4. Item-based patterns then initiate tightly specified searches for slot fillers.
5. Slots may be filled either by single words or by whole phrases. In the latter case, the attachment is made to the head of the phrase.
6. To fill a slot, a word or phrase must receive support from cues for word order, prosody, affixes, or lexical class.
7. If several words compete for a slot, the one with the most cue support wins.

The details of the operation of this parser are controlled by the competitions between specific lexical items and the cues that support alternative assignments. Consider the case of prepositional phrase attachment. Prepositions such as *on* take two arguments: The first argument is the object of the preposition; the second argument is the head of the prepositional phrase (i.e., the word or phrase to which the prepositional phrase attaches). We can refer to argument 1 as the local head or endohead and argument 2 as the external head or exohead. Consider the sentence *the man positioned the coat on the rack*. Here, the endohead of *on* is *rack* and its exohead (the head of the whole prepositional phrase) could be either *positioned* or *the coat*. These two alternative attachment sites for the prepositional phrase are in competition with each other.

Competition also governs the interpretation of verbs as either transitive or intransitive. Verbs like *jog* that have transitive and causative and intransitive readings can be represented by two competing lexical entries. When we hear the phrase, *since John always jogs a mile*, we activate the transitive reading. However, if the full sentence then continues as *since John always jogs a mile seems like a short distance*, then the intransitive reading takes over from the transitive one. Consider these two illustrations of the results of a few attachment competitions:

Mary likes a young soldier:
Mary – likes – (a – (young – soldier))
The cat the dog chased ate the cheese:
((the – dog) – chased – (the – cat)) – ate – (the – cheese)

For detailed examples of the step-by-step operations of this type of processor consult MacWhinney (1987) or O'Grady (2005).

Feature-Based Patterns

Although item-based patterns can be used to generate nearly all word combinations, there is good evidence that children soon go beyond item-based patterns to learn more general combinatorial rules. Consider the learning of the pattern that places the adjective before the noun in English. At first, children pick up a few item-based patterns such as *nice + object, good + object*, and *pretty + object*. They acquire these patterns during the learning of new adjectives from the input. For example, children may hear the form *nice kitty*, from which they create the pattern *nice + X*. At first, the slot filler is limited to the original noun *kitty*, but it is then quickly generalized to all possible objects. When the child then begins to learn the parallel patterns for *good* and *pretty*, the process of slot generalization becomes quicker, as the child begins to realize that words like *nice, good*, and *pretty* that describe characteristics of objects all accept a related object in the following syntactic position. This linking of item-based patterns then gives rise to a feature-based pattern that specifies the combination *modifier + object described* for English. Other early feature-based patterns include *possessor + possession (John's computer)* and *locative + location (behind the tree)*. Once children have learned these more general patterns, they apply immediately to newly learned words.

Feature-based patterns can also apply to the positioning of nouns as topics in languages like Hungarian or Chinese. These languages encourage the formation of sentences that place nominal topics in initial position, according to the feature-based pattern *topic + comment*. At first, children may pick this up as an item-based pattern. For example, they might hear a Hungarian sentence of the shape *the glass # empty* with the # sign indicating an intonational break between the topic and the comment. They first encode this as a pattern linked to *glass*. However, after hearing a few more parallel patterns for other nouns, they then extract a general feature-based pattern, just as they do for the *modifier + object described* pattern for adjectives. Studies such as MacWhinney (1975) and Lee (1999) have demonstrated that children use these patterns productively by age 2.

Grammatical Markers

The account of grammatical acquisition presented previously is highly anglocentric. English is rather unique in terms of the extent to which it relies on strict word order patterns, rather than on grammatical markers for case and agreement. English does have a few grammatical markers, such as the final /s/ that can mark plurality, possession, or subject–verb agreement in the present tense when the subject is third person singular. But English only marks case in the pronoun through distinctions such as *he* vs. *him*. Other languages, such as Japanese, Hungarian, Navajo, or Russian, permit a far wider variation in the order of words, because the roles and links between words are marked by a rich system of grammatical morphemes, including both prefixes and suffixes. For example, it is always possible to spot the direct object in Hungarian, because it ends with a final /t/ on the noun, as in the contrast between the nominative form *kabát* (coat) and the accusative *kabátot*.

At first, children seem blissfully unaware of the presence of these grammatical markings, treating complex multimorphemic words as if they were single units. For example, a child might use the word *cookies* even before learning the singular *cookie*. At this point, we can refer to the unanalyzed two-morpheme combination *cookies* as an *amalgam* (MacWhinney, 1978). The child language literature is replete with examples of uses of inflected amalgams before the child has learned the stems. For example, Brown et al. (1968) reported use of *can't, won't*, and *don't* at a time when *can, will*, and *do* were absent. Similarly, Leopold (1949, p. 8) reported use of *sandbox* at a time when *sand* was still absent. Children also use inflected forms before they have acquired the inflections. Kenyeres (1926) reported that his daughter used the inflected Hungarian word *kenyeret* (bread + accusative) at 16 months, when there was no other evidence for productive use of the accusative "-et." Moreover, Hungarian children often use *kalapáccsal* (hammer—with) before demonstrating productive use of either the stem *kalapács* (hammer) or the instrumental suffix -*val*. Of course, for the child, the main interest value of a hammer involves its use as an instrument, just as a child may be particularly interested in having more than just one cookie.

One can also argue that precocious usage of a string indicates underanalysis. Peters (1977) noted that, when her 14-month-old child controlled only 6 to 10 words, he said quite clearly *open the door*. Similarly, my son Ross produced *no, Mommy, I don't want to go bed* and *I like it; I love it* at a time when the first two-word combinations were just emerging. The use of amalgams can also produce grammatical errors. For example, if children learn *like it* and *want some* as amalgams, they can produce errors such as *I like it the ball* or *I want some a banana*. Clark (1977) reported the utterance *hat on gone now* in which *hat on* is acting as a unit with *on* as an unanalyzed suffix.

A fairly strong type of evidence for the nonproductivity of early affixes or word endings is the fact that, when they first appear, affixes are seldom overgeneralized (Ervin, 1964). Children begin by saying *went* and *saw*, and overregularizations such as *goed* or *sawed* typically do not occur before correct irregular forms are produced. Later, when errors like *goed* and *sawed* begin to appear, they serve as evidence of the productivity of the past-tense suffix as well as evidence of its earlier nonproductivity. After a few weeks, the child corrects these errors and returns to correct use of *went* and *saw*. This pattern of correct performance with an intermediate period of overgeneralization produces a U-shaped curve that has a different developmental profile for each verb.

It is possible to track the rise of affix productivy by teaching children new, nonce words. For example, Berko (1958) showed children pictures of an imaginary creature called a "wug" and then asked them how you would call two of them, as illustrated in Figure 8.6. This method can be extended quite generally to study the productivity of all sorts of affixes, compounds, and other word formation devices. In general, children make fewer morphophonological errors on common irregular words than on rare irregular words (MacWhinney, 1978). This effect indicates that children rely on rote to produce at least some inflected forms. Frequent forms can be acquired as chunks or amalgams because they are heard so often.

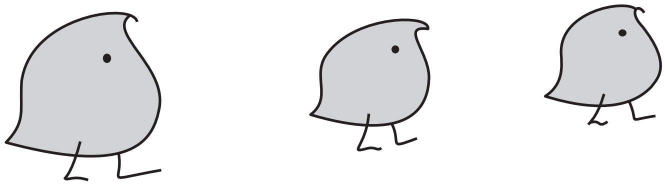

FIGURE 8.6 The "wugs" test of Berko (1958).

The absence of productivity for a suffix should not be taken as absence of the underlying concept. For example, Brown and Bellugi (1964) found that children would refer to *many shoe* and *two shoe* at a time when there is still no clear evidence for the productivity of the plural suffix. However, the words *many* and *two* by themselves show that the child not only thinks in terms of the concept of plurality, but also has succeeded in finding two ways of expressing this concept. At this point, acquisition of the plural is driven not by the child's need to express concepts, but by the need to match the formal structures of the adult language.

COMMUNICATIVE DEVELOPMENT

Babies and their parents engage in conversations even before the child has begun to produce words. These conversations may share smiles, gazes, coos, and grunts (Snow, 1977). Parents of young children will speak to them as if they were full conversational participants. For examples, one can browse the transcripts linked to audio at http:/childes.psy.cmu.edu/browser such as those in the Eng-USA/Brent corpus. These early dialogs demonstrate the extent to which children acquire language not only to solve problems or express themselves, but also to participate fully in conversational interactions. Even these early conversations allow us to engage socially as members of dyads and groups. To the degree that there is a fundamental urge to produce language, it is in large part an urge not to talk, but to converse.

This urge to socialize affects mothers as well as infants. Papoušek and Papoušek (1991) showed that mothers use rising pitch contours to engage infant attention and elicit responses, falling contours to soothe their babies, and bell-shaped contours to maintain their attention. In general, these patterns are useful not only for directing attention to new words (Thiessen, Hill, & Saffran, 2005; Thiessen & Saffran, 2007), but also for involving babies in the "melody" of conversation (Locke, 1995), even before they have learned "the words."

Conversations between mothers and their infants involve a variety of alternating activities. Infants tend to produce positive vocalization when gazing into their parents' eyes (Keller, Poortinga, & Schomerich, 2002). When infants produce negative vocalizations, parents often respond by touching and cuddling them. However, infants will produce more vocalizations when parents vocalize to them, rather than merely respond with touch or gesture (Bloom, Russell, & Wassenberg, 1987). A longitudinal study of naturalistic talk (Snow, Pan, Imbens-Bailey, & Herman, 1996) found a continuing increase in child speech during 10-min segments from 4 at 14 months to 7 at 20 months and 11 at 32 months. This ongoing growth of participation in conversations emphasizes the extent to which infants are being mainstreamed into a world of continual conversational turn-taking.

The logic of parent–child conversational turn-taking is not fundamentally different from that used between adults. The basic rule underlying all forms of turn-taking (Sacks, Schegloff, & Jefferson, 1974) is that, at any given moment, one of the participants is deemed to "have the floor." While that participant holds the floor, the other participants are supposed to pay attention to the conversational contribution. At some point the speaker begins to yield the floor and thereby invites a new conversational contribution. Signals that invite a new contribution include pauses, questions, and drops in intonation. Of course, conversations are not controlled as carefully as the flow of traffic through signal lights. Often there are collisions between speakers resulting in overlaps. At other times, there are complete breaks in the interaction. All of these features can be detected in vocal–visual interactions between mothers and children as young as 12 months. What distinguishes parent–child dialogs from adult–adult dialogs is the extent to which the parent uses specific devices to interpret children's ill-formed actions as conversational actions and the extent to which the parent attempts to maintain and guide the interaction, both verbally and physically.

Toward the end of the first year, children develop increasing ability to control conversations through specific routines. The most well-developed routine is pointing. Children show reliable responding to pointing by about 10 months. They are able to look at their parents' faces and use their gaze and pointing to locate objects. Soon after this, by about 12 months, children begin to produce their own communicative pointing (Lempers, 1979). In the period between 12 and 15 months, just before the first words, children also develop a set of intonational patterns and body postures intended to communicate other detailed meanings (Halliday, 1975).

Parents provide interpretive scaffolds for many of the child's early communicative behaviors (Bruner, 1992). After the child produces a smile, the parent may then respond with a fully fledged verbal interpretation of the meaning implicit in the smile, as in, "Is David having fun?" If the child shakes a spoon, the mother will attempt to interpret this gesture too, suggesting, "Ready for dinner?" Beginning around 9 months, this sequence of child action and maternal interpretation takes on a choral quality involving alternating, rather than overlapping, contributions (Jasnow & Feldstein, 1986). By combining verbal responses with the child's gestures, mothers are able to produce a scaffold on which children can construct a vision of communicative interactions. The transcripts with videos available from http://childes.psy.cmu.edu provide many illustrations of choral sequences of this type.

Snow (1999) argued that early participation in conversational interactions is the primary support for the initial stages of language acquisition. She emphasized the extent to which early words serve social functions in games and routines, rather than serving merely to request objects. Crucially, language learning depends on the construction of a shared intersubjective understanding of the intentions of the parent. Conversational sequencing is the scaffold on which this understanding develops. Sequencing receives support from the processes of identification (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996), embodiment (MacWhinney, 2008b), and imitation (Meltzoff, 1995). Together, these processes allow us to construct a complete image of the other person as a complete conversational partner who is participating and acting in ways that are parallel to the ways we ourselves act.

The growth of children's vocabulary is heavily dependent on specific conversational input. The more input the child receives, the larger the vocabulary (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). Children from higher socioeconomic status (SES) groups tend to have more input and a more advanced vocabulary (Arriaga, Fenson, Cronan, & Pethick, 1998). More educated families provide as much as three times more input than less educated families (Hart & Risley, 1995). Social interaction (quality of attachment, parent responsiveness, involvement, sensitivity, and control style) and general intellectual climate (providing enriching toys, reading books, and encouraging attention to surroundings) predict developing language competence in children as well (van IJzendoorn, Dijkstra, & Bus, 1995). Children with verbally responsive mothers achieve the vocabulary spurt and combine words into simple sentences sooner than do children with less verbally responsive mothers (Tamis-LeMonda &

Bornstein, 2002). These facts have led educators to suspect that basic and pervasive differences in the level of social support for language learning lie at the root of many learning problems in the later school years.

THE DEVELOPMENT OF LITERACY

Increased input during early childhood leads to increases in vocabulary growth and other aspects of language structure. These differences in input quantity and quality continue to widen as children get older, with children from higher SES and more educated families receiving more instruction both in the home and in the school in language forms, reading, literature, and composition (Dickinson & Moreton, 1993).

As children move on to higher stages of language development and the acquisition of literacy, they depend increasingly on wider social institutions. They may rely on Sunday school teachers as their source of knowledge about Biblical language, prophets, and the geography of the Holy Land. They will rely on science teachers to gain vocabulary and understandings about friction, molecular structures, the circulatory system, and DNA (Keil, 1989). The vocabulary demands placed by such materials can be enormous, with a typical textbook in biology requiring the learning of as many as 1,000 technical terms.

Students will rely on peers to introduce them to the language of the streets, verbal dueling, and the use of language for courtship. They will rely on the media for exposure to the verbal expressions of other ethnic groups and religions. When they enter the workplace, they will rely on their coworkers to develop a literate understanding of work procedures, union rules, and methods for furthering their status. By reading to their children, by telling stories, and by engaging in supportive dialogs, parents set the stage for their child's entry into the world of literature and schooling (Snow, 1999). Here, again, the parent and teacher must teach by displaying examples of the execution and generation of a wide variety of detailed literate practices, ranging from learning to write through outlines to taking notes in lectures (Connors & Epstein, 1995).

It is important to recognize that the literate practices used in today's schools are specific adaptations to the requirements of our current educational system. In the past, a great deal of emphasis was placed on the learning of Greek, Latin, and Hebrew. Currently, we see a relatively greater emphasis on the acquisition of technical vocabulary, including programming languages. If foreign languages are taught, they are no longer the classics, but rather major living languages such as Spanish or Chinese.

Educators and parents are likely to attribute a general decrease in young people's abilities to the advent of tools for Web searching: Students have access to an encyclopedia of knowledge far greater than that of their parents. In many ways, our concept of literate practices is undergoing continual transformation as technological advances in video, telecommunications, and computers allow us to explore new modes of communication (McLuhan & Fiore, 1967). However, to maintain cultural continuity, students will still need to be able to appreciate the structure of a Greek drama, the rules of formal debate, and the allegorical features in the *Divine Comedy*.

CONCLUSIONS

This discussion of language learning has examined the various cognitive and social processes that move the child into the verbal interplay of what Augustine called the "stormy intercourse of human life." These forces involve dynamic and emergent processes that link core language learning abilities with social input and general learning mechanisms. Many of the auditory and cognitive abilities underlying language are available to other primates; but only humans possess the full set of articulatory, cognitive, and social abilities that are required for human language. Although there is no single special gift underlying language and no genetically encoded knowledge about languages, language acquisition is supported by a rich collection of abilities that have accumulated through 6 million years of human evolution. Together, these abilities represent a unique capacity for learning and using language.

There is clear individual variation in many of these abilities. For example, we know that, overall, girls are faster than boys in their learning of both vocabulary and grammar (Bornstein, Hahn, & Haynes, 2004). Children with specific language impairment (SLI) (Bishop, 1997) show marked deviation from the normal pattern of language development. Despite these many individual differences, and despite wide variation in language input and linguistic structures, all children eventually succeed in learning their native language. This is because learning to speak is such a fundamental part of becoming human.

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