CHAPTER 10

Language Development:
From speech perception to first words

George J. Hollich
Department of Psychological Science, Purdue University
&
Derek M. Houston
DeVault Otologic Research Laboratory
Department of Otolaryngology, Indiana University School of Medicine

Introduction & Overview

Language is amazingly useful. We use it to talk about things that are not present, to communicate abstract concepts and thoughts in our heads, and even (through writing) to pass on such ideas when we are not physically present. Furthermore, we seem to be the only species that does so in a manner that is so organized, complex, and productive. Language would seem to be the capstone of the human evolutionary experience.

Unfortunately, by some accounts, learning a language ought to be impossible. With enormous acoustic variation between human voices and words, the sheer size of our vocabularies and the complexity of grammar, infants would seem doomed to failure in their attempts to make sense of it all. Indeed, Gold (1967) argued that to induce the rules of language from the input would take longer than a human lifetime.

Yet like the bumblebee who goes on flying in spite of the mathematical impossibility of such a feat, children do learn their language–and quickly. Infants utter their first words at around 12 months of age. By eighteen months of age, their productive vocabularies increase rapidly to approximately 50 words and their development surges as they characteristically acquire, on average, 9 new words a day (Carey, 1978). Thus, in just a little less than two years, infants go from crying to talking.

For anyone who has tried to learn additional languages later in life, this is an amazing feat. This feat is made even more impressive given that infant don't have the advantage of being able to use their first language to guess how a new language might work. Furthermore, this task is complicated by the fact that language has many parts. To learn a language, infants must discover the salient sounds and auditory units of their language (a task called *phonology*); infants must also learn the meaning for words (a task called *semantics*), and finally, infants must learn the rules for how words and different word forms can be combined to express new meanings (a task called *grammar*).

To solve the separate tasks of phonology, semantics, and grammar, infants make use of a wide variety of skills. Infants can use their understanding of how communication works (a skill called *pragmatics*) as well their understanding of the subtle non-verbal cues that parents use to aid in comprehension. Infants also make use of many perceptual skills that are not specific to language (such as the generalization and categorization abilities covered in Chapter **7**). Finally, each episode of successful (and unsuccessful learning) sets the stage for subsequent acquisition. That is, once children have some linguistic knowledge (knowledge about how words work) they use this knowledge to aid them in subsequent acquisition.

In the coming pages, we will cover how infants move from being *universal perceivers,* equally capable of learning any of the world's languages, to being *specialists* in the sounds (phonology), meanings (semantics), and structure (grammar) of their own native tongue, and how infants ultimately move to being *language-learning sophisticates*, able to learn the meaning of words very quickly and understand complicated sentences and questions, even to the point of being able to produce words that they have never actually heard, such as past tenses and plurals.

The Universal Baby: Birth – 6 months

Infants come into the world ready to learn any one, or more, of the world's languages. The first six months of life is a time of many changes corresponding to infants' growing ability to communicate with the people around them, perceive the sounds of speech, recognize the melody of their native language, and begin to make the first connections between sight and sound.

Early Production and Social Skills

Newborns typically communicate their needs by crying. These cries are reflexive responses to feelings of hunger, sleepiness, or discomfort. During the next few months, young infants start making more intentional vocalizations – first vowel-like cooing sounds and then exploratory sounds such as raspberries and lip smacking and eventually alternations of vowel-like and consonant-like sounds that combine to resemble syllables.

Infants receive and respond to social and affective communication from a very early age. A normal-hearing newborn will respond to sounds with an eye blink or a startle response or by crying, and may also turn their heads in the direction of sounds. Newborns will also react differently based on the affective quality of the caregiver's voice. Also, infants make eye contact with speakers by 2 months of age. (See part 4 for chapters that more thoroughly describe the social-emotional development of infants). These behaviors may help encourage caregivers to communicate more with infants. And it is possible that the emotional information infants derive from speech motivates them to attend more carefully to speech and encourages language acquisition.

Early Speech Perception

In stark contrast to their limited social and productive abilities, infants possess remarkable perceptual abilities at birth, and even before (Chapters 3 & 5). Normal-hearing infants are born with an extremely acute perceptual system. They are able to differentiate many of the speech sounds that distinguish words across all of the world's languages, even when the differences are very subtle.

For example, take the difference between the [p] in "pat" and the [b] in "bat". Both of those speech sounds are produced with the same articulatory movements (i.e., putting the two lips together and then releasing them and vocalizing). The only difference between the two is

that for the [b] there is no or very little time between the release of the lips and the beginning of the vocalization whereas for the [p] there is a short (< 100 ms) lag between the release of the lips and the beginning of the vocalization. This meaningful difference between vocal sounds is called a *phonemic contrast*.

In the late 1960s, Peter Eimas and his colleagues tested young infants' discrimination of these two speech sounds (Eimas et al.,1971). They chose this contrast to test because earlier work had shown that adults discriminate those sounds *categorically*. That is, synthesized samples that they heard that had a lag between the release of the lips and the vocalization ("voice onset time" or "VOT") of 0 to 20 ms they heard as [ba] and all examples that had a VOT of 40 ms or greater were heard as [pa]. Adults are unable to discriminate differences that fall within the same category (e.g., a 0 ms VOT vs. a 20 ms VOT) but are able to discriminate the same difference when it falls *across* different categories (e.g., a 20 ms VOT vs. a 40 ms VOT). This kind of effect is called *categorical perception*.

Eimas et al. tested 2-month-old infants' discrimination of those sounds using the *High Amplitude Sucking Procedure* (see Figure 1). They found that 2-month-olds could detect 20 ms changes in VOT when the 20 ms change crossed phoneme boundaries but not when they fell into the same category. These findings showed that very young infants not only can discriminate /b/ and /p/ but do so categorically, as do adults.

That investigation sparked an enormous amount of research, which has shown that young infants are able to discriminate many different speech sounds. For example, within the first 6 months of life they are able to discriminate [b] and [d], [r] and [l], [m] and [n], [w] and [y], and [b] and [w] (Jusczyk, 1997). There is also evidence that young infants are able to discriminate some speech sounds that their adult counterparts are not able to discriminate. For example, 6- to 8-month-olds in Japanese-speaking environments are able to discriminate [ra]-[la] whereas their adult counterparts have much difficulty.

Findings like these have led to a common view that infants are born as *universal language perceivers*. That is, they are able to discriminate all sounds that could possibly be relevant for any of the world's languages. However, while their speech perception capacities are very acute at birth, much of their speech discrimination abilities are shaped and enhanced by the language(s) that they are exposed to. In the next section we will see how infants' speech discrimination abilities change to fit the language they are exposed to.

Even by birth infants have had some linguistic experience. In utero, the fetus is able to hear some sounds, including the mother's voice. Several investigations have shown that newborns have already learned some characteristics of their mother's speech patterns. DeCasper and Fifer (1980) used another sucking methodology to investigate newborn's preference for their own mother's speech to the speech of another woman. They found that newborns sucked faster in response to their own mother's speech patterns. Using similar methodology, Mehler et al. (1988) found that newborns could discriminate between their own language and some foreign languages.

How are newborns able to make such distinctions between their mother's and a stranger's speech or between different languages at birth? Recent investigation has shown that newborns' discrimination for different languages happens when the rhythmic and intonational properties (called *prosody*) of the languages differ substantially (Nazzi et al., 1998). They can even discriminate the languages when the speech is filtered in a way that removes all information except the rhythm and intonation. Importantly, these are the very properties that are available to the fetus *in utero*, suggesting that fetuses become sensitive to the rhythmic and intonational properties of their mother's speech and their native language from prenatal experience in the womb.

By 6 months of age, infants' experience with language allows them to recognize well-formed phrases or sentences. Thus, infants show a preference (measured by duration of looking time) for sentences that have pauses inserted *between* clauses to sentences with pauses *within* clauses, even when the speech is similarly filtered. For example, infants preferred passages like "The cat chased the mouse. [pause] The mouse ran into the hole. [pause] The cheese was…" to passages like "The cat chased [pause] the mouse. The mouse ran into [pause] the hole. The cheese was…." It is possible that early sensitivities to rhythmic and intonational properties of speech may ultimately contribute to learning about the grammatical organization of speech.

Multimodal Perception

Acquiring language requires not only learning about speech sounds, but also being able to connect what one sees with what one hears. There is evidence that infants have the perceptual capacity to relate the two at a very young age. In one study, 2-month-olds were presented with two videos simultaneously – one of a woman producing an /i/ sound and one of

the same woman producing an /a/ sound with only one of the corresponding two vowels presented at a time. Infants tended to look longer at the matching video for both of the vowels, suggesting that they detected the association between the shape of the articulations and the sounds that they produce (Kuhl & Meltzoff, 1982). The findings that infants are sensitive to the association between auditory and visual aspects of speech are one example of infants' integration of information from multiple sensory modalities when forming percepts about the world. Numerous investigations have shown that young infants are highly sensitive to the events in the world that are conveyed through multiple sensory modalities.

Perhaps the most dramatic evidence of relating what infants hear with what they see comes in the form of early "word learning." That is, part of the earliest language acquisition involves learning associations between the sound patterns of words and meaning. Recent investigations have shown that by 6 months of age, infants are already starting to learn the meanings of some very common words. Using the Preferential Looking Paradigm (see Figure 2), Tincoff and Jusczyk (1999) presented 6-month-olds with two videos, one of their mother, the other of their father, playing side-by-side simultaneously. They also presented them alternating recordings of a voice saying "mommy" or "daddy". They found that the infants looked more often at the correct video than the other video in response to hearing the words. Of course, it is not known whether or not 6-month-olds know that speech sounds "mommy" and "daddy" actually refer to their own mother and father or if they simply have noticed that those speech sounds and objects are associated (e.g., simply noticing that they tend to hear "mommy" when mother is present). More advanced, *referential,* word knowledge (knowing that words can "stand for" objects) is thought to come at a later age, which will be discussed in the final section.

Universal Baby Summary

Investigations over the past 35 years into the speech perception abilities of infants have begun to uncover the remarkable perceptual capacities that develop even before birth. These early perceptual abilities enable young infants to detect the subtle properties in speech that distinguish words, acquire knowledge about the rhythmic and intonational properties of the ambient language, link speech sounds to the facial articulatory movements that form them, and learn the names of some common objects in their world, such as their own mother and father.

The Native Language Specialist: 6 – 12 months

Toward the end of the first year of life, infants begin to exhibit a developing knowledge of, and specialization for, their native language. This specialization includes a newfound ability to babble and understand social cues (see Chapter 15), losing the ability to distinguish some non-native sounds, and learning to use certain acoustic properties to segment the fluent flowing stream of speech.

Production and Developing Social Skills

Infants make vocalizations from birth but around 6-7 months they typically begin producing an important type of babbling, which is called canonical or *reduplicated babbling* and is characterized by repetitions of the same speech sounds, such as "ga-ga", "ma-ma", "goo-goo". The characteristics of early babbling may reflect fundamental constraints of the vocal apparatus. MacNeilage and colleagues (2000) have found that certain consonant-vowel combinations within syllables tend to co-occur as a result of how the tongue is positioned. For example, consonants that are produced with the tongue placed forward in the roof of the mouth tend to co-occur with vowels that are articulated with the front part of the tongue raised (e.g., "day") whereas consonants that are produced with the back of the tongue placed in the back part of the mouth tend to co-occur with vowels that are articulated with the back part of the tongue raised (e.g., "go").

Babbling also appears to happen with the hands. Both normal-hearing infants and deaf infants make rhythmic gestures with their hands in a way similar to vocal babbling, and both babble vocally. Thus, some have proposed that both types of babbling are in large part a result of the development of motor skills. However, there is evidence that babbling (both verbal and signed) is influenced by the input to the child. Petitto et al. (2004) recently showed that the manual babbling of normal-hearing infants exposed to sign language more closely resembled the rhythmic properties of sign language than the manual babbling of normal-hearing infants exposed only to spoken language. Moreover, when infants around 11 months of age begin producing *variegated babbling*, which is characterized by strings of varying syllables (e.g., "bagoo"), infants exposed to languages of different rhythms tend to babble in ways that reflect these differences. Taken together, these findings suggest that the language infants are exposed to influences their early vocal productions. We will see below that infants' language-specific early productions mirror some of their perceptual sensitivities to language-specific input.

While infants are producing sounds that reflect what they hear, their communication is also becoming more engaged with the people around them. They become increasingly more sensitive to emotional expression in voices and faces and become more emotionally expressive. Also, infants begin demonstrating an understanding of referential gestures. For example, while a 6-month-old will look at a pointing finger, a 9-month-old will look at what the finger is pointing at. At the same time that infants are showing better understanding of communicative intent and producing speech sounds that are beginning to take on the characteristics of their native language, numerous investigations of the speech perception and language skills of infants during the second half of the first year of life suggest that they are learning much about the structure and organization of the speech sounds in the ambient language.

Shaping of the perceptual system

Exposure to a language affects infants' perceptual systems. The most direct evidence of this comes from studies of speech discrimination in older infants. Whereas infants up to around 6- to 8-months of age are able to discriminate most speech sounds regardless of their relevance to the ambient language, 10- to 12-month-olds lose the ability to discriminate many contrasts that do not signify different words in their native language. For example, Japanese-learning 10- to 12-month-olds do not discriminate the /r/ and /l/ contrasts discussed above. For some other contrasts, the ability to discriminate improves with age. For example, French and English learning infants' ability to discriminate a contrast relevant only for English ([d]-[ð]) does not differ whereas English speaking adults can discriminate this contrast much better than French speaking adults (Polka et al., 2001). These findings and others suggest that infants begin life with some general auditory processes that allow them to discriminate many contrasts and then exposure to the ambient language influences their perceptual system and changes what they can and cannot discriminate (see Houston, 2005, for a review).

Some investigators have developed theoretical models to explain sensitivity to nonnative contrasts. Best (1994) proposed the Perceptual Assimilation Model (PAM) which posits that discrimination of a contrast depends on whether and how the two speech sounds are categorized into native-language perceptual categories (e.g., the variations of [b] that would be labeled as [b]). If the two sounds fall within one perceptual category, listeners are not likely to discriminate them. If they fall into different perceptual categories, listeners typically will

discriminate them. If one or both do not fall into any native categories, then listeners are still likely to discriminate them – though less so than if they fall into different categories. Before infants have formed mature perceptual categories of sound their discrimination of contrasts are likely to be more universal and less like their adult counterparts.

Other investigators have proposed that the distribution of variants of speech sound categories in the input influences how infants perceive and discriminate speech sounds (e.g., Jusczyk, 1997; Kuhl, 1991). For example, Jusczyk (1997) proposed that the distribution of input to infants causes them to develop a perceptual weighting scheme such that acoustic features that are important for distinguishing words in the ambient language receive more attention. Thus, infants lose the ability to discriminate the non-native speech sounds that differ on features that are not relevant to their language.

Kuhl (1991) has proposed that infants' speech sound categories are influenced by the most common phonemes they hear. That is, by 6 months of age, infants' become sensitive to common acoustical values and form perceptual prototypes based on them. These prototypes act like a magnet; indeed, variations of speech sounds surrounding the prototype are perceived as being equivalent as the prototype. Evidence for this effect comes from studies which show that infants are less likely to discriminate between a prototypical sound and a nonprototypical sound than a pair of nonprototypical sounds–even when the two pairs of sounds are acoustically equally dissimilar.

Computations of the ambient language

Much of what infants learn about language appears to occur by them spontaneously picking up on regularities in speech rather than by being explicitly taught. In this way, infants are viewed by many as *statistical learners*–they encode speech sounds and implicitly compute how often sounds occur and their sequences. There are two types of evidence for this view. One type of evidence is indirect. Several studies have shown that infants become sensitive to properties of their native language that they would not likely become sensitive to unless they were computing the frequency of occurrence of speech characteristics. For example, there are many more 2-syllable words in English that begin with a stressed syllable (e.g., *doc* tor) than with an unstressed syllable (e.g., gui *tar*). Using the Headturn Preference Procedure (see Figure 3), Jusczyk et al., (1993) presented 6- and 9-month-olds with lists of both kinds of words. The

6-month-olds showed no preference for either kind of words, whereas 9-month-olds oriented longer to the words that follow the predominant stress pattern of English – i.e., they begin with a stressed syllable.

Similarly, investigators have found that 9-month-old infants but not 6-month-olds orient longer to non-words made up of phoneme sequences that are more common in their native language (e.g., "bis") than phoneme sequences that are not common (e.g., "zeeg"), even if the phonemes themselves were common in the native language (Friederici & Wessels, 1993; Jusczyk et al., 1994). The findings suggest that infants become sensitive to the frequency of occurrence of syllable stress and orderings of phonemes in the ambient language between 6 and 9 months of age. Presumably, they become sensitive to these properties by implicit computations of the speech sounds that they hear.

Another type of statistical learning is infants' sensitivity to the *transitional* probabilities of syllables (e.g., the probability that given syllable X the next syllable will be Y is the transitional probability of XY). To see how this might work, consider a baby whose name, let's say, is Julie. The baby will hear her name on many occasions, but embedded in different speech contexts – "Hello, Julie, how are you?"; "Don't worry Julie, mommy's here"; "Where are Julie's socks?". In all these, and countless other sentences, the one constant is the bisyllable "Julie" – the syllable 'Ju' is always followed by the syllable 'lie' (thus the transitional probability of 'lie' following 'Ju' is close to 1.00).

In a recent study Saffran et al.(1996) investigated 8-month-olds' sensitivity to the transitional probabilities of syllables in an artificial language. They presented infants with 12 consonant-vowel (CV) syllables for two minutes at a constant rate. The syllables were organized into four 3-syllable sequences (e.g., /da/ro/pi/) and the order of the sequences was balanced so that each sequence was followed by and preceded by the other three sequences an equal number of times. Thus, each pair of syllables either had a 1.00 probability of co-occurrence (e.g., /da/ was always followed by /ro/) or a .33 probability of co-occurrence (/pi/ was followed by three different syllables). After the 2-minute exposure, infants were presented with repetitions of 3-syllable sequences that were either 1.00 probability sequences (e.g., /da/ro/pi) or .33 probability sequences (e.g., /pi/go/la/ or /tu/da/ro/). Infants oriented longer to the .33 probability sequences, suggesting that they learned something about the transitional probabilities of the syllables.

These findings provide evidence that by 8 months of age, infants' perceptual and cognitive abilities allow them to implicitly encode "statistical" information about speech sounds and lend support to the idea that infants' sensitivity to the properties of the language, such as rhythm and phoneme ordering, is a result of implicitly performing statistical computations of the ambient language.

Segmenting words from fluent speech

When we speak, words flow together fluently without any obvious pauses or other markers of where one word ends and the next begins. We can appreciate this when listening to a person speaking an unfamiliar language. It sounds fast, like there is nothing to distinguish one word from another. But this perceptual effect occurs only because we do not know the words of the language. For infants coming into language for the first time, their impression of the language they are learning may be similar to ours when we hear a foreign language. While speech to infants differs from that used to speak to adults, infant-directed speech is also continuous with no clearly marked word boundaries (van de Weijer, 1998). In order to learn the meanings of words, infants must find (or *segment*) them in fluent speech. But how do they do this before they know many words? Investigations of infant speech segmentation show that infants' sensitivity to the properties of the ambient language plays a large role in their segmentation of words from fluent speech.

In a seminal study, Jusczyk and Aslin (1995) investigated infant word segmentation. Using the headturn preference procedure (see Figure 3), they familiarized 7.5-month-olds with two passages, each of which contained a target word six times. Then they presented infants with repetitions of four words – one word repeating during each trial. Two of the words were those that had occurred in the passages; the other two words did not. Infants attended longer to the words that were in the passages than to the other words, suggesting that they were able to segment words from fluent speech. Follow-up investigations have shown that English-learning 7.5-month-olds are not able to segment all words from fluent speech. They can segment ones that follow the predominant stress pattern of English (e.g., doctor, candle) but not ones that follow the less common stress pattern (guitar, surprise). These findings suggest that English-learning infants' sensitivity to the rhythm of their language influences their ability to segment words from fluent speech. Similar investigations have shown that English-learning infants'

sensitivity to the orderings of phonemes in the ambient language also plays a role in segmentation (see Houston, 2005, for a review).

Language specialist summary

During the second half of the first year of life, infants become much more engaged with their caregivers and perhaps show a desire to communicate with language. This is evidenced in two ways. One is that infants begin to produce sounds that sound more and more like the language they are hearing. Another is that they are encoding statistical properties of their language into memory, suggesting that, at least on some level, they are attending to the speech that is around them. These skills converge on an important ability for developing a vocabulary– the ability to segment words from fluent speech. Being able to segment and encode the sound patterns of words from fluent speech puts infants in a position to learn the meanings of those words.

Language Learning Sophisticate: 12 – 18 months

A child's second year of life is an exciting time. Along with the advent of their very first recognizable words, children transform into what Pinker (1994) referred to as "vacuum cleaners" for words, acquiring up to nine new words per day. Not only do infants in this stage quadruple the size of their vocabulary, but also they begin to use words productively in a way that helps communicate their needs. For example, a 15-month-old might say "cookie" to mean "I want a cookie," or "no" to refuse a piece of broccoli. For parents, the advent of this single word stage is a good thing, because it allows for a specificity of communication that was lacking at earlier stages. For infants, it is a time when they are truly beginning to grasp all the skills of learning to link sound to meaning: from social pragmatic abilities, to discovering appropriate constraints on word learning, and even to understanding the rudiments of grammar. In short, infants are becoming language learning sophisticates, with all the necessary abilities in place to 'explode' into language.

To see the complexity of this task, consider a mother trying to teach her child the word for pig. "Hey look at the big pig!" she says. The child must not only understand that labeling is what mom has in mind; then they must correctly identify the appropriate word to link in the speech stream (not "the" or "big"), and also somehow figure out that the label refers to the animal not to its ears or the sound it is making. And then the infant needs to do this many hundreds more times in learning the names of objects, often in situations where mom doesn't explicitly label what she is talking about – perhaps even using the word when the referent isn't even present. This is the essence of the new language learning sophistication that infants exhibit as they enter the second year of life. This sophistication comes from a combination of social pragmatic understanding, an understanding of constraints on the possible meanings of words, and a newfound expertise with linguistic rules (called grammar).

Social Pragmatic Understanding.

If the essence of language understanding is linked to understanding of communication (see Chapter 15), then this is the age at which infants first seem to "get" what the caregiver is trying to talk about. They seem to have what MacNamara (1982) called a "naming insight;" they ask their parents and practically anyone else: "what's that?" It is as if they have discovered that they can use language to talk about the world and get what they want. Thus, infants at this age seem to reliably follow pointing and eye gaze, and they won't mislabel something that the

experimenter didn't appear to intend to label. And most importantly, infants' ability to follow these cues is correlated with later linguistic competence (Carpenter et al., 1998)

Social eye gaze. A variety of studies have noticed that infants begin to successfully follow social cues such as eye gaze between 12-18-months of age. For example, Scaife and Bruner (1975) found that 100% of 11- to 14-month-olds would spontaneously look in the same direction an experimenter was looking. Recent studies have shown that infants can use this ability to learn labels. For example, using the *intermodal preferential looking procedure*, Hollich et al. (2000) had experimenters label a boring object just using social eye gaze (see Figure 4). Even 12-month-olds would resist attaching the label to the most interesting object, and 19-month-olds successfully learned that the boring object was the object the speaker intended to label. These results imply that 12-month-olds will only learn a label if the speaker is looking at the object during labeling.

Sensitivity to referential intent. Eye gaze isn't the only thing that infants use to determine label meaning. In another clever series of studies, Tomasello et al. (1996) found that infants could infer meaning by watching the speaker for clues for *referential intent,* or what object they meant to label. In this study, the experimenter played a finding game with 18-month-old infants. The experimenter would say that they were looking for the "gazzer." Then they would look into first one box, then another. Upon opening the first and second boxes, the experimenter made a face and shook their head as if that wasn't what they were looking for. When they opened a third box, they smiled and nodded. When tested later, infants indicated they thought the label was for the object found in the third box. Likewise, Campbell and Namy (2003) found that infants would not misattach a label heard (over a baby monitor) while infants were looking at an object. This study, and others like it indicate that infants are not only cognizant of *how* to learn words, but they also understand when *not* to learn them. Indeed, Bloom (2000) has suggested that understanding social pragmatic intent is the primary skill that infants need to learn language, and the skill that separates humans from other animals.

Other Constraints on Word Learning

Along with developing social understanding, infants appear to have picked up several other heuristics about possible *constraints* on meaning that help them quickly to narrow the range of hypotheses about the meaning of new words.

Whole object bias. A majority of words in the vocabularies of infants are objects at the basic level of categorization (see Chapter 7): nouns such as *bike* or *bottle*, which highlight individual entities and their global shapes, rather than their constituent parts or accompanying actions. A child who assumes that novel words highlight (i.e., name) objects would be at a considerable advantage in the task of acquiring a lexicon, and there is considerable evidence for the existence of such a bias in older children. Woodward (1993), for example, presented 18-month-old children with a novel word and two possible referents. One referent was a visually attractive display representing an event (e.g., brightly colored dye diffusing through water); the other was a novel object in a static display. Despite a salience preference for the event, the children looked at the object more when asked to find the novel word.

Lexical Contrast. One of the easiest ways for young infants and children to learn new words is in comparison to the words they already know. Specifically, Eve Clark (1987) suggested that in a case where infants knew one word, they might infer the meaning of an unknown word. This phenomenon has also been called *mutual exclusivity*, which refers to the idea that infants know that they can exclude objects that already have labels as possible candidates for new labels (Markman & Wachtel, 1988). For example, picture an infant in a grocery store in the fruit section. The mother might say "here's an apple, and here's a mango!" Since the child knows what an apple is, learning the word for mango is easier. Indeed, even if the mother only said "Here's a mango" (when in with some apples) the child could likely infer the meaning because they already know the word for apple, and can guess that "mango" refers to the novel object.

Categorical induction. Children also understand something about how words referring to particular categories of objects get extended. That is, after learning a number of words, infants begin to make guesses about how words might be extended to other similar objects. This process, called *categorical induction*, is harder than it looks, because we have words to label all kinds of categories, from solid objects completely defined by shape (such as a chair) to substance terms where shape is irrelevant (such as rock, wood, or even toothpaste). Indeed, Samuelson (2002) found that children will extend a new word (for a "C"-shaped novel object made of wood) on the basis of shape, but only if the object labeled fits the category of a solid. However, if the researchers labeled an "object" not well-defined by shape (e.g. a "c"-shaped object made of glitter), then infants ignored shape–especially if they had learn a few substance

terms (such as frosting, Jell-O, lotion) beforehand. This suggests that even very young infants can use what they know about the categories they already know to extend new words.

Grammatical Understanding

Recognizing parts of speech. Despite the large majority of first words being for concrete objects (which are likely easier to learn anyway), children learn words for things other than objects, and they seem to use language itself to help cue them when such learning is happening. This process has been called *syntactic bootstrapping* (Mintz & Gleitman, 2002), because infants are using grammar to discover possible meaning. Thus, for example, children assume that words proceeded by articles like 'a', 'an', or 'the' typically name objects, while words with adjective endings label properties (such as the "fepish one"). In a dramatic example of this type of ability, Waxman and her colleagues (Waxman & Booth, 2001) have demonstrated that when 14-month-olds see a purple toy and are told that "this one is blickish," these infants will extend "blickish" to other purple objects. In contrast, if told "this one is a blicket," 14-month-olds will extend the word blicket to other similarly-shaped toys. This sensitivity to *morphology* (the different forms that words can take) is one of the early signs that infants are grasping some aspects of grammar at this age and that they can use aspects of grammar in learning new words.

Understanding word order. Not only do infants know about parts of speech, but evidence also indicates that infants understand something about how words combine to make meaning (a rule system called *syntax)*, although these same children are not yet producing very many words in combination. In a seminal series of studies, Hirsh-Pasek and Golinkoff (1996) found that 19-month-olds would look at the correct picture when asked to "See Big Bird and Cookie Monster bending!" versus "See Big Bird bending Cookie Monster!" Notice that it is not enough to know that Big Bird, Cookie Monster, and bending are involved. That is, infants must not only know something about the individual meanings of the words, but they must also know exactly how these words combine to create new meanings.

Question comprehension. Finally, in addition to knowing about parts of speech and word order, by 15 and 20 months of age infants know a little bit about how questions work. To demonstrate this, Seidl, Hollich, and Jusczyk (2003) tested infants' developing understanding of questions by familiarizing 15- and 20-month-olds with a scene of an apple hitting a flower and then asking not only a simple question, such as "Where is the flower?", but also "What hit the flower?" (a question that asks for the subject of the action), and "What did the apple hit?" (a

question that asks for the object). Notice that the answers to these "subject" and "object" questions depend on understanding the relationships among words and how questions that start with "what" differ from questions that start with "where." Indeed, the answers to these questions are actually the opposite of the objects overtly mentioned in them. Thus, if infants were only pulling out the word "flower" when asked "what hit the *flower*?" the infants would look at the flower when they were supposed to look at the apple. Instead, both 15- and 20-month-olds looked significantly longer at the apple when asked "What hit the flower?," and 20-month-olds even looked longer at the flower when asked "What did the apple hit". These results indicate that infants have a fairly sophisticated understanding of grammar including parts of speech, word order, and question construction, before they have reached their 24th month.

The wug test. Not only are infants aware of morphology, word order, and grammatical rules while learning new words, but if they are tested in just the right manner, some 18-month-olds can produce new word forms that correspond to the rules of their native language. In one of the earliest examples of this, Jean Berko Gleason (1958) had children guess the plural form of a new word. Thus, an experimenter would introduce a new object and say, "This is a wug, see the wug." Then experimenter would introduce an identical object and say, "Now there are two of them. There are two ___?" Some children would inevitably complete this sentence with the word "wug*s*," even though they had never heard this plural before. These results shows that infants, who are not yet combining words productively, still know something about how to make grammatically correct new words.

Language Specialist Summary

In the second year of life, as infants say their first recognizable words, their comprehension abilities indicate a sophisticated understanding of nearly all aspects of learning a language. Infants can learn and extend a new word in as little as one repetition using social cues and cognitive constraints, such as the whole object bias or lexical contrast (using known words to learn the meanings of new words). And although the majority of words in their vocabulary are concrete nouns, they can learn and use words from all different classes, including social words such as "bye-bye" and "night-night" and adjectives such as "red" or "wooden." They accomplish this in part by using subtle grammatical distinctions in word endings (*morphology*) and ordering of the words (*syntax*) in complex questions. They even

indicate that they understand the difference between a question like “Where is the flower?” and “What hit the flower?” Thus, even before infants have begun to combine words productively, the available evidence suggests that all the component parts are in place for rapid acquisition of their native language.

Chapter Summary

Over the first two years of life, infants move from the primitive communication of crying to using specific words to get what they want. Along the way, they exhibit a threefold increase in sophistication in their social production skills, cognitive/perceptual skills, and linguistic skills. In the first six months of life, babies demonstrate sensitivity to nearly all the sounds found in all the world's languages. From 6 to 12 months of age, this sensitivity combines with a newfound skill at *segmentation*, and mapping frequent words to meaning, to allow infants to demonstrate their first comprehension of words (*semantics*). From 12 to 18 months, this comprehension has lead infants to begin to express themselves with their first words and develop heuristics about how to use eye gaze and other social cues, along with other constraints to more quickly learn new words. They even have grasped the first rudiments of grammar. Together these skills at phonology, semantics and grammar put infants in the ideal position to quickly acquire their first language.

Checklist of key concepts

- **Categorical Induction**: Using known words to guess how new ones might be extended to a whole category.
- **Categorical perception**: Hearing some sound differences as identical if they come from the same phonemic category.
- **Constraints**: Inferences about how new words might work.
- **Grammar**: Knowledge of the rules of combining words (syntax) and creating word forms (morphology).
- **High amplitude sucking procedure**: Using sucking as a way to test for infants' noticing sound differences.
- **Intermodal preferential looking procedure**: Using looking as a way to test infants knowing the meaning of a word.
- **Lexical Contrast/Mutual Exclusivity**: Assuming one word per object. This lead to knowledge that a new word must refer to an object that does not yet have a name.
- **Morphology**: Knowledge of different forms of words (eg. word endings).

- **Multimodal perception**: Linking across different perceptual systems (e.g. linking sight with sound.
- **Perceptual assimilation model**: Believes learning contrast is dependant on how sounds are categorized by the native language.
- **Perceptual magnet effect**: Tendency to hear sounds categorically.
- **Phonemic contrasts**: The subtle sound difference between similar words.
- **Phonology**: Study of the speech sounds and relationships among speech sounds that form the smallest units of language.
- **Pragmatics**: Study of language use in practice
- **Prosody**: The melody and rhythms of language.
- **Reduplicative babbling**: Repeating the same sounds over and over.
- **Referential intent**: Ability to induce what a person is labeling through eye gaze and other social acts.
- **Segmentation**: Finding words or other important units in the fluent stream of speech.
- **Semantics**: Study of word meanings and their use.
- **Statistical learning**: Using the regularities in speech the make inferences about possible words.
- **Syntactic bootstrapping**: Using syntax to figure out the meaning of new words.
- **Syntax**: Knowledge of how words and phrases can be combined.
- **Transitional probabilities**: The likelihood that one syllable will follow another.
- **Variegated babbling**: Vocal productions characterized by strings of varying syllables (e.g., ‘bagoo)
- **“Whole Object” bias**: Bias to attach labels to wholes over parts or actions.

References

Berko Gleason, J. (1958). The child's learning of English morphology. *Word, 14*, 150—177.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development, Volume 255.*

Best, C. T. (1994). Learning to perceive the sound patterns of English. In C. Rovee-Collier & L. P. Lipsitt (Eds.), *Advances in Infancy Research* (Vol. 9, pp. 217-304). Norwood, NJ: Ablex.

Bloom, P. (2000). *How children learn the meanings of words*. Cambridge, MA: MIT Press.

Campbell, A. L., &Namy, L. L. (2003). The role of social referential cues in verbal and non-verbal symbol learning. Child Development, 74, 549–563.

Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan & G. A. Miller (Eds.), Linguistic Theory and Psychological Reality. Cambridge, MA: The MIT Press.

Clark, E. V. (1987). The principle of contrast: A constraint on acquisition. In B. MacWhinney (Ed.), *Mechanisms of language acquisition: The 20th annual Carnegie symposium on cognition* (pp. 1 – 34). Hillsdale, NJ: Erlbaum.

DeCasper, A. J., & Fifer, W. P. (1980). Of human bonding: Newborns prefer their mothers' voices. *Science, 208*, 1174-1176.

Eimas, P. D., Siqueland, E. R., Jusczyk, P., & Vigorito, J. (1971). Speech perception in infants. *Science, 171*(968), 303-306.

Friederici, A. D., & Wessels, J. M. I. (1993). Phonotactic knowledge and its use in infant speech perception. *Perception & Psychophysics, 54*, 287-295.

Gold, E. M. (1967). Language identification in the limit. Information and Control, 16, 447-474.

Hirsh-Pasek, K., & Golinkoff, R. M. (1996). *The origins of grammar: Evidence from early language comprehension*. Cambridge, MA: MIT Press.

Hollich, G., Hirsh-Pasek, K., & Golinkoff, R. M. (2000). Breaking the language barrier: An emergentist coalition model for the origins of word learning. Monographs of the Society for Research in Child Development, 65(3, Serial No. 262).

Houston, D. M. (2005). Speech perception in infants. In D. B. Pisoni & R. R. Remez (Eds.), *Handbook of Speech Perception*.Cambridge, MA: Blackwell.

Jusczyk, P. W. (1997). *The discovery of spoken language*.Cambridge, MA: MIT Press.

Jusczyk, P. W., & Aslin, R. N. (1995). Infants' detection of the sound patterns of words in fluent speech. *Cognitive Psychology, 29*(1), 1-23.

Jusczyk, P. W., Cutler, A., & Redanz, N. J. (1993). Infants' preference for the predominant stress patterns of English words. *Child Dev, 64*(3), 675-687.

Jusczyk, P. W., Luce, P. A., & Charles-Luce, J. (1994). Infants' sensitivity to phonotactic patterns in the native language. *Journal of Memory & Language, 33*(5), 630-645.

Kuhl, P. K. (1991). Human adults and human infants show a "perceptual magnet effect" for the prototypes of speech categories, monkeys do not. *Perception & Psychophysics, 50*, 93-107.

Kuhl, P. K., & Meltzoff, A. N. (1982). The bimodal perception of speech in infancy. *Science, 218*, 1138-1141.

Macnamara, J. (1982). Names for things. Cambridge, MA: MIT Press.

MacNeilage, P. F., Davis, B. L., Kinney, A., & Matyear, C. L. (2000). The motor core of speech: A comparison of serial organization patterns in infants and languages. *Child Development, 71*, 153-163.

Markman, E. M., & Wachtel, G. A. (1988). Children's use of mutual exclusivity to constrain the meanings of words. *Cognitive Psychology, 20*, 120 – 157.

Mehler, J., Jusczyk, P. W., Lambertz, G., Halsted, N., Bertoncini, J., & Amiel-Tison, C. (1988). A precursor of language acquisition in young infants. *Cognition, 29*, 144-178.

Mintz, T., & Gleitman, L. (2002). Adjectives really do modify nouns: The incremental and restricted nature of early adjective acquisition. *Cognition, 84*, 267 – 293.

Nazzi, T., Bertoncini, J., & Mehler, J. (1998). Language discrimination by newborns: toward an understanding of the role of rhythm. *Journal of Experimental Psychology: Human Perception and Performance, 24*(3), 756-766.

Petitto, L. A., Holowka, S., Sergio, L. E., Levy, B., & Ostry, D. J. (2004). Baby hands that move to the rhythm of language: Hearing babies acquiring sign languages babble silently on the hands. *Cognition, 93*, 43-73.

Pinker, S. (1994). The Language Instinct: How the Mind Creates Language. New York, NY: William Morrow & Co.

Polka, L., Colantonio, C., & Sundara, M. (2001). A cross-language comparison of /d/ - /ð/ perception: Evidence for a new developmental pattern. *Journal of the Acoustical Society of America, 109*(5), 2190-2201.

Saffran, J. R., Aslin, R. N., & Newport, E. L. (1996). Statistical learning by 8-month-old infants. *Science, 274*, 1926-1928.

Samuelson, L. (2002). Statistical regularities in vocabulary guide language acquisition in 15- to 20-month0olds and connectionist models. *Developmental Psychology, 38, 1016-1037.*

Scaife, M., & Bruner, J. S. (1975). The capacity for joint visual attention in the infant. *Nature, 253*, 265-266.

Seidl, A., Hollich, G. & Jusczyk, P.W. (2003). Early understanding of subject and object Wh-questions. *Infancy, 4,* 423-436.

Tincoff, R., & Jusczyk, P. W. (1999). Some beginnings of word comprehension in 6-month-olds. *Psychological Science, 10*, 172-175.

Tomasello, M., Strosberg, R., & Akhtar, N. (1996). Eighteen-month-old children learn words in non-ostensive contexts. *Journal of Child Language, 23, 157-176.*

Van de Weijer, J. (1998). Language input for word discovery. Wageningen, The Netherlands: Ponsen & Loijen, bv.

Waxman, S., & Booth, A. E. (2001). Seeing pink elephants: Fourteen-month-olds' interpretations of novel nouns and adjectives. *Cognitive Psychology, 43*, 217-242.

Woodward, A. (1993). The effect of labeling on children's attention to objects. In E.V. Clark (Ed.), *Proceedings of the 24th Annual Child Language Research Forum* (pp. 35-47). Stanford, CA: CSLI.

Table 1: Universal Baby (Birth – 6 months). Infants are born with a host of skills that put them in the position to acquire any language that they hear.

Type of Skill	Skill	Examples
Early Production/Social	Crying	Cry to communicate hunger, pain, discomfort.
	Match Emotion	Will match the expression of caregive
Early Speech Perception	Categorical Perception	Can distinguish between subtle phone differences–even those not not in the native language.
	Detect melody of speech	Distinguish between different langua based on rhythmic properties
Multimodal Perception	Face-Vowel Connection	Can tell difference between faces produci different vowels
	Associative Word Learning	Can connect frequent sights and soun such as “mommy” to a picture of mo

Table 2: Native Language Specialist (6 – 12 months). Toward the end of their first year, infants begin to exhibit skills that suggest they are specializing in their native language and figuring out how language works.

Type of Skill	Skill	Examples
Production/Social Skills	Reduplicated babbling	Repeat same speech sounds.
	Follow a point	Look in direction of point.
Distinguishing sounds	Speech Contrasts	Can distinguish subtle phoner differences.
Segmentation	Stress Detection	Segment words based on stres
	Statistical Learning	Can use probability to determ if syllables go together.
	Phonotactics	Familiar words “pop out.”

Table 3: Language Learning Sophisticate (12 – 18 months). In the second year of life, infants not only begin to use their first words, but they demonstrate all of the skills necessary to expertly learn and use language.

Type of Skill	Skill	Examples
Production/Social	First Words	Use words to communicate interests, ideas, wants.
	Eye Gaze	Follow eye gaze to 'correct' object.
	Pointing	Follow points to 'correct' lab
	Expression	Use expression to find 'correc label.
Perceptual/Cognitive	Whole Object	Learn new words on the basis whole objects.
	Contrast	Can use contrast to discover meaning of new words.
	Categorical Induction	Extend new words on basis of experience with other similar words.
Linguistic	Part of Speech	Nouns label shape, adjectives label color
	Word Order	Can tell Cookie monster push big bird from big bird pushing cookie monster.
	Question Understanding	Know difference between 'wh is the apple?' and 'what hit th apple?'

Figure 1. High Amplitude Sucking Procedure. The infant is seated in a car seat and given a pacifier that is connected to a pressure transducer and computer that measures each time the infant produces a hard suck. During a habituation phase, the computer presents a sound (e.g. ba) each time it registers a suck from the infant. At first, infants usually produce sucks at a fast rate, presumably because they are stimulated by the speech sound. After some time, infants typically *habituate* to the repeating speech sound and decrease their sucking rate. When their sucking rate decreases enough to reach a pre-established 'habituation criterion,' they enter a test phase. During the test phase, infants in a *control* group are presented with the same sound (e.g. "ba") while other infants in an *experimental* group are presented with a novel sound (e.g. "pa"). If the sucking rate of the experimental group increases more than the sucking rate of the control group during the test phase, it is taken as evidence that infants can detect the change in sounds and respond to them.

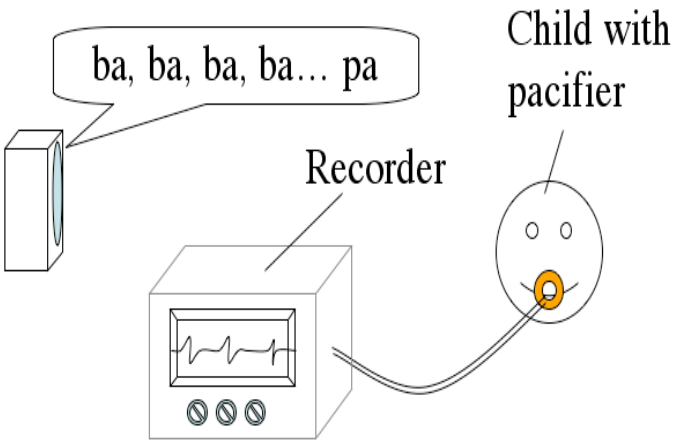
ba, ba, ba, ba… pa
Child with pacifier
Recorder

Figure 2. The intermodal preferential looking procedure. Children sit in front of a large display with two possible screens to watch. Infants prefer looking at the screen that matches the audio. Thus, a child might see a ball and a book on the screen. If asked to "look at the book," infants will look longer at the book, and will look longer at the ball when asked to "look at the ball."

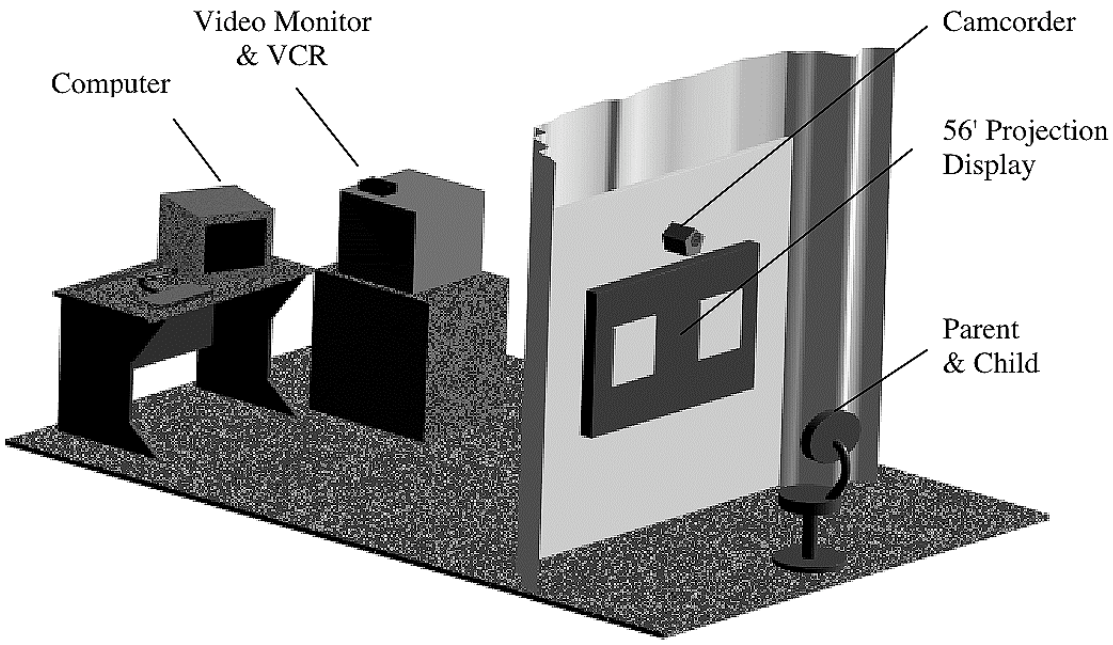

Figure 3. Headturn Preference Procedure. Infants are seated on their caregiver's lap in a 3-side booth with a light on each side. At the beginning of each trial, the infant's attention is brought to a neutral position by blinking the middle light until the infant looks at it. Then the center light stops and one of the two side-lights begins blinking. When the infant looks to that light a stimulus is presented from behind the light and continues playing until the infant looks away for 2 or more seconds. A difference in looking time to the blinking lights in response to one type of speech stimulus compared to another is taken as evidence that the infant can discriminate the two stimulus types and prefers one over the other.

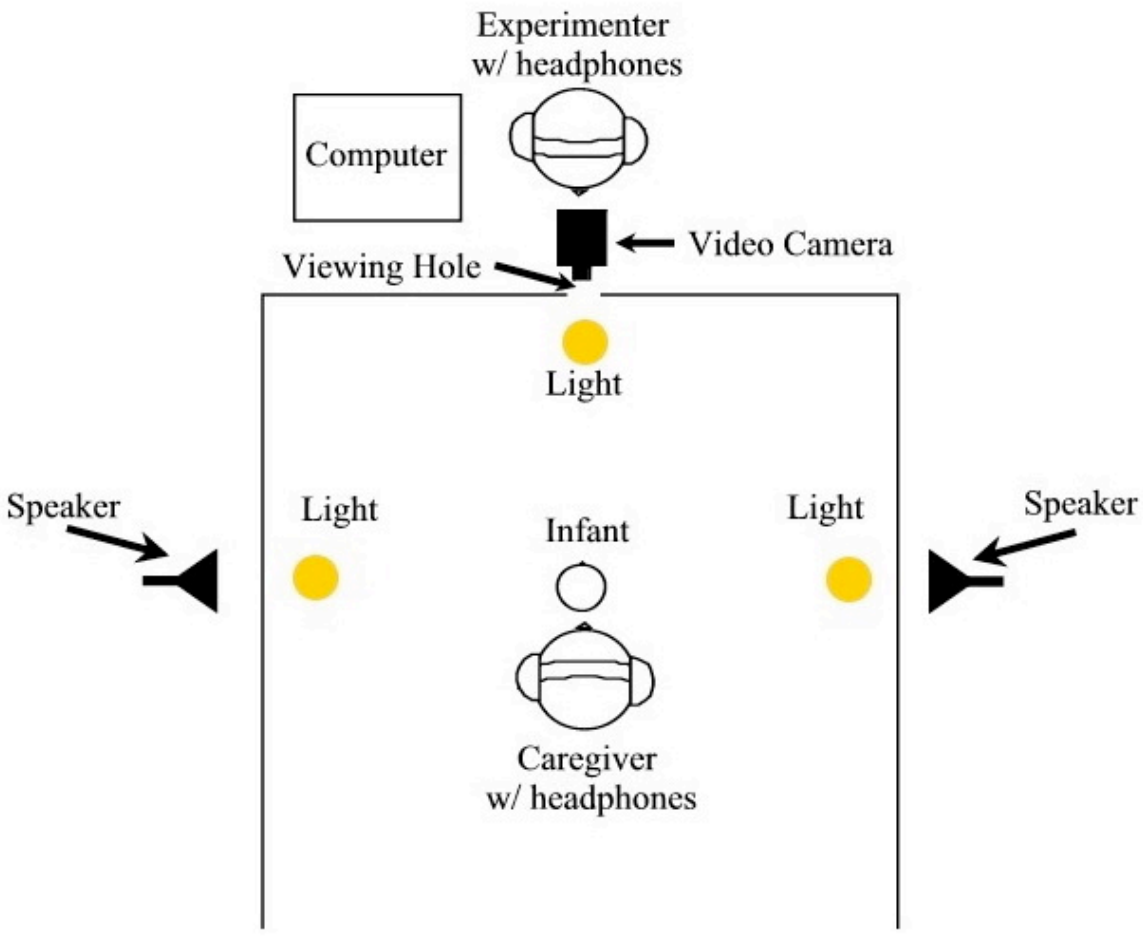

Figure 4. The interactive preferential looking procedure. In this version of preferential looking procedure, an experimenter labels an object on one side of a flip-board. During test trials, infants are tested on their ability to learn the label.