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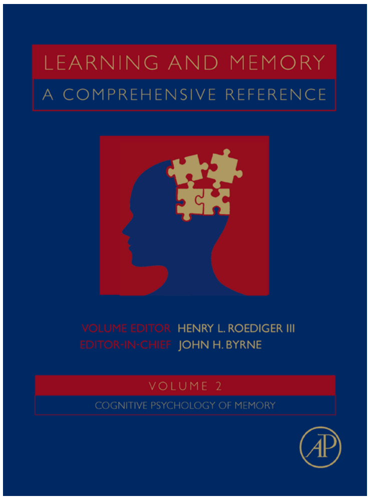

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2.30 Language Learning

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2.30.1 Introduction

2.30.1.1 What Is Language, and What Makes It a Unique Learning Problem?

Language presents an unparalleled problem for any account of human learning. As adults we have little insight into, or memory of, the learning task we faced during infancy and early childhood. Adult language processing is normally so efficient that we cannot introspect the cognitive or neural processes that accompany such prosaic language-uses as making small talk or listening to a story – processes that include attention-modulation, classification, retrieval, inference, and cognitive control.

By examining language development in infants and children we may gain insight into the challenges, progress, and process of this singularly important and universal learning task. The overall topic is extremely complex, and a thorough treatment would include detailed consideration of phenomena including multilingualism, second-language learning, language loss, aging, developmental disabilities, genetics, and animal learning. Due to space limitations, however, and the intricacies of each of these topics, this overview will focus on the paradigmatic phenomenon of first-language learning by healthy infants and children.

To begin, we must address the thorny question of what makes language a unique modality for social information, and why language acquisition might be a singularly difficult problem for the cognitive and social sciences.

2.30.1.2 Why Is Language Hard to Learn?

Human languages (numbering between 3,000 and 8,000, depending on definitions and some unknowns) share some basic features. The world's languages differ in many regards: the set of sound-distinctions that change the meaning of an utterance (or movements that change the meaning of a sign); how meaning-elements can be altered and combined to express complex meanings; what specific meanings are encoded by words (and by derived words, phrases, or idioms); and how various speakers and listeners in a community may use language for different purposes in different situations. Given the stunning variability of the world's languages, effort has been made to identify linguistic universals. The broadest universals are: hierarchical structure (e.g., rules for combining, changing, and deleting/reducing phonemes (speech sounds), morphemes (smallest meaning units), words, and phrases); arbitrariness of form; modifiability of forms (by assimilation, simplification, or metaphor); and combinatorial complexity. Other universals are more specific. For example, despite phonological variability across languages, there is a common ordering by which, for example, vowels are accrued. As another example, all languages can somehow refer differently to *self* versus *other*. Other universals are more like parameters that take one of several 'values,' and these must be learned by children presumably from culture-specific input (as opposed, in the case of 'true' universals, to learning from some universal experiences).

Despite these universals, the profound differences between languages make it hard to specify children's ability to learn language. Children must be prepared to learn language with phonological tone variations (e.g., Mandarin dialects; Yoruba) or percussive 'click' or air-ingestive noises (Sindhi, Xhoso, Zulu), or languages like Hawaiian with very limited phonology. In terms of morphology (i.e., patterns of variation in word structure), children must be prepared to learn languages with limited verb morphology but extensive use of auxiliary verbs, like English, or languages with extensive verb inflections and vowel harmony (i.e., where the root vowel changes the verb's inflections), like Hungarian. Specific examples abound: children learning English must make some verbs reflexive by adding '[possessive pronoun]-self,' whereas children learning Hebrew must learn to affix /hit-/ to most verbs – unless the first sound is a fricative (e.g., /s-/), in which case there is a complex switching of phonemes in the root verb and inflected affix. Mohawk uses a morphological inflection /-atat-/ to indicate reflexive action, but also has a 'semireflexive' morpheme to indicate relatively high involvement or self-generation of an activity. Many more examples can be found in syntax: for example English-speaking children learn that roles (subject, object) are cued by word order; Italian-speaking children must learn to use other cues (e.g., animacy). In semantics, English-speaking toddlers must learn that 'diaper' and 'underwear' refer to things with similar shapes that cover the same body parts but different material and contexts of use, whereas 'hat' and 'gloves' differ in shape and body parts but share material and contexts of use; and 'clothes' refers to all of these but is a mass noun (which usually refer to uncountable things like liquids). Finally, in pragmatics Spanish-speaking children must learn different second-person pronouns for adults and peers; Japanese children must learn different honorifics for men and for women; English-speaking children may say 'you' in all cases.

Thousands of between-language differences like these highlight the complexity of the learning problem faced by children and the difficulty of specifying what children might be prepared to learn *a priori*. Yet even within a language the learning problems are daunting. For example, the regular English past tense inflection is an affix /-ed/ after the main verb. But in fact the phonological form can be /-d/ (e.g., 'bugged'), /-t/ ('marked'), /-ed/ ('blasted'), or /-id/ ('melted'). Moreover, different speakers or dialects use different variants of the same ending, *and* the phoneme before the ending changes the sound of the ending. Thus, in spoken language there is much more variability of form than in writing. Also, there are many irregular past-tense forms: 'run'/'ran' or 'swim'/'swum' (medial vowel change); 'is'/'was' (initial consonant-vowel change); 'go'/'went' (different word), etc. Ignoring the reasons for these differences, from the learner's position most of these are at best only loosely predictable. They must be memorized as exceptions, or inferred from subtle patterns (e.g., verbs ending in /-ing/ ['bring'; 'sing'] have a medial vowel change (/-i-/ to /-u-/).

Children sometimes learn these exceptions early: for example 3-year-olds are sensitive to a constraint on pluralizing the head of a compound noun, which sounds grammatical for irregulars ('mouse-eater' to 'mice-eater') but not regular nouns (e.g., 'rat-eater' to *'rats-eater') (Gordon, 1985). No one teaches children this explicitly, but by age 3 children have begun to learn not only the obvious rules but less-obvious conditional regularities like these. This illustrates children's preparedness to acquire a massive hierarchical system of probabilistic heuristics and exceptions for allowable forms of words, phrases, and sentences. There is much evidence that 2- and 3-year-olds are learning to treat language as an abstract, modifiable, combinatorial system of conventional forms, transformations, and uses (Gordon, 1985; Clark, 1997; Tomasello, 1999; Bates et al., 2003). Yet 3-year-olds still have much to learn. This is a critical point: it is often assumed that children are astoundingly good language-learners despite the intrinsic difficulty of the task. Certainly the task seems difficult, but compared with what? Vision? Motor skills? Such questions are difficult to answer because they require an information-theoretic comparison of different learning problems, and making any such comparison in an even-handed way would be difficult or impossible. Similarly, it is nearly meaningless to claim that children learn language 'quickly.' Compared with what? Learning calculus? Learning to drive? Any such comparison is so problematic that the absurd difficulty of the question becomes obvious. Children require a good five years of steady, ample language input (for hours every day), with massive social and physical support, to achieve fluency. The cost of failure is exclusion from social interaction and information. Stated like this, it becomes hard to defend any assumptions about the specialization of language-learning processes.

To move from fuzzy assumptions toward a clearer understanding of the language learning problem and how children solve it, the following sections summarize what infants learn in the first year, what toddlers learn in the second and third years, what preschoolers learn in the third and fourth years, and what older children continue to learn thereafter. A critical issue throughout is how these changes differ from language to language. It is critical because we want a valid characterization of the universal capacity for language learning. First, though, we address two factors that are part and parcel of that capacity: the ecological context of first-language learning and the relation of language learning to the human genome.

2.30.1.3 The Context of Language-Learning 'in the Wild'

Language is used differently in different communities, and this is part of the learning problem for infants. Infants and toddlers are not consciously reflecting on language as a learning 'problem' akin to some monumental homework assignment. Their motives are to affiliate with caregivers, maximize hedonic states and minimize unpleasant ones, predict what other people will do, and join in positive social exchanges whenever a felicitous opportunity arises. Language is an integral part of the events that fit these motives: it is present in all sorts of social events from birth and even before (DeCasper and Fifer, 1980). The point is often forgotten: infants are not *trying* to learn language. They are trying to satisfy dynamic endogenous needs and modulate their affective states. This requires action, reaction, and learning about dynamic social environments. Language is a diffuse category of information that variably (but not randomly) occurs concurrently with social events. Sometimes language information is correlated with ongoing social events and variables, as during one-on-one baby-talk. Other times it is independent of the infant's experience, as when a caregiver chats with another adult while feeding the infant. Thus, an infant's language input is *sometimes* tailored to her ongoing experience. Sometimes it is not.

Thus, to understand how infants and children can acquire any language we must consider in part the range of language-uses in infants' social environments. For example adults modify their speech when speaking to infants, and infants prefer to hear infant-directed speech (Cooper and Aslin, 1990; Pegg et al., 1992). It therefore seems infant-directed speech should facilitate infants' language learning, and in fact it can facilitate adults' learning (Golinkoff and Alioto, 1995). However, there are language communities where adults do not address babies. Still, infants in these communities seem to acquire language at about the same rate as infants who regularly hear infant-directed speech (Lieven, 1994), though they might experience some delays in productive competence (Brown, 1998). Thus infant-directed speech is not a 'hard' prerequisite of learning, although it might accelerate *some* aspects of language acquisition.

The points are that (1) all cultures do not communicate with their infants in similar ways; (2) it is not obvious how different cultural practices influence language learning: we must test these empirically (e.g., Bornstein et al., 1998). Other examples in the following sections show that our intuitions of 'what matters' in language learning often lack empirical support.

2.30.1.4 How to Think About Genetic Factors in Language Learning

There is no doubt that language is a species-specific capacity. Some universal language features are not acquired by any other species, however smart their members are in other regards. Specifically, hierarchical structure, modifiability/extensibility of forms, and combinatorial complexity are all absent or profoundly limited in our nearest evolutionary neighbors, the great apes (Terrace et al., 1979; Deacon, 1997). What, then, allows learning in nearly every child in every human community?

Explanations from genetic causes have limited power to explain language outcomes (Braine, 1992; Elman et al., 1996; Karmiloff-Smith, 1998). Certainly language learning requires genetic coregulation of brain development that leads, in a protracted and dynamic cascade of multifactorial changes, to particular information processing phenotypes. Yet that claim is very different from a stronger claim, that some specific evolutionary adaptation(s) were propagated in our ancestors *because they coded for* specialized, species-specific (and adaptive) language phenotypes. That is possible but entirely hypothetical. Nevertheless, strong claims for *specialized* genetic bases of language have been made, buttressed by reference to the well-publicized discovery of a family with many members who have severe language deficits (Gopnik, 1997). Affected family members shared a point mutation (i.e., single-amino-acid substitution) of a gene in chromosome 7 (Lai et al., 2001). The gene, dubbed FOXP2, induces RNA transcription to affect the expression of an indeterminate number of other genes, including some that code for proteins that affect neural structures (e.g., calcium channels). The downstream effects of FOXP2 mutations have been hotly debated. Vargha-Khadem et al. (1998) found differences in several brain regions including Broca's area (left inferior-frontal cortex), which is nonexclusively involved in language production, and caudate nucleus (in the basal ganglia), which is involved in motor coordination and which communicates with frontal cortex. Both changes might explain the profound speech deficits in affected family members. However, those deficits are hardly isolated: affected family members also show generalized motor coordination deficits. Given that language production is an incredibly elaborate feat of motor coordination, one would expect *general* motor problems to manifest as speech deficits. Another finding is that most affected members show mild verbal *and* nonverbal mental retardation. This is not surprising because a transcription factor could have widespread effects on neural development.

Comparative studies further complicate the FOXP2 story. Multiple species – mice, for example – have versions of FOXP2. Mice FOXP2 differs from human FOXP2 by three base changes (i.e., amino acid) (Enard et al., 2002). However, two of these are unique to humans and hypothesized to have evolved in the last 200 000 years. Thus, although FOXP2 interacts with brain development in complex ways to produce many cognitive and behavioral effects, it is possible that recent mutations lead to new hominid neural and cognitive phenotypes that 'tipped the scale' to permit, among other cognitive capacities, language. It is also possible that the correlation is spurious.

In sum, although genes must be related to language learning, researchers have only recently started asking more sophisticated questions about the relations: what role do FOXP2 and other genes play in emergent cascades of neural and neurochemical processes during brain development? How are the neural networks that develop for association learning, perceptual-motor learning, and social-information processing altered by the coactivation of mutated gene forms? Such questions are central to our eventual understanding of language abilities and their expression as developmental products. However, current answers to these questions are almost pure speculation.

2.30.1.5 Are There Critical Periods for Learning?

There is a popular idea that language fluency can be attained only during a limited window of age, after which brain plasticity becomes reduced and fluency is difficult or impossible to achieve (Lenneberg, 1967). This is consistent with evidence of partial reduction in plasticity with age (Stiles, 2000) and with computational models wherein early input patterns have a greater effect on learned network weights than later input patterns (i.e., 'starting small'; Elman, 1993; Smith et al., 2001).

Most evidence for a critical period in language learning comes from studies relating L2 (second-language) competency to age-of-acquisition, controlling for years of exposure. (Critical periods in phoneme discrimination are discussed in the section titled ‘Classification problem: speech sounds in the infant’s sound-scape.’) Johnson and Newport (1989), for example, tested adult Korean and Chinese immigrants on English syntactic distinctions. They found a linear decline in competence with increasing age of acquisition, from 8 to 39 years, but no difference in starting ages ranging from 3 to 7 years. This suggests a gradual, continuous decline from about 7 years to adulthood in the capacity to master syntactic details of a new language.

Subsequent studies have shown that it is difficult to predict what syntactic competencies will be compromised by missing early experience. Mayberry and Lock (2003) compared adult English-speakers to adults who learned English in late childhood after learning (1) a signed language, or (2) a non-English spoken language, or (3) no language (as profoundly deaf infants in speaking family). Non-language learners were impaired in processing all sentence types, including simple ones. Early signers or non-English speakers were compromised only in processing complex or noncanonical sentences, especially dative alternations (“The father gave a boy a dog”) and relative clauses (“The boy who is chasing the girl is happy”), both of which can be considered generally difficult English syntactic structures. However, performance on complex sentences did not differ between the latter groups, suggesting that modality of first language has little effect on what forms are easier or harder to learn in L2.

Despite such converging evidence for critical period effects in articulation and syntax, the exact nature and cause remain controversial. Many studies do not document or factor out the learning conditions of immigrants of different ages, but these conditions are quite important: child immigrants are often immersed in school, whereas adults might spend time with other L1-speaking adults and receive far less L2 input (Stevens, 1999). In fact, some researchers argue there is little or no compelling evidence of critical periods for language (Birdsong, 1992; Flege, 1999). For example, a study of U.S. census data from a large sample of Spanish- and Chinese-speaking adults found that educational attainment (in U.S. schools) accounted for more variance in self-reported English fluency (26% and 42%, respectively) than age of arrival (6% and 9%, respectively) (Hakuta et al., 2003). Notably, the modest (<10% of variance) schooling-independent effect of age showed no inflection during a particular age range: the function was nearly linear, indicating no discrete cutoff in learning capacity associated with, e.g., puberty. However, Stevens (1999) also used census data and found subtle nonlinearities when regressing the probability of immigrants responding that they speak English ‘very well’ or ‘well’ against age of immigration, with the greatest change between 1 and 7 years of age. However, because census methods have limited sensitivity and validity, and because behavioral evidence shows no age range during which L2 learning rapidly declines (Johnson and Newport, 1989), we tentatively conclude that there is no narrow period of development (i.e., 1–3 years) during which language learning becomes crystallized or limited. Future research could tackle intriguing questions, such as why some adults learn L2 and achieve complete fluency, but others learn L2 during adolescence and never approach fluency.

2.30.1.6 Summary

The past two decades have shed considerable light on some *general* questions about the human capacity to learn language. From comparative studies we have learned that, although some nonhuman animals can learn and use up to a few hundred abstract symbols and respond correctly to short, simple, concrete sentences (Savage-Rumbaugh et al., 1993), there is no evidence they can flexibly and productively use symbols for a wide range of meanings (e.g., abstract/nonphysical concepts) or truly flexible syntactic structures, not to mention morphology. Nor do nonhuman animals show prosaic language uses like word play, commenting on absent referents, metaphor, humor, or nonliteral speech.

It seems clear that there is no precipitous critical period for learning, although there is some evidence for a gradual decline in the probability of mastering subtle phonological and syntactic distinctions of a new language, over starting ages ranging from about age 7 years to adulthood.

Finally, recent studies of language change provide fascinating insight into children’s role in language evolution (i.e., creolization): specifically in systematizing language structures (Senghas and Coppola, 2001; Senghas et al., 2004). For example, creole-signing children spontaneously create syntactic distinctions that mirror distinctions in natural languages (e.g., manner vs. path of motion), whereas those children may conflate manner and path of motion in their nonlinguistic gestures (indicating that the distinction is not *obligatory* but specially formalized in the new language). Other studies indicate that the SVO (subject-verb-object) word order canonical in English, for example, is not a 'natural' order: new signers may create an SOV sign order (Sandler et al., 2005).

Keeping in mind these concerns and conclusions about the learning environment and the genome in first-language learning, we now describe critical findings about how children acquire fluency. The results are organized by age divisions that are roughly defined by changing age-related learning tasks and social contexts. Despite this organization, much of language learning will be ongoing and continuous rather than stage-like. In all that follows, it can be assumed that a developmentally constant demand is to understand what other people are trying to communicate, and master enough abstract language forms to interpret others' meanings and to produce one's own messages such that one's intentions and perspectives can be inferred by others. It should also be assumed, despite some organization into distinct sections, that children do not learn separate aspects of language (syntax vs. morphology vs. pragmatics), rather that these theory-laden and historical distinctions are typically interrelated in human language processing data (Bates et al., 2003).

2.30.2 What Is Learned in the First Year

2.30.2.1 Classification Problem: Speech Sounds in the Infant's Soundscape

Languages do not use all the same speech sounds. Adult speakers of language X cannot always pronounce, or even discriminate, some phonemes of language Y. For example English voiced bilabial consonants form two phonemes, [b] and [p], that differ only in voice onset time (VOT, or the time between onset of vocal cord vibrations and air release). By contrast, in Thai the same spectrum is divided into three phonemes. English-speaking adults perceive the VOT spectrum as two discrete categories, with a high-entropy region around the /b/–/p/ distinction, but do not perceive a third category in the region of the added Thai contrast. How, if adult speakers cannot even perceive all phonemes, do infants learn whatever complement of speech-sound distinctions is relevant in their language?

During the third trimester of gestation the fetal auditory system is sufficiently developed to begin learning some abstract properties of speech sounds produced by the mother. Although the amniotic sac filters the acoustic content of speech, enough invariants are retained in this filtered signal that, after birth, neonates prefer the sound of their mother's voice (DeCasper and Fifer, 1980). Neonates also perceive some phonetic distinctions such as the /b/–/p/ VOT contrast (Eimas et al., 1971). This suggests that the extensive and well-demonstrated plasticity of auditory cortex (Ohl and Scheich, 2005), which begins prenatally, responds in humans to acoustic invariants of speech.

During the first few months infants become sensitive to differences between phonemes (consonants and vowels), including differences in place of articulation and VOT (Trehub, 1973; Eimas, 1974). Phoneme perception develops such that by 9–12 months infants are sensitive to native contrasts but less sensitive to nonnative contrasts (Werker and Tees, 1999). Werker and Tees (1984) found a decline from 6 to 12 months in English-learning infants' discrimination of a Hindi /Ta/–/ta/ contrast and a Nthlakampx /k'i/–/q'i/ contrast (defined by place of articulation). These distinctions (unlike, e.g., /ba/–/da/) are also subtle for nonnative adults (Werker and Tees, 1999), but can be learned with practice (McClelland et al., 2002). This suggests a sensitive period in phonological development. Phonological processing difficulties for L2 distinctions might, in some cases, lead to larger difficulties with speech processing that resemble L1 language delays (Tallal, 2004).

Despite evidence for a sensitive period in phonological development during the first year, adaptation of the auditory system to language-specific input begins well before 9–12 months. Within their first few days infants discriminate native (French) from foreign (Russian) speech (Mehler and Cristophe, 1994), though discrimination depends partly on how phonologically different the languages are (Nazzi et al., 1998). Whatever neurological changes accompany 9- to 12-month-olds' loss of sensitivity to nonnative contrasts, it is not the case that younger infants are insensitive to native speech features.

2.30.2.1.1 What categories are infants prepared to learn? Insights from signed languages

To gain insight into what is distinctive about learning to perceive speech, we can consider how infants learning signed languages acquire the basic linguistic units, that is, motor forms including hand shapes, manual motions, and other body motions (e.g., facial gestures). In what ways, if any, has brain development evolved to favor processing and learning of speech sounds over other modalities?

It is not clear that language learning is at all specialized for speech. Petitto and Marentette (1991) argued that deaf children learning signed languages begin manual 'babbling' by 10 months or earlier. The emergence of a production distinction between signing and gesturing suggests prior perceptual analysis of hand morphology of signs. How young can infants perceive differences in hand shape that carry meaning differences in a signed language? Schley (1991) found 3-month-olds could discriminate at least one hand-shape difference. Though this is not conclusive it suggests there is no great delay in perceptual learning of language-relevant forms in nonspeech modalities. Further, Baker et al. (2006) suggest a critical period in acquiring hand-shape phonology: hearing infants at 4 months classified same- from different-shape tokens (from ASL); 14-month-olds did not. The timing of this loss of sensitivity is roughly similar to loss of nonnative speech sound sensitivity (Werker and Tees, 1999) and is further supported by evidence that older infants learning spoken language lose the tendency to interpret novel gestures as symbolic (Namy and Waxman, 1998).

2.30.2.2 Beyond Phonology: Finding the Words

When do infants begin to perceive larger units – specifically, combinations of speech sounds that we hear as words and phrases? This has been a major topic of research in the past decade. For example Jusczyk et al. (1993) found that infants around 7 months discriminate (and prefer) the stress pattern of their native language (e.g., strong-weak in English, e.g., 'mother'; 'bottle'). This preference could help infants parse words in the speech stream; a critical ability because there are no clear acoustic markers of the boundaries of words. How else might infants learn to separate words and inflections in the ongoing speech stream?

Another source of word-boundary information is the likelihood that two phonemes will occur in sequence within some word in a given language. Consider the phrase 'pretty baby,' which has a word boundary between /-y/ and /b-/ but, for all the infant knows, might be three words (e.g., 'pritt ebay bee'). However, the probability of the phoneme sequence 'eeb' in English is much less than the probability of 'tee' or 'bay,' so the former parsing is more likely. Infants can learn such differences in transitional probabilities within minutes, simply by listening to an artificial language with controlled transitional probabilities (Saffran et al., 1996). Thus, before their first birthday infants encode cues to the structure of words. These learning abilities are not specific to word-learning nor to humans: infants can learn analogous transitional probabilities in musical motifs (Saffran et al., 1999) or sequences of visual shapes (Kirkham et al., 2002). Also, tamarin monkeys can learn transitional probabilities in speech phonemes (Hauser et al., 2001). Thus, however important the phoneme-sequence-learning capacity is, it is not sufficient for human speech processing. Also, infants might learn words spoken in isolation faster than embedded words (Brent and Siskind, 2001), suggesting that word segmentation is, despite sequence-learning abilities, resource demanding and/or error prone.

2.30.2.3 First Words: Content and Conditions of Learning

2.30.2.3.1 What do infants know about words?

Deciphering the speech stream involves more than segmenting individual words: children need to associate certain sequences of phonemes with contexts of use or kinds of referents. How do infants learn word meanings? Infants by 4 months attend more to the sound of their own name than another name with the same stress pattern (Mandel et al., 1995). By 7 months such preferences extend to high-frequency words (e.g., 'cup'; Jusczyk and Aslin, 1995). By 11 months infants represent the phonological details of familiar words (Swingley, 2005). How readily do infants learn such representations? Eight-month-olds, after hearing a word several times, discriminated it from other words as long as two weeks later (Jusczyk and Hohne, 1997).

It seems infants can learn and remember sounds of specific words several months before they start using them productively. However, increased attention to familiar patterns is not the same thing as symbolic understanding. When do infants learn to associate words with object types, people, events, or properties? At 8 months infants show a slight tendency to associate an object that was recently paired several times with a novel word, but only if the speaker moved the object in synchrony with saying the word (Gogate and Bahrick, 1998, 2001). The importance of intermodal synchrony underscores the fragility of infants' word-referent associative learning. By 11–14 months, infants are sometimes above chance at attending to an object previously paired with a novel word 6 to 9 times (Woodward et al., 1994). However, it is unclear how much (or little) input is needed for various referents or situations, and whether infants learn anything beyond a weak intermodal association (Shafer and Plunkett, 1998). In other words, we still do not know when and how infants learn words as abstract symbols.

In interpreting all this literature a caveat is in order: much older preschoolers are sometimes insensitive to gross word-form violations (Barton, 1980), suggesting that phonological/lexical knowledge may remain immature long after infancy. The confusing range of sensitivity and insensitivity shown in various studies of infants and preschoolers (e.g., Fisher et al., 2004) demands more sophisticated models than currently exist. One issue is that infants are very sensitive to contextual factors (Naigles, 2002), so the exact conditions of input *and* of testing must be meticulously detailed and compared in order to make sense of different studies of infants' word-form knowledge.

2.30.2.4 Beyond Words: Learning Phrase Structure and Lexical-Syntactic Categories

Infants show some awareness of other linguistic patterns in the first year. Fernald and Mazzie (1991) showed that infants are sensitive to prosodic (i.e., melodic) contours of infant-directed utterances that correspond with different messages or meanings (e.g., approval vs. prohibition). Interestingly, prosodic patterns show some consistency across languages (Fernald et al., 1989; Grieser and Kuhl, 1998), suggesting that many societies come to exploit prosodic distinctions that are salient to infants, as a way to draw attention to distinct messages before infants can comprehend specific words or phrases.

Prosodic information might also help infants learn syntactic distinctions. Adults detect phrase and clause boundaries based on speech cues (intonation, stress, pauses, word duration), even when listening to a foreign language (Pilon, 1981). Although these cues are sometimes unpredictable or misleading, they may be more predictable in infant-directed speech (Stern et al., 1983). Several studies (e.g., Hirsh-Pasek et al., 1987; Jusczyk, 1997) indicate that 8- to 10-month-olds expect pauses at syntax-relevant clause and phrase boundaries. This preference is not specific to spoken language; infants also prefer pauses at phrase boundaries in classical music (Krumhansl and Jusczyk, 1990). Also, although prosodic structure could highlight syntactic structure in languages with strong word-order cues (e.g., English) it might be less useful in languages where syntax is carried by inflections (e.g., Hungarian; Icelandic). Still, English-learning infants as young as 2 months can use prosodic clause cues to represent two-word sequences, at least briefly (Mandel et al., 1996).

Infants in the first year might distinguish between kinds of words that correspond to different syntactic categories. Shi and Werker (2003) found 6-month-olds discriminate so-called content ('open-class') words (e.g., 'chair,' 'hide') from grammatical ('closed-class') words ('the,' 'you'), and prefer the former, even in a foreign language. No common phonological cue differentiates these word classes across languages, but some combination of cues is probabilistically available in any language (Morgan et al., 1996). The implication is that languages evolve a lexical 'division of labor *and* form,' so content words have more distinctive phonology than syntactic units. This might contribute to a developmental shift in the kinds of words infants learn as they populate their lexicon and acquire syntax (see the section titled 'New math: populating the lexicon').

It is not just that infants associate more interesting-sounding words with open-class units; they also learn sequences of words. Gómez and Gerken (2000) found that 12-month-olds developed expectations for order and repetition dependencies in small sets of artificial CVC words (e.g., 'pel' can start a sentence *or* follow 'vot'). After training, infants heard novel 'sentences' that were 'grammatical' or 'agrammatical' and listened longer to agrammatical sentences. Thus infants are sensitive to the same types of transitional probabilities between words that Saffran et al. (1996) showed for phonemes. This might support syntax learning.

This finding (see also Marcus et al., 1999) does not show that 12-month-olds have learned syntax, but that they are minimally sensitive to more- versus less-likely orderings of syllables or lexemes, given well-controlled input. Yet syntax involves more than order, and more than just CVC syllables. It involves a number of abstract categories or form classes, systematically related in various ways to other categories, under a system of complex principles and probabilities for changing and combining units. Currently we only know that infants discriminate (1) familiar from less-familiar orderings of syllables; (2) acoustic and prosodic cues that correlate with phrase and clause boundaries; and (3) phonological cues that differentiate broad syntactic categories (e.g., content vs. grammatical words). It remains unknown how this learning contributes to later syntactic knowledge in the next several years.

2.30.2.5 First Uses: Reasons to Learn Language

Recall that, although language researchers describe infants as trying to solve a taxonomy of massively complicated mapping problems, that description is imposed upon the infant whose goals are to stay regulated, reduce uncertainty, and maximize hedonic states. Caregivers who help infants meet these goals sometimes emit streams of vocal noises (or gestures). Why should infants learn these? One reason must be that infants are motivated to affiliate with people, and interested in what people say. Infants must pick and choose information in rich environments. Some human features, such as faces (Fantz, 1963), voices (DeCasper and Fifer, 1980), and hands (Deák et al., 2006) tend to attract infants' attention. If caregivers also talk about their actions while infants are watching them, it can give infants good input for learning words. Hart and Risley (1995) showed that language input – amount and variability of speech – predicts infants' language skills into preschool. Similarly, Tamis-LeMonda et al. (2001) found maternal responsiveness (i.e., reacting quickly and appropriately to the infant's signals) at 9 and 13 months predicted language outcomes including age at first words and acquisition of 50 words. Notably, mothers' responses to infants' vocalizations and play prompts (e.g., acting on a toy while commenting) were the best predictors of language outcomes.

2.30.2.6 Using Social Inferences to Bootstrap Learning

A major shift in our understanding of child language was sparked by evidence that early language is interwoven with intentionality (i.e., awareness of other people's mental states and emotions). Although this awareness becomes more precise and explicit through childhood, its first measurable signs emerge around 9–18 months of age.

Much research has focused on attention-sharing, periods when two or more individuals shift attention to a common focus. Such episodes facilitate communication, because the topic of conversation can be highlighted by extra-linguistic behavior (i.e., if interlocutors comment on whatever has their attention, and both are focused on the same thing, they will tend to share topic). Research and theory of the development of attention-sharing skills in infants, and its relation to language development, is reviewed by Baldwin and Moses (2001), Deák and Triesch (2006), and Tomasello (1999). In short, infants sometimes follow an adult's gaze or pointing gesture by 12 months of age, though the ability improves from 9 to 18 months (Butterworth and Jarrett, 1991; Deák et al., 2000; Brooks and Meltzoff, 2002). Infants might be either more likely to do so, or do so for longer, if the parent verbally encourages them to follow (Flom and Pick, 2003). Thus, parents' speech acts initially have an attention-modulating function for infants.

Does sharing attention conversely facilitate language development? There is no evidence of this in the first year, but early attention-sharing skills seem to support rather sophisticated inferences in the second year (see the section titled 'Inferring the meaning behind the words').

2.30.3 What Is Learned in the Second Year

During the second year toddlers' language will advance in several critical ways. Some burgeoning sensitivities of infants become active. Research points to advances in three major areas: lexical knowledge, pragmatics, and syntax. These areas are tightly related, but because research often treats them separately, the following section treats them (artificially) as separate.

2.30.3.1 New Math: Populating the Lexicon

There has been controversy about what kinds of words toddlers first understand. The first 50 words typically include many generic object labels ('bottle'), proper names ('Lara,' 'mommy'), words for actions or modifiers ('up,' 'more'), and social routine words ('bye bye') (Nelson, 1973). One debate is whether first words are highly context restricted or under extended and, therefore, limited in abstraction. Snyder et al. (1981) found about half of 13-month-olds' first 50 words were in fact contextually restricted; yet some should be by definition (e.g., 'bye-bye,' 'peek-a-boo'). Huttenlocher and Smiley (1987) found infants rarely use labels in contextually idiosyncratic ways. Toddlers know so much less than adults about the referent categories of words that their semantic representations must be limited or distorted. Yet one study hints at fairly rapid corrections. Woodward et al. (1994) found 18-month-olds better than 13-month-olds at extending a novel word to a new exemplar like the training object. Thus, toddlers quickly learn to generalize generic words from first (idiosyncratic) referents to abstract classes and thereby reduce contextually restricted uses.

Once toddlers extend words taxonomically, they must still adjust the boundaries of the referent category. Toddlers sometimes overextend words (e.g., use 'ball' for all spheres; Rescorla, 1980) or underextend them (e.g., excluding penguins from 'bird'). Yet such errors do not indicate an inability to map words onto sensible categories. Most overextensions, for example, are based on spurious perceptual or functional similarities (Clark, 1973; Nelson, 1979). Also, there is no evidence that toddlers *typically* over- or underextend words. Many overextensions have a pragmatic basis and do not reflect systemic conceptual confusion (Thompson and Chapman, 1977). That is, when a 1-year-old calls a stranger 'daddy' she is probably not questioning her own legitimacy, but noticing some similarities between a novel referent (strange man) and a familiar one (daddy). Given the child's many lexical gaps, such remote similarities might constitute the only basis for choosing a rarified 'known' word to indicate the referent.

As children receive input they will modify the boundaries of word-meanings using factors such as typicality (White, 1982; Wales et al., 1983). However, we do not know which input factors alter these boundaries, or how.

Despite these early challenges, toddlers make rapid progress in populating their lexicons. One story is that after children learn 50–75 words their rate of word learning accelerates: the 'naming explosion.' This suggests that, after learning some symbolic mappings, toddlers achieve insight about the abstract meanings of words. We do not, in fact, know what higher-order realizations or inferences, if any, facilitate 1-year-olds' word-learning ability. Here, however, are some relevant facts.

First, 1-year-olds tend to interpret others' actions as symbolic. These include gestures as well as words (Namy and Waxman, 1998; Childers and Tomasello, 2002, 2003), so the acceleration is not strictly based on some insight about word-like sound strings. Second, many infants accelerate in word learning around 50–75 words, but others do not (Fenson et al., 1994). Thus, individual infants differ in word-learning trajectory, for reasons that remain unclear despite decades of attempted explanations (e.g., Nelson, 1979).

One hypothesized explanation is that an acceleration in word learning is related to new classification skills (Gopnik and Meltzoff, 1992). Evidence is suggestive but inconclusive. Another idea is that as children learn more words they develop more robust connections among the word representations in neural networks. As the neural representation patterns (i.e., vectors) evoked by particular words become more stable and better defined, this stability can make it easier to learn new word-referent associations (Plunkett et al., 1992; Gasser and Smith, 1998). For example, as children learn words they learn how certain word types (e.g., object labels) are associated with certain referent features (e.g., shape and material), and this can guide inferences about new word meanings (Smith et al., 2003). Thus, increasing semantic knowledge supports new word learning. This is an important principle of word learning throughout childhood and adolescence (Anglin, 1993; Deák, 2000b).

The acceleration in 1-year-olds' word learning is not uniform across kinds of words. An important finding (Fenson et al., 1994; Bates and Goodman, 1999) is that nouns dominate infants' first 50–100 words; however, relational words (i.e., verbs and adjectives) are thereafter learned relatively faster, and become a relatively larger proportion of new vocabulary. Another shift occurs after toddlers know about 300–500 words; learning of grammatical words and morphemes then accelerates. An exciting finding is that this pattern holds (in broad strokes at least) across at least a few Indo-European languages including Italian (Caselli et al., 1999; Devescovi et al., 2005), which differs from English in syntax. There are language-specific differences in vocabulary growth trends, but the relation between vocabulary growth and acceleration of relational words (first) and grammatical words (second) appears robust.

2.30.3.2 Inferring the Meaning Behind the Words

In the second and third years the attentiveness that even younger infants show toward other people, especially in propensity to share attention and monitor others' emotions, becomes more sophisticated and interwoven with language. For example toddlers can use nonlinguistic social cues to reduce uncertainty of a speaker's referential meaning. Baldwin (1995) found 18-month-olds map a novel word onto whatever the speaker was attending to, not what the infant was attending to, even if they were attending to different things. Toddlers do even more sophisticated tracking and encoding of social cues accompanying others' speech acts. Akhtar et al. (1996) had 2-year-olds and two adults looking at objects in boxes. All participants looked at three objects, and then one adult left the room. The remaining adult then examined the fourth object, and the absent adult then returned, looked in the box and said, "... I see a gazzer in there!" Toddlers tended to associate 'gazzer' with the fourth object, though the returning adult never had picked it up, and the adult who picked it up had never said the word. From this it seems toddlers can infer the most plausible referent of a particular speaker's comment or label. Although this finding has invited competing explanations, converging evidence (Diesendruck et al., 2004) shows that 2-year-olds do in fact use social information (e.g., who was present when some referent was the focus of attention, the speaker's emotion while examining an object or performing an action, etc.) to associate words with referents. Toddlers also modify their own communicative behaviors to take into account an interlocutor's social knowledge (O'Neill, 1996), suggesting that they use information related to other people's mental states or knowledge in order to use and learn language effectively.

We cannot tell how reliably and accurately toddlers use social information to guide inferences about speakers' meanings. All studies are done in simplified, controlled 'best-case' environments, whereas the complex, messy world of everyday social interactions might be too variable to help toddlers make inferences. There are, however, two reasons to believe they can. First, young children with autism typically have profound deficits in joint attention and social inference skills and typically very delayed language skills in childhood and adulthood (Loveland and Landry, 1986; Mundy et al., 1990). Thus, infants who do not make use of social information have impaired language development (this is just correlational, but consistent with the hypothesis above). Second, there is naturalistic evidence that parents constrain the social context of their spontaneous communications with toddlers in somewhat predictable ways (Ninio and Snow, 1996; Pan et al., 1996). Thus, the messiness and unpredictability of everyday interactions is partly limited by parents.

2.30.3.3 Combinatorial Explosion: Putting Words Together

The robust relation between vocabulary growth and acquisition of relational and syntactic words (or morphemes) extends to toddlers' syntactic competence (Bates and Goodman, 1999; Devescovi et al., 2005). Apparently toddlers need a 'critical mass' of words for objects, relations, events and states before they can assemble these units productively. Besides this regularity, how does early syntactic expression and comprehension develop in the second year?

Much work has focused on toddlers' two-word utterances. Early combinations are produced with regularity about the same time as the 50–75 word threshold, or 18–24 months. In four children studied by Bloom et al. (1975) an MLU (mean length of utterances, in morphemes) of 1.5 or better (e.g., about half of utterances having two words) was achieved around 22–24 months. Toddlers' first 2-word productions are described as 'telegraphic' because they lack grammatical words and inflections. Nonetheless, they express a variety of relations including action ('Kathryn jumps'), locative action ('tape on there'), locative state ('I sitting'), static state ('Caroline sick'), recurrence ('more milk'), possession ('Mommy sock') and others (e.g., negation) (Bloom et al., 1975). Some types of relations (e.g., action) are systematically verbalized before others (e.g., locative state), even across languages (Braine, 1976). It is unclear whether this is due to conceptual, syntactic, or motivation factors. However, 1-year-olds show some sensitivity to input in the relational meanings they learn. Choi et al. (1999) found differences in Korean and English toddlers' acquisition of spatial predicates such that Korean toddlers are more attentive to spatial relations (e.g., tight- vs. loose-fitting containment) with distinct words in Korean.

A key issue concerns the early emergence of syntactic categories in two-word utterances (Bloom et al., 1975). Such utterances are usually syntactically (and semantically) ambiguous: does 'Mommy sock' denote possession, action (e.g., putting-on), spatial contiguity, or something else? Syntax might help us disambiguate these alternatives, but are there incipient syntactic categories in toddlers' first combinations? Bloom et al. examined subjects' ordering of morphemes and substitutions (e.g., saying 'her jumps' and 'Kathryn jumps'). Such pronominal constructions suggest an intermediate step toward abstract categories like 'subject'. Two of four children were extensive pronoun users, suggesting proto-syntactic classes, but the individual differences makes interpretation difficult (see also MacWhinney, 1978, for evidence on early diversity of morphosyntactic development). Valian (1986) later showed, however, young 2-year-olds' productions of several form classes (noun, determiner, adjective, preposition, noun phrase, and prepositional phrase) to be well differentiated. Also, two-word speakers understand fully formed sentences better than telegraphic ones (Shipley et al., 1969). Thus, 2-year-olds know more about the correct syntax of individual words than it seems from the combinations they produce, and even 1-year-olds might have some rudimentary expectations (e.g., associating the first noun in a sentence with an actor; Hirsh-Pasek and Golinkoff, 1996). A critical question is how infants and toddlers acquire this knowledge. This has been controversial (Braine, 1976; Maratsos and Chalkley, 1980; Bates and MacWhinney, 1982; Pinker, 1984; Tomasello, 1992), and an adequate treatment is impossible due to space limitations. Nevertheless we will provide a historical synopsis.

Maratsos and Chalkley (1980) proposed that toddlers register long-term patterns of co-occurrence in use (and non-use) of words in particular patterns or contexts, in order to eventually learn syntactic frames. This theory, a precursor of connectionist models and early alternative to a Chomskian learning acquisition device (a mythical organ by which language input is assimilated to an innate syntax), offered a plausible means of incremental input-dependent learning. This type of account and its limits are insightfully critiqued by Maratsos (1998).

For a flavor of the history of this sort of 'nativist versus empiricist' debate, consider the controversy over children's acquisition of transformations over rules-with-exceptions. The test case is English past-tense verb forms, with a regular /t/ or /d/ suffix, but various exceptions including vowel change ('come'/'came'), consonant change ('make'/'made'), word change ('go'/'went'), or no change ('cut'/'cut'). Such messiness is hardly unique to English past-tense: English plural nouns have the same property, as do, for example, German gender categories and many other syntactic forms in many languages. The question is how children can acquire diverse forms for the same type of transformation. A relevant finding is that toddlers sometimes overregularize, producing forms like 'goed,' 'runned,' or 'breaked' (not 'went,' 'ran,' or 'broke'). Notably, such forms are often not the earliest produced; toddlers sometimes produce 'went,' then 'goed' for a while, then ultimately the correct irregular (Cazden, 1968). This right-wrong-right progression intrigues linguists because it suggests a progression from individual word-forms to a syntactic rule to rule-with-exceptions. Marcus et al. (1992) found that past-tense overregularizations are infrequent but variable across time and child, and the right-wrong-right pattern is an idealization with high variability. Also, individual overregularization rates correlate with the frequency of irregulars in the child's lexicon and linguistic environment.

How can we explain the variability of these errors across time and child of these errors? Marcus et al. (1992) argued that exceptions must become strong enough as memory traces to be retrieved before the rule is applied. This idea is only partly explanatory, but it leaves open the possibility of fleshing out the account by testing simulations of learning in artificial neural networks (ANNs). Despite early (and often spurious) objections to this approach, it is clear that many complex patterns, including overregularizations, can be modeled by ANNs (Plunkett, 1992; Hadley et al., 1998; Morris et al., 2000; Lewis and Elman, 2001). For example, a syntactic distinction considered by Chomskian theorists to be unlearnable (under 'Poverty of the Stimulus' arguments; see Pullem and Scholz, 2002, for critique) was shown by Lewis and Elman (2001) to be learned by a fairly simple ANN taking training input from natural speech samples.

Toddlers' syntactic knowledge can also be tested in experimental paradigms. For example Akhtar and Tomasello (1997) show that 3-year-olds, but not 2-year-olds, readily induce, from just a few instances, whether a novel word is transitive or intransitive. Although 2-year-olds learned that novel words referred to actions, they did not appropriately generalize their transitive or intransitive status. (Naigles, 2002, offers another interpretation.) Moreover, toddlers will accept and interpret agrammatical uses of familiar verbs (*"The zebra goes the lion") in ways that suggest fluid phrase/frame structure representations (Naigles et al., 1992). In short, although toddlers are starting to learn the syntactic properties of different words and phrases, their specific knowledge is variable, ephemeral, and unorganized by abstract distinctions such as transitive/intransitive.

2.30.4 What Is Learned in the Third and Fourth Years

2.30.4.1 Acquiring Semantic Relations

As children's vocabulary grows beyond a certain size they must work out a variety of semantic relations, such as inclusion, overlap, and exclusion. For example, are all pets animals? Could any puppy be an herbivore? Deák and Maratsos (1998) showed that 3-year-olds readily produce different labels for an item, and these respect the same semantic relations that adults recognize: if asked about a dog puppet, "Is it a cat?" children reply, "No, it's a dog!". If asked "Is it a doll?" they reply "No, it's a puppet!". The near-errorless pattern of rejections and same-category substitutions suggests that 3-year-olds – and perhaps 2-year-olds (Clark and Svaib, 1997) – represent semantic relations. As early as children know enough words to begin filling in semantic frameworks, they can constrain inferences and naming decisions.

What about adding new words to semantic frameworks? Even 2-year-olds try to make reasonable interpretations of novel words with respect to other words they know, how the word was used, and properties of the referent (Waxman and Senghas, 1992). For example preschoolers can use contrast to interpret new words (Au and Glusman, 1990): if they hear something described "not the red one, but the chromium one," they infer that 'chromium' names an unfamiliar color. Contrary to some claims (Markman and Wachtel, 1992), 2- to 5-year-olds do not by default assume that each word refers to a mutually exclusive category (Waxman and Senghas, 1992; Mervis et al., 1994; Savage and Au, 1996; Deák and Maratsos, 1998; Deák et al., 2001). However, under circumstances like high working-memory load, preschoolers may adopt a temporary mutual exclusivity approach (Liittschwager and Markman, 1994), possibly to simplify the learning task (Deák, 2000a; Deák and Wagner, 2003).

How do preschoolers eventually learn appropriate semantic relations? First, speakers sometimes couch words in meaningful information, like statements of contrast (Au and Glusman, 1990; Callanan, 1990); however, such information is not always enough (Deák and Wagner, 2003) and is more useful to older children (Smith, 1979). Second, syntactic context is sometimes helpful (Naigles, 1990), though for many words in many languages it is a very weak cue. Third, children sometimes analogize from familiar morphological (Anglin, 1993) and semantic (Johnson et al., 1997) relations, but the limits on such analogizing are not known. In short, we usually do not know how preschoolers situate a new word in an existing semantic framework.

2.30.4.2 New Uses of Language

Preschool children's language skills develop in the service of social knowledge and interaction. Different language communities value different linguistic skills (Heath, 1983), and 3- and 4-year-olds are improving at using language for different purposes (i.e., genres such as narrative, conversation, or teasing), in different contexts (e.g., home vs. school; mealtime vs. circle time) and with different interlocutors (e.g., siblings, peers, parents) (Dunn and Shatz, 1989; Dunn, 1996; Slomkowski and Dunn, 1996; Pan and Snow, 1999). Navigating these different contexts requires very flexible linguistic skills, and although preschoolers are not yet fully fluent, the preschool years bring great advances in the ability to use language appropriately in different situations.

2.30.5 What is Learned in Later Childhood

2.30.5.1 Learning the Nuances

A cursory survey of the child language literature indicates that children show basic fluency by 4 years of age and mastery of basic morphological and syntactic structures by about 5 years.

What remains to develop is the ability to apply basic linguistic knowledge in contexts that are more challenging or complex, or that require integration of linguistic and paralinguistic (and nonlinguistic) information within and between utterances. For example, Campbell and Bowe (1983) told children stories with a low-frequency homonym (e.g., during a car trip a "hare ran across the road"). Children were shown to interpret 'hare' in its dominant meaning (i.e., 'hair'), though this interpretation was nonsensical. Although children have difficulty learning homonyms (Doherty, 2004), and answering ambiguous questions (Waterman et al., 2000), this particular error involves integrating information across utterances in order to interpret (i.e., represent meaning of) a statement. Similarly, 6-year-olds have trouble flexibly attending to paralanguage and semantic content to interpret mixed messages (e.g., "My mommy gave me a treat" said in a sad voice); they tend to rigidly attend only on the most salient kind of information (Morton et al., 2003). This might explain older children's difficulty understanding jokes, irony, and sarcasm. In general, as children get older they can make more precise and context-appropriate inferences about a speaker's meaning, while maintaining syntactic, semantic, and pragmatic coherence over longer passages of conversation or narrative. This expansion in the 'scope' of linguistic performance is seen in semantic, syntactic, and discourse processing.

2.30.5.1.1 Learning the nuances of relational semantics

Children sometimes have difficulty inferring the extensions of semantic relations, especially when novel words are involved. Class inclusion relations (inclusion, overlap, and exclusion) are among the simplest between categories (though not the only ones; e.g., Lakoff, 1987). Thus, the assertion "some fish are eaten" requires representing some overlap between two classes (fish and food).

Recall that by 3 years children can use familiar words in semantically appropriate ways (Deák and Maratsos, 1998). By 4–5 years they can infer the relation of a novel word to familiar ones based on class inclusion statements. For example if told "A *pug* is a dog" (where *pug* is novel), kindergartners usually infer that a pug must be an animal, but do not infer that a pug is a dog if told "A pug is an animal" (Smith, 1979). Still, the use of semantic information improves with age. Deák and Wagner (2003) attempted to teach children several novel words and the relations between them using class-inclusion statements. Four- and 5-year-olds learned few relations, whereas 6- and 7-year-olds learned most. It is unknown why older children are better at using direct input to learn semantic relations. Perhaps they sometimes analogize from familiar semantic relations (Johnson et al., 1997).

2.30.5.1.2 Learning complex online syntactic judgments

Another synthetic linguistic skill is interpreting syntactic relations in the 'real time' of conversation. Adults quickly and reliably determine when a sentence is irreparably ungrammatical, as from an agreement error. However, adults can also withhold judgments in the face of an ambiguous sentence until all 'legal' interpretations of syntactic structure have been checked. For example in an auxiliary omission error such as "Mrs. Brown working at the library called home to say she would be late," adults can withhold judgment until the end of the sentence (Blackwell et al., 1996). Children, by contrast, prematurely try to resolve syntactic ambiguities before parsing is complete.

For instance, Trueswell et al. (1999; Hurewitz et al., 2000) demonstrated that 5-year-olds prematurely resolve a noun-modifier clause (e.g., "Put the frog on the napkin in the bowl") as destination-marking prepositional phrase. That is, they interpret "on the napkin" as a destination marker, placing an isolated toy frog onto an empty napkin instead of putting a frog already on a napkin into a bowl. The error unfolds as children listen to the sentence, as shown by eye-movement analysis: whereas adults shift gaze to the frog on the napkin, 5-year-olds look at the incorrect (second) frog early and do not show awareness of the ambiguity of the modifier. Interestingly, 5-year-olds can in other contexts correctly produce the same syntactic structure. Thus even when children can produce complex syntactic structures, they may make on-line parsing errors.

Children's syntactic judgments also become faster from 6 to 10 years. Children in this age range are in general slower than adults at detecting violations of agreement or word order, and are relatively slower to notice violations early in a sentence rather than late in the sentence (Kail, 2004). Moreover, semantic incongruity within a sentence seems to distract 6-year-olds and keep them from noticing syntax errors (Windsor, 1999). Such findings suggest limitations of working memory or processing efficiency. Grammaticality judgments require holding several sentence constituents in memory, and increased processing speed and efficiency from 2 to 10 years (Kail, 1991), as well as increased verbal working memory capacity (Gathercole et al., 1992), should make syntactic processing faster and more reliable.

2.30.5.1.3 Learning the nuances: reference, pragmatics, and implicature

Syntactic judgments and constructions fundamentally involve pragmatic factors (Bates and MacWhinney, 1982). As children gain fluency, and adults expect them to maintain good discourse cohesion, they must master a wide variety of devices for maintaining good discourse cohesion: topic–introducing-and-shifting (e.g., "There was this guy. He..."), topic-continuing (e.g., "yeah, and..."), perspective-shifting (e.g., "No, *he* didn't do it, *she* did!"), etc. As these examples show, pronouns and generic descriptions are important elements of discourse (Karmiloff-Smith, 1979). Adults, for example, find it jarring to continue to use unique individuation within a narrative:

> Chris and Heidi went to a new restaurant. The waitress asked Chris and Heidi if Chris and Heidi wanted drinks. "No," said Heidi. Heidi had already had some wine.

Preschoolers can use pronouns for coherent reference; for example they use simple cues (e.g., gender) to pick out a pronoun referent (Blakemore, 1990). Five-year-olds who lag behind in this ability show other narrative comprehension deficits (Cain and Oakhill, 1999; Yuill and Oakhill, 1991). By 7 years, however, children select and substitute pronouns in more pragmatically appropriate ways (Lloyd et al., 1995; Hickman and Hendricks, 1999). Specifically, the ability to use an interlocutor's knowledge to select unambiguous referential terms develops from 4 to 7 years (Ackerman, 1993), during the same period when they improve at drawing inferences about a speaker's meaning based on nonliteral semantic and discourse implications (e.g., Özçalıskan, 2004).

2.30.5.2 From Fluency to Flexibility and Meta-Language

2.30.5.2.1 Cognitive flexibility in child language

Each of the linguistic achievements of late childhood involves greater precision of interpretation or production. This precision requires representing different perspectives (Clark, 1997), which in turn requires representational flexibility (Deák, 2003). Flexibility involves processes including shifting attention, generating/selecting new representations, suppressing prior cues and associations, etc. Deák (2000b; 2003) found that children's flexibility in using cues to infer novel word meanings develops from 3 to 6 years, and individual differences in flexibility predict vocabulary, but are unrelated to children's ability to inhibit lexical associations. One interpretation is that word-learning flexibility is independent of some related cognitive control processes, but nevertheless predicts word-learning efficacy. A significant question is whether the same kind of cue-using flexibility is used by children to make complex syntactic and discourse interpretation. There is as yet no evidence addressing this question.

Cognitive flexibility encompasses children's growing ability to formulate and select appropriate but nonobvious representations of a referent or sentence in light of contextual information. For instance, interpreting /har/ as a synonym for rabbit, not hair (Campbell and Bowe, 1983), requires flexibility and selectivity in retrieving alternate word meanings. Such sorts of cognitive control are prominent in mature language abilities.

Some claims about the development of cognitive flexibility have focused on limitations on cognitive resources such as working memory and inhibitory processes (Diamond, 1998). Evidence for these claims is mixed at best (Deák and Narasimham, 2003; Zelazo et al., 2003), but there is so little research on effects of working memory and inhibition on flexible representations during language processing that the matter is unresolved.

Another idea is that cognitive flexibility, including flexible language processing, rests on children's developing ability to coordinate multiple response-contingencies in their response selection (Zelazo et al., 2003). For example, Zelazo et al. (2003) claim 3-year-olds cannot use a two-level hierarchy of verbal rules to guide classification responses. Three-year-olds readily sort cards by either of two rules (color or shape), for example, but when asked to switch from one to the other they continue to follow the first rule (Zelazo et al., 1996). Is the problem their inability to handle the complexity of a hierarchy of rules? It seems 3-year-olds use quite complex linguistic contingencies to formulate or interpret syntactic utterances, at least in ideal circumstances (e.g., Bates and MacWhinney, 1982; Slobin, 1982), so it is difficult to assimilate natural language performance into Zelazo et al.'s (2003) theory. However, there is some evidence that children who do not flexibly respond to changing rules can benefit from semantic and pragmatic support (Munakata and Yerys, 2001; Kirkham et al., 2003). Also, studies of feedback suggest that children's errors are based on misunderstanding the rules or failing to notice rule-switch cues (Bohlmann and Fenson, 2005), consistent with the argument that cue comprehension is a critical factor in children's linguistic flexibility (Deák, 2003). Although it remains unclear how late-developing language skills intersect with the development of cognitive control, the two are not strongly correlated in individual 4- and 7-year-olds (Brophy et al., 2002), suggesting some dissociation.

2.30.5.2.2 Becoming an expert language user

As children's language skills become consolidated, they become faster and more accurate, especially when processing or producing more complex and novel utterances. This is hardly surprising but it raises key issues. One is that there are no neurobiological accounts of later language development. This is surprising given recent findings that fairly brief language training interventions can measurably change children's neural activity during language processing. This indicates prolonged neural plasticity (Shaywitz et al., 2004).

Another issue is that the large literature on expertise acquisition (Feltovich et al., 2006) is disconnected from the literature on later language development – which might be considered a nearly universal type of human expertise. The result of this disconnect is an odd conceptual separation of similar phenomena. For example, children acquire expertise in phonology such that lexical representations are organized in phonological similarity neighborhoods (Luce and Pisoni, 1998), which have characteristic perceptual expertise effects (Vitevitch, 1997). Five- to 7-year-olds have fewer similarity neighborhoods than adults (Charles-Luce and Luce, 1990), but these become refined with phonological and vocabulary development. Another near-universal form of human expertise, face processing (Gauthier et al., 1999), is acquired in ways that reveal plasticity and input-driven effects. It is likely that in the next decade language expertise, like face processing and other examples of childhood expertise, will no longer be viewed in outmoded nativist terms, but as a complex, emergent product of input-expectant learning.

2.30.5.2.3 Knowledge about language

Older children develop metalinguistics, or the ability to reflect on language (Gombert, 1992). Metalinguistic awareness focuses on dissociation of representations, as between a word as an action and as a symbol of whatever it represents. For example children might have trouble judging which is a longer *word:* 'mosquito' or 'cow,' because they conflate the words with their referents. Metalinguistic development might facilitate discourse facility (e.g., Morton et al., 2003): to the extent that specific lexical and syntactic acts underspecify a speaker's meaning, the ability to reflect on speech acts *per se* can help children understand nonliteral language (e.g., irony, sarcasm, or figurative language; Levorato and Cacciari, 2002).

Young children's metalinguistic knowledge has been tested in synonym and homonym usage. Doherty et al. (2004) found preschoolers' ability to identify homonym word pairs (baseball bat vs. flying bat) improved from 3 to 4 years of age and predicted understanding of false beliefs (i.e., inferring that another person can have an incorrect belief) even when vocabulary development was controlled. This suggests that metalinguistic knowledge develops in conjunction with other meta-representational skills.

How does metalinguistic knowledge develop? Older preschoolers show a tenuous association of printed word to referential meaning (Bialystok, 1997). However, this seems to improve with bilingual experience, possibly because bilingual children have more experience dealing with the abstract nature of linguistic representations as they switch codes to talk with different people (Bialystok et al., 2000). However, this argument is tentative, as there is so little research on the development of metalinguistic knowledge.

2.30.6 Conclusions

Three critical positions have been alluded to above, and these are central to the ongoing study of child language learning.

First, as advances in neuroscience fundamentally change our understanding of human cognition, they challenge persistent myths and assumptions about language. Basic findings about the developing bases of language in the brain, including the plasticity of language development (Bates et al., 2003), render ideas like Chomsky's 'language acquisition device' quaint. The growing sophistication of computational simulations of language learning support neurally plausible accounts of language development. However, because methods for measuring neural function and change in infants and children are so limited, much remains to be discovered.

Second, despite extensive use of terms like 'syntax,' 'semantic,' 'morphology,' and 'discourse,' these are conveniences based on historical convention in linguistics. Though there do seem to be some aspects of nearly pure syntactic knowledge, for example (Maratsos, 1998), more typical are complex interrelations among aspects of linguistic knowledge (e.g., Hay and Baayen, 2005). For example, there are no *a priori* neural dissociations between syntax and semantics (Bates et al., 2002). The interrelatedness of linguistic knowledge can be shown in children as well as adults. An intriguing question is how neural and psychological specialization of various aspects of language emerge during development.

Finally, research on different populations, including infants and children with various developmental disorders, and adults with neurological and sensory deficits, and a wide range of languages, will be necessary to understand typical language development. Studies of communicative learning in nonhuman species, and of nonlinguistic learning in humans (e.g., Childers and Tomasello, 2003) are also necessary. Despite the challenges of synthesizing such a vast range of research, the history of child language research clearly shows that a myopic focus on competent, healthy, educated English speakers leads to mistaken assumptions about the nature of language and language learning.

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