CHAPTER 3

Language Acquisition

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INTRODUCTION

Language is about as close to magic as we can get. We push air through our lungs, vibrate our vocal cords, and move our mouths, and as a result, we can make the people around us become aware of past events, understand our thoughts or plans, perform actions, or come to have new beliefs. This magic is made possible by the shared cognitive systems, or grammars, of speakers and listeners. This shared grammar represents the sounds that make up the morphemes and words that bear meaning, and the rules of syntax that combine words into phrases and sentences that convey meaning. The study of language acquisition aims to uncover how this shared cognitive system arises within the mind of a human child. How does a child exposed to the vibrations of air caused by our utterances come to build a cognitive system for producing and understanding an unlimited number of sentences?

Answering this question requires a broad understanding of the kinds of tools that children use to solve the language learning problem. These tools include resources coming from extralinguistic cognition and from domain-specific biases that define grammatical knowledge for any language. Because language learners by necessity learn the language of their environment, a major contributor to language acquisition is likely to be the ability to track statistical information in the environment and to make use of patterns that are revealed in this information. This ability may be aided by other kinds of extralinguistic cognition, such as the perceptual capacities that shape how sounds are perceived as language or the conceptual capacities that undergird the meanings of words and sentences. Children must also use linguistic information in acquiring the grammar of their language. Partial knowledge in one domain of language may make available new resources for representing and identifying aspects of grammar in another domain of language. Similarly, architectural constraints on possible grammatical structures may also play a key role in shaping how children map their experience with language onto a grammatical system, essentially guiding them to look for certain kinds of information in their experience. Finally, because language is used predominantly as a tool for communication, understanding other people's goals and intentions will play a significant role in helping children to identify why people say the things they do, which in turn may contribute to their ability to identify the meanings of sentences.

In what follows, we consider how children identify the grammatical system that supports the ability to produce and understand new sentences, considering phonology, lexicon, syntax and semantics. In each case, we try

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to identify the independent contributions of experience, domain-specific biases, prior knowledge and extralinguistic cognition in shaping how a grammar grows inside the mind of a child.

PHONOLOGY

Perhaps the first task that learners must solve in acquiring a language is to identify its phonology, that is, the sound system of the language. Children must learn which acoustic variations in the speech they hear convey differences in meaning—that is, which ones come from the set of sound categories in their language, or phonemes, that speakers can combine into different words. Children must also learn the allophonic rules in their language that produce systematic variation within a sound category, so that a particular phoneme is pronounced differently depending on where it appears in a word. Learning phonology takes place together with word segmentation, the task of identifying word boundaries in a continuous speech stream. Children's abilities to track the statistical distributions of sounds and syllables in their input, combined with their developing knowledge of the rules in their language that govern those distributions, allow them to solve these two problems in tandem.

Phonemes and Rules

A phonology consists of two parts: a phonemic inventory, the set of sounds that are contrastive in the language, and a rule system, the system determining the linguistic environments in which particular sounds can and cannot occur.

A phonology is importantly different from the phonetics, which encompasses the articulatory processes involved in producing speech sounds and the acoustic properties that these sounds have. A phonology instead defines the distinctions that lead to meaningful differences in words and those that do not. For example, the [p] that occurs in the word [pɪt] is articulated differently from the one in the word [spɪt]. There is a longer delay between the release of the lip closure and onset of voicing associated with the vowel in the first word than in the second. The first [p] is aspirated, and the second is not. And this articulatory difference is reflected in the acoustics. But no words in English differ minimally in terms of this delay. This phonetic distinction is not contrastive and hence is not represented as a difference in phonological inventory of English speakers. The two distinct sounds are categorized as the same from the perspective of the phonology, just like a dachshund and a Great Dane are both categorized as dogs, despite their physical differences. Sounds that are both physically and psychologically distinct, such as [p] and [b], are contrastive, in that words that differ in these sounds also differ in meaning, as in [bɪt] versus [pɪt]. Importantly, not every phonetic distinction has a corresponding phonemic distinction. And languages differ with respect to which phonetic distinctions are treated as the basis for phonological categories and which are not.

The second component of a phonology concerns the rules governing the distributions of sounds in the language. Keeping to our example, the two [p]s just described are in complementary distribution—they cannot occur in the same word environments. The aspirated [p] occurs only when it is the first segment in a stressed syllable. The unaspirated [p] occurs in all other environments. So, we can say that these two sounds are related by rule to a single underlying category. The single phonemic category /p/ has two phonetic realizations, or allophones, determined by the phonological context.

The phonemic inventory and distributional rules vary from language to language and so must be learned. This learning process consists in identifying the underlying categories and determining the rules that govern the choice of allophones in different contexts.

Learning Phonemic Categories

In order to assess how children acquire the underlying categories, it is important to first understand how they perceive speech prior to acquiring these categories and then to ask how they use their experience to identify them.

Adult listeners demonstrate categorical perception: Although they can discriminate small differences within a category, perceptual discrimination is enhanced at category boundaries (Liberman, 1957; McMurray, Tanenhaus, & Aslin, 2002). When presented with computer-generated stimuli that either fall within a single category or cross a category boundary, adults discriminate better when the pair of sounds crosses a boundary than when it falls within a boundary, even if the size of the acoustic difference is identical. Infants, like adults, show enhanced discrimination of acoustic-phonetic differences that cross category boundaries (Dehaene-Lambertz & Dehaene, 1994; Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Werker & Lalonde, 1988). This is true even for categories that are not represented in the language in the child's environment (Eimas et al., 1971; Werker, Gilbert, Humphrey, & Tees, 1981; Werker & Tees, 1984). These sensitivities are also shared across species, suggesting that they reflect basic perceptual processes and are not strictly linguistic in nature (Kuhl & Miller, 1975; Mesgarani, David, Fritz, & Shamma, 2008; Ramus, Hauser, Miller, Morris, & Mehler, 2000).

Because phonological categories vary across languages, infants must learn which distinctions are meaningful in their language. For example, Hindi contains a contrast between an alveolar [d] and a retroflex [D] that is not represented in English (although the natural variability in English /d/ sometimes includes retroflex pronunciations, as in sequences like *our doll*). Infants at 6 to 8 months of age are able to discriminate these sounds, unlike English speaking adults, though this ability declines by around the first birthday (Werker & Tees, 1984). This widely replicated pattern of broad sensitivity in young infants followed by language-specific discrimination in older infants and adults indicates that the development of phonological categories involves maintenance of initial auditory sensitivities rather than the creation of new categories from a perceptually neutral acoustic space (Kuhl et al., 2006; Narayan, Werker, & Beddor, 2010; Polka & Werker, 1994). The initial perceptual sensitivities of infants are maintained or sharpened as a function of experience (Kuhl et al., 2006; Maye, Weiss, & Aslin, 2008; Narayan et al., 2010), but there is no evidence that brand new phoneme categories can be induced solely from language listening experience.

The loss of the "universal listener" abilities involved in the identification of phoneme categories does not involve pruning perceptual abilities, however. The auditory system retains its categorical perception for nonnative speech sounds if the stimuli are not presented as speech (Werker & Tees, 1984). Instead, learning phoneme categories involves a functional reorganization, whereby initial perceptual distinctions get recoded as linguistic distinctions (Nazzi, Bertoncini, & Mehler, 1998; Werker, 1995). These linguistic distinctions may be identified from the distributional characteristics of the speech in the environment. Phonemic distinctions will be expressed through distributions that highlight the existence of two categories (e.g., many instances of [d] and [D] with fewer tokens falling in the space between these extremes), whereas variation of tokens within a category will be expressed through a more uniform distribution.

Maye, Werker, and Gerken (2002) showed that infants can track such frequency information and use it to change their phonetic category boundaries. Six- to 8-month-old infants were presented with stimuli from an 8-step voicing continuum from [da] to [ta]. In one condition, many of the items fell along the extreme ends of the continuum, with few in the middle, yielding a bimodal distribution of tokens. In the other condition, the most frequent items fell in the middle of the continuum, yielding a unimodal distribution of tokens. After 2 to 3 minutes of familiarization, infants were tested on their ability to discriminate the endpoints of the continuum. Those infants who were familiarized to the bimodal distribution showed better discrimination than those familiarized to the unimodal distribution.

Another source of information for building phonetic categories comes from their phonological environments. Feldman, Myers, White, Griffiths, and Morgan (2013) exposed 6- to 8-month-old infants to a uniform distribution of vowels from a continuum between [a] ('ah') and [ɔ] ('aw'). Half of the babies heard each of the sounds in distinct word forms (i.e., *gutah* versus *litaw*). The other half of the babies heard both vowels in both word forms (i.e., *gutah*, *gutaw*, *litah*, *litaw*). After being familiarized to these words, infants were then tested to see if they could distinguish between alternating pairs of syllables (*tah* versus *taw*) with vowels drawn from the ends of the continuum versus repetitions of a single syllable with a vowel drawn from the center of the continuum. Only those infants who were familiarized to distinct word forms were able to discriminate the alternating syllables from the nonalternating ones. Thus, the occurrence of sounds in distinct phonological environments provides evidence for learners about the identity of the sounds.

Learning Allophonic Rules

The categories that are built for linguistic representation feed forward into the learning of allophonic rules, the rules that govern alternations of sounds from within a single category. Seidl, Cristià, Bernard, and Onishi (2009) familiarized English- and French-learning infants with a pattern that linked the choice of a stop [t] versus a fricative [s] to the quality of the preceding vowel. Specifically, infants heard syllables in which nasal vowels (produced with airflow through the nasal cavity) were followed only by fricatives, and oral vowels (produced with airflow only through the oral cavity) were followed only by stops. English-learning 4-month-olds were able to learn this dependency. In French, nasal vowels contrast with oral vowels, so French-learning 11-month-olds were also able to learn this rule. However, English-learning 11-month-olds, who are acquiring a language in which the oral-nasal difference is allophonic, were not able to learn the rule. Because the English-speaking infants had acquired a single category containing both oral and nasal vowels, they were unable to learn a rule that depended on nasality. The very same sounds function differently in the mental representation of speech by the end of the first year of life, and these representations feed forward for subsequent learning.

Similarly, Onishi, Chambers, and colleagues (Chambers, Onishi, & Fisher, 2003; Onishi, Chambers, & Fisher, 2002) taught 16-month-old infants two kinds of phonotactic constraints, which are language-specific restrictions on which sequences of sounds are possible and where in a syllable certain sounds can occur. Infants learned a simple positional regularity in which /b/ was allowed only as the first sound in a syllable, and a context-dependent regularity in which /b/ occurred after /ae/ but not after /i/. Infants were able to learn both kinds of regularity. Importantly, conditioning distributions of consonants on the speaker's voice or identity in a third study did not induce learning. That is, children were able to learn rules conditioning sound distributions on linguistic information like word environments, but not on speaker identity, a language-external factor. Thus, these experiments not only demonstrate infants' rich abilities to learn novel distributional constraints on allophones, but they also indicate that such learning is restricted to the kinds of regularities that languages regularly encode.

Word Segmentation

Acquisition of the phonological inventory of a language takes place concurrently with the acquisition of word-segmentation abilities. (See Nazzi et al., 2016, for review.) Segmentation of word forms from the speech stream also plays a critical role in the acquisition of words as pairings of form and meaning. Word segmentation abilities at earlier ages are predictive of vocabulary size at later ages (Newman, Ratner, Jusczyk, Jusczyk, & Dow, 2006), and newly segmented words are easier for 17-month-old infants to link to a meaning than are wholly novel words (Graf Estes, Evans, Alibali, & Saffran, 2007).

Jusczyk and Aslin (1995) showed that word segmentation abilities first develop between 6 and 8 months of age. They familiarized 7.5-month-old English-learning infants to two monosyllabic words (*cup* and *dog* or *bike* and *feet*). Infants then heard four passages, each containing six repetitions of one of the four words. Infants showed a preference for the passages containing the familiarized words, indicating that they had recognized those words. This recognition implies that they were able to segment the familiarized words from the passages. This result failed to extend to 6-month-old infants.

Six-month-olds can segment words under some circumstances, however. Unlike Jusczyk and Aslin (1995), Bortfeld, Morgan, Golinkoff, and Rathbun (2005) showed that 6-month-old infants could segment unfamiliar words from a passage if these words were preceded by highly familiar words, such as the infant's name or the word "mommy." (See Brent & Cartwright, 1996, for a computational model of word segmentation based on familiar words.)

Infants as young as 7.5 months of age can use the rhythmic units of their language to segment words. In English, a majority of words are stressed on the first syllable (Cassidy & Kelly, 1991; Cutler & Carter, 1987). Correspondingly, English-learning infants between 6 and 9 months of age show a preference for stress-initial words over stress-final words (Jusczyk, Cutler & Redanz 1993). This result does not derive from a general perceptual preference for stress-initial words; French-learning infants between 4 and 6 months of age show the opposite preference (Friederici, Friedrich, & Christophe, 2007). These preferences also contribute to segmentation. Jusczyk, Houston, and Newsome (1999) showed that English-learning 7.5-month-olds successfully segment trochaic (strong-weak) words such as "doctor" from a passage, but that they missegment iambic (weak-strong) words such as "guitar." By 10.5 months, infants are able to successfully segment the iambic words as well.

By 8 months of age, infants may also be able to use order of syllables within words as a cue to the location of word boundaries. Saffran, Aslin, and Newport (1996) showed that 8-month-old infants use the transitional probability between two syllables (i.e., the probability of two syllables occurring together) as a cue to word boundaries, based on the assumption that two syllables that frequently co-occur are part of the same word (Brent & Cartwright, 1996). These authors familiarized infants to 2 minutes of continuous speech made up of randomly concatenated sequences of four trisyllabic "words," such as "pabiku, todabu." They then tested infants' listening preferences to these words as compared to sequences of syllables that had occurred in the familiarization, but were taken from different words, so that they exhibited a lower transitional probability. Infants listened longer to the "words," suggesting that they use the transitional probabilities as evidence for where the word boundaries occur in this artificial language. Eight-month-olds are unable to use transitional probabilities to segment words of varying length (E. K. Johnson & Tyler, 2010; Mersad & Nazzi, 2012); however, they could do so if one of the words was a highly familiar word. This finding suggests that infants can combine multiple sources of information in word segmentation.

By 9 months, infants can use phonotactic properties of their language to help segment words from the speech stream. By 6 months, infants show a preference for sequences of sounds that are possible in their language over sequences that are impossible (Jusczyk, Luce, & Charles-Luce, 1994). And by 9 months, they demonstrate better segmentation of words with high between-word phonotactic probabilities at their edges (e.g., [zt]) than words with high within-word probabilities (Mattys & Jusczyk, 2001).

Between 10 and 12 months of age, infants can use the prosody of their language, or its stress and intonation patterns, as a cue to word segmentation. Children are sensitive to breaks between prosodic units at extremely early ages. Newborns can tell the difference between stimuli with and without prosodic breaks (Christophe, Dupoux, Bertoncini, & Mehler, 1994; Christophe, Mehler, & Sebastián-Gallés, 2001). By the age of 9 months, infants have developed knowledge about prosodic phrases in their language: They react when a prosodic phrase is disrupted by the insertion of a break (Gerken, Jusczyk, & Mandel, 1994; Jusczyk et al., 1992). And 10- and 12-month-olds can use those prosodic breaks to constrain word identification (Christophe, Millotte, Bernal, & Lidz, 2008; Gout, Christophe, & Morgan, 2004; Millotte et al., 2010). Gout et al. (2004) conditioned infants to turn their heads when they heard the word "paper." Then, they exposed the infants to sentences in which that same sequence of syllables occurred within a phonological phrase (e.g., *[the scandalous **paper**] [sways him] [to tell the truth]*), or across a phonological phrase boundary (e.g., [*the outstanding **pay**] [**per**suades him] [to go to France]*). They found that these infants turned their heads more often when the syllables occurred within a phonological phrase than when it spanned a phonological phrase boundary, indicating that the presence of a phrase boundary disrupted their ability to recognize the word "paper." These results suggest that children use phonological phrasing as a cue for word segmentation.

In sum, infants' ability to segment words from the speech stream undergoes significant development between 6 and 12 months of age. At first, they can segment only highly frequent words. Over time, infants develop word segmentation strategies based in the rhythmic properties of words, the statistical properties of the syllable transitions, and the phonotactic and prosodic features of their language.

Summary

In acquiring the phonology of their language, children organize the acoustic information in the speech signal into phonemic categories and infer the allophonic rules that specify how sounds from one category systematically vary depending on surrounding sounds or their position in a word. Properties of children's extralinguistic auditory system allows them to perceive all sound contrasts that languages might make use of, but based on the statistical distribution of the sounds they hear, children eventually form language-specific representations that encode only the meaningful contrasts in their language. Simultaneously, children learn to segment the continuous speech stream into words, aided by their statistical sensitivity to syllable distributions as well as their knowledge of the rhythmic properties, prosody, and phonotactics of their language. Next we look in more depth at how children learn what those words mean and how to use them.

LEXICON

Consider what you, as a proficient adult speaker of a language, know about your lexicon, or the set of words in your language. You know their phonological forms; you can pronounce words like a native speaker and identify them in the speech of others around you. In the previous section, we discussed how children learn the phonology of their language and solve the problem of word segmentation. You also know what words mean; you can map from those phonological forms to the specific concepts they pick out. These mappings from sound to meaning are arbitrary and language-specific. If you speak English, the phonological form /fi/ means a cost or a charge (*fee*), but if you speak French that same phonological form means a girl or daughter (*fille*).

But before we consider how children learn the mappings from sounds to meanings in their language, we consider another part of your knowledge about words: how to use them in sentences. As an adult speaker of English, you know that the word "arrive" can be used after a helping verb like "will": You can say *Elliott will arrive*. You also know that the word "arrival" can be used after an article like "the": You can say *The arrival of Elliott was unexpected*. Furthermore, you know which environments these words cannot occur in: You cannot say **Elliott will arrival* or **The arrive of Elliott was unexpected.* (The asterisk indicates that a string of words is unacceptable in a particular language.) Part of your knowledge about words includes features that we call grammatical categories, which determine their distributions in sentences. Even though "arrive" and "arrival" have similar meanings, their different grammatical categories (verb versus noun) lead to different sentence distributions. Learning which words belong to which grammatical categories is yet another problem that children need to solve when learning their lexicon.

Grammatical Categories

Grammatical categories—such as noun, verb, and adjective—are names for the features that determine which syntactic environments lexical items can appear in. When we say *arrival* is a noun, we mean that the "noun" feature allows *arrival* to occur after articles but not after helping verbs, for example. When we say *arrive* is a verb, we mean the "verb" feature allows *arrive* to occur after helping verbs but not after articles.

These grammatical categories sometimes correlate with semantic categories, but there are many exceptions: we're often told that a noun is a "person, place, or thing" and that verbs describe actions, but the verb *believe* does not really describe an action, whereas the noun *destruction* does.

Grammatical categories come in two flavors: lexical and functional. Lexical categories include the familiar categories of noun, verb, and adjective—these are what we might call "content words," and they are also open class, meaning that we can easily coin new words that fall into these categories. Functional categories are closed class, meaning that it is hard or impossible to coin new words in these categories, and they contain less referential content. Some functional categories include determiners, such as *the*, *a*, *some*, *most*; pronouns, such as *I*, *you*, *he*, *she*, *it*; modals and auxiliaries ("helping verbs"), such as *have*, *be*, *may*, *will*, *can*; and morphemes (pieces of words) that signal tense and agreement, such as past tense *-ed*, present progressive *-ing*, and plural *-s*. Functional categories frequently signal when specific lexical categories are upcoming; for example, determiners are signals for nouns. These signals might be useful information in children's learning processes.

Using Distributional Information to Categorize Words

Because a word's grammatical category determines its distribution in sentences, children may be able to use that distributional information as a signal for the grammatical categories of new words. Computational simulations have probed the extent to which distributional regularities in speech to children can support word categorization. Many of these simulations have achieved fairly high success in categorizing words into grammatical categories based solely on these patterns in how words cluster together and which words tend to occur next to each other (Cartwright & Brent, 1997; Mintz, 2003; Mintz, Newport, & Bever, 1995, 2002; Redington & Chater, 1998; Redington, Chater, & Finch, 1998). For example, Mintz (2003) used an algorithm that clustered words based on similarities in their immediately preceding and following sentence environments ("frames"). This algorithm was reliably able to separate nouns from verbs based only on the information in these frames. These types of models show that there is a distributional signal for the grammatical categories of words in speech to children. Furthermore, many experimental studies have found that children are skilled at detecting and using that signal.

From extremely early ages, children appear sensitive to the differences between function words and content words, which tend to have different acoustic and phonological properties cross-linguistically. Across languages, function words are often unstressed, shorter than content words, have reduced vowels, and appear at prosodic boundaries (e.g., Monaghan, Chater, & Christiansen, 2005; Shi, Morgan, & Allopenna, 1998). Even newborns demonstrate sensitivity to these differences. In a study by Shi, Werker, and Morgan (1999), newborns heard repetitions of English words selected from an audio recording of natural maternal speech. Infants' attention to these audio stimuli was tested using a procedure called high-amplitude sucking, which measures infants' sucking strength and rate on pressure-sensitive pacifier. Infants learn that they can control the presentation of an audio stimulus by sucking harder, and the researchers measure how the rate of these high-amplitude sucks declines over time as infants lose attention. Once this rate declines to a certain threshold, infants are considered to be "habituated" to the stimulus, and a new test stimulus is played. If infants consider this new stimulus different from the previous one, they should recover attention ("dishabituate") and therefore increase their rate of high-amplitude sucks. Shi et al. habituated infants to a list of either content words or function words and then tested them on new words from the same category or the opposite category. Infants who were habituated to content words recovered attention and increased their sucking rate when they heard function words, and vice versa, but did not recover attention when they heard new content words. It therefore appears that newborns are able to discriminate the phonological differences between function and content words. This ability may enable infants to begin categorizing words into functional and lexical categories from the earliest stages of language acquisition.

Learning the specific phonological forms of function words in the infant's target language takes place over the first year of life. Infants are able to segment function words in their own language by the age of 6 months (Höhle & Weissenborn, 2003; Shi, Marquis, et al., 2006), and differentiate real function words from phonologically similar nonsense function words between the ages of 8 and 11 months (Hallé, Durand, & de Boysson-Bardies, 2008; Shafer, Shucard, Shucard, & Gerken, 1998; Shi, Cutler, Werker, & Cruickshank, 2006; Shi & Lepage, 2008; Shi, Werker, & Cutler, 2006). Children at early stages of sentence production frequently omit function words in their own speech, but repeat sentence prompts with real and nonsense function words at different rates, indicating that they know the difference (Gerken, Landau, & Remez, 1990).

Once the forms of function words are learned, they become useful in learning other new words. Early on, they can serve as anchors in the speech stream: 8-month-olds can use known function words to segment new content words (Shi & Lepage, 2008). Older infants can use function words as a signal for specific lexical categories. For example, 14- to 16-month-olds who are familiarized with a nonsense word preceded by a determiner (e.g., *my kets*) react with surprise when the same nonsense word occurs in an environment in which nouns cannot occur, such as after an auxiliary (*will kets*) (Hicks, Maye, & Lidz, 2007; Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004; Shi & Melançon, 2010). Infants also react with surprise when a nonsense word preceded by a modal (*will dak*) is later preceded by a determiner (*my dak*) (Hicks et al., 2007). This finding suggests that children use the determiner and auxiliary functional categories to identify the lexical category of an unknown word: Hearing a determiner tells them that this word is a noun and therefore should occur only in places where nouns can occur, and hearing an auxiliary tells them that this word is a verb and should occur only in places where verbs can occur.

Children deploy their knowledge of function words during online language comprehension to help identify known words. A study by Cauvet et al. (2014) trained 18-month-old French-learning children to respond to a target noun preceded by a determiner (e.g., *la balle*, "the ball") or a target verb preceded by a pronoun (*je mange*, "I eat"). At test, children recognized the target words more frequently when they were preceded by another word from the correct functional category—when the target noun was preceded by a determiner or when the target verb was preceded by a pronoun. Other studies have found that 2-year-olds show better and faster sentence comprehension when singular nouns are preceded by determiners than by ungrammatical or missing function words (Gerken & McIntosh, 1993; Kedar, Casasola, & Lust, 2006; Shipley, Smith, & Gleitman, 1969).

Furthermore, children can use functional categories to infer aspects of a content word's meaning. Even though grammatical categories do not correlate perfectly with semantic categories, some imperfect correlations do exist: For example, nouns tend to label object kinds, adjectives tend to label object properties, and verbs tend to label events. Children as young as 1 year old can use known function words to infer whether a novel word labels an object kind or property (Hall, Waxman, & Hurwitz, 1993; Mintz & Gleitman, 2002; Smith, Jones, & Landau, 1992; Taylor & Gelman, 1988; Waxman, 1999; Waxman & Booth, 2001; Waxman & Markow, 1998). Twelve-month-olds who hear an object labeled as *a blicket* will select another object of the same kind when asked for another blicket (Waxman & Markow, 1998). Thirteen-month-olds who hear a purple horse labeled as *a daxish one* will prefer to select a novel purple object over a different-colored horse (Waxman, 1999). This behavior suggests that 1-year-old infants can distinguish the distribution of nouns and adjectives based on co-occurring functional categories and use that knowledge to infer that a novel word in a noun context labels an object kind whereas a novel word in an adjective context labels an object property.

Slightly older infants are also able to use the presence of functional verbal morphology to identify that a novel word labels an event rather than an object. He and Lidz (2017) habituated 18-month-olds to a scene of a penguin spinning, labeled either by a novel word in a noun context (e.g., *It's a doke*) or in a verb context (*It's praching*). At test, children saw a scene of the penguin performing a different action, labeled by the same audio. Children dishabituated when they heard *It's praching* labeled that new scene but not when they heard *It's a doke*. These infants appear to have used the co-occuring functional categories to identify whether the novel word was a noun or verb and therefore what concept it should label. Infants who heard the novel word after a determiner identified the word as a noun and therefore an object name and were not surprised to hear this word label the same object performing a different action. By contrast, infants who heard the novel word with verbal morphology (*-ing*) identified the word as a verb and therefore an event name and were surprised to hear this word label a different action. Identifying the signals of a new word's grammatical category—its distributional context and co-occurring function words—allows children to both categorize and make inferences about the meaning of that word.

Bootstrapping from Prosody

In addition to distributional information, children's knowledge of the prosodic features of their language may feed their categorization of words. Recall that children are sensitive to prosodic breaks in their language from a very young age. If these breaks typically fall at the edges of phrases centered around certain grammatical categories, then children might be able to use them to identify those phrase boundaries and differentiate words of different grammatical categories. This process of using prosodic information to infer something about the syntactic properties of a phrase or clause is called prosodic bootstrapping (Christophe et al., 2008; de Carvalho, Dautriche, & Christophe, 2016; Gleitman, Gleitman, Landau, & Wanner, 1988; Gout et al., 2004; Gutman, Dautriche, Crabbé, & Christophe, 2015; Morgan, 1986; Morgan & Demuth, 1996; Morgan, Meier, & Newport, 1987; Morgan & Newport, 1981; Wanner & Gleitman, 1982).

A study by de Carvalho et al. (2016) found that French-speaking preschoolers can use the position of a prosodic break to identify the category of an ambiguous word. Four-year-olds were asked to complete a sentence fragment that contained a noun/verb homophone, such as *ferme*, which can either mean "farm" (a noun) or "close" (a verb). The category of the word was disambiguated by prosody. In the sentence [*la petite ferme*] [*est très jolie*] ("the little farm is very nice"), the prosodic break after *ferme* indicates that it is a noun; by contrast, in the sentence [*la petite*] [*ferme la fenêtre*] ("the little girl closes the window"), the prosodic break before *ferme* indicates that it is a verb. After hearing *la petite ferme,* 4-year-olds who heard a prosodic break before *ferme* provided completions indicating that they interpreted *ferme* as a verb, whereas children who heard no prosodic break interpreted the word as a noun. A similar result was found for 3-year-olds in a looking time experiment. These results suggest that preschoolers can exploit prosodic information in quite sophisticated ways: The prosodic breaks in a sentence allow them to identify which prosodic phrase contains an ambiguous word, and therefore to determine whether the word should be analyzed as a verb or a noun during online sentence comprehension.

Why would identifying the prosodic phrase containing a word be useful in identifying the category of that word? On one hypothesis, children's prosodic knowledge interacts with their knowledge about function words in their language. If function words tend to occur at the edges of prosodic phrases, then these words might help children categorize the co-occurring content words that the phrases are built around (Gutman et al., 2015; Morgan, 1986; Morgan & Demuth, 1996). For example, children might perceive that a string of words, such as *The cute little girl will dance*, contains two prosodic phrases, one starting with a determiner and one with a modal: [*The cute little girl*] [*will dance*]. If children know to pay attention to these function words at the edges of prosodic phrases and know that determiners signal nouns and modals signal verbs, then they might be able to label these phrases: The first is a noun phrase, and the second is a verb phrase. A computational model by Gutman et al. (2015) was able to differentiate noun phrases from verb phrases in child-directed speech with fairly high reliability by tracking the distribution of function words at the edges of prosodic phrases and by building off of a small "seed" of known object and action words.

Properties of Grammatical Categories

We have seen that statistical sensitivity to the distribution of words in the input, in conjunction with prosodic knowledge, can help children categorize words in their language. But children also use category information to infer properties of new words: for example, that words used in noun contexts label object kinds, words used in adjective contexts label object properties, and words used in verb contexts label events. This knowledge does not emerge straightforwardly from the distribution of these words in the input but rather from some knowledge about the types of meanings these categories can have. Where does this knowledge about the relation between grammatical categories and meanings come from?

It is possible that some knowledge about the properties of linguistic categories may be intrinsic to the language learning mechanism. Pinker (1984, 1989) was an early proponent of the hypothesis that the language learning mechanism contains knowledge of innate linking rules between meanings and the syntactic forms that can express those meanings. Therefore, understanding properties of the meaning of an utterance can help the learner infer syntactic properties of that utterance: a strategy called semantic bootstrapping. If the learner has innate knowledge that nouns label object kinds and verbs label events, then words that speakers seem to use to label object kinds must be nouns, and words that speakers use to label events must be verbs.

Conversely, if a group of words appear in a distribution that would indicate they are nouns, those words are likely to label object kinds; if a group of words appear in a distribution that would indicate that they are verbs, then those words are likely to label events.

We have already seen that children by the age of 18 months appear to know these linking rules. The 18-month-olds tested by He and Lidz (2017) understood that a consequence of being a noun meant that *doke* referred to an object, whereas a consequence of being a verb meant that *praching* referred to an event. However, this behavior does not necessarily prove that these linking rules are innate; it is possible that children could have learned the relations between grammatical categories and meanings by the time they are 18 months. Gutman et al.'s (2015) computational model was able to learn more general categories of nouns and verbs by tracking prosodic breaks and function words, when seeded with knowledge of words for a few common objects and actions. The authors proposed that children might learn the semantic properties of noun and verb categories by noticing that a few common words map onto perceptually salient categories such as concrete objects and causal actions. That is, if children are already likely to perceive their world in categories such as "object" and "action" and can learn that some words are used to label these categories, they might conclude that words having similar distributions are likely to label similar categories. Words that distribute like known words for objects are also going to label objects, and words that distribute like known words for actions are also going to label actions. If this hypothesis is correct, then the linking rules that children know by 18 months would be a consequence of the way they perceive the world in certain categories and the way they expect language to reflect those categories.

Further work is needed to determine whether the semantic properties of nouns, verbs, and adjectives are innately specified or learned through experience. However, there are other syntactic properties that follow as consequences of a word's grammatical category, many of which would be difficult or impossible to learn by observation. Pinker (1984) highlighted one important syntactic consequence of being a noun or a verb that may fall into the impossible-to-observe category. Both nouns and verbs can take full clauses as complements: You can say *Aaron claimed [that Bill saw Eva]* or *Aaron believed the claim [that Bill saw Eva]*. Furthermore, in the first sentence, you can question part of the embedded clause: *Who did Aaron claim [that Bill saw]?* However, you cannot question the exact same part of the embedded clause in the second sentence: **Who did Aaron believe the claim [that Bill saw]?* is not a possible question about the person Bill saw. English speakers can question parts of the clausal complements of verbs, but not nouns. This is a constraint that would be very difficult to learn by observation, because children are not able to observe which sentences in their language are not possible, only the ones that *are* possible. Furthermore, this constraint seems to hold cross-linguistically. For these reasons, Pinker and many others hypothesized that the constraint on questioning parts of the clausal complements of nouns comes from innately specified linguistic knowledge. If children have knowledge about the constraints on question formation that are obeyed by all human languages, all they will need to learn is whether a word is a noun or a verb, and they will know whether it is possible to question the clausal complements of that word.

The question of whether domain-specific knowledge or learning through experience is responsible for children's awareness of word properties also has been hotly debated for functional categories like determiners. Children display very early sensitivity to the presence of determiners in their input, but their early speech tends to omit determiners, leading some to wonder when children know that these words are part of the same grammatical category "determiner." Valian (1986) studied the speech of six 2-year-olds and found that when these children did use determiners, they used them in appropriate sentence environments and differentiated them from other prenominal categories, such as adjectives. Valian, Solt, and Stewart (2009) and Yang (2013) found that children use the category "determiner" productively from the earliest ages at which they start combining words: Once they begin producing multiple different determiners, they use these determiners interchangeably before nouns, indicating that they consider them members of the same category and know the distribution of this category. These results are in contrast to a claim that children at the relevant age lack the determiner category (Pine & Lieven, 1997; Pine & Martindale, 1996; Tomasello, 2000, 2003).

Valian and colleagues (2009) hypothesized that children are innately aware of the range of categories that languages can make use of, "determiner" being one of these categories, and therefore determiner acquisition involves mapping words in their language to this category. In order to provide strong support for the innateness hypothesis, it would be necessary to show that very young children have not only grouped determiners together based on their distribution in the input but are aware of what it means to be a determiner—that determiners have specific properties, which lead to specific constraints on their behavior.

Studies with older children have shown that they are sensitive to some interpretive consequences of being a determiner. In a study by Wellwood, Gagliardi, and Lidz (2016), 4-year-olds heard a novel word in a determiner context (e.g. *gleebest of the cows*), in an adjective context (*the gleebest cows*), or in a context where either a superlative determiner or adjective could occur (*the gleebest of the cows*). Children were asked to choose from a set of cards that showed multiple spotted cows. On some cards, most of the cows were by the barn but the spottiest cows were not; on other cards, the spottiest cows were by the barn but most of the cows were not. When children heard *gleebest* in a determiner context, such as *Gleebest of the cows are by the barn*, they preferred the cards where most cows were by the barn but the spottiest cows were not. When children heard *gleebest* in other contexts, they preferred the opposite cards. It appears that children assigned the novel word a quantity-based meaning only when it occurred in the determiner context; they assigned the word a quality-based meaning otherwise. These children were able to use the context in which the novel word occurred to categorize it as a determiner or adjective. Furthermore, they knew that only determiners, not adjectives, are restricted to having quantity-based interpretations.

In summary, children's knowledge about grammatical categories in their language goes beyond the distribution of these categories and includes information about other syntactic or interpretive properties of these categories. Children know that nouns label objects, adjectives label object properties, and verbs label events; they also know that determiners but not adjectives can have quantity interpretations. Furthermore, a word's grammatical category will have consequences on other dependents of that word in a sentence: It is possible to question part of a clause introduced by a verb but not by a noun. Some of these properties might be learned through observation—for instance, by observing that certain categories of words map onto perceptual categories such as "object" and "action." But many of these properties are difficult or impossible to observe, and yet seem to hold true cross-linguistically—such as constraints on question formation. In order for children to learn these constraints consistently in the face of very scarce evidence, it is likely that their learning process is guided in part by domain-specific linguistic knowledge, intrinsic to the language-learning mechanism.

Lexical Meanings

So far we have discussed how children learn the grammatical categories of words in their language as well as some semantic and syntactic properties associated with those categories. Now we consider how children learn the meanings of specific words in their language. Recall that a word's sound does not signal its meaning. The meaning "a black-and-white farm animal that produces milk" is encoded by the sequence of sounds [kaʊ] (*cow*) in English and [vaʃ] (*vache*) in French. The sound sequence [fi] means a cost or charge in English (*fee*) and a girl or daughter in French (*fille*). How do children learn these arbitrary, language-specific mappings between form and meaning? There are two possible signals: the situations in which the word is used and the word's syntactic properties. Here, we' discuss how statistical sensitivity, extralinguistic cognition, and prior linguistic knowledge may help children detect these signals and use them to draw inferences about word meanings.

Learning by Observation

One very old hypothesis about word learning, dating back to the philosopher John Locke (1690/1998), proposes that children can learn the meanings of words by observing what they are being used to label in the world. For example, English-speaking children hear the sequence of sounds [kaʊ] frequently in contexts where cows are present and learn that those sounds are used to label cows. This strategy has been called word-to-world mapping (Gleitman, 1990): A child learns the meaning of a word by observing the real-world contingencies of its use, or what possible referents for the word are present in the world when the word is being uttered.

Extralinguistic cognition could be very helpful in using this word-to-world mapping strategy, particularly if a child can figure out what in the world a speaker is referring to when using a particular word. Young children are adept at detecting some nonverbal cues that indicate what adults are referring to when they speak. Infants as young as 9 to 12 months old can follow a pointing finger and a speaker's eye gaze to locate what a speaker is attending to (see, e.g., Baldwin & Moses, 1996), and slightly older children use the speaker's eye gaze as a cue to the referent of a novel word (Baldwin, 1991, 1993). For example, the 18- and 19-month-olds in Baldwin's (1991, 1993) experiments checked what a speaker was attending to when they heard a novel word spoken and interpreted the object that the speaker was looking at as the referent of that word, even when another object was more salient.

But it is possible that cues such as eye gaze and the physical presence of the referent when the word is being uttered will be more reliable for learning certain types of words than others. Gillette, Gleitman, Gleitman, and Lederer (1999) conducted a simulation of word learning with adults in order to investigate this question: Does the extralinguistic context in which a noun or a verb is uttered provide enough information to infer its meaning, or is it more helpful for some words than for others? The experimenters presented adult participants with videos of mother–child interactions, in which the most common nouns and verbs uttered by the mother were indicated by a beep, and asked participants to guess what word the beep stood for. These adults were able to identify the correct noun 45% of the time based on the visual information alone but could identify the correct verb only 15% of the time. Later simulation studies, such as by Medina et al. (2011), found a similar result: In general, visual contexts seem to be more informative for identifying nouns than verbs. This asymmetry parallels the acquisition trajectories of nouns and verbs in many different languages: When children begin talking, they produce nouns almost exclusively, and verbs come later (Bates, Dale, & Thal, 1995; Caselli et al., 1995; Gentner, 1982). Perhaps this order of acquisition is related to how strongly extralinguistic information supports learning nouns, as opposed to verbs, by observation.

Statistical sensitivity may also help a learner infer the meaning of a word through observation. Many studies have found that children can also be quite good at fast mapping: learning the meaning of a word from a single presentation (Baldwin, 1993; Carey, 1978; Carey & Bartlett, 1978; Dollaghan, 1985; Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005; Heibeck & Markman, 1987). But if the context is not informative about a word's meaning the first time a child hears it, the child may be able to track information about what the word is being used to label across many different exposures. This strategy is called cross-situational learning (e.g., Blythe, Smith, & Smith, 2010; Smith & Yu, 2008; Vouloumanos, 2008; Xu & Tenenbaum, 2007; Yu & Smith, 2007). For example, Smith & Yu (2008) presented 12-month-olds with pictures of geometric shapes paired with novel words. During each trial, two words were presented in the context of two shapes, such that the pairing of each word with its referent was ambiguous. However, each word–shape pairing was disambiguated over the course of 12 trials. Averaging across all of the trials, the authors found that these infants preferred to look at the correct referent for the majority of the novel words. It appears that these infants were able to map multiple labels to multiple objects by tracking how these labels were used across different trials, even though each single presentation of a word was ambiguous with regard to its referent.

Thus, although learning by observation can be difficult for certain word categories and in ambiguous contexts, it might be easier if learners can track statistical evidence for a word's meaning across many different contexts. But a more fundamental issue remains. The particular word that a speaker uses to refer to something in the world depends on how the speaker conceptualizes that stretch of the world. Word learning is not actually word-to-*world* mapping but word-to-*concept* mapping: The task of the child is not to map a word to a particular object or event in the world but to the concept under which the speaker has represented that object or event. Quine (1960/2013) illustrated this issue with the following thought experiment: Suppose that a stranger learning the language of a foreign country heard a native say "gavagai" while pointing to a running rabbit. What does "gavagai" refer to: the rabbit, the rabbit's ears, the act of running, a potentially delicious meal? The language learner must identify how the speaker conceptualized the scene in order to learn the meaning of this word.

Even in the realm of concrete nouns, the task of word-to-concept mapping can be quite difficult. When a speaker says "dog" in the presence of a furry domestic canine, how do children know that this word refers to the whole animal and not the dog's tail or whiskers? How do children know this label is not restricted to a particular breed of dog but could be extended to other dogs, although not to other types of pets or animals?

One theory proposes that children operate under learning biases that constrain the meanings they will hypothesize for a new noun. Markman (1994) posited three such biases: that a word will likely refer to an object kind rather than part of an object (the whole-object bias); that a word will likely refer to a basic-level category like "dog" rather than a subordinate category like "Dalmatian" or a superordinate category "animal" (the taxonomic bias); and that a word is not likely to label the same object that another known word already labels (the mutual exclusivity bias). All three of these biases have some degree of experimental support. Children generalize novel words presented as nouns to object kinds that share the same category, identifying the novel word as a label for the whole object rather than a part of the object (Balaban & Waxman, 1997; Markman & Hutchinson, 1984; Waxman & Markow, 1995; Woodward & Markman, 1998). They also prefer to generalize novel nouns to basic-level categories, such as "bird," rather than subordinate categories, such as "robin," or superordinate categories, such as "animal" (Hall & Waxman, 1993), and assume that a novel noun names an object for which they do not already have a word (Markman & Wachtel, 1988). Children's biases in word learning may therefore help them avoid the "gavagai" problem by restricting the range of concepts they think a new noun is likely to label.

Constraints like the whole-object, taxonomic, and mutual exclusivity biases might help children tackle the word-to-concept mapping problem for concrete nouns. But this problem appears vastly more difficult for verbs. These same biases do not immediately apply to verbs because verbs label events rather than objects (P. Bloom, 1994), and it is unclear whether analogous biases would apply to the way that verbs label events (Gleitman, 1990). Verbs were more difficult for the adults to identify than nouns in Gillette et al.'s (1999) word learning simulation, and several factors might conspire to create this difficulty. First, verbs are not necessarily uttered at the same time as the event they are describing but frequently are used to talk about past or future events instead. Beckwith, Tinker, and Bloom (1989) surveyed a corpus of maternal speech to children and found that the verb *open* was used 37.5% of the time to refer to something not in the present context. Second, the same event can be described by different verbs depending on the speaker's perspective: An event of a lion running after a gazelle could be described as the lion *chasing* the gazelle, or the gazelle *fleeing* the lion (Gleitman, 1990). A child attempting to learn whether a new verb means *chase* or *flee* would have little help from the context, because the contexts in which *chase* is used are identical to those in which *flee* is used. Finally, certain verbs describe events and states that cannot be observed at all: Attitude verbs, such as *think*, *want*, and *hope*, describe an individual's internal beliefs or desires, but these do not have observable physical correlates (Gleitman, 1990). Because observational learning appears insufficient in these cases, children must use different tools to overcome the challenges of verb learning.

Syntactic Bootstrapping

Children have another tool for acquiring verb meanings: the types of syntactic structures that verbs can occur in. If children know or can figure out the syntactic properties of a new verb, and they also know how those syntactic properties are related to verb meanings, then they might be able to infer aspects of the new verb's meaning. This strategy is called syntactic bootstrapping (Gleitman, 1990; Landau & Gleitman, 1985; Lasnik, 1989).

What relations between syntactic information and meaning might a child be able to exploit in verb learning? One type of syntactic information that is potentially easy to observe is the arguments in a sentence containing a verb. For example, a verb like *hit* can occur with a subject and an object in a sentence like *Sally hit her sister*. These arguments label participants in the event described by the sentence: The subject labels the person who did the hitting (the agent), and the object labels the person who got hit (the patient). Even if a child does not know the meaning of the word "hit," if that child is aware that subjects tend to name agents and objects tend to name patients, then she might infer that this sentence describes an event where Sally was the agent and Sally's sister was the patient.

Gertner, Fisher, and Eisengart (2006) found that children are able to use information about subjects and objects to infer which event a new verb labels. They played 2-year-olds a sentence with a novel verb, such as *The duck is gorping the bunny*, in the context of two different events: a scene with a duck pushing a bunny and a scene with the bunny pulling the duck's legs. The researchers used a method called preferential looking, which takes greater looking time toward one visual stimulus over another as evidence for how children understand a sentence. Children who heard *The duck is gorping the bunny* preferred to look at the scene where the duck was pushing the bunny: They interpreted *gorping* as pushing rather than leg-pulling. By identifying that *the duck* was the subject and *the bunny* was the object of *gorp*, these children were able to conclude that *gorp* named an event in which the duck was the agent and the bunny was the patient. Children were able to use the types of syntactic arguments that occurred with the novel verb to infer which event that verb labeled, given two options.

Not all verbs are able to occur in transitive sentences. Verbs such as *sleep*, *arrive*, and *fall* are intransitive: They occur in sentences with a subject only. That is, you can say *Doug fell* but not **Doug fell Andrew*. It appears that a verb's ability to occur in a transitive or intransitive sentence is related to the types of events it labels. Verbs like *hit*, *push*, and *bump* that occur in transitive sentences tend to label causative events with one participant acting on another. Verbs like *sleep*, *arrive*, and *fall* that occur in intransitive sentences tend to label noncausative events that have only one participant, such as the individual who is sleeping, arriving, or falling. Children might therefore exploit this correlation between clause type and event type in making an inference about the event a verb labels. In a preferential looking study, Naigles (1990) found that children who heard a transitive sentence, such as *The duck is gorping the bunny*, were more likely to look at a scene in which a duck pushed a bunny than at a scene in which a duck and a bunny wheeled their arms separately. By observing that the verb occurred in a transitive sentence, children inferred that it described a causative action: a pushing event rather than an arm-wheeling event. Naigles also found the reverse pattern for children who heard an intransitive sentence, such as *The duck and the bunny are gorping*: These children preferred the noncausative arm-wheeling event rather than the pushing event.

It appears that children are sensitive to the type of sentence containing a novel verb and will use that information to infer which event the verb labels, given two choices. One influential hypothesis proposed that children behave this way because they expect the number of arguments of a sentence to match one to one the number of participants in the event the sentence's verb describes (Fisher, Gertner, Scott, & Yuan, 2010; Gleitman, 1990; Naigles, 1990; Yuan, Fisher, & Snedeker, 2012). This hypothesis has been tested extensively, and children's tendency to infer that transitive verbs name causative 2-participant events has been replicated many times over, in children as young as 22 months old. (See, e.g., Fisher et al., 2010, for a review.) Lidz, Gleitman, and Gleitman (2003) corroborated this tendency in 3-year-old children learning Kannada, a Dravidian language spoken in south India, which has a verbal morpheme that signals when a verb is causative. This morpheme is a much more reliable cue to causative meaning than transitivity, because a verb can occur in a transitive sentence without necessarily having a causative meaning. Nonetheless, children acted out causative meanings for transitive verbs, even without the causative morpheme, and they acted out noncausative meanings for intransitive verbs, even with the causative morpheme. Even though these children speak a language that provides a more reliable morphological signal for causativity, they preferred to rely on transitivity when deciding whether to interpret a verb with a causative meaning.

Children therefore appear to use transitivity as evidence that verbs label causative 2-participant events. However, beyond Naigles's (1990) seminal experiment, later studies have not found consistent behavior with intransitive verbs: Children who hear intransitive sentences with novel verbs do not reliably prefer events with one participant, beyond what would be expected by chance (Arunachalam & Waxman, 2010; Noble, Rowland, & Pine, 2011; Yuan et al., 2012). These findings are puzzling under the hypothesis that children expect one-to-one matching between the arguments of a sentence and participants in the event the sentence describes. However, they are consistent with a weaker learning strategy: Perhaps children merely expect that each argument names a participant, but not necessarily vice versa (Williams, 2015). In this case, the sole argument of an intransitive sentence could name one of the participants in a 2-participant event, making both the 1- and 2-participant events possible referents for the novel verb. Further work is needed to determine the source of children's behavior with intransitive sentences, and what this reveals about the specific inference that children make when using clause type as evidence for verb meaning.

Children also may be able to draw inferences about verb meanings from other types of complements, or syntactic dependents that follow a verb. In the sentence *Sally hit her sister*, the complement of the verb *hit* is the noun phrase *her sister* (the object). But in the sentence *Jim thought that Gina liked him*, the complement of the verb *think* is a whole clause. If there are correlations between the types of complements a verb can take and the meanings a verb can express, then children might be able to use a verb's complement as evidence for its meaning.

Some initial evidence that complements might be useful sources of information comes from Landau and Gleitman (1985), who studied the language acquisition of English-speaking blind children. They found that these children acquire meanings for the verb *look* relative to their own haptic exploration rather than to sight: Blind children respond to the request to "Look up!" by reaching upward with their hands, whereas sighted children wearing a blindfold turn their heads upward. The meaning that the blind children have assigned to *look* is supported by the contexts in which this word is used: Blind children hear *look* in situations when a relevant object is nearby, and therefore haptic exploration is possible. Yet somehow these children manage to differentiate *look* from other verbs, such as *touch* and *hold*, which also are used when a relevant object is nearby but are interpreted as contact terms rather than perception terms. The researchers hypothesized that the syntactic distribution of *look* compared to *touch* and *hold* drives this difference in interpretation. *Look* takes different complements from *touch* or *hold*: You can say *look at that picture* but not **touch/hold at that picture,* and *look down* but not **touch/hold down*. Perhaps the blind children in this study used the differences in complements among these verbs to infer that they have different types of meanings, even though they heard them in the same physical contexts.

Further evidence that children use verb complements to draw inferences about verb meanings comes from the acquisition of attitude verbs, such as *think*, *want*, and *hope*. Recall that these verbs are particularly hard to learn because they name internal states of speakers' minds (Gleitman, 1990; Gleitman et al., 2005). A large body of literature also has argued that young children may have difficulty acquiring attitude verbs because they lack the mental state concepts that these verbs label; in particular, children fail in certain tasks to demonstrate the ability to represent others' beliefs (the so-called developing theory of mind, e.g., Astington & Gopnik, 1991; Flavell, Green, & Flavell, 1990; Gopnik & Wellman, 1994; Perner, 1991). However, more recent work finds that children's failure on these tests may be due to experimental and pragmatic factors rather than immature belief representations (e.g., Hansen, 2010; Z. He, Bolz, & Baillargeon, 2012; Helming, Strickland, & Jacob, 2014; Lewis, Hacquard, & Lidz, 2017; Onishi & Baillargeon, 2005; Rubio-Fernández & Geurts, 2013).

Yet even if children have the ability to represent speakers' mental states, learning which verbs label these mental states is not a trivial matter. These mental states do not have obvious physical correlates, and it is difficult to tell when mental states rather than actions are under discussion: If a speaker uses a new verb, how does a child know whether the verb labels what someone is feeling or what someone is doing? In the human simulation study by Gillette et al. (1999), adults were particularly bad at identifying attitude verbs from the visual contexts in which they were uttered; sometimes they could identify action verbs, such as *hit*, but they almost never identified attitude verbs, such as *think.* However, attitude verbs do have a reliable syntactic signal: their ability to take full clauses as complements. We can say *Jim thought that Gina liked him*, but not **Jim danced that Gina liked him*. Therefore, even though children may have difficulty identifying attitude verbs from the situational contexts in which they are used, children might be able to identify them through their syntactic distribution—specifically, by paying attention to which verbs take clausal complements (Fisher, Gleitman, & Gleitman, 1991; Gleitman et al., 2005).

Furthermore, differences in the clausal complements of attitude verbs might help children tell certain attitude verbs apart from each other. Attitude verbs fall into two major classes: Verbs like *think* and *know* convey meaning about speakers' beliefs, whereas verbs like *want* and *demand* convey meaning about speakers' desires. Cross-linguistically, these two classes of attitude verbs also differ in the properties of their clausal complements. In English, this difference is reflected in the tense (finiteness) of the complement. Desire verbs, such as *want*, tend to occur with nonfinite complements: We can say *I want John to be at home* but not **I want that John is at home.* By contrast, belief verbs, such as *think*, tend to occur with finite complements: We can say *I think that John is at home* but not **I think John to be at home*. The specific syntactic property that differentiates the complements of desire verbs from those of belief verbs varies across languages but seems to obey the following generalization: The complements of belief verbs look like declarative main clauses in each language, and the complements of desire verbs do not (Hacquard, 2014; White, Hacquard, & Lidz, 2017). If children are aware of this generalization, they might be able to use it to infer whether an attitude verb expresses a desire or a belief meaning.

A study by Harrigan, Hacquard, and Lidz (2016) found that 4-year-olds draw different inferences about the meaning of an attitude verb depending on whether they hear it with a finite or a nonfinite complement. The researchers tested the verb *hope*, which is special in its ability to take both types of complements: We can say *I hope to win the prize* or *I hope that I will win the prize*. This verb is also relatively rare in speech to children and is therefore less familiar than other attitude verbs, such as *think* or *want*. Without much prior verb knowledge to rely on, these preschoolers treated *hope* more like *think* when they heard it with a finite complement, and they treated it more like *want* when they heard it with a nonfinite complement. It seems that preschoolers can use the syntactic properties of an attitude verb's complement to infer whether the verb has a belief or a desire meaning.

With both action verbs and attitude verbs, children use their syntactic knowledge to overcome the challenges of word-to-concept mapping. Despite the difficulties of learning verb meanings by observation, children are able to identify aspects of their meanings by observing the syntactic structures that verbs occur in. Children use the arguments in a sentence to infer what type of event is labeled by a verb in that sentence, and they use more specific properties of a verb's complement to infer whether and how that verb labels hard-to-observe events, such as mental states. By identifying a verb's syntactic properties, and knowing something about how those syntactic properties map onto aspects of the verb's meaning, children can draw sophisticated inferences about the types of events that a verb can describe.

Summary

Children use a variety of tools to learn the lexicon of their language: both the grammatical categories of words and their meanings. Statistical sensitivities—tracking the distribution of words in the input and the extralinguistic contexts in which these words are used—can help learners group words into grammatical categories. Sensitivity to the contexts in which words are used can also help learners identify what some of these words refer to, at least for concrete nouns. But prior linguistic knowledge also intersects with statistical sensitivity to solve the missing pieces of the lexicon puzzle. Knowledge of the properties of grammatical categories helps children identify properties of a word's meaning that may not be identifiable just from the word's distribution in the input. Furthermore, knowledge of the syntactic structures in which a word can occur, and the ways in which syntactic structure maps onto meaning, helps children infer the range of concepts a new word can label, even if those concepts do not have observable physical correlates. Knowledge about the syntax of the child's language therefore plays an important role in word learning. Next we discuss how this syntactic knowledge is acquired.

SYNTAX

The system of rules in your language that allow you to combine words and morphemes into larger hierarchical structures is called syntax. Languages vary in some of their syntactic properties, such as the order of words and phrases. For example, children need to learn whether their language puts the subject before the verb and the object after the verb like English does, or whether the subject and object appear in a different order. However, languages do not seem to vary across other syntactic properties, such as organizing phrases into hierarchical structure. For example, in all languages, the subject of the sentence is structurally separate from the unit formed from the verb and the object (Baker, 2001). Furthermore, languages vary in which relations hold between specific elements of a sentence, but all languages encode these relations across hierarchical structures rather than linear strings of words (Chomsky, 1957, 1975). Children need to determine how their language behaves with respect to the syntactic properties that vary cross-linguistically but might take for granted the properties that do not vary, such as hierarchical structure and structure-dependent relations.

Clause Structure

Within a sentence, grammatical categories combine in specific ways into phrases, and these phrases combine into clauses with larger hierarchical structure. The order in which these units combine determines different hierarchical arrangements, with different meanings. For example, in English the noun *boy* can combine with a determiner *the* to form a noun phrase *the boy*. This noun phrase can be the object of a verb like *bite*, to produce a verb phrase: *bite* [*the boy*]. This verb phrase can combine with tense and agreement morphology as well as a subject noun phrase, such as *the cat*, to produce a full clause: *The cat* [*bites* [*the boy*]]. If these units were combined in a different order, we would get a different meaning: *The boy* [*bites* [*the cat*]].

In English, subjects generally precede verbs, which precede objects: English has "SVO" order. Knowing this word order allows you, as an adult speaker of English, to infer the structure of a sentence. In many sentences, if *the cat* comes before the verb *bite*, you can infer that *the cat* is the subject, whereas if *the boy* comes before *bite*, you can infer that *the boy* is the subject. However, this word order can vary across languages. Japanese tends to have SOV order, where the equivalent to *The cat bites the boy* would have an order like *The cat the boy bites*. Irish has VSO order: The Irish equivalent to this sentence would have an order like *Bites the cat the boy*. In order to assign a syntactic structure to sentences they hear, children must learn the property of their language that determines whether the subject and object precedes or follows the verb.

Children appear sensitive to their language's word order from a young age. As soon as children begin combining words, their utterances display the correct order of words in their language (L. Bloom, 1970; Brown, 1973). But even before they begin combining many words, children are able to infer properties of sentence structure from the order of words in a sentence. Hirsh-Pasek and Golinkoff (1996) played English-speaking 17-month-olds sentences in the context of two scenes: one showing Big Bird washing Cookie Monster and the other showing Cookie Monster washing Big Bird. Children who heard *Big Bird is washing Cookie Monster* looked more at the scene where Big Bird was doing the washing, and children who heard *Cookie Monster is washing Big Bird* looked more at the opposite scene. It appears that these children could identify the subject of the sentence based on its word order and inferred that the character labeled by the subject was the agent of the action. Recall that slightly older children could use this word order information to arrive at the correct interpretation of a novel verb: After hearing a sentence like *The duck is gorping the bunny*, they inferred that *gorp* must label an event where the duck was the agent rather than the bunny (Gertner et al., 2006). These children could identify where subjects and objects occur in sentences and use this information to make inferences about the sentence's meaning.

How do children develop this early understanding of word order? In the last section we discussed a strategy called semantic bootstrapping that could help children learn the grammatical categories of some words based on the types of meanings those words have. It also has been proposed that another form of semantic bootstrapping helps children infer the syntactic structure of sentences from the meanings of those sentences (Grimshaw, 1981; Pinker, 1984, 1989). Suppose a child hears a sentence like *The cat bites the boy* in the context of a scene where a cat bites a boy. If that child represents the scene as a biting event where the cat is the agent and the boy is the patient, and knows that the phrase *the cat* refers to the cat and *the boy* refers to the boy, she might be able to identify which phrases in the sentence are labeling the agent and which phrases are labeling the patient. If she furthermore knows that the agent of the event corresponds to the subject of a sentence and the patient corresponds to the object, she will be able to identify that *the cat* is the subject and *the boy* is the object. This information, combined with the knowledge that *bites* is a verb, will tell her that subjects come before verbs and objects come after verbs. She might then expect future English sentences to have SVO word order.

This semantic bootstrapping strategy relies on children being able to perceive scenes in the world under the right type of conceptual structure to align with the structure of sentences they are hearing. Prelinguistic infants appear to perceive events under conceptual structures that distinguish participant roles like "agent" from other participant roles like "patient." Children as young as 6 months represent agents as special participants in events, with intentions and goals (Csibra, Gergely, Bíró, Koos, & Brockbank, 1999; Leslie, 1995; Luo, Kaufman, & Baillargeon, 2009; Woodward, 1998). This agent role of an event therefore may be perceptually available for children to map onto a particular linguistic structure, such as the subject of a sentence. But in order to use this strategy, children do not just need to represent scenes with conceptual structure that can map onto sentence structure; they also need to represent those scenes in the same way as the speaker of the sentence did. Because a lion running after a gazelle could be described as either a "chasing" or a "fleeing" event (Gleitman, 1990), a child who hears *The gazelle fled the lion* to describe this scene would need to represent the scene as a fleeing event with the gazelle as the agent in order to infer that *the gazelle* is the subject of the sentence. If she instead represented the scene as a chasing event with the lion as the agent, she might mistakenly conclude that *the lion* is the subject in this sentence. Therefore, not all sentences will be equally informative about word order under this strategy.

This strategy also assumes that the child knows how agents and patients of events are represented linguistically in different structural positions in a clause: namely, that agents normally are represented as subjects and patients as objects. This pattern happens to be a very robust one cross-linguistically for active, transitive clauses (Baker, 1988; Dowty, 1991; Fillmore, 1968; Jackendoff, 1972). It is this "agents-are-subjects" expectation that allows our hypothetical learner to infer that *the cat* is the subject of *The cat bites the boy*, based on her knowledge that *the cat* labels the agent of the event being described. The 17-month-olds in Hirsh-Pasek and Golinkoff's (1996) study demonstrated knowledge of this generalization: They knew that when *Cookie Monster* appeared as the subject of the transitive sentence, the Cookie Monster character had to be the agent and not the patient of the action.

Further work has shown that children have such a strong expectation that the subject of a sentence will name the agent of the event that they have difficulty overriding this expectation in cases where the generalization does not hold. For example, children sometimes misinterpret passive sentences as active sentences, responding to a sentence like *The boy was bitten by the cat* by acting out or pointing to a situation where the boy bit the cat rather than a situation where the cat bit the boy (Bever, 1970; Turner & Rommetveit, 1967). It has been proposed that this behavior is due to children's strong expectation that the subject of the sentence names the agent of an event, along with difficulty detecting the cues that signal passive sentences or difficulty using those cues to revise initial interpretations (Bever, 1970; Huang, Zheng, Meng, & Snedeker, 2013; Li, Bates, & MacWhinney, 1993; Maratsos & Abramovitch, 1975; Stromswold, Eisenband, Norland, & Ratzan, 2002; Turner & Rommetveit, 1967); but see alternative interpretations in Borer and Wexler (1987, 1992), Brooks and Tomasello (1999), Demuth (1989), Gordon and Chafetz (1990), and F. N. Harris and Flora (1982). Children's expectation that agents are subjects may be such a useful principle in guiding the interpretation of basic clauses in their language that it sometimes leads them to make errors in interpreting nonbasic clauses.

Children therefore might be able to use principles like "agents-are-subjects" to identify the order of subjects and objects in their language, aligning their structured perception of events in the world with the structure of sentences describing those events. As long as children hear some clear cases where the sentences they hear align with their perception of the events being described, this semantic bootstrapping strategy might enable them to identify whether their language places the subject or object before or after the verb. But simply identifying that subjects, verbs, and objects occur in a particular order does not by itself tell the child that those units are arranged in a structural hierarchy—that verbs and objects form a unit and that subjects are structurally separate from that unit (e.g. Baker, 2001). How do children learn that sentences are built with this type of structure, with units built from smaller units? Because hierarchical structure is a feature of all human language, it is possible that children take this for granted: The language learning mechanism is constrained such that children acquiring any language will hypothesize only hierarchically structured syntactic representations (Chomsky, 1975).

Evidence for hierarchical structure in phrase representations has come from experimental work with children as young as 18 months old. Lidz, Waxman, and Freedman (2003) investigated whether these infants represented a noun phrase, such as *the yellow bottle*, as one big unit with no internal structure or whether *yellow bottle* forms a smaller unit inside the phrase: *the* [*yellow bottle*]. Adults have this nested representation, which is revealed in sentences like *I'll give Sarah this yellow bottle* and *I'll give you that one*. In this sentence, the word *one* does not refer just to a bottle—it refers to another *yellow* bottle. Because *one* can refer back to the string of words *yellow bottle*, those words must be a unit in the sentence. Lidz et al. showed 18-month-olds a picture of a yellow bottle and named it with a noun phrase that contained an adjective: *Look! A yellow bottle*. Then the infants saw a picture of another yellow bottle and a blue bottle, and heard either a sentence with the word *one* (*Do you see another one?*) or without (*What do you see now?*). Infants looked more at the yellow bottle than at the blue bottle, but only when they heard the word *one*. That is, they interpreted *one* to refer not to any bottle but specifically to another yellow bottle: They represented *yellow bottle* as a unit inside the phrase *a yellow bottle*. Even at very early stages of syntactic development, children's syntactic representations contain hierarchical structure.

Children can identify where subjects and objects occur in a sentence in their language and represent sentences with hierarchical structure even before they are producing many full sentences of their own. However, once children do begin producing sentences, two characteristics of their speech have led researchers to question the completeness of their sentence representations. One of these phenomena is the so-called root infinitive stage of early child speech, in which young children use the infinitive form of a verb instead of the tensed form. Because there are links between the morphological form of a verb and its position in a clause, a sizable literature has investigated whether children's root infinitive productions reflect immature knowledge about where verbs and other functional elements occur in the hierarchical structure of a clause (Bar-Shalom & Snyder, 1997; Guasti, 2002; Guilfoyle & Noonan, 1988; Haegeman, 1995; T. Harris & Wexler, 1996; Legate & Yang, 2007; Phillips, 1995; Platzack, 1990; Poeppel & Wexler, 1993; Radford, 1990; Rizzi, 1993, 1994; Schaeffer & Ben Shalom, 2004; Weverink, 1989; Wexler, 1994, 1998). The cause of this phenomenon remains a puzzle, but children generally pass through the root infinitive stage before they are 3 years old.

A second phenomenon is young children's omission of overt subjects in languages that require them, such as English. A large body of literature has investigated whether these early subject omissions reflect immature knowledge about the property of English main clauses that makes overt subjects obligatory or whether they reflect the interaction of other cognitive and linguistic factors, such as immature working memory, pragmatics, and prosody (Allen, 2000; P. Bloom, 1990; Gerken, 1991, 1994; Guasti, 2002; Hyams, 1986, 1992, 2011; Hyams & Wexler, 1993; Kim, 2000; Rizzi, 1993, 1994; Serratrice, 2005; Valian, 1991; Valian & Aubry, 2005; Valian & Eisenberg, 1996; Valian, Hoeffner, & Aubry, 1996; Wang, Lillo-Martin, Best, & Levitt, 1992). The source of children's early subject omissions is still under debate, but by the age of 3 children produce overt subjects consistently in languages that require them.

To summarize our discussion so far, children's acquisition of the clause structure of their language is informed by domain-specific constraints on their linguistic representations, interacting with properties of their perceptual system. Alignment between children's conceptual representations of events around them and the structure of at least some sentences that describe those events may help children identify which phrases label agents or patients. If children then expect that agents are subjects of transitive clauses, they can identify how their language orders subjects and objects with respect to the verb in a sentence. Although the completeness of children's early sentence representations has been debated, the structural hierarchy of subjects, verbs, and objects within a sentence, as well as the structural hierarchy of words within a single phrase of a sentence, may be something children take for granted. Hierarchical structure is common to all the world's languages, and children at the earliest stages of syntactic development appear to have hierarchically structured phrase representations. The requirement that linguistic expressions contain hierarchical structure therefore may be an innate constraint imposed by children's language learning mechanism.

Syntactic Dependencies

Syntactic dependencies are relations between elements in a clause or across clauses, determined by the syntactic properties of those elements and the structures they occur in.

Here we consider how children acquire two types of dependencies. The first type occurs in the sentence *Jane is playing the piano*. In this sentence there is a dependency between the auxiliary verb *is* and the *-ing* form of the verb, which work together to tell you that the sentence is in the present progressive, so Jane's playing is ongoing. This type of relation can hold across intervening material, as in the sentences *Jane is softly playing the piano* and *Jane is softly and beautifully playing the piano.* Because this dependency holds between two morphemes in a certain syntactic relation, it is a type of morphosyntactic dependency. A second type of dependency occurs in questions like *Which sonata is Jane playing tonight?* Here there is a dependency between the "wh-phrase" *which sonata* and the verb *playing*: We understand this question as asking about the missing object of that verb. We also find this type of relation in a relative clause like *I love the sonata that Jane is playing in the concert*, and this relation can hold across a lot of intervening material: *I love the sonata that Tony thought the program said that Jane is playing in the concert.* Because the object of the verb appears to have moved to a different position in these sentences, these dependencies are called movement dependencies. They also frequently are called filler-gap dependencies because the moved element is a filler that becomes associated with a gap later on in the sentence.

An important feature of these relations is the fact that they are defined over the hierarchical structure of elements in a sentence (Chomsky, 1975). In other words, the relations that elements of a sentence can enter into depend on their structural positions with respect to each other. For instance, the dependency between *is* and *-ing* does not hold between *is* and any sequence of sounds pronounced "ing" that occurs after it: We do not get this dependency in sentences like *Jake is a singer* or *The probability is vanishingly small*. We get this dependency only between *is* and an *-ing* morpheme that occurs on the main verb in the sentence. This dependency is defined over a particular structural relation between *is* and *-ing*, not the linear order of these two sounds. And it is not the case that any string of words can enter into a movement dependency in a wh-question or relative clause; only strings that are units within the hierarchical structure of the sentence can move. In the sentence *Jane is playing which sonata in the concert?*, the string of words *which sonata* is a unit, so it can move to the front of the sentence, creating a movement dependency: *Which sonata is Jane playing in the concert?* However, *which sonata in* is not a unit, so those words cannot move together: We cannot say **Which sonata in is Jane playing the concert?* Movement dependencies are constrained by the hierarchical structure of the sentence and can hold only between structural units in the sentence.

Morphosyntactic Dependencies

Children's statistical sensitivities and extralinguistic cognition interact to help them identify morphosyntactic dependencies in their language. Experimental work with very young children has found that they can track the statistical signature of dependencies like the *is-ing* relation, but this ability is mediated by their memory resources. Santelmann and Jusczyk (1998) played 18-month-olds sentences with the sequence *is* Verb-*ing*, a real English dependency, as well as sentences containing the sequence *can* Verb-*ing*, which is not an English dependency. For example, some children heard sentences like *Everybody is baking bread*, and other children heard sentences like **Everybody can baking bread.* Eighteen-month-olds preferred to listen to sentences with the *is* Verb-*ing* sequence over sentences with the *can* Verb-*ing* sequence, indicating that they knew that *is* and -*ing* signal a real morphosyntactic dependency in English. These children also preferred sentences with *is* Verb-*ing* when a 2-syllable adverb came between *is* and the verb, but not when a longer adverb intervened: They still were able to detect this dependency in sentences like *Everybody is often baking bread* but not in *Everybody is effectively baking bread*. It appears that these infants' limited memory resources interfered with their ability to detect the signal of this morphosyntactic dependency. That is, children needed to be able to hold enough linguistic material in memory in order to detect the co-occurrence of *is* with -*ing*, and longer intervening adverbs taxed their limited memory resources enough to prevent them from detecting this dependency.

Santelmann and Jusczyk's (1998) results indicate that English-speaking children are aware of the morphosyntactic dependency between *is* and -*ing* by the age of 18 months, although their memory resources are not always sufficient to detect this dependency in their input. What allows children to become aware of this dependency? Results from artificial language learning studies suggest that children can track co-occurrence patterns in their input to learn nonadjacent dependencies, such as the one between *is* and -*ing* in English (Gómez, 2002; Gómez & Maye, 2005). Recall that in our discussion of word segmentation, young children could use statistics to track the probability that certain nonsense syllables would occur next to each other (e.g., Saffran et al., 1996). Now the question is whether children can track the probability that certain strings will occur together across intervening material—for example, that *is* will co-occur with -*ing* with different verbs in between. Gómez and Maye (2005) tested 15-month-olds' abilities to detect these types of nonadjacent dependencies in an artificial language. These children heard "sentences" like *pel-vamey-rud*, *pel-wadim-rud*, and *pel-tapsu-rud*, in which a dependency between the nonwords *pel* and *rud* obtained across a variety of intervening nonwords. After training, these infants were able to recognize this *pel*-X-*rud* dependency in new "sentences" that contained it, as long as their training contained enough variety in the nonwords that came between *pel* and *rud*. This finding suggests that children as young as 15 months old are able to detect the statistical signature of nonadjacent dependencies, provided they hear enough variety in the intervening material.

Because morphosyntactic dependencies like the one between *is* and -*ing* in English are defined over hierarchical structures in a sentence rather than over the linear order of words, these relations can hold across large amounts of intervening material. Children's ability to detect the statistical signatures of nonadjacent dependencies is therefore crucial for learning these morphosyntactic dependencies in their language. But these statistical sensitivities interact with their extralinguistic cognition: Children need sufficient memory resources to recognize these dependencies over longer distances and may be unable to keep both parts of the dependency in memory if the amount of linguistic material between them grows too large. Children's ability to detect morphosyntactic dependencies in their language develops as their memory resources mature.

Movement Dependencies

Learning movement dependencies similarly involves interaction among children's statistical sensitivities, extralinguistic cognition, and domain-specific biases. We have seen that movement dependencies can hold only between structural units in a sentence. Because this structure dependence is a universal property of human language, it is something that children might take for granted: It might be an intrinsic constraint imposed by their language learning mechanism (Chomsky, 1975). This constraint would provide useful guidance for learning movement dependencies in their language: Once children can identify the hierarchical structure of a sentence, they will know that only units within that structure can move, and therefore they will know which instances of movement are possible and impossible.

Takahashi and Lidz (2008) and Takahashi (2009) used an artificial language learning paradigm to test children's knowledge of structure dependence. Following a method developed by Thompson and Newport (2007), they constructed artificial grammars in which some sequences of nonsense word categories could be optional, repeated, or substituted by other categories, which affected the probabilities of certain word categories occurring after others. After being trained on this artificial language, adults and 18-month-olds were tested on sentences that contained movement. Adults accepted sentences when one of the optional, repeated, or substituted category sequences was moved: They used the differences in transitional probabilities to group these sequences into units and recognized that those units could move. Eighteen-month-olds likewise accepted sentences with moved units and showed surprise when they heard sentences with moved sequences that were not units. In other words, these infants knew that only strings of words that form a unit within a structural hierarchy could take part in movement relations, even though they had never heard movement before in this task. Once they were able to identify the hierarchical structure of these sentences, they were able to identify possible and impossible instances of movement in this artificial language. Their knowledge of structure dependence allowed these learners to draw conclusions about syntactic relations beyond what they were exposed to in their input.

But knowing which elements of a sentence can and cannot move is only one step in learning movement dependencies. Children also need to be able to identify when this movement happens in sentences they hear. When adults hear a filler (a moved word) in a sentence, they quickly identify that the sentence contains a movement dependency and predict gaps where that filler could be interpreted (Crain & Fodor, 1985; Frazier & Clifton, 1989; Frazier & d'Arcais, 1989). Children are able to parse certain wh-questions in this predictive manner by the age of 5. Omaki et al. (2014) asked 5-year-olds questions like *Where did Lizzie tell someone that she was gonna catch butterflies?* and found that children interpreted the wh-word *where* as describing the location of the first verb that it could be associated with. English-speaking children interpreted this sentence as a question about the location of telling, and Japanese-speaking children interpreted the Japanese analog as a question about the location of catching, because the verb for "catch" comes before the verb for "tell" in Japanese word order. These children did not wait to hear the full structure of the sentence before resolving the movement dependency: They predicted that the wh-word could be interpreted with the first verb they encountered. In order to do this, children needed to detect cues in the sentence that told them a filler was present, predict upcoming structure, and keep the filler in memory while hearing the rest of the sentence, so they could access it and integrate it into their sentence representation as soon as possible. Children's developing extralinguistic cognition, in addition to their developing linguistic knowledge, might mediate their ability both to detect cues to movement dependencies and to resolve these dependencies accurately.

Some studies have found suggestive evidence that English-learning children develop the ability to detect movement dependencies in English sentences between the ages of 15 and 20 months (Gagliardi, Mease, & Lidz, 2016; Seidl, Hollich, & Jusczyk, 2003). Gagliardi et al. (2016) used a preferential looking method to test comprehension of wh-questions like *Which dog did the cat bump?* and relative clauses like *Find the dog that/who the cat bumped*. They found an interesting U-shaped learning pattern. Fifteen-month-olds appeared to arrive at the correct interpretation for both types of sentences: They looked more at a dog that got bumped than at a dog that was the agent of bumping. But 20-month-olds appeared to comprehend only wh-questions and relative clauses with *who*, not relative clauses with *that*. Twenty-month-olds' surprising failure with certain relative clauses might demonstrate the development of syntactic knowledge: They have learned to represent the full movement dependencies in these sentences but have difficulty detecting when relative clauses with *that* contain these dependencies. The word *that* is ambiguous in English—it occurs in many contexts other than in relative clauses—so words like *who* or *which* are much clearer cues to movement dependencies. Fifteen-month-olds, in contrast, might be arriving at the right answer through a heuristic that does not require them to parse the full movement dependency, thereby avoiding these difficulties with relative clauses.

Relative clauses therefore might pose challenges to the parsing mechanisms of early learners. However, children's difficulty in comprehending relative clauses throughout development has led many researchers to question whether children's linguistic representations of these dependencies are at fault. Children produce relative clauses as young as 2 years of age (Corrêa, 1995; Guasti, Dubugnon, Hasan-Shlonsky, & Schneitter, 1996; Labelle, 1990; McKee, McDaniel, & Snedeker, 1998), but even through their preschool years, children have difficulty comprehending some types of relative clauses when asked to act them out or point to a matching picture (de Villiers, Flusberg, Hakuta, & Cohen, 1979; Goodluck & Tavakolian, 1982; Hamburger & Crain, 1982; Sheldon, 1974; Tavakolian, 1981). Preschoolers have particular difficulty with relative clauses in which the filler is interpreted as the object rather than the subject of the verb. This is the difference between relative clauses like *the dog that the cat bumped* and *the dog that bumped the cat*: In the first, *the dog* is interpreted as the object of *bump*, and in the second, it is interpreted as the subject. Some researchers have attributed children's difficulty with object relative clauses to immature representations of these sentences (Labelle, 1990; Tavakolian, 1981), inability to represent certain object relatives that children have not frequently heard before (Arnon, 2009; Brandt, Kidd, Lieven, & Tomasello, 2009; Kidd & Bavin, 2002; Kidd, Brandt, Lieven, & Tomasello, 2007), or non-adult-like constraints on when this type of movement dependency can occur (Adani, Forgiarini, Guasti, & Van der Lely, 2014; Adani, Van der Lely, Forgiarini, & Guasti, 2010; Belletti, Friedmann, Brunato, & Rizzi, 2012; Friedmann, Belletti, & Rizzi, 2009). However, the sentence processing literature has found that adults also have difficulty with object relatives, reading them more slowly than subject relatives, which has been attributed to constraints on how memory is accessed in resolving these dependencies. (See Wagers & Phillips, 2014, for a review.) It therefore is possible that preschoolers' difficulties in interpreting these sentences might stem from the same type of memory constraints (e.g., Arosio, Yatsushiro, Forgiarini, & Guasti, 2012; Haendler, Kliegl, & Adani, 2015).

In summary, in order to learn syntactic dependencies, children must both detect these dependencies in their input and arrive at a structural representation for them. Children's extralinguistic cognition interacts with their domain-specific linguistic biases during both of these steps. Statistical sensitivities help children detect which morphemes are involved in a morphosyntactic dependency and which types of words signal that a movement dependency is present. Memory resources also contribute to this process, because children must be able to maintain and access linguistic information in memory in order to recognize and resolve dependencies that hold across intervening material. But domain-specific biases also play an important role. If children take for granted that dependencies are defined over hierarchical structure, it may make it easier to learn them: Once children have identified the structure of a clause, they will have information about what types of dependencies can hold between elements in that structure.

Summary

Children use their extralinguistic perceptual and memory systems, statistical sensitivities, and domain-specific knowledge about the nature of linguistic representations to learn the syntax of their language. Children might be able to infer which phrases of their language are subjects and objects by observing whether those phrases label agents or patients in their representations of events in the world. Children's statistical sensitivities and memory resources help them detect and resolve syntactic dependencies between elements of a sentence. But children may not need to learn that elements in a sentence are arranged in a structural hierarchy or that syntactic dependencies operate over this hierarchical structure: These are syntactic properties common to all of the world's languages, so children might take them for granted. The nature of the language learning mechanism constrains children's early linguistic representations to be hierarchically structured and constrains children to posit syntactic dependencies only between units in this structure. Knowledge about the syntactic properties of human language in general therefore allows children to draw inferences about the syntactic structure of their own language.

SEMANTICS

Semantics is the study of how linguistic expressions convey meaning. The meaning of a sentence is more than just a sum of the meanings of the words but depends on sentence structure as well. We have seen that sentences like *The dog chased the cat* and *The cat chased the* dog convey different meanings despite having all the same words. These sentences have different meanings because the role that each of the noun phrases plays is different in each sentence.

Sentence structure contributes to many aspects of sentence meaning, not just role assignment. For example, the way that pronouns are interpreted depends on their syntactic context. Pronouns make a contribution to sentence meaning that is underspecified. Assigning an interpretation to the pronoun (and hence to the sentence) depends on the context of use. In the sentence *Allison thinks that she will get the job*, the pronoun can be interpreted as referring either to Allison or to some other salient individual in the context.

When a pronoun gets its interpretation based on the interpretation of some other phrase, the relation between the two expressions is subject to syntactic conditions. For example, the pronouns *she* or *her* may get their reference from (corefer with) *Belinda* in sentences like *When she was in the interview, Belinda spilled some water* and *Belinda said that my brother interviewed her*. But the pronouns all must refer to someone other than Belinda in sentences like *She was in the interview when Belinda spilled some water* and *Belinda interviewed her.* Thus, while we can characterize pronouns as those expressions whose reference can be determined by other parts of the sentence, the conditions under which such referential dependencies hold are constrained by syntax in ways that we discuss in the following section "Interpreting Pronouns."

Other kinds of semantic relations between words and phrases also are dependent on properties of sentence structure. For example, the sentence *Every student didn't complain about his grades* is ambiguous. This sentence can express the idea that no students complained. It also can express the weaker idea that some students complained and others did not. This ambiguity arises because of the relative scope of negation and the universal quantifier *every*. Scope is the domain in which a quantifier or other operator can influence how other expressions are interpreted. In this sentence, *every* can be interpreted either outside or inside the scope of negation. If the sentence means "every student is such that he didn't complain about his grades," we get the stronger reading, whereas if it means "not every student complained about his grades," we get the weaker meaning.

In the remainder of this section, we consider the acquisition of constraints on pronoun interpretation and on quantifier scope. These issues have been a focus of research in language acquisition because they reveal the highly abstract nature of the rules governing the interpretation of sentences and thus highlight the potential disconnect between the nature of experience and acquired grammatical knowledge.

Interpreting Pronouns

Pronouns can fix their reference through some other noun phrase, but there are constraints on the kinds of sentences in which this can happen. These constraints are based on two factors: structural hierarchy and structural locality.

The role of hierarchy can be seen in the contrast between *When she was in the interview, Belinda spilled some water* and *She was in the interview when Belinda spilled some water*. In each of these sentences, the pronoun precedes *Belinda* in the linear order of words, but in the second sentence, the pronoun is "higher" in the structural hierarchy. The notion of height in linguistic structures is expressed though a relation called c-command (Reinhart, 1981). One expression c-commands another if the smallest unit containing the first also contains the second. In the first sentence provided, the pronoun does not c-command *Belinda*, but in the second sentence, it does. In addition, one expression binds a second expression if it c-commands the second expression and corefers with that expression (Chomsky, 1981). But we cannot interpret the second sentence above with the pronoun coreferring with *Belinda*: It has to refer to someone else. In other words, the pronoun cannot bind *Belinda.* The relevant constraint on pronoun interpretation, known as Principle C, is thus that a pronoun cannot bind its antecedent (Lasnik, 1976); stated slightly differently, a referring expression like *Belinda* cannot be bound (Chomsky, 1981).

The structural notion of locality, when combined with c-command, explains the contrast between *Belinda said that my brother* *interviewed her* and *Belinda interviewed her*. In both sentences, *Belinda* c-commands the pronoun, but only the first allows coreference. This is because of the locality condition, known as Principle B (Chomsky, 1981), requiring that a pronoun not be bound in the smallest clause containing it. In the first sentence, the pronoun and *Belinda* are in different clauses, so *Belinda* can bind the pronoun and the two expressions can corefer. But in the second sentence, the two expressions are in the same clause, so *Belinda* cannot bind the pronoun: The coreferential interpretation is ungrammatical. Instead, the pronoun must refer to someone else.

Early work on the acquisition of Principle B found that children as old as 5 were sensitive to c-command but not to locality (Chien & Wexler, 1990), and hence allowed coreference in sentences like *Belinda interviewed her.* (See also Grodzinsky & Reinhart, 1993; Thornton & Wexler, 1999, among others.) However, Conroy, Takahashi, Lidz, and Phillips (2009) found that children do respect the locality portion of Principle B, and they argued that earlier results derived from methodological artifacts and biases coming from online sentence processing.

Principle C has played a very prominent role in arguments concerning the origins of grammatical knowledge. Because children are exposed only to sentence-meaning pairs that are grammatical, it is a puzzle how they acquire constraints like Principle C, which bar certain sentences from expressing otherwise sensible interpretations. How can one acquire rules about the interpretations that sentences cannot have?

Crain and McKee (1985) examined English-learning preschoolers' knowledge of Principle C, asking whether children know that a pronoun can precede its antecedent but cannot c-command it. The experimenters used a truth-value judgment task, in which participants observe a story acted out by the experimenter with toys and props. At the end of the story, a puppet makes a statement about the story. The participant's task is to tell the puppet whether he was right or wrong. Crain and McKee presented children with sentences like *While he was dancing, the Ninja Turtle ate pizza* and *He ate pizza while the Ninja Turtle was dancing* following stories with two crucial features. First, the Ninja Turtle ate pizza while dancing. This makes the interpretation in which the pronoun (*he*) and the referring expression (*the Ninja Turtle*) are coreferential true. Second, there was an additional salient character who did not eat pizza while the Ninja Turtle danced. This aspect of the story makes the interpretation in which the pronoun refers to a character not named in the test sentence false. Thus, if children allow coreference in these sentences, they should accept them as true, but if children disallow coreference, then they should reject them as false. The reasoning behind this manipulation is as follows. If children reject the coreference interpretation, then they must search for an antecedent for the pronoun outside of the sentence. Doing so, however, makes the sentence false.

Crain and McKee found that children as young as 3 years old accepted sentences like *While he was dancing, the Ninja Turtle ate pizza* in contexts that made the coreferential interpretation true but overwhelmingly rejected sentences like *He ate pizza while the Ninja Turtle was dancing* in identical contexts. The fact that they treated the two sentence types differently, rejecting coreference only in those sentences that violate Principle C, indicates that by 3 years of age, English-learning children respect Principle C.

The observation that Principle C constrains children's interpretations raises the question of the origin of this constraint. The fact that children as young as 3 years of age behave at adult-like levels in rejecting sentences that violate Principle C often is taken as strong evidence for the role of c-command in children's representations and hence for the role of hierarchical structure in shaping children's interpretations. (See Kazanina & Phillips, 2001, for supporting evidence from Russian.)

This view may be further bolstered by work demonstrating that children as young as 30 months display knowledge of Principle C. Lukyanenko, Conroy, and Lidz (2014) conducted a preferential looking experiment in which infants saw two videos side by side. In one video, a girl (Katie) was patting herself on the head. In the other video, a second girl patted Katie on the head. Infants were then asked to find the image in which "She is patting Katie" or the one in which "She is patting herself." Infants in the former condition looked more at the video in which Katie was getting patted by someone else, whereas those in the latter condition looked more at the video in which Katie was patting herself.

To determine whether children's interpretations were driven by Principle C, as opposed to an alternative nonstructural heuristic, Sutton, Fetters, and Lidz (2012) and Sutton (2015) tested children in a preferential looking task like Lukyanenko et al. (2014) and also in a task measuring sensitivity to hierarchical structure. Children saw three objects: a big red train, a medium-size yellow train, and a small yellow train. They then were asked to find "the big yellow train." Correct interpretation requires restricting the adjective *big* to apply to the phrase *yellow train*. Sutton et al. measured the speed with which the children looked to the correct object and used that to predict the speed with which they arrived at the correct interpretation of the Principle C sentences. They found that these structural processing measures were significantly correlated, although measures of lexical processing speed and vocabulary size were not predictive of Principle C performance. Together these findings suggest that the computation of hierarchical structure is a critical component of children's understanding of sentences, which are subject to Principle C from the earliest stages of syntactic development.

Quantification and Scope

Some sentences with quantifiers permit readings that do not follow directly from simple mapping of surface form to semantic interpretation (Büring, 1997; Horn, 1989; Jackendoff, 1972, among others). Consider the sentence *Every horse didn't jump over the fence*. This sentence is scopally ambiguous. On the interpretation that "every horse is such that it didn't jump over the fence," the sentence means that none of the horses jumped over the fence. Here *every* takes scope over negation. We call this an isomorphic interpretation because the scope relation between *every* and negation coincides with their surface positions. Another possible interpretation is that "not every horse jumped over the fence," which means that some horses jumped and some did not. In this case, negation takes scope over *every*. We call this a nonisomorphic interpretation because here negation takes scope over the whole sentence (i.e., in a position different from the one it occupies in surface syntax).

Musolino, Crain, and Thornton (2000) tested children's comprehension of quantificationally ambiguous sentences. They found that while adults can easily access the nonisomorphic interpretations of such sentences, 4-year-olds systematically assign such sentences an isomorphic interpretation only. This was true also for sentences like *The Smurf didn't buy every orange*, in which the isomorphic reading is the opposite from that of *Every horse didn't jump over the fence*. In the first sentence, 4-year-olds interpret negation as scoping over *every*, taking the sentence to mean "it is not the case that the Smurf bought every orange." In the second sentence, they interpret *every* as scoping over negation, taking the sentence to mean "every horse is such that it didn't jump over the fence." The authors take the finding that children systematically assign these sentences isomorphic interpretations to conclude that young children, unlike adults, systematically interpret negation and quantifiers on the basis of their position in overt syntax.

Musolino et al.'s (2000) findings, however, do not tell us the nature of the representations underlying children's resistance to nonisomorphic interpretations. One possibility is that children's overly isomorphic interpretations reflect the linear arrangement between quantifiers and negation. Alternatively, children's interpretations may be constrained by the surface c-command relations holding between these elements. These alternatives arise because c-command and linear order are systematically confounded in the materials used by Musolino et al.

In order to tease these possibilities apart, Lidz and Musolino (2002) compared English-speaking children's scope interpretations with those of Kannada-speaking children. The canonical word order in Kannada is subject-object-verb (SOV), and Kannada displays the same kind of scope ambiguities as English with respect to negation and quantifiers (Lidz, 2006). These properties are illustrated in sentences like *Naanu eraDu pustaka ood-al-illa* ("I didn't read two books"), which has the word order "I two books read not." This can mean "it is not the case that I read two books," where negation takes scope over the numeral, or "there are two books that I did not read," where the numeral takes scope over negation.

The crucial difference between Kannada and English is that in Kannada, linear order and c-command are not confounded. In both languages, negation c-commands the direct object in the structure of the sentence. However, the linear order of the words is different in the two languages: Negation precedes the object in English but follows the object in Kannada. Lidz and Musolino (2002) found that children interpret sentences like *The Smurf didn't catch two guys* with negation taking scope over the numeral, independent of the language being acquired. This finding illustrates that children's scope assignment preferences reflect the hierarchical relation of c-command and not merely the linear order of words.

Subsequent work on children's scope assignment reveals that their limitations likely derive from the pressures of online sentence understanding. First, Musolino and Lidz (2006) showed that children can access nonisomorphic interpretations when they are heavily supported by the discourse. These authors found a significant increase in nonisomorphic interpretations in contrastive contexts like *Every horse jumped over the log but every horse didn't jump over the fence.* Viau, Lidz, and Musolino (2010) went on to show that experience with contrastive contexts make children more readily accept nonisomorphic interpretations even in noncontrastive contexts. These results suggest that children's difficulties have more to do with deploying their knowledge in real time than with acquiring that knowledge in the first place.

Origins of Quantifier Meanings

By the age of 4, children have acquired the complex mapping between syntactic hierarchy and semantic interpretation in language. But how are quantificational terms acquired to begin with? Here we consider the cognitive and linguistic resources that contribute to quantifier acquisition.

Humans have multiple ways of representing information that is relevant for quantification. First, we have an ability to approximate the number of items in a scene through the approximate number system (ANS; Dehaene, 2009; Feigenson, Dehaene, & Spelke, 2004; Whalen, Gallistel, & Gelman, 1999). The ANS is a system that provides nonexact representations of cardinality, is present in infancy (Izard, Sann, Spelke, & Streri, 2009; Xu & Spelke, 2000), and increases in acuity throughout development (Halberda & Feigenson, 2008; Halberda, Ly, Wilmer, Naiman, & Germine, 2012). Between the ages of 3 and 4, children also acquire a system of precise cardinality, whereby they can represent the number of items in a scene exactly and refer to that quantity with number words (Carey, 2009; Gelman & Gallistel, 1978; Wynn, 1992). Finally, infants also can represent sets (Feigenson & Carey, 2003) and can keep track of multiple sets, allowing them to increase the number of individuals they can track in memory (Feigenson & Halberda, 2004, 2008).

Halberda, Taing, and Lidz (2008) asked whether children required knowledge of precise number in order to acquire the meaning of *most*, whose meaning depends on numerosity. They found that acquisition of precise number concepts is not a prerequisite for acquiring *most*. Many children acquire *most* prior to learning precise cardinality. Odic, Halberda, Pietroski, and Lidz (n.d.) went on to show that many children who have just acquired precise cardinality concepts and who have just counted the items in an array nonetheless will use the ANS to answer questions like *Are most of the animals giraffes or lizards?* This finding suggests that early acquisition of *most* is grounded in the ANS as a way of measuring cardinality. Odic et al. (2013) extended these results to *more*, showing that children acquire *more* at around 3.5 years, prior to many children's acquisition of precise cardinality.

Properties of children's cognitive systems for representing number therefore affect their early interpretations of quantifiers. But their linguistic knowledge may help them identify which words are quantifiers and therefore should receive a quantity-based meaning. Recall that the 4-year-olds in Wellwood et al. (2016) assigned a novel word like *gleebest* a quantity-based interpretation when it occurred in the syntactic position of a determiner or quantifier (e.g., *gleebest of the cows*) but assigned it a quality-based interpretation when it occurred in the syntactic position of an adjective (*the gleebest cows*). Children therefore can use their knowledge of the distribution of quantificational elements to infer that words that distribute like quantifiers must express quantificational meanings.

Preschoolers also appear to be sensitive to a subtler property of quantifier meanings that holds true cross-linguistically. Think about the sentence *Every girl is on the beach*. In order to assess whether this sentence is true, all you have to do is consider the set of girls in the discourse and see whether they are all on the beach. You do not have to consider boys or anything else in the discourse that is not a girl. This is due to a property of *every* called conservativity, and it is a property shared by all quantifiers in human language (Barwise & Cooper, 1981; Higginbotham & May, 1981; Keenan & Stavi, 1986).

Hunter and Lidz (2013) investigated 4- and 5-year-olds' knowledge of conservativity by seeing whether children could learn a novel quantifier that did not have this property. Children were trained to select cards that corresponded to the meaning of a novel quantifier (*gleeb*). In one case, the intended meaning of *gleeb* was "not all": Children were shown that *Gleeb girls are on the beach* only matched cards where not all girls were on the beach. In this case, *gleeb* is conservative because only the girls need to be considered in order to verify the sentence. In the other case, *gleeb* meant the mirror image of "not all": *Gleeb girls are on the beach* only matched cards where not all people on the beach were girls. This version of *gleeb* is not conservative because all of the beach-goers, not just the girls, need to be considered in order to verify the sentence. After training, children showed evidence of learning the conservative *gleeb* but failed to learn the nonconservative *gleeb*. This finding suggests that preschoolers know that words presented in quantifier contexts must have conservative meanings as a consequence of being quantifiers.

Thus, children's acquisition of quantifier meanings is influenced by both linguistic and extralinguistic factors. Properties of children's developing cognitive systems for representing number affect how they interpret words whose meaning depends on numerosity, but prior linguistic experience with the distribution of quantifiers helps children infer which words have number-based meanings to begin with. Further domain-specific linguistic constraints restrict the types of meanings for quantifiers that children will consider.

Summary

When we examine children's acquisition of the constraints on sentence interpretation, we see strikingly specific and early knowledge of the ways sentence structures can map to possible sentence meanings. The interpretations that children assign to pronouns, and the interpretations that children avoid, reveal their knowledge of the cross-linguistic constraints on when pronouns can corefer with other noun phrases in certain structural configurations. Children's interpretations of quantifiers reflect sensitivity to the structural positions of quantifiers within a sentence as well as the possible quantifier meanings that human languages allow. This linguistic knowledge interacts with children's extralinguistic cognitive systems, which influence their ability to process complex sentence structures online and represent the number concepts that quantifiers express. But because children's early knowledge of the interpretations that pronouns and quantifiers cannot have cross-linguistically would be extremely difficult to acquire by observing the interpretations that are possible in their language, this knowledge likely stems from constraints inherent to their linguistic system. Children's early semantic knowledge is therefore particularly revealing about the rich structure of the mechanism that guides their language learning process.

CONCLUSION

Within the first 6 years of their lives, children develop the ability to speak with and understand those in their community by acquiring a shared cognitive system—the grammar of their language—that links speech sounds with meanings. Just as our visual faculty is exposed to light and interprets that signal to infer the structure of the object that the light is reflecting off of, our language faculty, when exposed to speech sounds, interprets those signals to infer the structure and meaning of the sentence underlying those sounds. In order to acquire the ability to map sounds to meanings, the language faculty must do this kind of inference at two levels. It must infer both the structures of the sentences produced by speakers and the grammars of the speakers that produce those sentences. Through our discussion, we have seen that the cognitive structure underlying sentences (i.e., the grammar of the language) is highly complex. Our grammatical system includes knowledge of the sounds our language makes use of and the rules governing their distributions, the meanings of words and how they can be combined into sentences, the hierarchical structures of those sentences and dependencies that can hold between elements of that structure, and the ways those structural arrangements give rise to specific sentence interpretations. The architecture of the human language faculty further constrains which rules, structures, and interpretations are possible in any human language. Because children share this cognitive architecture with the rest of the human species, their language faculty is similarly constrained in the types of grammars it can infer. Thus, children's language learning process is shaped not only by their experience with the speech of their community members but by the structure of the language learning mechanism that interprets that experience.

In some ways, our discussion of language acquisition has been idealized: The language learning process can differ for children who are not monolingual, hearing, or typically developing. But these differences are often variations on the same theme. Bilingual children acquire the phonology, lexicon, syntax, and semantics of each language they are exposed to, although they do so with greater ease and proficiency if they hear both languages consistently from an early age. (See Hoff et al., 2012; J. S. Johnson & Newport, 1989; Oyama, 1978; Pearson, Fernandez, & Oller, 1993, among others.) Deaf children exposed to signed languages from an early age acquire a full grammatical system with all of the same components as a spoken language, but one that pairs meaning with visual instead of auditory signals (e.g., Stokoe, 1960). However, in some severe cases, the language learning process can be disrupted by factors intrinsic or extrinsic to the language learner. Cognitive or developmental disabilities can affect children's ability to produce language or process the language they hear, resulting in expressive or receptive language disorders that may persist past childhood (Aram, Ekelman, & Nation, 1984; Bishop, 1997; Clahsen, 1991; Paul, 2007). Children who are deprived of linguistic input until late in development may display grammatical deficiencies into adulthood (Curtiss, 1976; Mayberry & Eichen, 1991; Newport, 1990; Senghas & Coppola, 2001). This finding suggests that the early childhood years are a sensitive period for the development of grammar.

Studying the development of language reveals the complex interaction between children's experience and the tools they bring to this challenging task. Only human children develop language, because only human children are equipped with the cognitive capacities to do so: the capacity to represent complex concepts and understand what other humans mean, to detect patterns in the auditory or visual signals used to convey those meanings, and to interpret those patterns in just the right way to infer the same complex cognitive system as the other language users in their community. They are able to succeed in this task because they are not so different from us. Like other members of the human species, children are equipped with a cognitive faculty specialized for language that guides their process of inferring just the right grammar from their experience. Language acquisition provides us with a window into the rich structure of this human language faculty and how it develops in interaction with its environment and the rest of human cognition.

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