HANDBOOK OF PSYCHOLINGUISTICS

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Chapter 27
Language Learning in Infancy

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1. INTRODUCTION

Learning language is one of the most impressive and intriguing human accomplishments. Think about the vast differences between the healthy 12-month-old child who says “Ah! Ah!” with hands held up in the air, eager to be lifted from the highchair, and the same child six months later using recognizable two-word combinations coordinated with gestures (e.g., “Mommy out!”). Within the next year that child will start using an impressive complement of morphosyntactic skills to produce utterances that reflect considerable linguistic sophistication (e.g., “Mom! I wanna get outta this chair now!”). The child’s desire may be equally intense in each of these situations, yet clearly the typical 2-year-old has advanced significantly beyond the 1-year-old in her ability to effectively use her native language to make that particular desire known to those around her. The goal of developmental psycholinguistics is to map the endogenous and exogenous forces that converge to shape and guide this set of developmental achievements.

Over the past five decades, the field of language development research has been at the center of the debate between nativist and constructivist approaches to understanding human cognition. In the early 1960s, Chomsky’s proposal that language acquisition was innately guided by a Language Acquisition Device offered a powerful solution to the logical problem of how children learn language, a view still ardently embraced by many in the field. Since that time, however, an alternative view has been gaining momentum, gathering logical and empirical support for the idea that a child’s linguistic knowledge is constructed rather than triggered, emerging as a consequence of the child’s experiences with the linguistic and non-linguistic world (e.g., Bates & MacWhinney, 1979; Braine, 1976; Slobin, 1973). Proposals on how exactly the child accomplishes this task have taken several different forms over the years, and with each new decade, theoretical and methodological advances have strengthened the case for this alternative to nativism. The goal of this chapter is to outline some key features of current proposals on how the child constructs a language. We first briefly review the standard nativist approach, and then discuss some recent developments in theory and research from diverse disciplines.
that have contributed to a shift in emphasis in research on language development in productive new directions. Then we review three lively areas of current research on language learning in infancy: early speech perception, lexical development, and listening for meaning. This review will of necessity be quite eclectic, focusing on a few studies within each of these areas that exemplify new perspectives that are now coming to the forefront in this field.

2. NATIVIST VIEWS OF LANGUAGE DEVELOPMENT

How and why does the child’s linguistic behavior change so dramatically over such a short period of time? Much of the research on this topic has assumed that this process is driven by innate and highly specialized mental structures (a “mental organ,” Chomsky, 1981). That is, learning language involves the operation of a specifically linguistic maturation bioprogram (i.e., Universal Grammar) as it processes specifically linguistic input (e.g., Chomsky, 1981; Lenneberg, 1967). According to this perspective, this innately specified system is what makes it possible for the child to determine which of all the possible linguistic rule systems characterizes their particular native language. Indeed, the goal of much research in modern linguistics has been to map the diverse set of principles and features that describe the rule systems of any and all of the world’s languages. Of course, in setting out on this daunting task, one is soon struck by the vast richness and complexity of human grammars.

If the central question is how grammars come to be mastered, such complexity is particularly disheartening, especially in light of the prevailing assumption among nativist theorists that the environment falls far short of providing what children need in order to learn rich systems of linguistic representations on their own. According to Chomsky (1981), speech by adults is so full of hesitations, false-starts, mispronunciations, and ungrammaticalities that it could not possibly be an adequate model from which to abstract complex and subtle linguistic regularities. Even if one acknowledged that child-directed speech is typically more coherent in structure than adult conversation (e.g., Snow & Ferguson, 1977), ethnographic research reveals substantial differences in the extent and nature of linguistic interactions with infants across cultures (e.g., Schieffelin & Ochs, 1986). Thus, it was apparently impossible to identify a universal set of features of child-directed input necessary for acquisition to take place (e.g., Lieven, 1994). Moreover, the wisdom of relying on a simplified child-directed register as the basis for grammatical development was called into question. Since speech to children is typically simpler than speech to adults, learning a grammar may be hindered by the fact that the input is limited in the scope and extent of the detailed syntactic information it can provide (Gleitman et al, 1988). Most significantly, several studies have demonstrated that caregivers do not provide enough explicit information to prevent the child from building overly general grammatical systems. This mistake, it was assumed, can only be overcome by linguistic input that provides “negative evidence”, i.e., information about what sentences are not permitted by the target language (Marcus, 1993, cf. Sokolov & Snow, 1994).
These limitations of the input must be interpreted in the context of assumptions regarding what types of mechanisms are used by the language-learning child. In a famous examination of what would make languages "learnable," Gold (1967) proposed that children are general learners who test hypotheses about grammatical rules against example sentences that they hear in the target language. In this demonstration, Gold provided what was considered to be compelling evidence that a general learner cannot induce the grammars of certain types of formal languages (which are derived from the class of natural languages) if it receives only "positive evidence" (i.e., only sentences that are grammatical in the language). The only conditions under which learning could be successful are: (1) if the learner is provided with negative evidence (i.e., cues to what sentences were ungrammatical), or (2) if the learner possessed strong initial biases about the types of hypotheses to consider in the first place. We should note that Gold's learner incorporated an all-purpose learning mechanism that is clearly unlike any that has been proposed for young children. However, since several studies showed that explicit negative evidence is rare and is not universal in child-directed speech (e.g., Brown & Hanlon, 1970; Marcus, 1993), the only conclusion deemed reasonable at the time was that children must come pre-wired with a universal set of representational constraints on the types of grammars that are possible in human languages (e.g., Pinker, 1979). In other words, the complexity of the end-product and the indeterminacy of input to children (i.e., the "poverty of the stimulus") appear to comprise compelling evidence that grammars cannot be learned. As Tomasello (2003) has recently put it, this view assumes that adult grammars go far beyond what children are capable of building given the resources available to them, i.e., "you can't get there from here" (p. 2). Since most children do become relatively proficient at grammar within the first few years of life, it was logical to assume that it was only via a rich system of innately specified rules and representations, i.e., Universal Grammar, that all children could possibly zero-in on the particular set of rules that characterize their native language (e.g., Chomsky, 1975; Pinker, 1999, 2003).

Finally, this view also makes strong claims regarding the relations between linguistic and non-linguistic cognition. That is, the language faculty involves special processing mechanisms that are specifically dedicated to mediating the acquisition and processing of language. Moreover, sub-systems are themselves "modularized" in terms of components of the language faculty as traditionally defined by linguists, i.e., phonology, semantics, grammar, pragmatics (e.g., Fodor, 1983; Pinker, 1991; Levelt, 1989). Because these sub-components of language are assumed to be distinct in terms of the representations they employ, they are viewed as structurally autonomous and informationally encapsulated, not only from each other but also from the rest of non-linguistic cognition (e.g., Pinker, 1991). In sum, this nativist view of language development focuses on the specificity of the young child's complex grammatical knowledge, the biological origins of its nature, and the universal course of its acquisition. As framed by Pinker (1994):

Language is a complex, specialized skill, which develops in the child spontaneously, without conscious effort or formal instruction, is deployed without awareness of its underlying logic, is qualitatively the same in every individual, and is distinct from more general abilities to process information or behave intelligently.
For these reasons, some cognitive scientists have described language as a psychological faculty, a mental organ, a neural system, and a computational module. But I prefer the admittedly quaint term ‘instinct’. It conveys the idea that people know how to talk in more or less the sense that spiders know how to spin webs...spiders spin spider webs because they have spider brains, which give them the urge to spin and the competence to succeed (p. 18).

3. A PARADIGM SHIFT: NEW PERSPECTIVES ON LANGUAGE LEARNING

Although nativist views of language acquisition are forceful and still widely endorsed, there has been ongoing controversy about the adequacy of such theories as an account of how children develop competence in language. Some critiques directly challenge the logic of arguments made by Chomsky, Pinker, and like-minded theorists, questioning such core assumptions as the universality of generative grammar, the autonomy of syntax in language processing, and the fundamental unlearnability of language (e.g., Bates & Goodman, 1999; Braine, 1994; Pullum & Scholz, 2002; Tomasello, 1995). Other critiques focus on empirical evidence inconsistent with particular nativist assertions. For example, the claim that negative evidence is not available when children make grammatical errors, an assumption central to the “poverty of the stimulus” argument at the heart of Chomsky’s theory, is not supported by a recent analysis of parents’ reformulations in speech to children (Chouinard & Clark, 2003). These diverse challenges, both philosophical and data-driven, have fueled debate over four decades about the explanatory adequacy of nativist theories of language learning.

However, in recent years this debate has begun to change in focus and tenor, not only in response to explicit critiques within linguistics and developmental psychology, but also in response to research findings and theoretical insights from farther afield. An alternative perspective on language learning has been gathering force, amplified by new developments in research areas that formerly made little contact with theoretical debates on the nature of language development (see Kuhl, 2004; Seidenberg & MacDonald, 1999; Tomasello, 2003). We focus on four such developments that have begun to change the direction of research on early language acquisition: first, the emergence of more “user-friendly” theories of language and language use; second, the contribution of computational approaches to modeling language processing and learning; third, provocative findings from experimental research on learning and cognitive processing by infants; and fourth, insights from studies with children and non-human primates on the role of social cognition in communication. In different ways, these diverse areas all motivate and support an emerging alternative view of language learning.

3.1. New Ways of Understanding Language and Language Use

While generative theories have favored a view of linguistic competence defined exclusively in terms of grammatical knowledge, recent developments in both linguistics
and psycholinguistics have shifted the focus to a more inclusive view of competence, one that incorporates performance factors that guide language use. Within the newly emerging area of cognitive-functional linguistics, "usage-based" theorists emphasize the essential connection between the structure of language and how language is used to communicate (e.g., Croft, 2001; Goldberg, 1995). According to this view, linguistic competence cannot be reduced to knowledge of a core grammar as Chomsky claimed, but rather draws on a wide range of cognitive and social capabilities and on knowledge from diverse domains. Rejecting fundamental nativist assumptions about the nature of language, usage-based theories demand a very different view of what is involved in language learning (Tomasello, 2003).

In psycholinguistics as well there has been a dramatic shift away from models of speech processing that embody nativist assumptions, in favor of models that emphasize statistical and probabilistic aspects of language (Seidenberg, 1997). Until recently, the dominant processing theories have been those that presuppose the modularity of language, focusing on syntactic parsing strategies presumed to be automatic (see Frazier, 1987). For example, adults reading potentially ambiguous sentences such as "Put the apple on the towel into the box" are confused in predictable ways, presumed to result from of an irresistible initial tendency to interpret the prepositional phrase (PP) "on the towel" as modifying the verb and thus specifying the destination of the action. In fact, the first PP modifies "apple" rather than "put," a reduced relative clause that attaches to the noun phrase rather than the verb phrase, catching the reader by surprise. Such classic "garden-path" effects were replicated in hundreds of experiments based on nativist assumptions, providing support for the idea that default syntactic processing strategies are automatic and impervious to influence from other sources of information. But this picture is changing, with the emergence of new experimental paradigms that use more revealing techniques for monitoring on-line comprehension. For example, when adults are able to look at a relevant visual scene while hearing "Put the apple on the towel into the box," different results emerge (Tanenhaus, Spirey-Knowlton, Eberhard & Sedir, 1995). If a single apple on a towel is present in the scene along with a second towel and a box, listeners look briefly at the lone towel when they hear the first PP, before looking at the box. This is the behavioral equivalent of the garden-path effect observed previously in reading studies. However, if two apples are present in the scene, one on a towel and the other on its own, the same sentence is no longer perceived as ambiguous and there is no evidence of misinterpretation. To the contrary, the presence of the second apple provides immediate non-linguistic contextual support for interpreting "on the towel" as modifying the noun, crucial information that enables the listener to identify the correct referent. This experiment by Tanenhaus et al. was one of many recent studies using eye-tracking techniques to show that listeners integrate probabilistic information from multiple sources in interpreting spoken language, rather than defaulting to inflexible syntactic processing strategies (see Trueswell & Tanenhaus, 2005).

These new theoretical perspectives on language use emerging within linguistics and psycholinguistics are not only "user-friendly" in their emphasis on the flexibility and resourcefulness of mature language processing, but also "child-friendly" in their
developmental implications. Their influence on current research on early language learning is evident at several levels. Developmental theorists using observational techniques are testing predictions from usage-based theories, namely that children develop linguistic competence gradually, learning to produce new constructions item by item, rather than advancing by triggering innately specified grammatical rules that function in an all-or-none fashion (e.g., Lieven, Pine, & Baldwin, 1997; Tomasello, 2003). Researchers are also using new experimental techniques for assessing early speech-processing abilities to explore how infants in the first year track distributional information in spoken language (Saffran, Werker, & Werner, in press), and how by the second year they are able to interpret speech incrementally based on probabilistic information, similar to adults (Fernald, McRoberts, & Swingley, 2001). These are just a few examples to illustrate the more general point, that the application of probabilistic constraints is not only central to understanding adult competence in language processing but is now being extended to theories of language acquisition as well. Seidenberg and MacDonald (1999) make the case that the processes of constraint satisfaction that are critical to mature language production and interpretation are the same processes used by infants as they begin to make sense of speech and break into language.

3.2. Computational Approaches to Language Use and Language Learning

The idea that attending to distributional information in speech might be critical in language learning was proposed many years ago (Maratsos & Chalkley, 1980), at a time when nativist views of language dominated the field. Another reason why this early interest in distributional learning was initially eclipsed was that the computational resources necessary for exploring such questions empirically were not yet widely available. In recent years, however, computational approaches of different kinds have become increasingly influential in research on language development, ranging from statistical analyses of language patterns to connectionist models. Because large corpora of spontaneous speech by parents and children are now accessible through the Child Language Data Exchange System (CHILDES) data bank (MacWhinney & Snow, 1990), researchers are able to undertake detailed analyses of the kinds of distributional information available in the language directed to the child. For example, statistical models have been used to reveal cues in child-directed speech that could potentially aid the young language learner in identifying word boundaries (e.g., Brent & Cartwright, 1996; Christiansen, Allen, & Seidenberg, 1998; Swingley, 2005) and in classifying new words in the appropriate grammatical form class (e.g., Mintz, 2003).

Statistical models such as these provide evidence that information about the distribution of linguistic units at various levels is available in the speech stream that could, in principle, facilitate learning by the child. Connectionist models are well suited to tackle the next question, asking what kinds of outcomes are possible at different phases in development given a particular input and a general-purpose learning mechanism (Elman et al., 1996). These models typically represent information in a distributed fashion across a set of connections between input and output units, although representational features and network architectures have been varied in many interesting ways (e.g., Shultz, 2003;
Munakata & McClelland, 2003). Over training, the networks extract and represent patterns of regularities in the input, abstracting information from multiple sources simultaneously and at multiple levels of granularity. Guided by the non-linear learning mechanism, the networks allow solutions to be represented as the coordinated activity of the network as a whole (i.e., the patterns of connections across the weights) that can be evaluated at different points in the training.

For example, in a series of models of the acquisition of inflectional morphology (Plunkett & Marchman, 1991), networks were trained to map words from their stem (e.g., walk) to past tense (e.g., walked) forms using artificial languages with different proportions of regular and irregular verbs. These factors were evaluated in a parametric fashion, revealing information about the conditions under which the networks would make use of phonological regularities across stem–past tense pairs as well as the role of both token frequency (i.e., how many times a particular stem–past tense mapping was seen) and type frequency (i.e., how many different stem–past tense pairs shared the same overall pattern, e.g., ring-rang, sing-sang) in determining learning. These features predicted the learning patterns in the networks and have been examined in several studies of natural languages (e.g., Bybee, 1995). Plunkett and Marchman (1993) next examined learning of stem–past tense mappings in the context of a lexicon that gradually increased in size over the course of the training, i.e., incremental learning. That is, the ability of the networks to memorize particular stem–past tense pairs or to generalize to novel forms was sensitive to developmental changes in the overall size and composition of the training set. Again, the predictions of these models have led to examinations of the role of vocabulary size in children’s learning of morphosyntax and the impact of individual differences in vocabulary size on later grammatical outcomes (e.g., Marchman & Bates, 1994; Bates & Goodman, 1999).

Another example is Elman’s (1993) simple recurrent network (SRN) model which abstracted syntactic regularities across sequential occurrences of lexical items. The model was presented strings of words in “sentences” generated by a human-like artificial grammar. The task for the SRN was to predict the upcoming word in the sequence, a task that is inherently probabilistic given the many possible words that could come next, especially across sentence boundaries. However, the task of “listening ahead” in essence forced the network to track distributional relations across the words, encoding the syntax of the sentences in terms of the varying conditional probabilities that were inherent in the example sentences. Interestingly, the network was successful in this task only when limitations were place on the size of the “working memory” early in learning and then memory size was gradually increased across the course of training. The network’s limitation, as it turned out, was an advantage in learning the syntax of this artificial language, illustrating the importance of “starting small” (see also Newport, Bavelier, & Neville, 2001; Hertwig & Todd, 2003). While “starting small” may not always be necessary for successful learning (Rohde & Plant, 1999) and there are clearly limitations to what these models can tell us about human learning, such endeavors have served as natural tools for testing the conditions under which knowledge can emerge with exposure to different kinds of learning environments (e.g., Kersten & Earles, 2001). In addition, they have fueled new interest in exploring the ways in which knowledge is used and represented,
what kinds of information are available to the language-learning child, and what types of learning mechanisms can account for both the general patterns and individual variation seen across development (Elman et al., 1996; Elman, 2004, 2005).

3.3. Learning Strategies in Infancy

A third area in which recent developments have challenged traditional assumptions about language acquisition is research on infant learning strategies. When Skinner (1957) proposed that language was a behavior like any other animal behavior that could only be learned through gradual shaping and external reinforcement, Chomsky (1959) emphatically rejected this idea. The common observation that children begin to talk correctly in the absence of explicit positive or negative feedback was clearly at odds with the idea that language learning is achieved through a process of conditioning. Chomsky’s claim that principles of learning could not possibly explain how children master language was based on the behaviorist learning theory of the day, which was much too simplistic to account for the complexities of children’s linguistic ability. In recent years, however, researchers investigating early perceptual and cognitive development have made stunning discoveries about the learning capacities of young infants, and a new view of the potential role of learning in language development has emerged. Thus, while computational models reveal how much information about language structure is potentially available to the young language learner, these new behavioral studies confirm that infants are in fact able to learn from this information.

For example, Saffran, Newport, and Aslin, (1996) showed that eight-month-olds can segment a stream of meaningless syllables containing no acoustic or prosodic cues to word boundaries after only a few minutes of listening experience. The information infants are using to identify word-like units in this case is distributional evidence, the regularities in the relative position and order of particular syllables over the whole sequence. For example, one string of syllables consisted of *pa bi ku go la tu da ro pi ti pu do da ro pi go la tu*… After familiarization with this sequence, infants were tested with “words” that had occurred in the string, i.e., sequences of syllables that always occurred in the same order, such as *pobiku* and *golatu*. They were also tested with “non-words,” combinations of familiar syllables that spanned two different words, such as *kugola*. Although there was no acoustic information specifically marking word boundaries, the transitional probabilities were much higher between syllables within words than between words. Thus there was statistical information that could enable infants to identify the familiar word-like units in the stream of speech. The finding that they are capable of performing such computations reveals the sophisticated talents young learners bring to the task of segmenting speech, months before they are able to understand meanings in the words they hear.

3.4. Social Cognition in Infants and Non-Human Primates

Another domain of research that is yielding surprising findings relevant to language learning focuses on the abilities of human infants and animals of other species to
appreciate the mental states of others. Ethologists have long been interested in the communicative function of animal signals, attempting to establish criteria for determining whether primate vocalizations constitute intentional and semantically meaningful signals to conspecifics. Vervet monkeys, for example, give at least three acoustically distinctive calls in response to particular predators (Cheney & Seyfarth, 1997). When one of these call types is played back in field experiments in the absence of an actual predator, adult vervets react appropriately, taking a different escape route in response to a “snake call” than to an “eagle call.” These and other recent ethological observations have dispelled the prevailing assumption that primate communication is entirely reflexive and emotional in nature and thus must be very different from human communication. These findings are of interest to many outside the field of biology, posing questions of concern to philosophers, linguists, and psychologists. What sorts of mental representations underlie the production and perception of these primate calls? When a vervet gives a snake alarm call, is this analogous to a child crying out “Snake! Watch out!” on seeing slithery movement in the grass?

Cheney and Seyfarth (1997) conclude that vervet and human communication differ fundamentally, in that monkeys call and look at each other in order to influence each other’s behavior, whereas children do so in order to influence their attention or knowledge. According to these researchers, the lack of a theory of mind in vervets is one fundamental reason they are incapable of language. However, these questions are complex, and studies with other species show that animals as diverse as sea lions, parrots, and bonobos are capable of learning to use symbols and to distinguish between objects, actions, and modifiers. There is energetic debate about how these abilities should be interpreted and how they differ among species, in particular whether chimpanzees and other higher primates show more sophisticated competence in reading the goals and intentions of others than do monkeys (Tomasello & Carpenter, 2005).

This new wave of research on animal communication resonates in interesting ways with two flourishing areas of research with human children. The first area explores the growth of theory of mind in preschoolers (e.g., Wellman, 2002), while the second focuses on children’s early sensitivity to communicative behaviors such as emotional expressions, gaze direction, and pointing (Baldwin & Moses, 1996). Experimental studies using looking-time measures show not only that young infants can use such vocal and visual cues to guide their attention (e.g., Mumme & Fernald, 2003), but also that they use nonverbal referential cues in combination to make inferences about the goals and intentions of others (see Rochat, 1999). It may not be obvious what these studies of non-verbal communication in animals and infants have in common with the paradigms described in the three previous sections, which all seem more directly relevant to the new focus in language research on how children and adults evaluate multiple sources of probabilistic information in interpreting and using language. But the relevance of research on intentionality to this new focus will become clear when we review current research on lexical development. Through the work of Tomasello (2003) and others, it is increasingly apparent that the ability to learn what a word means and to use words in communication depend crucially on fundamental skills of joint attention and intention-reading. Because
language use involves mind-reading, children must learn to interpret others’ mental states and to integrate probabilistic information on this level with information at other linguistic and non-linguistic levels in order to interpret language and to communicate effectively.

In summary, for half a century research on language development has been dominated by theoretical claims and assumptions emerging from a powerful linguistic theory that defines competence in terms of innately specified grammatical knowledge. Recent developments in diverse fields outside the mainstream of linguistics are forcing re-examination of these assumptions from different angles, all suggesting alternative ways of thinking about how human language functions and what it means to learn a language. A dominant theme emerging from the new paradigms and findings in the four areas reviewed above is that human communication relies on the integration of many different sources of information, rather than on innately specified knowledge in an encapsulated, modular system isolated from other cognitive and social capacities. Seidenberg and MacDonald (1999) refer to this emerging perspective as the “probabilistic constraints” approach, which has as its central idea that language learning by children and language processing by adults both involve the use of “multiple, simultaneous, probabilistic constraints defined over different types of linguistic and non-linguistic information” (p. 570).

This theme is reflected in some of the most interesting new research on infant speech perception, early word learning, and the emergence of efficiency in spoken language understanding, to be reviewed in the following sections. The purpose of this brief review is to point to a few of the recent contributions to research on language acquisition in infancy that exemplify this sort of probabilistic perspective. We do not attempt to provide a comprehensive review of this area and certainly do not assume that this approach has all the answers. Instead, our goal is to describe new research on how children start out by attending to patterns in speech sounds in the first year and learn to listen for meaning in speech in the second year. By focusing on how infants, from the beginning, attend to multiple sources of information in making sense of spoken language, this approach emphasizes the continuity between current psycholinguistic theories about how language is used and emerging developmental perspectives on how language is learned.

4. LEARNING ABOUT THE SOUNDS OF SPEECH IN THE FIRST YEAR

To begin making sense of speech, infants must discern regularities in the sequences of sounds used by speakers of the particular language they are hearing. Hundreds of experiments on speech perception in the first year of life have shown that months before understanding or speaking a single word, infants become attuned to characteristic sound patterns in the ambient language (see Jusczyk, 1997). While early research in this area focused on discrimination and categorization of consonants and vowels, more recent studies are exploring infants' implicit learning of complex distributional patterns in spoken language and how these learning strategies enable infants to find the words, using multiple sources of information available in the sound patterns of continuous speech.
4.1. Early Attention to Speech Sounds

Given the abundance of findings in what is now regarded as one of the most exciting areas of research in cognitive development, it is hard to believe that infants' sophisticated speech-processing abilities are a relatively recent discovery. To give some historical perspective, in 1970 Bernard Friedlander published a research overview entitled *Receptive Language Development in Infancy: Issues and Problems*, motivated by the following concerns:

Judging by the theoretical and speculative literature as it stands today, receptive language development in infancy is a minor topic of marginal significance. Issues related to infant listening and receptive processes are virtually ignored in ... the new wave of language studies that assumed torrential proportions in the early 1960's. Though there is a general acknowledgment... that language input is a necessary prerequisite for the organization of speech, the topic is seldom accorded more than a few sentences... and some of these discussions are highly patronizing in tone. They seem to suggest that auditory perception in general and language perception in particular are topics on which thoughtful observers would hardly need to spend much time. There is little in this literature to suggest that the problem of how babies come to recognize the phonological, lexical, semantic, and grammatical systems in the language they hear represents a psychological, linguistic, and developmental problem of the greatest magnitude (1970, p. 7).

Friedlander's (1970) paper was more a lament than a review, because there was almost no research available at the time: "Hardly enough is known at a factual level about early listening processes and their role in language growth even to organize the phenomena in reasonably durable categories" (p. 8). Then just one year later the situation changed, when the first reasonably durable categories were discovered through the pioneering experiments of Eimas, Siqueland, Jusczyk, and Vigorito (1971). Using an innovative operant technique called the high-amplitude-sucking procedure, these researchers were able to show for the first time that young infants can discriminate and categorize speech sounds.

To fluent English speakers the speech sounds /b/ and /p/ sound clearly distinct, so it is difficult to appreciate how formidable this task could be to a linguistically inexperienced listener. In fact, these two consonants are acoustically very similar; moreover, /b/ and /p/ vary acoustically when combined with different vowels or when they occur in different positions in a word. Eimas et al. showed that even very young infants could discriminate /b/ from /p/, and just like adults, they failed to distinguish different tokens of /b/ that were acoustically distinct yet were members of the same phonetic category. Infants can also appreciate the fact that vowel tokens that are acoustically dissimilar may be equivalent in terms of their phonetic identity. Using an operant head-turn procedure, Kuhl (1979) showed that five-month-old infants readily discriminated /a/ from /i/ when spoken with the same intonation by the same female speaker. However, they grouped together several different tokens of /a/ that were acoustically variable, produced by male and female
speakers using both rising and falling pitch contours. These classic studies on early speech processing abilities showed that infants can attend to the acoustic variability relevant to the phonetic identity of speech sounds, while ignoring acoustic variability that is linguistically irrelevant.

The first experimental studies on early speech perception focused on infants’ ability to distinguish isolated syllables. The questions initially of interest derived from controversial issues in research on adult speech perception, with the infant representing the “initial state,” or the listener innocent of experience. Studies with infants were seen as test cases relevant to current debates about which acoustic features are most critical for human speech perception (e.g., Eimas & Corbit, 1973), whether speech and non-speech sounds are processed in fundamentally different ways (e.g., Jusczyk, Rosner, Cutting, Foard, & Smith, 1977), and whether speech sounds are represented in terms of phonetic features or syllables (Bertoncini, Bijeljac-Sabic, Jusczyk, Kennedy, & Mehler, 1988). While providing valuable information about early perceptual abilities crucial for speech processing, most of these early studies were “developmental” only in the sense that they showed these capabilities were already present at birth. A more dynamic picture has emerged in recent years as researchers have begun to focus on developmental change in speech processing strategies, first by exploring how experience with a particular language shapes perception, and second by asking how infants learn to recognize patterns in speech that may help them identify linguistic units.

4.2. Becoming a Native Listener

Although infants are clearly born with perceptual abilities and biases that equip them for organizing speech sounds into linguistically relevant categories, these perceptual grouping strategies are neither unique to humans nor unique to speech sounds. Other primates also organize human speech sounds categorically, and some other kinds of acoustic stimuli are perceived in a similar fashion (see Kuhl, 2004). What is presumably unique to humans is the perceptual learning that occurs over the first few months of life as a result of hearing a particular language. Adults often find it difficult or even impossible to distinguish certain speech sounds in an unfamiliar language. For example, native speakers of Hindi can easily discriminate the consonants /Ta/ and /ta/, but to monolingual English-speaking adults they sound like indistinguishable tokens from the English category /t/. However, six-month-old infants growing up in English-speaking families can effortlessly discriminate the Hindi contrast /Ta/ - /ta/ (Werker & Tees, 1984). Studies of adult perception of native and non-native speech sounds show that adults have become specialists, attentive to phonetic distinctions relevant in the languages they have learned but less discerning in making other distinctions. Yet infants must start out with the potential to make a wide range of distinctions. When does this process of perceptual specialization begin? Werker and Tees tested English-learning infants at three ages between 6 and 12 months, to investigate whether they retained their ability to discriminate non-native speech contrasts across the first year. Infants at each age listened either to the Hindi consonants /Ta/-/ta/ or to consonants from the Nthlakampz language, /k’il/-/q’il/,
which are also very difficult for English-speaking adults to discriminate. Almost all of the infants at 6–8 months could discriminate both non-English contrasts, although very few of the infants at 10–12 months were able to distinguish either pair.

Further evidence for the influence of the ambient language on infants’ emerging phonetic categories comes from research by Kuhl, Williams, Lacerda, Sterens, & Lindblom (1992), who showed that six-month-old infants hearing only Swedish or English already grouped vowels perceptually in categories appropriate to the language they were learning. Recent studies measuring brain activity are generally consistent with the behavioral findings showing increasing specialization for familiar speech sounds over the first year. At six months of age, infants show an electrophysiological response to changes in both native and non-native speech contrasts, but by 12 months the response is elicited only by changes in speech sounds native to the language the child has been hearing (e.g., Cheour-Luhtanen et al., 1995). These results indicate that auditory experience over the first-year results in neural commitment to a particular perceptual organization of speech sounds appropriate to the ambient language. Through early experience with the speech around them, infants adapt their perceptual strategies for efficiency in processing the language they are learning.

4.3. Finding the Words in Fluent Speech

Other studies of developmental change in speech perception have focused on the discovery procedures infants use to identify higher-order elements in spoken language. An influential article by Lila Gleitman and colleagues stimulated this new research direction (Gleitman et al., 1988). They proposed that infants might be able to use certain prosodic features in continuous speech, such as pauses and the vowel lengthening typically preceding pauses, as cues to the boundaries of phrases and clauses, a perceptual discovery strategy that could be useful to the child beginning to learn syntax. This “prosodic bootstrapping hypothesis” generated considerable interest, leading to experiments showing that 10-month-old infants seemed to recognize violations of common prosodic rhythms in the ambient language (e.g., Kemler Nelson, Hirsh-Pasek, Jusczyk, & Cassidy, 1989). Although there were also counterarguments against the view that prosodic cues are sufficiently regular as to provide reliable cues to syntactic units in speech (e.g., Fernald & McRoberts, 1995), the prosodic bootstrapping hypothesis stimulated the first wave of research exploring how infants might use lower-level acoustic cues in speech to gain access to linguistic structure at higher levels (see Morgan & Demuth, 1996).

The strong claim that young infants must first rely on prosodic information in order to organize segmental information in continuous speech has receded in light of new findings showing that infants are much more adept at identifying word-like units in fluent speech than anyone had imagined. Jusczyk and Aslin (1995) investigated the ability of seven-month-old infants to detect repeated words embedded in fluent speech. When infants were first familiarized with multiple repetitions of a word such as bike or feet and then tested in an auditory preference procedure with passages that either did or did not
contain the familiarized word, they preferred to listen to passages containing the familiar word. This finding indicated that infants were able to segment speech into words without benefit of exaggerated prosodic cues. However, prosody at the level of word stress does play a role in facilitating such segmentation. English-learning infants are more successful in segmenting words such as *bor*der that have a strong–weak accent pattern than words such as *guitar* that have the opposite pattern, because they have already learned that the strong–weak pattern is dominant in the language they are hearing (Jusczyk, 1998). In contrast, French-learning infants appropriately show the opposite bias, based on their experience hearing words with weak–strong accent patterns.

Many studies have now demonstrated infants' sensitivity to particular cues in the ambient language such as phonotactic regularities (Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993) and lexical stress (Jusczyk, Cutler, & Redanz, 1993), and their ability to take advantage of these cues in identifying word boundaries (e.g., Johnson & Jusczyk, 2001). In an influential study mentioned earlier, Saffran et al. (1996) showed that infants were also able to use sequential statistics to discover word-like units in continuous speech, in the absence of any other acoustic cues to word boundaries. Unlike the experiments on segmentation by Jusczyk and Aslin (1995) in which infants were first familiarized with samples of natural language, Saffran et al. exposed infants briefly to strings of meaningless syllables, i.e., stimuli that were language-like but entirely novel in their organization. After only a few minutes of passive exposure to these sounds, infants picked up on the regularities and attended longer during testing to sequences that deviated from these regularities. Using a similar training procedure, Chambers, Onishi, and Fisher (2003) showed that infants can also learn new phonotactic regularities after minimal exposure. Moreover, they can also quickly take advantage of such newly learned phonotactic patterns, using them as cues to identify the boundaries of novel words (Saffran & Thiessen, 2003). Thus although infants in the second half of the first year may already show a strong commitment to the particular sound patterns they have absorbed from hearing their native language, early speech processing remains a highly dynamic process. Infants remain open to new experience as they build on prior learning, drawing on multiple sources of information to find order in novel sounds.

Experimental studies of early speech processing proceed parametrically, typically investigating one isolated variable at a time. However, infants listening to natural speech are in fact confronted with multiple sources of information at any moment, some redundant and others in conflict. Building on a strong foundation of research on infants' use of individual cues to word boundaries, several recent studies have begun to explore how young language learners tackle this challenging problem. Just as research on adult speech processing now focuses on how listeners integrate probabilistic information from numerous sources (Seidenberg, 1997), developmental researchers are beginning to ask parallel questions of very young infants (e.g., Curtin, Mintz, & Christiansen, 2005; Mattys, White, & Melhorn, 2005; Thiessen & Saffran, 2003, 2004). These and many other new findings confirm the wisdom of Friedlander's (1970) intuition 35 years ago, "that the problem of how babies come to recognize the phonological, lexical, semantic,
and grammatical systems in the language they hear represents a psychological, linguistic, and developmental problem of the greatest magnitude” (p. 7).

5. LEXICAL DEVELOPMENT

These studies of early speech perception show that infants in the first year of life are becoming skilled listeners, capable of making detailed distributional analyses of acoustic-phonetic features of spoken language. Although such accomplishments are often cited as evidence for early “word recognition,” they are perhaps more appropriately viewed as evidence of pattern detection abilities pre-requisite for recognizing words in continuous speech. Identifying particular sound sequences as coherent acoustic patterns is obviously an essential step in word recognition, but this can occur without any association between sound and meaning. Laboratory studies show that around 5–6 months of age infants respond selectively to their own name (Mandel, Jusczyk, & Pisoni, 1995), and by 10 months appear to have some kind of acoustic-phonetic representation for a number of frequently heard sound patterns (e.g., Halle & de Boysson-Bardies, 1994). Because this selective response to familiar words in the early months of life can occur with no evidence of comprehension, it may constitute word recognition in only a limited sense. However, most infants do begin to respond to and utter sounds in meaningful ways by their first birthday, and one year later are able to speak dozens of words quite convincingly. In this section, we review research on children’s first speech productions and the course of early vocabulary growth, as well as the factors that influence word learning in infancy.

5.1. First Words

According to parents’ reports of their children’s spontaneous responses to speech, infants typically begin to associate sound sequences with meanings toward the end of the first year. By eight months, on average, many children respond appropriately to about 10 familiar phrases, such as “Where’s Daddy?” (e.g., by turning and crawling toward the door), or “It’s time for bath!” (e.g., by plopping down and attempting to remove their shoes) (Fenson et al., 1994). While it could be tempting to assume that the child is actually interpreting each of the words in these phrases, it is more likely that children are using a variety of cues, both linguistic and contextual, to make sense of these frequent expressions (e.g., Daddy just left the room, Mom is holding a towel standing next to a running faucet). At the same time, the fact that children do respond in these ways indicates that they are paying attention to the speech around them and beginning to understand it by associating certain sound patterns with particular contexts. Only a short time later, children begin to demonstrate an ability to understand individual words with less and less contextual support, an ability that will continue to improve over the next several months. Based on reports from more than 1000 parents, Fenson et al. (1994) cite that the median-level 10-month-old understands approximately 40 words, while the median-level 18-month-old understands more than 250 words, a more than six-fold increase.
The production of recognizable words begins, on average, just before a child's first birthday. These early words cross-cut a variety of linguistic categories, but are typically names for caregivers (e.g., mama), common objects (e.g., bottle, shoe), social expressions (e.g., bye-bye), with some modifiers (e.g., hat) and actions or routines (e.g., peekaboo, throw) (Nelson, 1973). New words tend to enter children's expressive vocabularies over the next several months at a relatively slow but steady pace, reaching an average of 300 words by 24 months and more than 60,000 by the time they graduate from high school (Fenson et al., 1993). Thus, after the slow start, many children appear to undergo a "vocabulary burst," a sudden and marked increase in how many words children use (e.g., Goldfield & Reznick, 1990; Mervis & Bertrand, 1995). Putting aside the difficulties of defining how much of an increase constitutes a "spurt" in rate of learning, the characterization of lexical development in terms of a sudden increase in learning rate has been interpreted to indicate two distinct phases of lexical acquisition (i.e., pre-spurt vs. post-spurt). Some researchers have associated this "burst" with the achievement of linguistic milestones, for example, children's new understanding about what words are for (the "naming insight") (e.g., Dromi, 1987; Bloom, 1973), improved word segmentation abilities (Plunkett, 1992), or enhanced word retrieval skills (Dapretto & Bjork, 2000). Other researchers have associated increases in lexical growth with cognitive advances related to the nature or organization of object concepts (e.g., Gopnik & Meltzoff, 1987).

However, other researchers have suggested that these increases in the rate of learning are relatively constant across the period, questioning the idea of a "spurt" at all, and hence, its role as a marker for other cognitive or linguistic events (Bates & Goodman, 1999; Bloom, 2000; Ganger & Brent, 2004). Moreover, work within a connectionist framework suggests that it may not be necessary to assume that any shift in the trajectory of vocabulary growth would be associated with the emergence of a new insight or learning mechanism at all. Instead, both the slow and steady pace of learning early on and the accelerated learning later can be accounted for within a single explanatory framework. In Plunkett et al. (1992) a connectionist network was trained to associate labels (i.e., words) to random-dot "images" (i.e., pictures). In the "language" and "world" of this network, several images had the same "name" and there was no information in the images regarding what the label should be. Just like in natural languages then, the mappings between labels and images were arbitrary and many-to-one. Importantly, however, in the network, a vocabulary "spurt" occurred without any shift in the underlying mechanism guiding the learning. That is, even though the identical network was solving an identical task throughout development, shifts in learning rate were observed in the behavior of the network. As summarized in Elman et al. (1996), "there is no need to build in additional architectural constraints or to invoke changes in the input to explain the vocabulary spurt. It is simply an emergent function of the processing" (p. 128). The shifts were a natural consequence of processing limitations that arise over the course of a gradual and continuous learning process that involves complex and multiply determined mappings.

The fact that learning words involves gradually building a system of mappings using a variety of linguistic and non-linguistic constraints is also evident when examining changes in the types of words that children produce. Even though children's first words
come from a range of lexical categories (e.g., Bloom, 1973), first words are typically open class or content words (nouns, verbs, adjectives), and only later grammatical function words such as prepositions, determiners, and pronouns. Within the open class, children’s first words tend to be referential (i.e., concrete nouns), and only later are children producing predicative terms (e.g., verbs and adjectives) (Bates, Bretherton, & Snyder, 1988; Benedict, 1979; Brown, 1973; Nelson, 1973). This dominance of concrete nouns in early vocabularies (sometimes referred to as a “noun bias”) is most evident in the first 200 words or so, after which there tends to be an increase in the proportion of vocabularies devoted to predicative terms, for example, verbs (e.g., go), adjectives (e.g., hot), and closed-class functors (e.g., and, of) (Dromi, 1987; Nelson, 1973; Bates et al., 1994).

Several explanations have been proposed for these developments. First, it is possible that open-class words are learned early because they are longer in duration, generally stressed, and phonologically less reduced than closed-class words (Morgan, Shi, & Alloppenna, 1996). Even six-month-old infants show a preference for listening to open class rather than closed-class words (Shi & Werker, 2001), and newborns are sensitive to the acoustic differences between these word types (Shi, Werker, & Morgan, 1999). Second, it might also be the case that the ability to learn predicates is dependent on amassing a particular body of referential terms, and that using words that do grammatical work (e.g., functors) is dependent on the acquisition of a set of content words on which they can operate (i.e., “from reference to predication to grammar,” Bates et al., 1994, p. 98). Third, concrete nouns are conceptually simpler than verbs and other predicates, and both of these types of open-class words are more conceptually transparent than grammatical function words (Gentner, 1982; Gasser & Smith, 1998). More specifically, it has been proposed that the early priority of nouns in children’s vocabularies reflects the fact that nouns are more “cognitively dominant” than verbs and closed-class items (Gentner, 1982; Gentner & Boroditsky, 2001). That is, nominals serve primarily to denote concrete objects that are more bounded and more perceptually individuated than, for example, verbal terms denoting states and processes which must rely on their arguments (i.e., nouns) to make sense. Relational words (e.g., closed class terms), in contrast, are “linguistically dominant,” in that they derive their meaning from other parts of the linguistic context and sometimes reflect relatively opaque grammatical constructs (e.g., gender) (Gentner & Boroditsky, 2001).

The general pattern of early nominals appearing before other more relational terms has been observed in the vocabularies of children from several language-learning communities, even though their languages have different typological features that potentially make them more or less “noun friendly” (Gentner, 1982; Caselli, Casadio & Bates, 1999; Jackson-Maldonado et al., 2003; Bornstein, et al., 2004). For example, Caselli, Casadio, and Bates, (1999) used parent report to contrast early vocabulary composition in young English- and Italian-learners. In spite of the fact that Italian, but not English, is a pro-drop language (i.e., the subject noun phrase can be omitted leaving verbs in the very salient sentence-initial position), a similar level of noun bias was observed in the two languages. Likewise, in a recent study of middle-class children learning English, Italian, Spanish, Dutch, French, Hebrew, and Korean, Bornstein et al. (2004) report few crosslinguistic
differences in vocabulary composition, with mothers of children in all language communities reporting more nouns than words in other language classes. Interestingly, Caselli et al. also report that Italian-learning children were likely to have more social terms and names for people in their vocabularies than English-learners, suggesting that cross-linguistic differences in vocabulary composition may be more attributable to social or cultural factors (e.g., a tendency to live near extended family) than specific features of the language. Similarly, in a study of children learning English, Italian, and Spanish in urban and rural communities (Bornstein & Cote, 2005), the observed variation in vocabulary size and composition was generally attributable to cultural factors, favoring urban over rural settings, rather than to the particular language being learned.

However, the claim that a “noun bias” may be a universal feature of early conceptual and linguistic development has been challenged by other studies of children learning Korean (Choi & Gopnik, 1995), Mandarin Chinese (Tardif, Gelman, & Xu, 1999), and Japanese (Fernald & Morikawa, 1993). All of these languages have features that make them more verb-friendly than English and Italian. For example, while both Italian and Mandarin are “pro-drop” languages, Mandarin verbs are considered to be more morphologically transparent than Italian verbs with their rich morphology. Indeed, naturalistic observational data indicated that young Mandarin-learners produced a higher proportion of verbs than nouns, compared to their Italian- and English-speaking peers (Tardif et al., 1999). This is in contrast to a consistent pattern of noun dominance using parent report, suggesting that parent report may tend to over estimate nouns (and underestimate verbs) in children’s vocabularies. Interestingly, Tardif et al. (1999) found that Mandarin mothers produced more verbs than nouns in their spontaneous speech to their children, and Fernald and Morikawa (1993) found that Japanese mothers labeled objects less frequently and less consistently than English-speaking mothers. In several studies, English-speaking mothers were more likely to use and elicit more nouns than verbs from their children, and place them in salient positions in the sentence when engaged in activities such as object-naming or book-reading (e.g., Hoff, 2003; Tardif, Shatz, & Naigles, 1997). Again, it appears unlikely that a single factor can account for the “dominance” of nouns in children’s early vocabularies, but rather children’s early vocabulary compositions are determined by a multitude of factors that happen to vary across languages and language-learning situations.

While many studies have examined the early stages of vocabulary development, it is still difficult to ascertain what a child really knows when they understand or produce a word. When talking about early lexical development, it is tempting to credit a child with “knowing” a word, as if word knowledge is something that the child either has or does not have, i.e., as if words are acquired in an all-or-none fashion. However, early studies noted that children’s early words (e.g., bottle) do not necessarily have the same meanings (e.g., white plastic 6 oz cup with the bright red screw-on lid) as they would for the adult (e.g., receptacles of all shapes and sizes from which one generally pours liquids). Early words are frequently used in very context-specific ways (i.e., under-extensions), only with reference to specific objects in specific situations (Bloom, 1973; Barrett, 1986; Harris, Barrett, Jones, & Brookes, 1988). At the same time, children’s early word uses
might also be considerably more broad (i.e., overextensions) than one would expect based on adult-like meaning categories (Bates, Benigni, Bretherton, Camerini, & Volterra, 1979). For example, a child using the word “dog” to refer to all four-legged animals (dogs, but also cats, cows, and horses) could be an example of a child misrepresenting the adult-like meaning for words. Yet, research has also shown that over- or under-extensions are actually relatively rare (Rescorla, 1980; Harris et al., 1988; Clark, 2003b), and may be less of a reflection of how children represent the word’s meaning in some sort of mental lexicon and more related to the child’s ability to put their lexical knowledge to work in real time (e.g., Huttenlocher & Smiley, 1987). That is, a child who uses the word “dog” when the family cat runs across his path may not actually think that dogs and cats are the same thing, but simply cannot generate the appropriate word in the heat of the moment. Interestingly, children’s over- and under-extensions are considerably more frequent in production than comprehension (e.g., Clark, 2003a), and an experimental study using a looking-preference procedure has shown little concordance between comprehension and children’s over- and under-extensions in production (Naigles & Gelman, 1995). Taken together with research on children’s processing of speech in real time, described in more detail below (e.g., Fernald, Perfors, & Marchman, 2006), these studies suggest that early lexical development is quite gradual. It involves not only building-up “adult-like” meaning representations, but also learning to use words in more and more contextually flexible ways and in more and more challenging contexts (Bates et al., 1979; Barrett, 1976).

5.2. Individual Differences in Vocabulary Development

So far, we have been talking about the general features of lexical development in “the modal child” (Fenson et al., 1994, p. 1). However, there is considerable variation in both when and how children build their receptive and expressive vocabularies (Bates et al., 1988, 1994; Bloom, Lightbown & Hood, 1975; Fenson et al., 1994; Goldfield & Snow, 1985; Nelson, 1973, Peters, 1977, 1983). For example, while many children show signs of word comprehension at 8 or 10 months of age, other children do not respond systematically to the speech around them until several months later. Similarly, some children produce their first words well before their first birthday, while others do not do so until 14 or 15 months of age. The “modal” 18-month-old has already built up a 50–75 word expressive vocabulary, yet other children do not amass this many recognizable words until 22 months or later. Some of these “late talkers” will catch up in vocabulary a few months down the road, while others will remain late and continue to be at risk for language or learning disorders (Bates, Dale, & Thal, 1999). Studies of variation in vocabulary composition have noted that some English-speaking children tend to adhere to a strong “noun bias” tendency, a so-called “referential style” of early word learning (e.g., Nelson, 1973; Pine & Lieven, 1990). In contrast, other children with a more “expressive” style tend to have a smaller proportion of concrete nouns, preferring more “canned phrases” (e.g., I wanna do that!) and social expressions (e.g., “no way Jose!”) (Nelson, 1973).

Such individual differences have been well-documented since the mid-1970s, based primarily on diary studies (e.g., Nelson, 1973). However, important progress in understanding
the extent of individual variation has been facilitated by large-scale studies which rely on reports from parents, e.g., MacArthur-Bates Communicative Development Inventories (CDI) (Fenson et al., 1993) and the Language Development Survey (Rescorla, 1989). While there are clearly limitations to this methodology (e.g., Mervis & Tomasello, 1994), this technique has enabled the examination of variation in lexical milestones in several languages, for example, English (Bates et al., 1994), Italian (Caselli et al., 1999), Mexican Spanish (Jackson-Maldonado et al., 2003), Hebrew (Maitel, Dromi, Sagi & Bornstein, 2000), as well as in children learning two languages simultaneously (Pearson, Fernández & Oller, 1993; Marchman & Martínez-Sussmann, 2002) and in children from urban and rural settings (Bornstein & Cote, 2005). Although there is clearly variation in early acquisition across languages (e.g., Caselli et al., 1999; Choi & Bowerman, 2001; Tardif et al., 1999), research has consistently demonstrated remarkable similarities across languages in the overall size of children’s vocabularies and the extent of the variation that is observed. Commenting on their comparative data across Spanish, English, and Italian, Bornstein and Cote (2005) noted a strikingly similar range of vocabulary knowledge in all three languages, leading these authors to conclude that individual variability is probably a universal feature of early language acquisition.

What are the sources of individual differences so early in development? Some studies have looked to child-factors, such as gender or birth order, to explain variation in lexical development. Studies have documented somewhat larger vocabularies and faster rates of growth in girls compared to boys (Fenson et al., 1994; Huttenlocher, Haight, Bryk, & Seltzer, 1991) and first-borns compared to later-borns (e.g., Hoff-Ginsberg, 1998). Recently, Bornstein and Cote (2005) note a consistent advantage for girls over boys in reported vocabulary in English, Italian, Spanish, across both urban and rural communities. While it is striking to see consistent gender effects in communities that likely vary in gender-based social expectations, these effects are generally small relative to overall developmental effects (i.e., the impact of gender is considerably smaller in magnitude than age effects). Like gender, the impact of birth order is relatively minor compared to other factors, but points to the suggestion that children, even those living in the same family, can differ in the frequency and character of interactions in which they engage on a regular basis.

Indeed, it is well-known that there are considerable individual differences in the quantity and quality of the talk that children hear (e.g., Huttenlocher et al., 1991; Huttenlocher, Vasilyeva, Cymerman, & Levine, 2002; Hart & Risley, 1995), and that several of these features of maternal talk are directly linked to children’s vocabulary outcomes (Hoff, 2003). In a recent large-scale study of low-income families, Pan, Rowe, Singer, and Snow (2005) found that variation in growth in children’s vocabulary from 14 to 36 months was significantly related to diversity of maternal talk, in particular, the number of different words produced during mother–child interaction. Thus, children who hear a rich vocabulary that includes a higher proportion of low-frequency or complex words are likely to develop their own vocabularies at a faster rate (see also Weizman & Snow, 2001; Hoff & Naigles, 2002). However, Pan et al. (2005) also found that features
of maternal knowledge (e.g., scores on standardized tests of language and literacy) and maternal mental state (e.g., depression index) also contributed to child outcomes.

Other researchers have characterized individual differences in terms of cognitive or processing abilities. Typically based on naturalistic data, several early studies proposed that children may vary in the tendency to select analyzed vs. unanalyzed units (e.g., Peters, 1983), the use of strategies for segmentation which favor “word-sized” vs. “phrase-sized” units (Plunkett, 1992; Bates et al., 1988), a predilection for “imitativeness” (Bloom et al., 1975), or the ability to use contextual or linguistic cues to retrieve words (Bloom, 1973). Other studies have used more processing-based measures to assess various skills that could underlie vocabulary development. Using a phonetic discrimination task, Werker, Fennell, Corcoran, and Stager (2002) found that 14-month-olds who were successful at learning phonetically similar words had relatively larger vocabularies. Interestingly, no relation was observed in 18-month-olds, suggesting that this type of skill may only be helpful at the beginning phases of building a vocabulary. Similarly, Swingley, and Aslin (2000, 2002) also found little relation between vocabulary size and the ability of 14- and 18-month-olds to identify words pronounced correctly and incorrectly. However, Fernald and colleagues (Fernald et al., 2001; Fernald, 2002) found that 18- and 21-month-olds who had larger production vocabularies were faster than their lower-vocabulary peers to recognize words based on partial phonetic information and were more efficient at using verb semantics to predict what was coming up in the sentence. Using a similar procedure, Zangl, Klarman, Thal, Fernald, and Bates (2005) found that infants with larger vocabularies were more efficient at processing words that were perceptually degraded. Finally, in a longitudinal sample, Fernald et al. (2006) have recently shown that efficiency of spoken language understanding was related to trajectories of growth in vocabulary from 12 to 25 months, as well as several indices of early grammar.

Thus, individual differences in children’s burgeoning vocabulary knowledge appear to be linked to a variety of skills that come into play during the processing of both linguistic and non-linguistic information during real-time language comprehension. While we are still a long way from knowing exactly how those factors operate over the course of development, it is likely that individual differences in lexical development are linked to a host of factors, both child-related and experience-related, that all contribute to the variation that is so pervasive in vocabulary development.

5.3. Early Word Learning

Observational studies and research using parental report measures can provide normative data on the rate and composition of vocabulary growth by children at different ages, as well as correlational data showing how environmental factors such as the amount and quality of parental speech relate to lexical development (e.g., Huttenlocher et al., 1991). However, an experimental approach is required to examine how young children make use of particular sources of information in the process of figuring out the meanings of novel
words. For example, imagine a scene where a two-year-old visiting her relatives is served an unfamiliar fruit pastry after dinner, and her mother exclaims “What a surprise! Rhubarb!” How is the child to make sense of this remark? Studies exploring versions of this question now number in the hundreds (see Bloom, 2000; Woodward & Markman, 1997). Here we provide a very brief overview of research on some of the factors influencing young children’s interpretation of novel words.

Discussions of this research question often start by framing the problem in terms of Quine’s (1960) vignette of a linguist visiting an unfamiliar culture, accompanied by a native guide who does not speak his language. As a rabbit hops across the scene, the guide exclaims Gavagai! How, Quine asks, can the stranger possibly interpret this utterance, given that the speaker could be referring to the rabbit, to a part of the rabbit, to the animal’s action, or to an indeterminate number of other aspects of the scene? Quine does not provide an answer to this conundrum, emphasizing instead the fundamental impossibility of knowing the intended meaning based on the evidence at hand. In the language development literature, however, it is assumed that a young child in this situation would most likely rapidly and automatically interpret gavagai as rabbit, without considering the myriad other possibilities. Thus the inherent indeterminacy of meaning that was the focus of Quine’s argument is circumvented by the young language learner thanks to interpretative biases that guide early word learning. The idea that word learning gets started with help from some sort of “object-category bias” is supported by experiments in which children are asked to consider novel words in relation to novel objects. When an unfamiliar object such as a toy animal is labeled with an unfamiliar name (e.g., ferret), children typically assume that the new word refers to the animal as a whole, rather than its tail, its color, or the stuff it is made of (e.g., Markman & Hutchinson, 1984).

Although a bias for naming the whole object is predictably observed in experiments of this sort, there is considerable debate as to how this phenomenon should be interpreted. What factors lead the child to guess that the new word ferret is a name for the animal as a whole and other animals of the same kind, rather than its parts or properties? Three different approaches to this question have been discussed extensively: The first approach emphasizes the importance of preverbal perception and cognition in guiding word learning. Because objects are perceived as bounded and coherent and thus are salient even to infants (e.g., Spelke, 1998), we are predisposed from infancy on to see the world as containing cohesive objects. This could explain why children as well as adults are biased to identify (and to name) an object as a whole before attending to its parts and other attributes (Gentner, 1982). Moreover, nouns naming concrete objects are conceptually simpler than relational words like verbs and adjectives, which can vary substantially in the perceptual features they refer to depending on the nouns they are associated with (e.g., a good cookie vs. a good dog). According to Gentner and Boroditsky (2001), such non-linguistic aspects of human perception and cognition in relation to language structure could account for the tendency of infants to learn names for objects before they learn names for actions and attributes. A second approach to studying factors that guide early word learning emphasizes the critical role of social cognition, a perspective that has roots in Vygotsky’s (1962) theory of social support for learning and in Bruner’s (1975) views
on how reference first emerges in preverbal communication. Current research on the social origins of linguistic knowledge focuses on children's emerging awareness of the referential intentions of others in figuring out what unfamiliar words might refer to. For example, several studies have shown that when children hear a novel word, they will connect it with an appropriate object only if they somehow appreciate that the adult intended to name the object (e.g., Baldwin et al., 1996; Tomasello & Barton, 1994).

A third approach to understanding early word learning proposes linguistic constraints that account for children's biases in interpreting novel words. According to Markman's (1989) influential formulation of this position, such constraints are default assumptions that serve to limit hypotheses as to possible meanings for a new word. In particular, the whole object assumption guides the child to associate a new word with the entire object, while the taxonomic assumption guides the child to extend that new word to other objects belonging to the same class rather than to thematically related objects. Another proposed word learning constraint is the mutual exclusivity assumption, a kind of exclusionary learning strategy that has recently been demonstrated in studies with infants as young as 15 months of age (Halberda, 2003; Markman, Wasow, & Hansen, 2003). When a young child is presented with a familiar object with a known name (e.g., a ball) along with an unfamiliar object (e.g., a whisk) and is then asked to find the dax, the typical response is to choose the whisk. One interpretation of this effect is that the child automatically maps the novel word onto the novel object rather than assigning a second name to the ball, guided by the default assumption that an object can only have a single name (e.g., Markman & Wachtel, 1988). Other researchers disagree that this effect is specific to word learning, arguing instead that it is grounded in pragmatic knowledge (see Bloom, 2000; Clark, 2003b). For example, Clark (1997) argues that children's bias against lexical overlap is best explained in terms of a "principle of contrast" which leads them to assume that differences in form should correspond to differences in meaning. It is interesting to note that even dogs show a related form of exclusionary learning, mapping novel spoken words onto objects for which no name has previously been learned (Kaminski, Call, & Fischer, 2004). However, although this finding suggests that a learning principle based on mutual exclusivity might not be specific to human language, it is also clear that animal learning of word-object associations differs in important ways from lexical learning by children (Bloom, 2004; Markman & Abelev, 2004).

The robust learning biases demonstrated in these experiments are certainly consistent with the notion that children rely on strategies specifically adapted for lexical learning. However, the view that such learning biases are automatic and language-specific has come under criticism from many directions. Children's early vocabularies do not consist only of nouns and include types of words (Hi! Up! More!) quite different from the object names supposedly favored by lexical constraints (Nelson, 1973). And for some first words (e.g., bath) that are technically nouns, it is not at all clear whether they are understood by the child as an object or an action, or as a routine involving both. Although word learning constraints are proposed as a solution to the problem characterized in Quine's (1960) dilemma, many scholars of early language learning (e.g., Bloom, 1993, 2000; Clark, 2003a, 2003b; Nelson, 1988; Tomasello, 2003) point out that the young child is
not really comparable to the linguist who speaks a first language different from that of the native guide, and that the guide is not at all like the parent of a small child. In the ecology of early parent–child interaction, the adult takes the perspective of the linguistic novice in many ways, providing both simplified language input (e.g., Lieven, 1994) and many pragmatic cues to reference using gaze and gesture that young children are able to use in figuring out what new words mean (Tomasello, 2003).

Another way in which Quine’s example of linguistic indeterminacy has been oversimplified as a model of early word learning is that novel objects do not always hop across the scene as the single most salient focus of attention. Imagine a variation of this scenario: the native guide fires his gun as he yells *Gavagai!* and the rabbit falls down dead. Under these circumstances, the linguist as well as the child would presumably not default automatically to a static whole-object interpretation of this string of sounds, but might assume *Gavagai!* meant something like *Watch out!* or *Got it!* or *Dinner!* The everyday situations in which word learning occurs are often much more dynamic and ambiguous than the experimental setups in which word learning is studied scientifically. In the example above in which the mother exclaims “Rhubarb!” as the dessert is placed on the table in front of her 2-year-old, the child will only gradually figure out what this word refers to, learning based first on the taste and texture of the cooked fruit and only later on other properties of rhubarb as a plant. Does this mean that a mapping error will occur, as the child automatically attempts to apply the new word to the pastry itself as a whole object? It seems more likely that the child will pick up on social cues indicating that the mother’s remark is addressed to others at the table and is not intended as a label, one of several reasons a word may simply be ignored on first exposure. After all, infants hear thousands of words in a week yet learn to use only one or two new words a day.

Although critics of the linguistic constraints position may object that the point of Quine’s (1960) example has been distorted in the developmental literature, they agree that young children face a daunting inductive problem in assigning meaning to an unfamiliar sequence of speech sounds. But it is possible to agree that children need to limit the potentially large number of hypotheses for word meanings without assuming either that this kind of inductive problem is unique to word learning, or that constraints in the form of default assumptions are the only way to solve the problem. Bloom (2000) points out that children face comparably complex inductive problems in other domains of experience all the time. When a child grabs the handle of an iron skillet sitting on a hot stove burner, she has to figure out what to avoid in the future in order not to get burned again. Is it the skillet or just the handle? Or could it be anything shiny and white like the stove? In this case, avoidance of the skillet itself might reflect a non-linguistic whole-object bias, a reasonable first guess until the child developed a deeper understanding of the causal processes involved. In another example of a proposed word-learning constraint that may be much more general in its scope, Markson and Bloom (1997) show that the phenomenon of “fast mapping” a novel word to a novel object is not limited to lexical learning. When children hear a novel word described as a *koba*, they remember which object the new word referred to; however, when they hear a novel object described as “the one my uncle gave me,” they are equally good at remembering which object the *fact*
referred to. Bloom and Markson (2001) argue that many of the findings about how novel words are extended are best explained in terms of general cognitive systems such as those involved in concept formation and intentional inference, rather than through proposed linguistic constraints that are dedicated uniquely to word learning.

In an early critique of the theory that linguistic constraints are essential for learning new words, Nelson (1988) pointed out that the first formulations of this position traced their intellectual roots to Chomsky's (1975) claims for innate mechanisms for learning grammar, extending this framework to lexical learning. This perspective is consistent with an emphasis on default learning strategies that privilege some sorts of information and are impervious to others. Just as some nativist theories of adult language comprehension posit autonomous parsing strategies favoring syntactic structure over all other kinds of linguistic information (e.g., Frazier & Rayner, 1987), the initial emphasis in constraints theory was on how children are restricted by strong, possibly innate, default assumptions as to what a new word might mean (e.g., Markman & Hutchinson, 1984). In more recent accounts of the linguistic constraints position, these word learning strategies are framed as more flexible heuristics, i.e., as somewhat "softer" constraints (Woodward & Markman, 1997). But the focus is still on how children are inherently limited in their interpretative strategies, rather than on how they may integrate different sources of information in different contexts.

As mentioned earlier, the idea of inflexible parsing strategies in adult comprehension has been challenged by many new studies showing how listeners integrate probabilistic information from multiple sources (Seidenberg, 1997). In research on early word learning as well, there is mounting evidence that infants use diverse sources of linguistic and non-linguistic information in making sense of new words, guided by learning biases that are construed more appropriately as preferences than as constraints (e.g., Bloom, 1993; Hollich, Hirsh-Pasek, & Golinkoff, 2000). As Nelson (1988) put it, "The connotation is quite different: Constraints imply restriction -- a closing down of choice; whereas preference implies free, but biased, choice" (p. 228). These new models of early word learning draw on insights articulated years ago in the "competition model" of Bates and MacWhinney (1979, 1987, 1989), namely that multiple sources of information are available to the young language learner and that the influence of different information sources varies both as a function of their strength as cues in relation to other cues, and also as a function of the developmental level of the child. Research on word learning is just beginning to investigate the relative contributions of multiple cues on novel word interpretation by children at different ages. For example, many studies have shown how the shape of a novel object influences children's categorization and naming. Although in their everyday experience, children often experience new objects in motion surrounded by other objects, almost all experiments on the "shape bias" have used isolated static objects as experimental stimuli. However, when Smith (2005) presented 2-year-olds with dynamic stimuli, she found that movement influenced children's judgments as to which objects were similar. Findings like this will lead developmental researchers increasingly toward a different formulation of the question, one more in line with the probabilistic constraints approach to investigating language comprehension by adults (Seidenberg & MacDonald,
1999). To get beyond the question "Is there or is there not a shape bias?" (e.g., Cimpian & Markman, 2005), studies will begin to investigate when and under what circumstances shape is an important factor in object categorization, and how shape interacts with other perceptual features as well as linguistic and social cues in the referential context in guiding the child's inference as to what a new word refers to.

6. LISTENING FOR MEANING IN SPEECH IN THE SECOND YEAR

Infants' early progress in developing language is often charted in terms of their increasing competence in understanding, producing, and learning individual words, an ability that is arguably shared in some respects with other species (Kaminski, Call, & Fischer, 2004; Seidenberg & Petitto, 1979). However, the ability to understand and use words flexibly in combination is a critical distinguishing feature of human language. Of course, it was Chomsky (1959) who pointed out long ago that multi-word sentences are much more than individual words strung together one-by-one. Grammatical sentences are made up of units of words that vary in size and are organized hierarchically in a large, but finite, set of complex ways that are not always obvious from the surface-level ordering of the words. While traditional views held that the language-learning child must be innately endowed with such grammatical knowledge, recent perspectives have continued to examine ways in which such proficiency can be constructed over the course of development. In this section, we review recent research on how infants develop impressive efficiency in understanding words in continuous speech across the second year, and on how they begin to use words in combination to express increasingly complex meanings through language.

6.1. The Development of Efficiency in Language Understanding

To make sense of the rapidly spoken strings of words that make up the language children hear, they must learn to process fluent speech efficiently, "listening ahead" to anticipate what is coming next in the speech stream using different sources of linguistic and non-linguistic information. Many recent studies using on-line measures of comprehension with adults have shown that skilled listeners draw on multiple sources of knowledge to process speech with remarkable speed and efficiency (e.g., Tanenhaus et al., 1995). With the refinement of eye-tracking techniques for use with infants, it is now possible to monitor the time course of spoken language understanding by very young language learners as well. Using a looking-while-listening procedure with English-learning infants from 15 to 24 months of age Fernald, Pinto, Swingley, Weinberg and McRoberts (1998) found dramatic gains in the speed and accuracy of word recognition over the second year. In this procedure, infants look at pictures of familiar objects while listening to speech naming one of the objects. Fifteen-month-olds responded inconsistently and shifted their gaze to the appropriate picture only after the offset of the target word, while 24-month-olds were faster and more reliable, initiating a shift in gaze before the target word had been completely spoken. A recent longitudinal study following infants from 12 to 25 months found that on-line measures of efficiency in speech processing were correlated with numerous more traditional measures of lexical
and grammatical development (Fernald et al., 2006). Moreover, analyses of growth curves showed that children who were faster and more accurate in on-line comprehension at 25 months were those who showed faster and more accelerated growth in expressive vocabulary across the second year. Success at word recognition in degraded speech is also correlated with vocabulary size in the second year (Zangl et al., 2005), further evidence that speech processing efficiency is related to other dimensions of early language development.

A possible benefit of the increase in processing efficiency over the second year is that it enables infants to identify words more quickly based on partial phonetic information, rather than waiting until the word is complete. However, one consequence is that the young language learner is increasingly confronted with problems of temporary ambiguity. When Allopenna et al. (1998) presented adults with objects that included candy and a candle and asked them to Pick up the can-, they waited to hear the next speech sound before orienting to the appropriate object. That is, they postponed their response until the final syllable of the target word made it clear which object was the intended referent. The child who hears Where’s the doll? in the presence of a doll and a dog is also faced with a temporary ambiguity, given that doll and dog overlap phonetically and thus are indistinguishable for the first 300 ms or so. Swingley, Pinto, and Fernald (1999) found that 24-month-olds in this situation also delayed their response by about 300 ms until disambiguating information became available. Even when they heard only the initial phonemes in familiar words (e.g., the isolated first syllable of baby or kitty), 18-month-olds were able to use this limited information to identify the appropriate referent (Fernald, Swingley, & Pinto, 2001). Further evidence for early use of phonetic information in a probabilistic fashion comes from studies by Swingley and Aslin (2000, 2002) showing that even younger infants can identify familiar words when they are mispronounced, but respond more strongly to the correct than to the incorrect version (e.g., baby vs. vaby).

Children also become increasingly attentive to prosodic and morphosyntactic regularities in speech that enable them to anticipate upcoming content words in the sentence, also relying on probabilistic information (Fernald & Hurtado, 2006). For example, 2-year-olds expect an object name to follow an unstressed article (Zangl & Fernald, under review). When an uninformative adjective occurs instead (e.g., Where’s the pretty CAR?), they “listen through” the prenominal word and wait for the noun before responding; however, if the adjective is novel and accented, they are more likely to misinterpret the unknown word as a potential object name (Thorpe & Fernald, 2006). That is, when the word preceding the target name is stressed as well as lexically ambiguous (e.g., Where’s the ZAV car?) it becomes relatively more noun-like, and 26-month-olds are more likely to respond accordingly by searching for a novel referent as soon as they hear zav, rather than waiting for the subsequent word that names the target object. This tendency of English-learning 2-year-olds to “false alarm” in response to stressed novel words preceded by the article the shows that they are integrating multiple probabilistic cues to predict what kind of word is coming next. Such studies using on-line measures of children’s comprehension as the spoken sentence unfolds reveal a critical dimension of emerging language competence that was impossible to monitor with precision using
off-line methods. As children learn to interpret words in combination, they develop efficiency in integrating distributional, lexical, prosodic, and other available sources of information, enabling them to make sense of words that are known while avoiding costly interference from unfamiliar words in the sentence that are not yet known.

6.2. Emerging Awareness of Relations among Words

By two years of age, most children are demonstrating impressive skill at interpreting the speech that they hear around them. Several studies using preferential listening techniques (e.g., Gerken, Wilson, & Lewis, 2005; Gomez, 2002) as well as neurophysiological responses (e.g., Friederici, 2005) show that children in the second year are increasingly attentive to regularities in speech that are relevant to the grammatical structure of the language they are learning. They have also built up a considerable repertoire of words in their production vocabularies, and are beginning to use two- or three-word combinations (e.g., mommy sock). Soon, however, utterances increase in length and complexity in various ways. Children add more verbs, adjectives, and other predicates to their working vocabularies, and substantively increase their use of prepositions, articles, and other closed-class forms that do grammatical work, including the productive use of inflectional morphemes (e.g., English past tense –ed). At the same time, there is also sizeable variation in exactly when and how children move into more grammatically complex utterances in their everyday language use. Indeed, while some children are reported to use primarily multi-word phrases and many closed-class forms by 24 months, other children are still primarily using nouns in single-word constructions (e.g., Bates et al., 1988; Bates & Goodman, 1999).

Who are the children who are more advanced in grammar at this age? Based on the norming data from the CDI: Words and Sentences, children with the highest grammar scores were also those children with the largest reported production vocabularies \( (r = 0.85) \) (Bates et al., 1994). In the same data set, Marchman and Bates (1994) found that size of verb vocabulary was concurrently related to the number of reported overregularizations of the English past tense inflection (e.g., daddy goed), accounting for significant variance over and above chronological age. These “mistakes” are typically viewed as a major milestone in the development of grammatical rule-based knowledge. Links between lexical development and grammar have also been reported longitudinally. Following 27 children, Bates et al. (1988) found that the best predictor of grammatical sophistication at 28 months (as measured by mean length of utterance, MLU) was size of vocabulary 10 months earlier. Bates and Goodman (1997) cite similar relationships in a sample of children followed monthly from 12 to 30 months.

Other researchers have targeted children at the extremes in acquisition (e.g., late vs. early talkers), revealing that children who were delayed in early vocabulary production were later delayed in the use of grammatical forms (Paul, 1996, 1997; Rescorla & Schwartz, 1990; Rescorla, Roberts, & Dahlsgaard, 1997, 2000; Thal & Tobias, 1994; Thal & Katch, 1996; Marchman & Armstrong, 2003) and that particularly precocious
children display grammar abilities that are commensurate with their vocabulary, even though they are considerably younger than peers at their same level (Thal, Bates, Zappia, & Oroz, 1996; Thal, Bates, Goodman, & Jahn-Samilo, 1997). Similar lexical–grammar links have been found in children with focal brain injury (e.g., Bates et al., 1997; Marchman, Miller, & Bates, 1991; Marchman, Wulfeck, & Saccuman, 2003; Thal et al., 1991), and Williams syndrome (e.g., Singer-Harris, Bellugi, Bates, Jones, & Rossen, 1997). More recently, studies have documented that lexical development and grammar are related to a similar degree in children learning more than one language, with grammatical abilities robustly linked to lexical level in the same, but not the other, language (Marchman, Martínez-Sussmann, & Dale, 2004). Finally, strongly heritability of the relation between lexical and grammatical level has been documented in behavioral genetic studies of monozygotic and dizygotic twins (Dale, Dionne, Eley, & Plomin, 2000). In other words, even though genetic factors make a relatively weak contribution to each aspect of language assessed individually, the genetic factors that influence lexical growth are the same as those that influence grammatical growth.

These studies all point to the idea that vocabulary and grammar development are highly interdependent, a view at odds with the nativist assumption that grammatical knowledge is autonomous and emerges independent of lexical knowledge. In light of the extensive individual variation that is observed in early language development, it is striking that lexical and grammatical skill “hang together” so tightly over acquisition, especially when abilities that would seem to more likely to travel together are less strongly related (e.g., reported lexical comprehension and production). Such interdependence is quite natural, however, within a view of acquisition in which domain-general learning mechanisms guide the child’s construction of a working linguistic system simultaneously at many different levels, in this case, learning words and learning grammatical rules. As Bates and MacWhinney (1987) proposed many years ago, “the native speaker learns to map phrasal configurations onto propositions, using the same learning principles and representational mechanisms needed to map single words onto their meanings” (p. 163, emphasis added). This type of domain-general continuity is directly modeled in connectionist and dynamical systems accounts of language development (e.g., Plunkett & Marchman, 1993; Elman et al., 1996; van Geert, 1998), and is at the core of probabilistic constraint-based explanations of many other psycholinguistic and developmental phenomena (e.g., Elman et al., 1996; Elman, Hare & McRae, 2005; Harm & Seidenberg, 2004; Tomasello, 2003). Interestingly, enhanced reliance on domain-general continuity has gained credibility in several frameworks in modern-day linguistics (e.g., Bresnan, 2001; Croft, 2001; Goldberg, 1995; Langacker, 1987). Finally, several recent studies have focused on ruling out indirect explanations for lexical–grammar links, for example, that lexical and grammatical relations derive from common influences from the environment or general cognitive or linguistic intelligence (e.g., Dale et al., 2000; Dionne, Dale, Boivin, & Plomin, 2003; Marchman et al., 2004).

Clearly, there is much more to be said about early vocabulary and grammar development. Studies are continuing to map out in more and more precise ways how those domain-general mechanisms might operate (e.g., Bates & Goodman, 1999; Tomasello,
2003; Elman, 2004; Naigles, 1996), and how those relations might change in character over development (Dionne et al., 2003; Tomasello, 2003). Yet, the picture that is gaining mounting empirical support portrays language acquisition as a gradual and continual process of mapping various types of linguistic entities onto communicative functions, using mechanisms that are shared across many different levels of the linguistic system.

7. CONCLUSION

Researchers who cross-cut the fields of cognitive science, developmental psychology, and psycholinguistics, have directly questioned key premises of the standard view of language acquisition (e.g., Bates & Goodman, 1999; Tomasello, 2003). Instead of a nativist and modular view, these researchers prefer to characterize language acquisition as a process of coordinating and integrating cognitive, linguistic and communicative information in the context of interaction with the physical and social world. Such “usage-based,” approaches (e.g., Tomasello, 2001, 2003; Goldberg, 1995; Bates & MacWhinney, 1987, 1989; Elman, 2004) generally adopt the idea that the complex and intricate linguistic knowledge that children have emerges gradually over the course of human interaction. The constraints that guide the building of linguistic systems are not necessarily specific to the task of language acquisition, but reflect a set of general learning mechanisms that come together in ways that are particularly good at building grammars from the speech that children hear. These perspectives can be traced back to somewhat different intellectual roots than those guiding the standard nativist view. For example, the interactionist perspectives of Piaget and Bruner (Piaget, 1952; Bruner, 1983) and principles derived from the modern incarnations incorporated in connectionist (e.g., Elman et al., 1996) or dynamical systems approaches (e.g., Thelen & Smith, 1994; Smith & Thelen, 1993) provide key theoretical and methodological tools. Through these perspectives the mechanisms of language learning are envisioned as considerably more interactive, incremental, and powerful than previously thought. In addition, the construction grammar or usage-based approaches in linguistics (e.g., Langacker, 1987; Givón, 1997) have offered a characterization of adult linguistic competence that is considerably more probabilistic, piecemeal, and “child centered” than traditional linguistic approaches (e.g., Seidenberg & MacDonald, 1999; Elman, 2004). Over the last several years, empirical studies demonstrating the remarkable abilities that young language learners bring to the task of acquisition have continually provided new insights into the powerful set of processing and representational mechanisms that characterize human cognition. Researchers have also embraced the study of individual differences and crosslinguistic research as ways to expand our view of how these mechanisms come into play during the real-time task of language learning (Slobin, 1997), i.e., how the child manages to “get there from here.” These perspectives provide the logical and empirical basis for shifting the focus of study from a child who learns words and builds a grammar in relative isolation to a child whose early life is filled with rich and diverse language-learning experiences that may vary in important ways from child to child, from family to family, and from linguistic community to linguistic community. As in other areas of current research on language processing and use by fluent adults, new research on language acquisition is moving away from the assumption that relatively
inflexible default processing strategies are the only way to account for the amazing complexity of early language learning. This brief review of research on how infants begin to make sense of speech sounds over the first two years of life has focused on emerging perspectives in the field. The skill of the human infant in integrating cues from multiple sources of probabilistic information is evident at every developmental level, as the infant first discerns regularities in patterns of meaningless sounds, then begins to appreciate words and their meanings and to build up more complex meanings through understanding and using words in combination.

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There are two main views about the nature of language development. These views can be traced back to the 'nature versus nurture' debate about how knowledge in any domain is acquired. The 'nativist' perspective dates back to Plato's dialogue, "The Meno." This view emphasizes the contributions of human nature to the acquisition of knowledge. It is supposed on the nativist approach to language that children are biologically fitted, as part of the human genome, with a theory of 'Universal Grammar' (e.g., Chomsky, 1965, 1975, 1996). Universal Grammar contains the 'core' principles of language, i.e., principles that are manifested in all human languages. In addition, Universal Grammar spells out particular ways in which human languages can vary; these points of variation are called parameters. Taken together, the principles and parameters of Universal Grammar establish the boundary conditions on what counts as a possible human language. Children navigate within these boundaries as the course of language development. Of course, experience determines which particular language children acquire, but nativists argue that much of the process of language acquisition is biologically driven, rather than being 'data driven.' The nativist approach views language learning as the by-product of a task-specific computational mechanism, with a structure that enables children to rapidly and effortlessly acquire any human language, without formal instruction and despite considerable differences in linguistic experience. Universal linguistic principles are not learned by the computational mechanism, but are implicit in the structure of the mechanism itself - i.e., these are in the Universal Grammar. This implicit (or built-in) knowledge explains how learners come to know more about language than they receive from experience. This is the nativist's solution to 'Plato's Problem.'