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CHAPTER 1

The General Nature of Human Language

A fundamental aspect of human language is that it is the primary means for communication among individuals. Oral discourse is the glue that connects members of the society. It is the primary means for the expression of affection and hostility and the principal vehicle for persuasion and social intercourse in human societies. The written language, providing for communication among members of the society not contiguous in space and time, is, of course, parasitic on the oral language and massively extends the communicative function of human language. The manual languages used by individuals who are hearing impaired have all the richness, complexity, and communicative potential of other human languages.

The Creative Nature of Human Language

A remarkable aspect of human language is its creativity. Every day the sentences we hear and produce are completely new. Except for fixed phrases such as "How are you?" and "Have a nice day," our conversations and our reading matter consist of sentences that are different from one another and different from sentences we have heard in the past. Yet we produce and understand sentences of our language with

no difficulty and very little conscious effort. The simple and prosaic act of speaking and hearing is really an amazingly creative activity. What is it that we know about our language that allows us to do this? Think of what our sentences have in common despite their uniqueness. Each is made up of words of our language, and each has its words arranged in a pattern that is characteristic of our language. Thus, any collection of words that we know, organized according to a pattern appropriate to our language, will constitute a sentence that we could either produce or understand.

It is at least theoretically possible to list all the words an individual knows (probably around 75,000), although it would be very difficult to actually do so. It is impossible, however, to list all the allowable sentence patterns in a language, simply because there is no limit to how long a sentence can be. For example, "The teacher praised the student who answered the question" is a fine sentence of English, but so is "The teacher praised the student who answered the question that was in the book" and "The teacher praised the student who answered the question that was in the book that was published in England." Rather than try to identify patterns, it is much more reasonable to describe the rules that create the patterns. In the three sentences in the above example, the rule of English for relative clause formation was applied one, two, and three times, respectively.

When words are organized by linguistic rules into a sentence, a structure is created that describes the relationship among the words of the sentence. The meaning of the sentence, then, is determined by the meanings of its words and the structural relationship among them. A great deal is said about the structural organization of sentences later in this book, but a couple of examples will help explain this concept. In English the sentence "John loves Mary" has the simplest structure possible: a subject ("John") and a predicate ("loves Mary"). "Mary loves John" has an entirely different structure ("Mary" being the subject and "loves John" the predicate); therefore, although the two sentences have the same words in them, they have completely different meanings. A slightly more complex example is demonstrated by the following two sentences: "The policeman warned the man who drove recklessly" and "The policeman warned the man and drove recklessly." They differ only by the little words *who* and *and*, but their structures, and therefore their meanings, are entirely different. In the first it is the man who is driving recklessly; in the second it is the policeman.

What we know, then, as speakers of our native language, is a set of words (a *lexicon*) and a set of rules (a *grammar*) to combine those words into sentences with structures indicating the relationships among the words. The rules that create structure, called *syntactic rules*, perform three fundamental kinds of operations. They create sentences with basic sentence structure, which in English is subject–verb–object, such as "John loves Mary." They allow elements of sentences to be moved around; for example, in the sentence "Mary was loved by John" the object of "love," "Mary," has been moved from the end to the front of the sentence. Finally, the syntactic rules allow simple sentences to be combined into complex ones. "The policeman warned the man who drove recklessly" is composed of "The policeman warned the man" and "The man drove recklessly." It is the ability of the syntax to create complex sentences that gives human language its unlimited creativity. The grammar also contains *phonological rules*, which determine the sound patterns of the language, the pronunciation of words, and the prosodic characteristics of sentences. *Morphological rules* govern the way affixes are attached to words to modulate their meaning or allow them to agree with other words. We create sentences by combining the words according to the rules, and we understand the sentences of others by understanding the words and computing the structure of those sentences. It is very useful, then, to be able to distinguish between what we know about a language, its lexicon and grammar, from what we actually do with language, which is speaking and understanding. Traditionally, linguists and psycholinguists refer to the former as *linguistic competence* and the latter as *linguistic performance*.

Linguistic Competence and Linguistic Performance

Our linguistic competence, then, consists of our knowledge of the lexicon and rules of our language. When we use our competence to produce and understand sentences, we are demonstrating linguistic performance. The subject matter of the discipline of linguistics is linguistic competence; psycholinguists study linguistic performance. The competence–performance distinction is very important in the study of all aspects of human language, especially the study of child language

and disordered language. We can only observe linguistic performance, but we often want to know the status of a person's linguistic competence. Many factors other than linguistic competence are involved in linguistic performance (performing on language tests, responding in language experiments, etc.). Thus, to assess people's linguistic competence by observing their linguistic performance (which is the only way to do it), one must be very clever and make sure the techniques provide the best possible answer. This is an issue to which I return repeatedly in this book.

A way to think about the grammar is as a translation device (or a complex code) that allows us to convert ideas into speech (encoding) and recover from the speech of others the ideas that they intend to convey (decoding). Language, however, does not have to be spoken; there are signed languages that have all the grammatical richness of spoken languages. In 1978, Siple reported that American Sign Language (ASL), the language of the deaf in the United States, was the fourth most common language in the United States. It has phonological, morphological, and syntactic rules, but its grammar is very different from that of English (Klima & Bellugi, 1979). The existence of signed languages that are demonstrably full, human languages is of great importance, because it demonstrates that the language capacity of humans is distinct from the ability to speak.

As it is possible to distinguish between language and speech, it is also possible to distinguish between language and thought. One way to demonstrate that thought is independent of language is to note that a single thought can be expressed in any human language; thus, the thought must exist independent of language. A philosopher of language, Jerry Fodor, argued that there exists "a language of thought" in a book by that name (1975). Furthermore, we can think of a variety of creatures who surely can think, but have no language—the higher primates (and probably dogs, cats, and hamsters, as well) and human infants.

Closely related to the distinction between language and thought is the distinction between language ability and general intelligence. Contrary to common belief, these two aspects of development are distinct and can be dissociated. It is part of psycholinguistic lore that the geniuses Albert Einstein and Noam Chomsky did not speak until they were 3 or 4 years old. I cannot attest to the truth of this claim, but children with specific language impairment (SLI) are, by definition, of normal intelligence yet severely delayed in their language development. There are other cases of children with profound intellectual impairments but good linguistic skills. Susan Curtiss (1988) reported on such a young woman, whom she called Marta, who has a testable IQ of 47 but who uses long, grammatically complex sentences. Williams syndrome is a form of mental retardation resulting from a genetically transmitted chromosomal abnormality. Despite their intellectual impairment, children with Williams syndrome acquire language rapidly and have good language skills in every area of language; they have large lexicons, create grammatically complex sentences, and use language socially.

The fact that language is distinguishable from thought and intelligence and the fact that it consists of a set of rules that operate solely on linguistic information have led to what is known as the *modular view* of language and language use. The idea is that human cognition is made up of a number of separate modules that interact with one another. One of these modules is the linguistic system, which operates only on linguistic information, but interacts with other aspects of cognition (memory, real-world knowledge, principles regarding the social uses of language, etc.) to determine actual language use.

We can see, then, that linguistic performance, while underlain by linguistic competence, relies on a number of other nonlinguistic abilities. To decode speech one must be able to hear and perceive the speech correctly and hold a representation of the speech sounds in working memory while computing an analysis of them as a series of words with structure. Thus, a person may fail to understand a sentence that is too long or spoken too quickly or in a noisy environment, even if her linguistic competence is adequate for her to understand the sentence in better circumstances. When we are attempting to test a child's linguistic competence, it is very important to make sure that we are not making the task more difficult because of performance factors unrelated to language. For instance, Goodluck and Tavakolian (1982) showed that sentences such as "The cow bit the pig that jumped over the gate" are easier for 4-year-old children to understand than the structurally identical "The cow bit the pig that kissed the sheep." It appears that having to process a sentence with three animate noun phrases increases the difficulty of a sentence for reasons having nothing to do with the child's linguistic competence.

By the same token, we must be careful not to make our sentences too easy because of factors unrelated to language. Very young children and agrammatic aphasics [illegible]

"The apple the girl is eating is red" even if they cannot understand "The cat the dog is chasing is black." This is simply because real-world knowledge tells them that girls, not apples, eat things, and apples, not girls, are red; thus, they do not have to decode the first sentence to understand it. In the second sentence, real-world knowledge doesn't help, so to understand the sentence, the child or the aphasic must figure out its structure; in this case they have difficulty. Thus, factors unrelated to linguistic competence can artificially enhance or inhibit a person's performance on tests and experiments.

Similar caveats apply to our evaluation of the language a child produces. It is by no means clear that we can assess a child's grammar solely by observing what she says. The grammar is certainly employed when a person translates an idea into a spoken sentence. After all, the meaning of the sentence is a function of its words and their structural organization. However, other nonlinguistic factors also affect speech production. We know that approximately a clause-sized chunk of an utterance is stored in working memory before speech begins (Garrett, 1988). Speech itself is a highly complex motor skill. Production of a simple sentence requires the organization of over 100 muscles of the mouth, tongue, and respiratory system. A hallmark of the speech of a young child is that sentences are very short, missing "little words" such as *a, the,* prepositions, and so forth. A number of studies have demonstrated, however, that children respond to (therefore, mentally represent) words that they do not yet produce. This is a particularly important consideration when one is evaluating the speech of a child with a language problem. Such children typically produce very short, spare sentences. It is crucial to determine whether their production is a result of a deficit in grammatical knowledge or in production ability.

This distinction between linguistic competence and linguistic performance is very important for people whose job it is to evaluate children's language. Communicative interaction always occurs in social contexts, with a great deal of shared information between the child and the people with whom she is talking. Thus, the meanings of the sentences she uses and understands are multiply determined. Children with very slightly impaired linguistic skills are often conversationally quite appropriate, so they are not identified as having a language problem. Later, when they attend school, they may have difficulty learning to read; only then will the underlying language disorder be discovered. The relationship between spoken language abilities and emerging literacy is only beginning to be understood, but it is profound. Many reading difficulties seem to be related to an inability to process linguistic structures. Children with readily observable language impairment in the early years almost inevitably have difficulty with reading when they begin school.

The Uniqueness of Human Language

The creativity described previously is a feature of human language and not of any other naturally occurring animal communication system. Some animal communication systems, such as the dance of the bee (von Frisch, 1953, 1962) and the songs of certain birds (Marler, 1991), are creative in the sense that they consist of units organized into patterns. The dance that the honeybee performs to indicate the location of food and the song a bird constructs to woo his mate do seem to be rule governed in much the same way that human language is. However, these systems lack the creativity of language that derives from the human ability to communicate any thought linguistically. The bee can dance only about the location of food; the bird can sing only to find a mate or mark his territory. Our closest relatives in the animal kingdom, the great apes (chimpanzees and gorillas), have communication systems in the wild that consist simply of a list of calls, each of which has a unique meaning. Their communication systems have no combinatorial power whatsoever.

Many experiments over the years have attempted to teach human-like languages to gorillas and chimpanzees. The most successful of these have been gestural communication systems patterned on, but certainly not as structurally rich as, American Sign Language. Apes can be taught a large vocabulary of individual signs and have even been known to combine a few signs. They certainly engage in communication with their handlers. Through these studies, we have learned a great deal about the cognitive abilities of these remarkable animals, but we have also learned that they cannot be taught a rule-governed communication system like that of humans (Premack, 1976).

The conclusion, then, is that language, if understood to be a system by which words are organized into structures by rules, is unique to humans. It is entirely possible that early hominids such as *Homo*

erectus or Neanderthal had linguistic systems similar to ours, but since none of those species still exists, *Homo sapiens* (us) seems to be the only animal with this special kind of linguistic communication system.

Although human languages vary a great deal in their words and grammatical rules (as anyone who has attempted to learn a second language in adulthood can attest), there are a number of basic similarities among the world's languages. Very few words in one language have direct translation equivalents in another (except, perhaps, for purely referential words, such as animal names and body parts). At the same time, lexicons are highly similar in that they all provide the means for talking about the things that humans need to talk about, although fine points of the meaning encompassed by individual words may differ, even in highly related languages. Lexicons are open-ended in that a language may add as many words as it needs as new concepts need to be expressed. For example, many industrialized nations need the word *microchip* in the lexicons of their languages, whereas other cultures can do nicely without it.

We have already alluded to a major similarity among all languages—that is, they all have rules that create structures. Furthermore, all rules of human language are "structure dependent." This means that the rules of syntax always make reference to the structure of sentences rather than to any nonstructural property. We can look to one of the syntactic rules that move things around for an example of a structure-dependent rule. If we want to make a yes–no question out of a sentence such as "The girl is intelligent," we move the verb to the front of the sentence for "Is the girl intelligent?" If, however, the initial sentence is "The girl who is a pianist is intelligent," we do not move the first instance of *is* to the front to form a question. That would give "*Is the girl who a pianist is intelligent?" (The asterisk in front of the sentence means that it is not a well-formed sentence.) Instead, we must move the *is* that is the main verb of the sentence—the verb that agrees with the subject of the sentence—for "Is the girl who is a pianist intelligent?" This is a structure-dependent rule in that the concept of "subject of the sentence" is a structural concept. In our example, the subject of the sentence is "The girl who is a pianist," a noun phrase modified by a relative clause. It could be indefinitely long—"The highly intelligent girl who is a pianist who played at Carnegie Hall . . . . " No matter how complex, the entire structure constitutes the subject of the sentence, and *is* agrees with it. Therefore, *is* is the element that moves to the front of the sentence to form a yes–no question. No human language has a rule such as "move the first verb to the front of the sentence to form a question" or "move the third word of a sentence to the front to form a question" or "say the sentence backward to form a question." Those impossible rules refer to nonstructural properties of sentences. Thus, there are *constraints* on the rules that form sentences, and many of them are the same for all human languages.

Although there are constraints common to all human languages, many features of language structure do vary widely. However, languages seem to be divisible into classes, depending upon the linguistic devices they employ, with sets of linguistic properties clustering together in a relatively small number of classes. One basic division between language types, for instance, is that some languages are right-branching and some are left-branching. This refers to the direction of embedding within complex sentences. In right-branching languages, such as English, relative clauses follow the noun phrase that they modify, whereas in left-branching languages, such as Japanese or Korean, the relative clause precedes. Thus, in English we would say, "The man I saw yesterday was my uncle," whereas in Japanese the sentence would be "Watashi ga kinoo atta hito wa watashi no ojisan desu," literally translated "I yesterday saw the man my uncle is." Whether a language is right- or left-branching is related to its standard word order, with that of right-branching languages usually subject–verb–object and that of left-branching languages subject–object–verb (Goodluck, 1988).

Another example of a basic division among languages is whether they allow sentences without explicit subjects. Languages such as Italian and Spanish, but not English, are so called "pro-drop" languages. They allow sentences such as "Raining" (English would require "It's raining") and "Eats an apple" if the subject of *eats* is obvious from the context (English would require "She eats an apple"). Many aspects of the auxiliary and modal systems are similar for pro-drop languages and differ for languages that do not allow pro-drop (Hyams, 1986).

Linguists have come to refer to these dimensions of variation in human languages as *parameters* (Chomsky, 1981; Hyams, 1986). Some parameters seem to be binary, such as the one that describes whether

a language is right- or left-branching. Other variations among languages are not so clear-cut. For instance, languages differ in the degree to which they rely on word order, as opposed to inflections, to encode grammatical information. On one end of the continuum is a language such as English, which has very severe restrictions on word order and no case markings except on pronouns. Thus, information about which is the subject of a sentence and the object of the verb must be encoded by placing the former in initial position and the latter immediately after the verb. Order is the only distinction between the meaning of "The man loves the woman" and "The woman loves the man." On the other hand, German has some constraints on word order, but they are not as severe as those of English because it also has case markings to indicate grammatical relations. Thus, to indicate that the woman loves the man, one may say either "Die Frau liebt den Mann" or "Den Mann liebt die Frau" because the article *den* signals that *Mann* is in the objective case in both sentences. Maximally different from English in this regard is Finnish, which has very few restrictions on word order (other than stylistic preferences) and a rich and complex system of case markings.

I say more about both the universal constraints on grammars and the parametric variation among languages later in this book. These theoretical ideas have played a major role in much contemporary research in language acquisition.

The Biological Basis of Human Language

The fact that language is unique to the human species (species specificity) and similar across languages (species uniformity) leads us to the hypothesis that drives most of modern language acquisition theory: There is a large "innate" component to human language. Innate is in quotation marks because the word means different things in different scientific contexts, so it is important to understand exactly what it means in a theory of language acquisition. Biologists refer to innate birdsong as the song of a bird who has never heard the song of its species. Language acquisition theorists certainly do not mean this, because a child who never heard human language would acquire no language at all. Another use of the term innate in biology is to refer to a characteristic of an individual that develops normally through maturation, needing no environmental input, such as the song of the *Teleoarvllus* cricket (Cairns, 1991; Cairns & McDaniel, 1991; Dawkins, 1986). Goldin-Meadow and her colleagues have for many years studied deaf children of hearing parents who are not exposed to a signed language. Such children develop their own wordlike gestures, known as "home signs," which they combine in order to communicate. The orders that they create are not arbitrary, however; indeed, they seem to invent very rudimentary rules governing word order (Goldin-Meadow & Mylander, 1990). Fascinating as these invented communication systems are, however, we would certainly not want to claim that a full human language would develop without input. Children must experience language, either spoken or gestural, to develop grammar and a lexicon.

What is really meant by the claim that human language is innate is that it is biologically based. Human infants are specially prepared by virtue of being human to acquire a language with the unique features of human language. We know that language is rooted in the neurological system. In the adult, language abilities are lateralized in one of the hemispheres of the cortex of the brain (the left for most right-handed people and 60% to 70% of left-handed people; for others it is lateralized in the right hemisphere). A great deal is now known about how language is stored in the brain, through studies of aphasics, people whose language ability is impaired as a result of damage to the language areas of the brain. Users of signed languages can also develop aphasia as a result of brain damage. They can use their hands for ordinary tasks, but experience difficulty in signing, as aphasics with spoken language have difficulty speaking, although their articulatory organs are unimpaired (Poizner, Klima, & Bellugi, 1987). A variety of other kinds of studies have demonstrated areas of the brain specialized for various functions. For instance, the brain-mapping techniques developed by Ojemann (1983) have demonstrated localization for lexical, semantic, syntactic, and short-term memory functions within the left hemisphere.

We assume that as the neurological system evolved, so did the human's language abilities (Pinker & Bloom, 1990). The similarities among human languages, then, derive from the genetic properties that characterize our species. The constraints on variation in human languages must arise from the fact that only certain forms of representation can be incorporated into the human neural structure.

Despite the very large variation among human cultures, with some seemingly more "primitive" than others, there is no such thing as a primitive language in a human society. People who hunt with bows and arrows and cook on open fires speak languages as complex and sophisticated as those of people in modern industrial countries.

Another argument for the biological basis of language is the phenomenon of the "critical period" for language acquisition. Languages seem to be learned much more easily before puberty than after. Moreover, second languages learned before puberty are usually spoken without an accent, whereas later-learned languages are not (Seliger, Krashen, & Ladefoged, 1975). The unfortunate individual who has not acquired any language before puberty has virtually no chance of ever learning a full human language. Such was the fate of a girl called Genie (Curtiss, 1977; Curtiss, Fromkin, Krashen, Rigler, & Rigler, 1974), who was imprisoned by an abusive father, unable to hear speech, until she was 13 years old. Linguists at the University of California, Los Angeles, attempted to teach her language, with mixed success. She acquired a vocabulary and some rudimentary word order rules, but was never able to acquire the morphological and syntactic rules of English. Newport (1990) studied the critical period effect in users of ASL. All had been using the language for over 30 years, but they differed in the ages at which they had initially acquired it; for some it was their native language, others had learned it in childhood, and still others learned it in adulthood. Newport demonstrated a dramatic difference between those who had acquired ASL in childhood and the older learners. Even the older learners (like Genie) fully mastered word order constraints, but they were markedly inferior to the younger learners in their knowledge of the morphology of ASL. Newport has demonstrated similar effects among people who learned English as a second language in youth versus adulthood. These related phenomena probably all derive from the neurological plasticity of the brain during the critical period. Damage to the left hemisphere of the brain is much less likely to result in permanent aphasia if it occurs before puberty than in adulthood (Foss & Hakes, 1978).

The proposition that human language is innate, then, is really that it is biologically based, in the same way that other characteristically human abilities (e.g., upright posture and the ability to solve problems) are. The neurologist Eric Lenneberg (1967), in arguing for the biological basis of language acquisition, noted that the acquisition of

language is more like a purely maturational skill, such as walking, than it is like a skill that must be taught, such as riding a bicycle. It does not need to be taught; all normal children achieve the skill naturally. In fact, the failure to either walk or talk constitutes a pathological condition. Lenneberg also pointed out that each of the biologically determined activities, such as walking and talking, has a regular sequence of development shared by all members of the species.

Uniform development is another kind of species uniformity that creates a very strong argument for the biological basis of the acquisition of language. Everywhere in the world, typical children babble in the first year of life and utter their first word early in the second. Petitto (1992) demonstrated that deaf children who are acquiring ASL also babble gesturally and follow the same developmental sequence in acquiring language that speaking children do. Utterance length is very similar for all child speakers (and signers), and some other properties of early speech are predictable developmentally, even though from the beginning the child's vocalizations reflect properties of the native language, as well. In every human community, language is acquired naturally, without specific instruction. Cultural norms with respect to child-rearing practices vary dramatically among human societies. There are some in which adults speak to children very little, and others in which most parents pay a great deal of attention to communication with their children. Although communication practice varies greatly, language acquisition does not.

Because the word innate has a number of different meanings, it is probably safer to characterize the view that language development is biologically based as *nativist*. The nativist view is that infants are specially prepared neurologically to organize the speech that they hear around them into a grammar that is a possible human language, which is constrained in the ways that all human languages are. Children end up with a richer system of knowledge than would be predicted from the sentences they hear if there were no genetically provided linguistic framework with which to organize those sentences. Although each child learning a particular language hears different sentences in her environment, all children in that linguistic environment end up with virtually identical grammars of the native language. This is because each child is creating the language anew using the same principles of organization. Language acquisition is a special case of the general puzzle identified by the philosopher

Bertrand Russell (1948): "How comes it that human beings, whose contacts with the world are brief and personal and limited, are nevertheless able to know as much as they do know?" (p. 5). Language is by no means the only feature of human cognition that is believed to be biologically based. Developmental psychologists are finding that infants seem to be predisposed to develop such concepts as causality and numerosity without (or with very little) experience (Spelke, 1988).

The experience of children acquiring a creole language is a fascinating and convincing example of the creation of language by children. When people speak different languages and must live and work together, they form what is known as a *pidgin*. This is a combination of the two languages, with common words agreed upon and stitched together with very little grammatical structure. A pidgin does not have the properties of a human language described above. It is a "rudimentary" communication system. When the pidgin speakers have children, however, they hear the pidgin as the language of the environment and create for themselves a language known as a *creole*, which is a fully human language. The organizational powers of the children's biologically based linguistic system have allowed them to form a rich language from an impoverished one (Bickerton, 1984, 1988).

The nativist hypothesis, incorporating as it does the claim that children acquire more language knowledge than would be predicted on the basis of the speech they hear, and also the claim that children do not have to be taught language, has been extremely controversial. It is similar to the nature–nurture debate that has taken place in many areas of human psychology. In the next chapter I explain that the controversial nature of this view of language acquisition derived from the fact that when it originated it was in fundamental opposition to the then-current ideas about language learning. Now all language acquisition theorists believe that there is a nativist component to language acquisition. The differences among them center on two issues: (a) the degree of importance of inborn factors in language development and (b) the question of whether those factors are uniquely linguistic (particular to a language module) or are features of general cognition.

CHAPTER 2

A Theory of Language Acquisition

In this chapter I sketch a contemporary theory of language acquisition, one that assumes that inborn biological factors interact with environmental information as children acquire their native languages. Before moving to current theory, however, it is instructive to take a look at the recent history of the study of language acquisition.

Historical Perspective

The field of language acquisition is one of the areas of psycholinguistics, which, in turn, is a hybrid field that combines the disciplines of cognitive psychology and linguistics. To get a sense of the historical development of language acquisition theory, then, it is essential to examine developments in the fields of psychology and linguistics.

In the late 1950s and early 1960s, psychology adhered to a philosophical position that had begun early in the 20th century. It was conceived of as a science of behavior, as opposed to a science of internal mental processes. The philosophical position was called *behaviorism*, and the psychologists who ascribed to it (virtually all academic psychologists with the exception of psychoanalytically oriented clinicians) were called behaviorists.

The fundamental tenet of behaviorism was that all organisms learned their behaviors according to the same principles of learning, and those principles responded only to the external experience of the organism. No inborn proclivities for particular behaviors were invoked to account for the acquisition of a creature's behavioral repertoire; nor were any internal mental representations assumed to exist. All behavior, then, was to be accounted for by a general *learning theory* that would apply to all organisms, animals as well as humans. Many varieties of learning theories were proposed by psychologists; despite their differences they all had in common the constraint that behavior was to be accounted for solely by describing the experience of the organism under investigation.

Probably the most famous behaviorist of the period was the late B. F. Skinner of Harvard. His learning theory, known as *operant conditioning*, was the most radical of all the theories and was the only one (with the exception of Mowrer, 1954) that was explicitly related to language acquisition (Skinner, 1957). It is conceptually simple and it provides a flavor of the behaviorist perspective. The idea is that an animal will produce a variety of behaviors; those behaviors that are rewarded (reinforced) will increase in frequency and intensity, whereas those that are not rewarded will fade. What appear to be complex behaviors are really only chains of simple behaviors that have been reinforced. There is a famous film of a pigeon Skinner had taught to "bowl." The pigeon would waddle in and hit a Ping-Pong ball with its beak, knocking down a set of pigeon-sized bowling pins. Skinner had *shaped* the bird's behavior by first rewarding him when he walked close to the Ping-Pong ball, then rewarding him selectively only when his beak touched the ball, then rewarding him selectively only when his beak touched the ball hard enough to make it move, and so on, until the individual rewarded behaviors formed a complex chain that gave the appearance of a single motor skill, bowling.

Because the behaviorist philosophy asserted that all animals and humans acquire behavior by the same principles, research was carried out primarily with animals. The principles, however, were extended to humans. The assumption was that speech in humans was a complex chain of individually rewarded behaviors, similar to the pigeon's bowling. The idea was that each infant emits speech sounds, and those of his environment are rewarded by his caretakers. Words are acquired when sequences of speech sounds that combine to make a word are rewarded; phrases and sentences constitute rewarded sequences of words.

This conception of language acquisition fit nicely with the way linguists were thinking about language in the same historical period. They described languages by first describing the sounds of the language, then the rules by which the sounds combined to make words, and finally the patterns by which words formed phrases and sentences. A language was regarded as a complex system of behavior, rather than as a system of knowledge shared by the speakers of the language (a notable exception was Sapir, 1933). There was no conception of the universality of human language or constraints on its form. It was once believed that human languages can vary without limit. This version of linguistics was called *taxonomic* because its primary goal was to discover and categorize the linguistic units of individual languages. In one of the most well-known linguistics books of this period, Bloomfield (1933) explicitly adopted a behaviorist view of language.

This discussion of behaviorist psychology and taxonomic linguistics has been very brief and has left out many details. You can read more about this period in Cairns and Cairns (1976) and Kess (1992). It is also interesting to note that Skinner extended his theories to the realm of language, politics, society, and the question of free will (Skinner, 1973).

The person who changed for all time our conception of language and its use was Noam Chomsky, a young Massachusetts Institute of Technology professor. The papers he wrote in the early 1960s claimed that language is not simply a collection of speech sounds organized into words and phrases; nor is it a complex chain of speech behaviors shaped in the infant; nor can it vary without limit. He said that human language comprises a complex set of rules that are known by speakers of a language and used by them to construct and perceive sentences in that language. Chomsky argued that linguistics should be thought of as theoretical psychology, and that psychology should be considered a theory of mind rather than of behavior. Further, he claimed, there is a fundamental similarity among all human languages, and that similarity is rooted in human biology. Children are not taught language by reward and nonreward, but acquire it naturally through an interaction between inborn structures and experience with the language of the child's environment.

Chomsky's ideas were highly controversial in the 1960s, in both linguistics and psychology. They detonated scientific revolutions in both fields, the repercussions of which are still being played out today. (A man named Thomas Kuhn wrote a fascinating book in 1962 titled *The Structure of Scientific Revolutions*. It is required reading for anyone who wants to truly understand the Chomskian revolution in linguistics and psycholinguistics.) Chomsky remains a controversial figure, but his ideas have changed forever the way we think about human language. Farsighted psychologists such as George Miller (1962, 1965) brought Chomsky's work to the attention of psychologists. Many of them came to understand the importance of his work for the discipline of psychology, and the field of psycholinguistics was born (e.g., Blumenthal, 1967; Brown & Hanlon, 1970; Fodor & Bever, 1965; Mehler, 1963; Savin & Perchonock, 1965).

Contemporary Acquisition Theory

The theory of acquisition that has developed since the early days of the Chomskian revolution is nativist in the sense that it is assumed that those aspects of human language that are universal are part of the biological preparedness that the human infant brings to language. Every human infant has the potential to acquire every human language with equal facility. Each language, in turn, incorporates universal principles of grammar and settings for all the relevant parameters that determine the variation in human languages. The collection of universal principles and parameters of possible variation is known as Universal Grammar (UG). Thus, we say that each child is born "knowing" the universal principles and the potential types of variation his language might incorporate. Each child is born "knowing" UG. This is, of course, a metaphor. What we actually mean is that the child's developing brain will construct only those representations allowed by the constraints on human language. It would be incapable of constructing a rule of grammar such that, for instance, a sentence was made into a question by moving the third word to the front. (Crain & Nakayama, 1986, actually demonstrated that children will not create such a rule.) Such a rule would be impossible in a human language; it would not be structure dependent and could not be constructed within the constraints of UG.

Chomsky is famous for coining the term "language acquisition device" (LAD) to refer to a human child. The child's mind takes as input the speech of the environment, organizes it according to the biologically determined properties of human language, and produces as output the grammar and lexicon of his native language. This enterprise is illustrated in Figure 2.1. The question of how the child receives environmental speech as input to the LAD is itself a major issue. We know that the speech signal is far from transparent in the way it encodes speech sounds. Consider something as simple as the vowel /I/ (as in *little*). It will be physically different depending on whether it is spoken by a man, a woman, or a child (because their vocal tracts are of differing sizes). It also will be physically different if it is in a sequence of fast rather than slow speech. Its physical representation will differ even by the words it occurs in. For instance, it will be different in a word like *kid* than in a word like *tip*. This latter fact is due to a phenomenon called *coarticulation*. When we speak, we do not utter one speech sound at a time. At any single moment our articulators are moving out of one speech sound, into another, and anticipating the next. The result is that the speech signal is continuous, and any single "slice" of the speech signal will contain information about several different speech sounds simultaneously. Thus, the /I/ in *kid* will be pro-

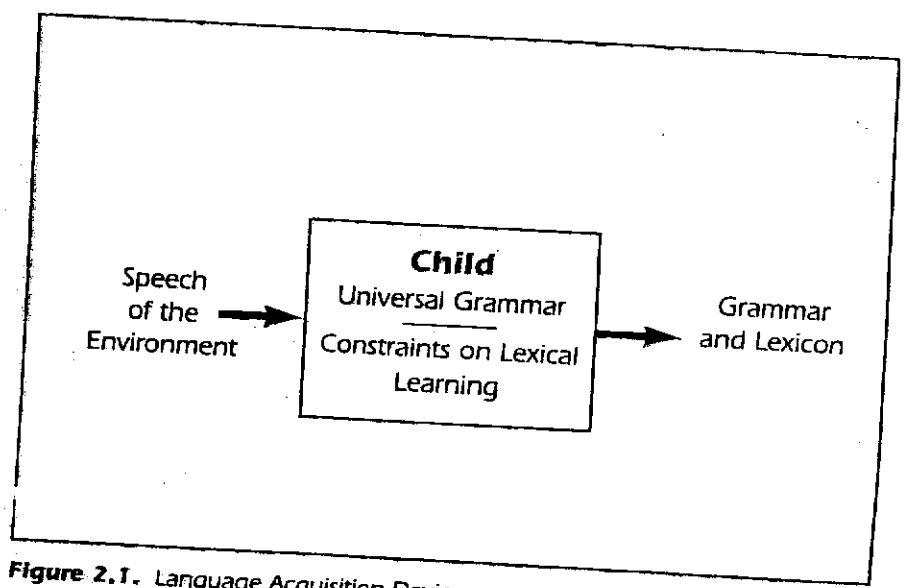

Figure 2.1. Language Acquisition Device

duced as the articulators are moving out of a /k/ and into a /d/, whereas the /I/ in tip is produced between a /t/ and a /p/. Add to this the fact that we do not pause between words; each word runs into the next. So the boundaries between words, as well as the phonemes within them, are hidden within the continuously varying stream of speech.

It is not fully understood how adults, who already know the words of their language, segment the speech stream into individual words. A major question that must be addressed by any theory of language acquisition is how the infant "gets into" the continuous speech stream. Clearly, he must be able to identify some words in the speech he hears and perceive some sort of phrasal organization among them. Psycholinguists think that human infants are predisposed to pay special attention to the prosodic characteristics—the changes of pitch, stress, and duration of fluent speech (Gleitman & Wanner, 1984; Hirsh-Pasek et al., 1987; Morgan, 1986) and that these characteristic prosodic features assist them in their initial entry into the speech stream. A number of researchers have noted that the prosodic characteristics of child-directed (especially infant-directed) speech differ in predictable ways from speech directed to adults. Pitch is higher and intonation is more exaggerated by greater pitch excursions. Fernald (1992) reviewed research from five languages other than English, from a variety of language families, and showed that all contain these features of child-directed speech. She argued that the prosodic characteristics of maternal speech evolved as did other mothering behaviors, such as rocking and stroking, in service of the maternal–infant bond, as well as to provide the infant an entry into the communication system of the species.

An adult understands sentences by creating a representation of words and their structural organization, based on her internalized grammar. The child, however, does not have a complete, mature grammar, so we must ask how he represents the language that he experiences. For this reason, we make a distinction between *input*, the speech that is present in the child's environment, and *intake*, the representations that are actually available to him as information for the creation of grammar at any given period of development. It is not possible, of course, for us to know just what aspects of the speech input are available to the child as intake. Some recent experiments have demonstrated that infants as young as 7 1/2 months old are able to

identify words in the continuous speech stream (Jusczyk & Anslin, in press). One of the most exciting areas of research in language acquisition involves the processing of speech by infants. The speech of the environment can be useful only if the child not only hears it, but perceives it, represents it, and uses it as information. This issue is especially important for an understanding of language disorders. One theory of the origin of language disorders is that such children do not process the speech of the environment as successfully as do normally developing children. Although they possess an intact UG, they have a problem in converting linguistic input into intake and using it in the construction of a grammar (Leonard, 1989; Leonard, Bortolini, Caselli, McGregor, & Sabbadini, 1992).

Figure 2.1 shows that the child constructs a grammar, but obviously he does not construct a complete adult grammar instantaneously. It would be more accurate to show that he constructs a series of grammars, ending with the complete grammar of his language. (This process may not be complete for some children until very late childhood.) We want to be able to describe the intermediate grammars that the child constructs on his way to having a complete grammar of the language. Each of the intermediate grammars is immature (or incomplete) from the point of view of the mature grammar, but each is the grammar of a possible human language. Put differently, the child's intermediate grammars must conform to Universal Grammar. Helen Goodluck (1988, 1991) has called this the "no wild grammars" constraint on child language. The theory that all intermediate grammars conform to Universal Grammar is known as Continuity Theory (Pinker, 1984).

An example of a feature of child language that conforms to UG, but not to the language of the environment, is the phenomenon of subjectless sentences in child English. It is a well-attested phenomenon that English-speaking children use subjects optionally, producing sentences such as "Change pants" and "Papa change pants" (Braine, 1973, cited by Hyams, 1986). Sentences without subjects are ungrammatical in adult English, but they do not violate UG. Many languages, such as Spanish, Italian, and Chinese, allow sentences without subjects if the speaker and hearer both understand who the subject is. So it is possible to say "mangia una mela" ("eats an apple") in Italian if everyone knows who is eating the apple (Hyams, 1986). Thus, we can see that this intermediate grammar, one allowing subjectless sen-

tences, while it is not English, does not constitute a violation of Universal Grammar.

The Child's Linguistic Input

A goal of a complete theory of language acquisition is to be able to describe exactly what information the child must extract from the speech of the environment to enable him to construct a grammar (and a lexicon) of his language and how that information must be presented to the child. Let us first think of the kind of information the child needs. It is not enough for him simply to hear grammatical sentences; he must experience sentence–meaning pairs (Crain, 1991). Hearing "The dog is chasing the cat" is useless unless one is able to pair that sentence with the nonlinguistic event of a dog chasing a cat. The sentence provides information about the correct word order of English only if there is some nonlinguistic way for the child to know that the sentence describes an event in which the dog is the actor and the cat is the object of the action. The process of relating basic sentence structures and simple events in the world (via a process known as *linking rules*) constitutes what Pinker (1984) has called *semantic bootstrapping*. In this way, the child "gets into" simple sentence structures by relating them to observed events in the world.

If the child needs to experience sentence–meaning pairs, it is pretty clear that speech presented without paired actions, such as one hears over the radio, would not suffice for language learning. What about television? Would passive exposure to speech on television constitute an adequate format for the child to acquire a grammar? Obviously, it would be unethical to perform experiments of this nature, but Sachs, Bard, and Johnson (1981) had the opportunity to observe a naturalistic test of this question. They reported the case study of two hearing children of deaf parents, who were discovered by a team of speech pathologists. While (unlike Genie, discussed in Chapter 1) the children had been reared in an affectionate home environment that met their physical and emotional needs, they only experienced language by watching television; their parents did not sign with them. The older child, Glen, was 3 years old when Sachs and her colleagues began to study the children. He knew some words and could combine them, but the organization of the words was aberrant.

Some examples are "That enough two wing," "Off my mittens," "This not take off plane." None of these sentences is typical of a child his age. His younger brother, Jim, who was 18 months old, did not speak at all. The speech pathologists visited Glen at regular intervals and had conversations with him. They did not attempt to teach him language, but they provided a communicative linguistic environment for him. In 6 months his language was age appropriate, and he became the language model for his brother. From this and similar anecdotal reports, we can guess that it is highly likely that, for language acquisition to be successful, the child's linguistic input must be in the form of social, interactive speech. An interesting exception to this observation comes from statements by their children whose parents speak a second language. Such children often appear to acquire the second language passively, much to the chagrin of their parents, who believe they cannot be understood. This "passive" learning is of a second language, however; it should not constitute a counterexample to the hypothesis that first languages must be acquired interactively.

Beyond the reasonable supposition that the child's input needs to be in the form of interactive, communicative speech, it is of great theoretical interest to know exactly what are the necessary properties of the child's linguistic environment and the language to which he is exposed for acquisition to take place. In recent research this question has been addressed by attempting to assess the role of the caretaker in the acquisition process (apart from producing speech with special prosodic properties). Within this body of research, there are two discernible threads. The first is concerned with the extent to which the child requires feedback from the environment, and the second deals with whether the speech the child hears must have special characteristics.

We no longer take seriously the view that children must be rewarded for structurally correct utterances and nonrewarded for incorrect ones. An early study by Brown and Hanlon (1970), conducted during the early days of psycholinguistics when the Chomskians were battling with the behaviorists, actually investigated this question. They showed that parents reward truthful statements whether or not they are structurally correct according to the adult grammar. For instance, a child in their study (Adam) was approved for the sentence "Draw a boot paper," but disapproved for "And Walt Disney comes on Tuesday," because it was inaccurate. In a more recent work (Fil-

"Brown and Hanlon Revisited"), Hirsh-Pasek, Treiman, and Schneiderman (1984) reported a similar concern with accuracy as opposed to structure.

Clearly, then, parents do not regularly point out to their children the errors that they make. In fact, children seem quite resistant to explicit correction. A famous example is the following exchange between a child and parent (reported by McNeill, 1966):

CHILD: Nobody don't like me.

MOTHER: No, say "nobody likes me."

CHILD: Nobody don't like me.

(Eight repetitions of this exchange)

MOTHER: No, now listen carefully; say "nobody likes me."

CHILD: Oh! Nobody don't likes me.

It has been suggested, however, that more subtle sorts of corrections and expansions from the caretaker may play a role in language learning. An important study by Cazden (1965), replicated by Feldman (1971), showed that expansions are less effective in accelerating language development than are relevant conversational replies. The distinction between these two types of response is illustrated by the following: If the child says "Doggie running," an expansion response would be "The doggie is running," whereas a relevant conversational response would be "Yes, and isn't he cute?" Newport and Gleitman (1977) reported some instances in which expansions affect performance on certain aspects of structure, such as use of the auxiliary. They (see also Gleitman, Newport, & Gleitman, 1984) suggested that expansions are useful only when they provide grammatical information for the child at a moment when his attention is focused on the particular form–meaning pair. They are not useful for signaling to the child when he has produced an ungrammatical sentence.

Thus, there is an important kind of information that is *not* available to the child in his environment. This is information about what structures are not part of his language. Psycholinguists call this *negative evidence;* no one tells him he is wrong, corrects him consistently (or successfully), or in any way gives him sufficient information about ungrammatical forms to assist significantly in language learning. There

may be some parents who are very conscious of their child's grammatical "errors" (some such people may be reading this book) and really do spend a lot of time correcting the child's language. Such parents usually think they are doing the right thing and are providing a good linguistic environment for their child. The best advice for such parents is that they should relax, merely make sure they communicate effectively with their children, and not drive the poor kids nuts about their language. (Kids need to enjoy talking.) While such parents certainly exist, parental input of this type could not possibly operate as a causal factor in language acquisition theory. For this to be the case, every parent everywhere would have to do it and every child everywhere would have to follow his parents' advice. This is obviously false. Finally, even if every ungrammatical utterance every child in the world produced were corrected by caretakers, we still could not rely on negative evidence to account for language acquisition, because children must acquire rules that mark as ungrammatical sentences they have never had the opportunity to say. Everyone reading this book knows that "Himself was shaved by John" is an ill-formed sentence of English, but we could not have acquired that knowledge by each of us saying a sentence of that form to our parents and being corrected for it. Many parents naturally assume that they play a major role in "teaching" their children language (while they would not for a moment think they had taught the child to walk), but a moment's reflection demonstrates that this could not possibly be a major factor in a general theory of language acquisition. We assume, then, that the child has access only to information from the environment about what is possible in his language, not what is impossible. We characterize this by saying that the child must build his grammar (and, it also turns out, most of his vocabulary) based solely on *positive evidence.* This fact has profound consequences for an understanding of how the child acquires knowledge of his language. We must account for every grammatical development that we observe by showing how it could have been acquired without negative evidence.

To see how we can account for development without appeal to negative evidence, let us look at a real example from the acquisition of English. It has been demonstrated that children go through a period (under the age of 3 or 4) when they think that a reflexive pronoun can function like a personal pronoun. Thus, they will think that "Grover patted himself" can mean that Grover patted Ernie, as well as that

Grover patted Grover. How can they ever learn that *himself* can refer only to the subject of such a sentence? No one tells them (this would be negative evidence). Sure, they only hear *himself* being used reflexively, but that is positive evidence. If they think *himself* can also be used to refer to someone outside the sentence, they will think that they just haven't happened to hear anyone use it that way yet. Maybe next week. After all, there are many grammatical constructions that a child (or an adult, for that matter) hasn't heard yet. Language would be impossible to learn if the child assumed that everything he hadn't heard was ungrammatical.

We know that children eventually acquire the grammatical knowledge that "Grover patted himself" can only mean that Grover patted Grover and not that Grover patted Ernie. We know this because we know that adults have this grammatical knowledge (and children grow up to be adults). We also know it because studies have demonstrated that children have this knowledge by the age of about 4 (McDaniel, Cairns, & Hsu 1990). How do they acquire this knowledge in the absence of negative evidence? There is a general principle of language that reflexives of a certain type must always refer to the subject of their clause. This is part of Universal Grammar. Once the child has classified *himself* as a reflexive of that type (and as distinct from personal pronouns), he will be able to apply the universal principle of language. Thus, the child's access to UG allows him to acquire a grammatical principle without negative evidence. This account relies, however, on the acquisition of lexical information, in this case that *himself* is a reflexive rather than a personal pronoun. There is, however, a lot we don't know about lexical learning. I have a great deal more to say about this particular example and other similar universal principles in Chapter 4. It is always a challenge, in developing a theory about how children move from one grammar to a more advanced one, to formulate the account with the assumption that they have only positive evidence available to them. These problems are called problems of *learnability*. It is not enough simply to formulate descriptions of the child's grammar at various points in time; we must also account for the learnability of each succeeding grammar.

We know, then, that a critical function of the speech of the environment is to provide children with positive evidence regarding the structures produced by the grammar of the language they are attempting to acquire. Psycholinguists have asked whether there are special properties of caretaker speech to children that are necessary to provide a linguistic model for them. It has been shown that adults as well as older children speak differently to infants and younger children than they do to each other (Shatz & Gelman, 1973). The speech adults address to infants and children is semantically simpler than the speech they address to other adults and is, as one would expect, geared to the cognitive level of the child. Structurally, it is also less complex. Sentences are shorter, with fewer embedded clauses, simpler verb phrases, and so on (Hoff-Ginsburg & Shatz, 1982; Snow, 1977). This type of speech has been nicknamed *motherese*.

What we need to know is whether this type of input is necessary to the language acquisition process or whether it has any relationship to the speed of language acquisition. There must clearly be some properties of the language input that are essential for language acquisition. It must be processable by the child, both structurally and semantically. If a child heard only discourse about international affairs in sentences with structures far beyond his processing ability, he would probably have some difficulty acquiring language. On the other hand, if he heard only speech of the form he produces, he would never receive sufficient information to make progress. In fact, a clever study by Shipley, Smith, and Gleitman (1969) demonstrated that children respond best to speech just a bit above their current level of production. Furthermore, they probably need to hear a great variety of structures in their language, so oversimplified input is not an advantage. Gleitman et al. (1984) have indeed demonstrated that, to the extent that fine variations in caretaker input can be shown to have an effect on subsequent child language, children seem to progress more rapidly with a richer input.

This issue—the speech of the developing child's environment—goes far beyond simply describing general features of caretaker speech, or motherese. What we need to understand for a complete theory of language development is exactly what sort of input from the environment the child must receive to develop a grammar of his language. Thus, with respect to studies of caretaker speech, we would like to know if there are particular features of that input that are related to particular features of the child's developing language. Obviously, such studies are very difficult because caretakers provide

a great variety of forms and children are rapidly acquiring many features of language.

The best attested relationship between caretaker speech and a particular feature of child language was identified by Gleitman et al. (1984). They found a statistically reliable relationship between the mothers' yes–no questions and the children's acquisition (or, in any event, use) of the auxiliary system. How can we explain Gleitman et al.'s finding that the more yes–no questions mothers used, the earlier auxiliaries appeared in the speech of the children? A very important aspect of the child's grammatical development depends on the acquisition of the auxiliary system of the language. These are words like *is* in "The cat is jumping" or *has* in "The cat has jumped." (I say more about the development of the auxiliary system in the next chapter.) These are precisely the units of sentences that are moved to the front in yes–no questions because they agree with the subject of the sentence (e.g. "Is the cat jumping?" "Has the cat jumped?"). Perhaps by using many yes–no questions, the mother provides the child with positive evidence about the auxiliary system of English. In yes–no questions, the auxiliary element is distinguished from the rest of the predicate, and it is made perceptually salient because it appears in sentence-initial position. Notice, however, that the incidence of yes–no questions in maternal speech accelerated only slightly the acquisition of the auxiliary system. If we did not have a construction that moves the auxiliary into a perceptually salient location, children would still learn the auxiliary system of English, using other kinds of information.

Developmental psycholinguists want to identify what information in the child's environment is necessary and sufficient for language acquisition to take place. We want to do this purely to further our theoretical understanding of normal language development and desire no practical application of that knowledge. It is unnecessary to improve on nature; a normal linguistic environment will provide normally developing children with the information they need. For people dealing with children with language disorders, however, knowledge about input speech is highly practical. If a child is not developing language normally, the entire therapeutic enterprise is about providing input to facilitate language development. Theoretical and empirical discoveries about necessary information for language development are absolutely crucial for the development of intervention strategies in speech–language pathology. It is unlikely that we will make such discoveries by naturalistic studies of caretaker–child language. We need good intervention studies of normally developing children that investigate the effects of theoretically motivated features of language on specific features of language development.

What is meant by "theoretically motivated features of language"? The linguistic theory that we are using can give us ideas about the kinds of information children need to develop grammars. Two examples can be drawn from facts about English discussed earlier in this chapter. We said that for a child to acquire a grammar requiring coreference between *Grover* and *himself* in the sentence "Grover patted himself," *himself* must be classified as a reflexive pronoun. When this happens, a universal principle of language will become engaged in the child's grammar. Thus, we know that this is the kind of lexical information the child needs for this aspect of development. Because all normally developing children acquire this feature of their grammar before the age of 4, we assume that this information is readily available in the child's environment.

Another example comes from our discussion of parameters of language variation. In English, all sentences must have subjects, even if they are not needed for the meaning of the sentence. Thus, an English speaker must say "It's raining," whereas an Italian speaker can say the Italian equivalent of "raining." Early child language (English as well as other languages) contains many subjectless sentences. The English-speaking child needs to obtain information from the environment to allow him to set this parameter of his grammar correctly. Put differently, he needs information that will allow him to figure out that subjects are not optional, but are essential in the language he is acquiring. Remember, this can be achieved only through positive evidence. Children are not corrected for leaving out subjects, and it wouldn't change things if they were. The mere fact that children hear sentences with subjects isn't enough; languages such as Italian, which allow subjectless sentences, also allow sentences with subjects. Anyway, children acquiring English also hear sentences such as "Want lunch now?" in casual conversation. What the English-acquiring child must have in his input are sentences with *meaningless* subjects such as "It's raining" and "There is a book on the table." Of course, children hear such sentences from infancy, so why do they use subjectless sentences until they are 2 1/2 or 3 years old? This highlights the distinction be-

tween input and intake. Perhaps the child has to be at a certain point in language development before he can pay attention to the presence of meaningless subjects in the speech of the environment. It may be a question of the child's being able to process ambient speech thoroughly enough to identify subtle features such as the one that distinguishes the meaningless (expletive) subject *there* from the "pointing" (or deictic) *there*. It may even be that the child has to hear a great many sentences with meaningless subjects before he is confident that he should alter his grammar to conform with a different parameter setting. This example highlights how acquisition theory can reveal important features of environmental language, as well as many of the salient questions that remain unanswered.

There is currently some debate about exactly how children set the parameters of their language. According to one view, each parameter is initially set to its unmarked setting (e.g., to allow subjectless sentences), and a particular feature of the language of the environment (e.g., the presence of meaningless subjects in our example) is said to *trigger* the switch to a grammar set for the other value of the parameter (Hyams, 1986). According to another view, Universal Grammar provides the child with a set of hypotheses about how his language might work. His task, then, is to listen for evidence in the speech of the environment that will allow him to determine which of the possible human variations his language represents (Valian, 1990). We need a great deal more information about how children acquire the correct parameter settings before this debate can be settled. However, the latter view, which depicts the child as a more active language learner than the former, seems more likely to comport with what we know about the nature of early child grammars and about the linguistic input that determines those grammars.

Another subject of debate in acquisition theory is the role of maturation in language development. Obviously, there are some effects of maturation, such as the fact that the first word appears around the same age for children everywhere (Slobin, 1973) and the fact that during the first 2 years of life there is an explosion of neural connectors in the left hemisphere of the child's cortex (Foss & Hakes, 1978). We have already suggested, as well, that the shortness of children's early utterances is a result of the limitation, due to immaturity, of their working memory system. The issue under debate, however, is whether children acquire aspects of UG by maturation or whether the entire grammatical framework is available to them as soon as they have the lexical knowledge and processing abilities to use it. I make this question more concrete in Chapter 4 when I address details of grammatical development.

Biological Preparedness for Language

In the last 20 years, a great deal of research has confirmed the hypothesis that human infants are biologically prepared to acquire language and indicated that human infants are born with physiological and perceptual abilities specialized for speech. Condron and Sander (1974) showed that prelingual infants synchronize their gross bodily movements with the prosody and structure of human speech. Called *interactional synchrony*, this behavior is exhibited in response to many varieties of human speech other than the child's native language, but not in response to nonspeech sounds. (Adults demonstrate interactional synchrony with conversational partners.)

The left hemisphere of newborns is typically larger than the right, and they are able to distinguish between human speech and other nonspeech sounds. Furthermore, this perceptual distinction is enhanced when stimuli are presented to the left hemisphere (Entus, 1975; Molfese, 1973). Very young infants show a preference for listening to speech rather than to nonspeech; they also show a preference for their mother's voice and prefer their native language to a nonnative one (Mehler et al., 1990). In the womb babies can hear only the general prosodic contours of speech, since the sound waves are damped by amniotic fluid. Languages and the speech of individuals do differ prosodically, so some of the learning that leads to these preferences may take place before birth. In any event, these results demonstrate that infants are sensitive to linguistic distinctions when they have had only minimal experience with language.

It is well known that if we can see someone speaking, the speech is easier to understand than if we can only hear the speaker. This has been experimentally demonstrated by degrading speech so that it is difficult to understand (Sumby & Pollack, 1954). Perception is far better if the speaker is in view. This shows that we have internalized knowledge about the relationship between speech sounds and the articulatory gestures used to produce them. This is not surprising, b-

ever, because, after all, we know a language that allows us to produce speech sounds. It appears, however, that infants who have not yet produced speech also have a sense of the relationship between articulatory gestures and speech sounds. Spelke and Cortelyou (1981) presented infants 10 to 16 weeks of age with tape-recorded speech and films of two women, one speaking the words that were being heard and the other speaking something different. The infants preferred to look at the film in which the woman was speaking the words on the tape. McKain, Studdert–Kennedy, Spieker, and Stern (1983) replicated these findings and demonstrated that the preference is more pronounced when the visual presentation is processed by the left hemisphere.

Until now I have managed to avoid technical language, but to facilitate understanding of the next few experiments described, I need to introduce the concept of the *phoneme*. Every language employs a variety of speech sounds; some of them are used to distinguish words from each other and some are not. For instance, in English /p/ and /b/ are used to distinguish words; we have *pig* and *big*. There are two types of /p/s, one like the /p/ in *pig* and the other like the /p/ in *spin*. The former is aspirated, and the latter is not. (Put your hand in front of your mouth and you will feel a puff of air when you say *pig* but not when you say *spin*.) The speech sounds that keep words distinct from one another are called phonemes; so /p/ and /b/ are different phonemes of English, but aspirated and unaspirated /p/ are not. There are languages, however, in which aspirated and unaspirated /p/ are phonemes. Each language selects from all the possible human speech sounds a small set that are distinctive. It is a linguistic universal that all languages have phonemes; which phonemes they are is specific to individual languages, however. The phonemes of a language exert a special influence on the perceptual systems of adults. Speech sounds that are members of the same phoneme will sound similar to one another even if they vary phonetically, and speech sounds that are members of different phonemes will sound completely different even if they are phonetically very close. This is known as the categorical nature of speech perception; it is more pronounced for consonants than for vowels. Thus, the adult's perceptual system seems specially tuned to detect best those sound differences that are distinctive in his language.

In a well-known series of experiments, Eimas and his colleagues (cited in Eimas, 1975) demonstrated that prelingual infants divide a speech continuum perceptually in much the way adults perceive distinctions between, but not within, phonemic categories. Because the babies in these studies do not yet possess a linguistic system in which the existence of phonemes could create perceptual categories, their categorical perception of speech constitutes an inborn perceptual ability necessary to the acquisition of a phonemic system. There is abundant evidence that the infant speech perception system develops rapidly. Kuhl (1992) demonstrated that infants could recognize vowels and syllables as similar when they were spoken by male, female, and child talkers. She also showed that 6-month-old infants perceive certain vowels as better exemplars of their vowel category than others; these are the vowels that are more phonetically "pure" versions of their vowel category.

Werker and her colleagues (e.g., Werker & Lalonde, 1988) made the remarkable discovery that 6-month-old infants perceive differences between speech sounds that are not phonemic in the language they are learning as sharply as do adult speakers for whom the distinction is phonemic. For example, Hindi makes a phonemic distinction between /t/ produced with the tongue tip touching the back of the teeth and /t/ produced with the tongue tip touching the ridge at the front of the roof of the mouth (called the alveolar ridge). English does not make such a phonemic distinction. These two types of /t/s are perceptually highly distinct for Hindi speakers, but to English speakers they sound the same. In one of Werker's many studies, 6-month-old infants perceived the difference between the two kinds of /t/ as well as do adult Hindi speakers; 10-month-old infants perceived the difference less well than did the 6-month-olds; and 1-year-old babies performed like English-speaking adults, having lost the ability to distinguish the two kinds of /t/. The ability to perceive distinctions between speech sounds that are phonemes in the child's language is, of course, maintained at adultlike levels.

It appears, then, that in the realm of speech perception we have an example of exactly the scenario our theory suggests. The infant is born with the ability to distinguish perceptually all the human speech sounds that are potential phonemes. Through experience with the speech of the environment, he identifies the phonemes of his language and incorporates them into his grammar. It is highly interesting that the perceptual distinctions between nonphonemes disappear about the time the child is beginning to acquire a vocabulary, which is filled with words that are kept distinct by phonemes. We