INFANTS' USE OF PROSODIC AND DISTRIBUTIONAL CUES IN ASSIGNING GRAMMATICAL CLASS

by

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Abstract

Infants' ability to learn new words, particularly nouns, increases dramatically in the months following their first birthday. The current experiment asks whether English-learning infants use prosodic cues, distributional cues, or both when deciding which word in a sentence labels an object. Both prosodic and distributional cues to nouns are available in speech to infants. Previous studies show infants' sensitivity to these types of cues, but it is unclear whether infants make use of these cues when assigning grammatical class. In this study, 16-month-old infants were tested to see which word in a sentence they would treat as an object label. The words infants were tested with provided either prosodic cues (sentence-final position and stress), distributional cues (a word preceded by *the*), both types of cue, or neither cue. The results reveal that 16-month-old infants use both prosodic and distributional cues to learn object labels.

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Introduction

A majority of the first words that English-speaking infants learn are nouns (Nelson, 1973; Tardif, Gelman & Xu, 1999). How do they pick those nouns out of the sentences they hear? Several cues are available in the input that could be used to predict which words might be nouns. This study looks at which of these available cues infants use when assigning grammatical class. Specifically, when provided with conflicting cues, do 16-month-old infants rely on prosodic or distributional cues when deciding which word in a sentence labels an object?

A challenge facing infants when first learning a language is that they need to know the meanings of words in order to learn about sentence structure. At the same time, they need to understand sentence structure in order to figure out the meanings of words. How do infants begin to develop either type of knowledge without having learned the other? This circularity is referred to as the bootstrapping problem. The focus of this paper is on how infants use sentence level cues to begin to learn about the grammatical class and the meanings of words.

Within a sentence, words can first be divided into two types, lexical and function words. Lexical words, such as nouns, verbs, adjectives, and adverbs, have relatively more meaning attached to them and are given greater stress in a sentence. Function words, such as articles, prepositions, and auxiliaries, provide relatively more structure than meaning, and tend to be acoustically and phonologically minimized. New-born infants appear to be sensitive to the perceptual differences between these two large word classes (Shi, Werker, & Morgan, 1999). By 6 months, they appear to show a preference

for lexical words (Shi & Werker, 2001). This first step is important because it suggests that infants are paying more attention to the words that carry meaning.

The present study asks how English-learning infants begin to further categorize the lexical words into grammatical classes such as nouns and verbs. Two theoretical approaches, Prosodic bootstrapping (Gleitman & Wanner, 1982; Morgan & Demuth, 1996) and Distributional learning (Cartwright & Brent, 1997), provide possible accounts of how infants might use sentence level cues to determine grammatical class. The prosodic bootstrapping hypothesis suggests that infants use prosodic cues to segment and parse words from the speech stream (Gleitman & Wanner, 1982; Morgan & Demuth, 1996). Distributional learning suggests that children child detect regularities in the input and use the frequency with which words co-occur to categorize words (Cartwright & Brent, 1997). For each of these theories, much research exists showing the availability of cues that could be used to distinguish nouns and verbs (Sorensen, Cooper, & Paccia,1978; Mintz, Newport, & Bever, 1995; Cartwright & Brent, 1997, Tardif, Shatz, and Naigles,1997; Mintz, Newport, and Bever, 2002). In addition, for each of these theories, infants have been shown to be sensitive to the available cues (Shady, 1997; Santelmann & Jusczyk 1998; Childers and Echols' study as cited in Echols and Marti (2004); Hohle et al., 2004; Fernald, McRoberts, and Herrera, in press). However, more research is needed to establish which cues infants actually use in determining grammatical class.

There are claims that nouns are easier to learn than verbs. For example, Gentner (1982) claims that the conceptual category that corresponds to nouns is simpler than that for verbs. Moreover, Gleitman & Gleitman (1992) point out that verbs are more difficult

than nouns, because in order to understand a verb, you must also understand the object(s) involved with that verb. While there is much debate over the universality of the "noun bias," there is unequivocal evidence that English-learning infants often show advantages in learning nouns over verbs (Nelson, 1993; Tardif, Gelman, & Xu, 1999). Therefore, the focus of this study is on noun learning, in order to examine infants early use of prosodic bootstrapping and distributional learning. In addition, the focus on nouns is restricted to object labels with the intention of maximizing the simplicity of the conceptual category.

The expression, "assigning grammatical class," is used throughout the current study to imply infants' ability to treat words of different grammatical classes differently when learning labels. It is not presumed that infants have explicit knowledge of a category for noun and verb.

This introduction will first explore the evidence for prosodic bootstrapping and second, the evidence for distributional learning, as ways that infants learn about grammatical class from sentence level cues.

1.1 Prosodic cues to grammatical class

Prosody is the information conveyed by a speaker that is above and beyond the segmental and lexical information provided by words alone. It includes stress, intonation, rhythm, and pauses, and gives shape to a sentence. The prosodic bootstrapping hypothesis, also referred to as the phonological bootstrapping hypothesis, suggests that infants use prosodic cues to segment and parse words from the speech stream (Gleitman & Wanner, 1982; Morgan & Demuth, 1996). Of the prosodic cues available in English, utterance-final position and stress are two possible cues infants

could use to pull object labels out of phrases. Utterance-final position is included here as a prosodic cue because it refers to the location of a word relative to the pause at the end of an utterance. In speech to infants, mothers are more likely to place object labels (nouns) than verbs at the ends of utterances (Tardif, Shatz & Naigels, 1997; Messer, 1981; Goldfield, 1993). Also in speech to infants, nouns tend to be the most stressed words in sentences (Messer, 1981). Further discussion of these topics follows. The two cues, utterance-final position and stress, tend to co-occur because sentence-final words are given extra stress, particularly lengthening, in English (e.g., Klatt, 1976). In fact, the extra stress on sentence-final words is exaggerated in infant-directed speech (Albin & Echols, 1996; Church, 2002).

1.1.1 Utterance position. For English-learning infants, utterance position could be used to roughly distinguish nouns and verbs because, in speech to infants, nouns are most often placed at the ends of utterances, and verbs are most often placed in initial or medial position in utterances. Tardif, Shatz, & Naigles (1997) looked at speech to infants from 6 English-speaking mothers, and found that nouns had a higher probability (approximately .36) than verbs (approximately .12) of occurring at the end of an utterance. Goldfield (1993) found similar results looking at the speech of 11 mothers talking to their 1-year-olds. Each mother was recorded for 12 minutes while playing with toys and for five minutes while playing without toys. The proportion of nouns appearing in final position (approximately .55) was much higher than that of verbs (approximately .06). Aslin, Woodward, LaMendola, and Bever, (1996) revealed that, when asked to teach their 12-month-old infants novel nouns, mothers placed the target nouns in

utterance final position 85% of the time. Therefore, if infants are sensitive to positional regularities, they could use final position as a cue to grammatical class.

Utterance-final position may offer another type of help in word learning. Information that occurs at the end of a phrase could be the easiest to segment and to remember. Slobin (1973) first suggested that linguistic information at the ends of words or sentences is more salient due to a recency effect. Indeed, English-speaking adults, hearing an unfamiliar language, are able to recognize target words that have been presented in final, but not medial, position in a sentence (Golinkoff & Alioto, 1995). Moreover, Childers and Echols' study (as cited in Echols & Marti 2004) showed evidence for the salience of final syllables. After being habituated to tri-syllabic sequences, 9-month-old infants looked significantly longer for changes in final than in non-final syllables.

If utterance-final position provides salience, we would expect this position to facilitate word learning equally for any grammatical class that occurs utterance-finally. However, since nouns in English often occur at the ends of sentences, this recency effect could be particularly facilitating for noun learning. In addition, if infants are sensitive to the frequency of nouns versus verbs in final position, the salience of utterance-final words may work together with the prosodic cue to grammatical class that utterance-final words provide.

1.1.2 Stress. Stress provides another way of pulling nouns out of sentences. Stress is defined as a change in pitch, amplitude, and/or duration. In English, syllables are considered stressed or unstressed. However, among the stressed syllables in a

sentence, some syllables may be given relatively more stress than others. This can be in the form of greater excursions of pitch, higher amplitude, or longer duration. Therefore, whereas monosyllabic nouns and verbs are both considered stressed syllables, they can have greater or lesser stress relative to each other in a sentence. Messer (1981) looked at the probability of names of toys being the loudest word in a sentence. Fifteen mothers of 14-month-olds were recorded speaking to their infants while playing together with toys. Names of toys had the highest probability of being the loudest word in a sentence (0.47). The probability of a verb being the loudest word in a sentence was 0.16. Adult data also show evidence that nouns are more highly stressed than verbs. Sorensen, Cooper, and Paccia (1978) found that for noun/verb homophones, like *coach,* nouns are typically longer in duration than verbs. They attributed this difference to phrase position by showing that when placed clause-finally, noun/verb homophones are approximately the same in duration. Even if nouns are longer than verbs because of where they tend to occur in a sentence, infants could be using the duration as a cue to grammatical class because it exists with some regularity in the input. In other words, while differences in noun and verb length may not be directly attributable to grammatical class, they can still provide a statistical pattern that predicts grammatical category.

While there are interesting differences in the stress patterns of multisyllabic nouns and verbs (Kelly & Bock, 1988), English speech is dominated by monosyllabic words. Aylet and Bull (1998) found that 85% of words in a corpus of task-oriented adult speech were monosyllables. It is possible that, in speech to infants, parents use simpler words, making this predominance of monosyllabic words even higher. Therefore, the current study has focussed on the cues available in monosyllabic nouns and verbs.

Are infants sensitive to relative stress among stressed syllables in English? Fernald, McRoberts, and Herrera (in press) looked at the effect of sentence position and duration on infants' ability to recognize a known word in a sentence. They found that, for words in sentence medial position, longer words were easier than shorter words for 15-month-old infants to recognize. However, in final position, longer and shorter words were equally easy to recognize. Together, these results indicate that both position and duration have an independent effect on word learning, suggesting that neither cue is simply a result of the other.

The literature reviewed above suggests that both stress and utterance position could be used to pull nouns out of sentences. It also suggests that infants are sensitive to both stress and utterance position. What remains to be learned is whether infants actually use these prosodic cues to assign grammatical class.

1.2 Distributional cues to grammatical class

As adults, when faced with a novel word, we use our knowledge of syntax to determine the grammatical class of the word. Syntax is the complex pattern of relationships that govern the way words come together in a sentence. While infants may not make use of syntax in an adult manner, it is possible that infants notice the co-occurrence patterns that syntax provides. Function words appear with some regularity before different classes of lexical words. For example, articles such as *the* and *a* often precede nouns, while modals such as *can* and *was* often precede verbs. Use of these patterns is called distributional learning (Cartwright & Brent, 1997). A child detects regularities in the input and uses the frequency with which words co-occur to categorize

words. The distributional learning theory helps suggest a solution to the bootstrapping problem. If infants can roughly learn about syntax from patterns of co-occurrence, they can learn more words. With these words they can eventually refine their understanding of syntax. Evidence suggesting that infants use distributional cues provided by syntax falls into three areas. First is the research showing that these cues are reliable enough that infants could make use of them. Second is the research showing that infants are sensitive to the function words that provide these cues. Third is the evidence that infants actually use these cues to assign grammatical class.

Looking at the first area of evidence, we need to know if the regularities between function words and nouns and verbs are reliable enough for infants to use to assign grammatical class. Using a distributional analysis, Mintz, Newport, and Bever (2002) addressed this question. Using the CHILDES database, they analyzed speech to English-learning infants under 2 years of age. They analyzed the 200 most frequent words in the corpus in terms of what words preceded the word and what words followed. They then calculated a similarity measure and formed clusters of words based on context. They found that nouns and verbs can be successfully categorized based on their co-occurrence patterns with surrounding words. This means that in the input to infants, there are positional regularities that could be used to roughly form words into the groups we call nouns and verbs. These findings confirm those of earlier studies (Cartwright & Brent, 1997; Mintz et al., 1995). Mintz et al.'s (2002) distributional analysis also revealed that the categorization of nouns was less precise when all function words were replaced by a single symbol representing the entire class of function words. This shows that distributional categorization is more accurate with recognition of specific function words.

These studies, taken together, confirm that syntactic cues are available in the input to infants.

Are infants sensitive to these available distributional cues? There are several studies showing evidence of infants' sensitivity to differences in function words. For example, at 16 months, but not at 12 months, infants show sensitivity to changes in function words (Shady, 1997). Twenty-four infants at each age listened to either a story with normal function words or a story with grammatically incorrect function words replacing the normal ones, for example, "This man has bought two cakes" vs. "Has man this bought two cakes." The 16-month-old infants who heard the story with the normal function words listened longer than those who heard the story with function words placed in incorrect word order patterns. Santelmann and Jusczyk (1998) found that at 18 months, but not at 15 months, infants are sensitive to the relationship between two grammatical morphemes, *is* and *–ing*. The 18-month-olds listened longer to passages with natural phrases, such as "everybody is baking bread," than to passages with unnatural phrases, such as, "everybody can baking bread." This task poses an additional challenge to infants since the two function morphemes are not adjacent. Hohle et al. (2004) looked at German-learning infants' ability to use distributional knowledge. They found that 14- to 16-month-old infants are sensitive to the co-occurrences of determiners and nouns. In the familiarization phase, infants listened to repetitions of a determiner followed by a novel word, e.g. *ein glamm*. This pairing implied that the novel word was a noun. In the test phase, infants heard passages of text containing the novel word used as either a noun or a verb. Using the head turn preference paradigm, Hohle et al. found that the infants listened longer, at test, to passages of text using the word as a verb than a

noun. Incidentally, when familiarized to the same novel word paired with a subject pronoun, e.g. *sie glamm,* implying that the novel word was a verb, the infants did not respond significantly differently to passages with noun versus verb syntax in the test phase. This suggests sensitivity to the differences in noun and verb syntax for German-learning 14- to 16-month-olds. It is important to note that German determiners are phonologically stronger than English determiners, so the German results may not reflect the abilities of English-learning infants. These studies (Shady, 1997; Santelmann & Jusczyk,1998; and Hohle, 2004) show that sensitivity to the distributional regularities of function words and their patterns in sentences is developing at around 14 to 18 months. They do not tell us whether infants at this age use their sensitivity to function words to determine grammatical structure. In other words, the limitation of these studies is that longer looking time indicates noticing a difference, but does not provide evidence that infants know what that difference means.

When do infants begin to use this type of sensitivity to assign grammatical class? Answers to this question are not entirely clear. Katz, Baker, and Macnamara (1974) found that 17-month-old girls could distinguish between a proper noun and a common noun based on whether or not the word was preceded by an article. Hall, Lee, and Belanger (2001) found that, for both girls and boys, 24-month-olds, but not 20-month-olds could distinguish between proper and common nouns. The Hall et al. study had a larger sample size, 16 boys and 16 girls at each age, compared with only five 17-month-old girls in the Katz et al. study. Gerken and McIntosh (1993) found that 25-month-old children better comprehended words that were preceded by a grammatical morpheme than an ungrammatical morpheme. These infants were taught new words in sentences

with a grammatical morpheme ("Find the bird for me"), with an ungrammatical morpheme, ("Find was bird for me"), with a nonsense syllable ("Find gub bird for me"), and with no morpheme ("Find bird for me"). Infants pointed to significantly more correct pictures in the grammatical morpheme condition compared to both the ungrammatical morpheme and the nonsense syllable conditions. Therefore, 24- and 25-month-old children appear to make use of function words. Are younger infants not using these cues, or is it difficult to reveal their competence in a study?

Studies showing that infants use syntactic cues at ages younger than 2 years have not properly controlled for prosodic cues. For example, Echols and Marti (as cited in Echols & Marti, 2004), in their 1999 study, reported that 18-month-old infants use syntactic cues to distinguish nouns from verbs. These 18-month-olds heard a novel word in either a noun frame, e.g. "That's a gep; it's a gep," or a verb frame, e.g. "It's gepping; see? It geps," while being familiarized with a creature and an action. In the test phase, infants continued to hear the novel word in a noun or verb frame (e.g. "Look at the gep" or "Look at it gepping"), while seeing two screens; one screen showing the same creature and a new action, and one screen showing a new creature and the original action. The infants who heard the noun frame looked longer to the same creature and the infants who heard the verb frame looked longer to the same action. It is interesting to note that the difference in the verb and noun frame was not only the function words, but also the position of the stressed syllable. Therefore, infants could have been responding to either syntactic cues, prosodic cues or both. Booth and Waxman (2003) showed that 14-month-olds responded differently to novel words that were syntactically nouns versus adjectives. When words were presented with noun syntax (e.g. "This one is a blicket." and "Can you

give me the blicket?"), the 14-month-olds were consistently able to map words to object categories. In some, but not all conditions, the 14-month-olds were able to map words presented with adjective syntax to object properties e.g. "This one is blickish." and "Can you give me the blickish one?" Booth and Waxman were able to show that the difference in performance between nouns and adjectives was not due to position in the sentence, since infants performed equally well when nouns were not presented in the final position at test (e.g., "Can you give me the blicket now?") However, it is possible that there is a longer pause between the words "blicket now," than between the words "blickish one" since "blickish one" is part of the same noun phrase. It is also possible that the words "one" and "now' differ in rleative stress. Therefore, the 14-month olds may have had both syntactic and prosodic cues available to them. In summary, there is evidence that infants as young as 14 and 18 months respond to cues and treat words of different grammatical classes differently. However, it is not clear which cues they are responding to.

This review of the literature reveals that both prosodic and distributional cues to grammatical class are available in the input to infants. In addition, infants appear to be sensitive to both prosodic and distributional cues. In terms of using these cues to assign grammatical class, 24- and 25-month-olds appear to use syntactic cues, but we do not know about younger infants. While 14- and 18-month-olds appear to use different types of cues to assign grammatical class, we do not know if the cues they use are prosodic, distributional , or both. The present study was designed to address this question.

In the present study, the question was asked whether 16-month-olds use distributional cues, prosodic cues, or both when learning a new object label in a sentence.

Infants were presented with sentences with two novel words, a noun and a verb. In one sentence type, one word had both prosodic and syntactic cues suggesting that it was a noun, and the other novel word had neither prosodic nor syntactic cues suggesting it was a noun. In the second sentence type the cues conflicted. One novel word had only prosodic cues suggesting it was a noun, and the other novel word had only distributional cues suggesting it was a noun. The critical question was, which of these words would infants map to a novel object? Because the sentences contained two novel words, the infant was forced to choose one label over the other. In the conditions where the cues were conflicting, the infant was forced to choose one cue over the other.

Four possible predictions follow from these theories. The prosodic bootstrapping theory would suggest that infants would use prosodic cues to determine which word labelled an object. Specifically, if prosodic cues are more powerful than distributional cues, we would expect infants hearing the sentence with conflicting cues to treat the word with prosodic cues only as an object label. The distributional learning theory would suggest that infants would use distributional cues to determine which word labelled an object. If distributional cues are more powerful than prosodic cues, we would expect infants hearing the sentence with conflicting cues to treat the word with distributional cues only as an object label. Infants may very well be able to use both prosodic bootstrapping and distributional learning. In this case, we would expect infants to respond to both cues. Responding to both cues could result in two possible outcomes. Infants may do the best when both cues are present, compared to when only one cue is present. Alternatively, because of the redundancy in cues, infants may respond similarly to words with both cues and words with either cue. The final prediction is that infants

would not use either cue to learn an object label. Given this result, we would not be able to draw conclusions about whether prososdic bootstrapping and/or distributional learning affect infants' abilities to learn an object label.

Method

The following experiment utilized the "preferential looking" paradigm of Golinkoff, Hirsh-Pasek, Cauley and Gordon (1997), which compares infant looking time to each of two videos presented simultaneously with an audio stimulus. When an infant appears to have understood the audio stimulus, looking time is found to favour the screen that matches the audio. In Golinkiff et al.'s original study, two experiments with 16-month-olds showed that infants' patterns of visual fixations favoured the screen that matched the linguistic stimulus. The "preferential looking" paradigm was chosen because it allows infants to demonstrate knowledge without requiring an overt response such as pointing or talking.

2.1 Participants

The participants were thirty-two 16-month-old infants, 16 boys and 16 girls, recruited through hospital visits to new mothers, and through voluntary response to public service announcements in the Greater Vancouver area. The mean age was 16 months 24 days (range = 16 months, 15 days to 17 months, 5 days). It is important to note that while these participants are referred to as 16-month-olds, they are all 16 ½ months or older, and as old as 17 months and 5 days. Subjects had no apparent health problems, were born at least 37 weeks gestation, and were exposed to English at least 80% of the time. Data from the first five participants were analyzed to determine the best age range for this task. Because this was a new design, testing infants with two novel words, it was important to ensure that infants were able to, at least, learn an object label

in the easiest condition, in which the cues lined up. Therefore, after testing the first 5 participants, the age range criteria was set at 16 months, 15 days to 17 months, 7 days. This meant excluding one participant on the basis of age (too young). Out of 42 infants tested, a total of 10 infants were excluded, 4 for equipment failure, 2 for failure to look during the orientation to the test screens, and 4 for failure to fit the criteria (too young as mentioned above [n=1], born earlier than 37 weeks gestation [n=1], reported trouble with hearing [n=1], exposure to less than 80% English [n=1]).

Parents were asked to fill out the MacArthur Communicative Development Inventory (CDI) (Fenson et al., 1993), Words and Gestures form either before or after their visit to the lab. This inventory was used for two purposes. First, infant scores in each condition could be compared to ensure that groups were well matched for vocabulary. Second, correlations between vocabulary scores and performance in each condition could be examined. Thirty out of 32 CDI's were filled out and returned, resulting in at least seven sets of CDI scores in each condition. Infants comprehended an average of 202 words and produced an average of 55 words. The Words and Gestures form was chosen, rather than the Words and Sentences form, because it provides information on comprehension as well as production. However, the Words and Gestures form only provides normative information up to 16 months. Therefore, the typicality of the group could not be assessed. Accordingly, CDI scores, in the current study, are reported as raw scores, rather than standard scores.

All infants received an "Infant Scientist" T-shirt and a diploma for their participation.

2.2 *Stimuli*

2.2.1 Audio Stimuli. The audio stimuli, for the familiarization phase, were four sentences, recorded by a female North-American English speaking adult. The sentences were recorded in a sound-proof room at the Interdisciplinary Speech Research Laboratory at UBC, using the SoundEdit audio program with an AKG condenser microphone placed approximately 12 inches from the speaker. The speaker was instructed to use an infant-directed speech style and to highlight the word at the end of the sentence, as if she was most excited about communicating the final word. Sentences were modelled by the experimenter, demonstrating heightened stress for the final word. Each sentence contained both a novel noun and a novel verb, and the sentences varied in terms of whether the noun or the verb was in final position.

The four sentences are listed here with the most highly stressed word in large capitals, and the other stressed word in small capitals. (Note that the noun and verb are both stressed relative to the other words in the sentence, but the final word has extra stress):

1. I ZUT the GEB
2. I GEB the ZUT
3. The ZUT can GEB
4. The GEB can ZUT

The two basic sentence forms were chosen for their symmetry in rhythm while presenting nouns and verbs in reversed positions. In the first two sentences, the cues line up; the final word has both prosodic and distributional cues suggesting that it is a noun. In the final two sentences the cues conflict; the second word has a distributional cue suggesting that it is a noun, and the final word has prosodic cues suggesting that it is a noun. This provides a way of teasing apart the effects of prosody and syntax.

Two novel words, *zut* (rhymes with *cut*) and *geb* (rhymes with *web*, and begins with the sound in *get*) were used. The words were chosen to be maximally different from each other while matching in syllable structure (i.e., CVC), and vowel length (i.e., short). While the initial /z/ in *zut* is rare in English compared with the initial /g/ of *geb*, the final /t/ of *zut* is more common that the final /b/ of *geb*. Therefore frequency of consonants was counterbalanced across the words, even though not by position in the word. Care was taken to ensure that the words differed by more than one feature from common English words. In addition, care was taken not to provide phonological cues to word class as follows. While some differences have been noted in vowel height and backness across nouns and verbs (Kelly, 1992), an analysis, by this author, of the vocabulary list in the MacArthur CDI, was undertaken to determine whether the patterns noted by Kelly hold in infants' early vocabulary. The analysis showed that the vowels in both nouns and verbs tend to be slightly high and front. Specific vowels were chosen for the novel words that were found in both nouns and verbs in the single words of the CDI. The vowel in *geb* is found in 8% of the nouns and 4% of the verbs, and the vowel in *zut* is found in 6% of the nouns and 8% of the verbs. The two words, *zut* and *geb*, were counterbalanced in the sentence frames to ensure that any phonological cues or neighbourhood effects present in one of the words would not be confounded with any of the independent variables.

Each sentence was recorded three or more times, to ensure that a final set of sentences could be chosen with similar duration, intensity, and pitch for the stressed and less-stressed words. Audio files were analyzed for duration, intensity and pitch using Praat software. Duration was measured as vowel duration in ms., pitch was measured as peak pitch in Hz., and amplitude was measured as peak amplitude in dB.

Audio stimuli for the test phase were the single words *zut* and *geb* spliced from sentences that were not used in the familiarization phase, and chosen for having values of duration, pitch, and amplitude in between those of the novel words in medial and final position. It was reasoned that by having intermediate stress values, we could eliminate the possibility that the prosody match to one of the words in the familiarization would determine performance. Values of duration, pitch, and amplitude for each word are shown in Table 2.1.

Table 2.1

Duration, pitch, and amplitude values for individual words

Audio	*Duration (in ms)*		*Pitch (in Hz)*		*Amplitude (in dB)*	
I ZUT the GEB	ZUT 169	GEB 313	ZUT 200	GEB 363	ZUT 72	GEB 82
I GEB the ZUT	GEB 221	ZUT 361	GEB 207	ZUT 452	GEB 76	ZUT 85
The ZUT can GEB	ZUT 167	GEB 330	ZUT 199	GEB 385	ZUT 82	GEB 86
The GEB can ZUT	GEB 224	ZUT 377	GEB 197	ZUT 359	GEB 76	ZUT 86
Zut (test)	199		258		86	
Geb (test)	280		281		84	

As seen in Table 2.1, *geb* is longer than *zut* in sentence medial position, and *zut* is longer than *geb* in sentence final position. In terms of both duration and pitch, values for highly stressed and less stressed content words do not overlap. In terms of amplitude, there is some overlap. Amplitude of highly stressed words ranges from 82dB to 86dB, and amplitude of less stressed words ranges from 72-82dB. However, within any individual sentence, amplitude values are always higher for the highly stressed word (Note that infants only hear one of these sentences). Average values for duration, pitch, and amplitude are shown in Table 2.2.

Table 2.2

Average duration, pitch and amplitude values

	Duration (in ms)	*Pitch (in Hz)*	*Amplitude (in dB)*
verbs in final position	353	372	86
nouns in final position	337	408	84
verbs in medial position	195	204	74
nouns in medial position	196	198	79

As seen in Table 2.2, in terms of words in final position, verbs were slightly longer in duration than nouns, but nouns were higher in pitch than verbs. Verbs and nouns were roughly equivalent in amplitude. In terms of words in medial position, nouns and verbs were roughly equivalent in duration, pitch and amplitude.

2.2.2 Visual stimuli. Two novel creatures were created, differing in size, shape, and colour. Neither creature resembled a known animal. Pictures of these creatures are shown in Figure 2.1. One was created from a trombone mute, painted blue, with antennas, a large face, and two legs added. This creature will be called the round object. The other creature was created from cardboard boxes and coloured paper. Curly hair made of shiny ribbons, eight legs, and a small face were added. This creature will be called the square object.

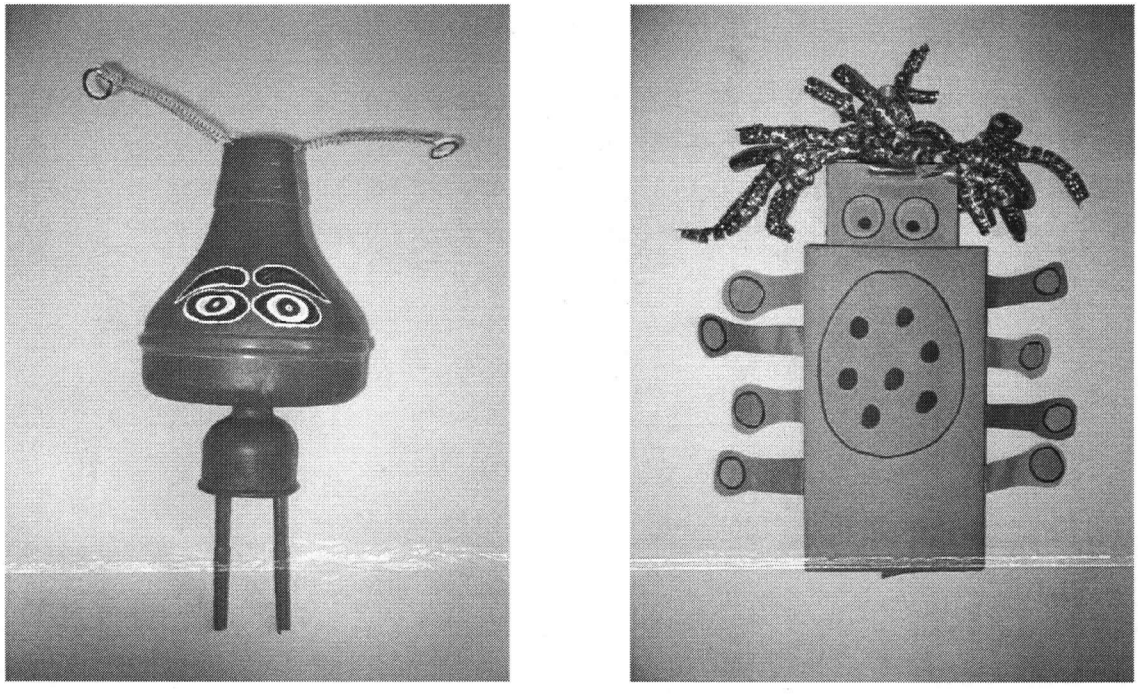

Figure 2.1 *Pictures of objects*

Two actions were chosen to be as different as possible from each other, while still fitting pragmatically with either sentence form, the transitive, (e.g., "I zut the geb"), as well as the intransitive (e.g., "The zut can geb"). In each case, an arm and hand were seen moving the creature. The arm ensured that the transitive sentence would make sense. The face of the adult doing the action was not included in the video to ensure maximum focus on the object and action, and to avoid the pragmatic discrepancy of a mouth not moving while a voice was heard. For one action, the object was flipped forward and back. For the second action, the object was moved upward and back through a zig-zag pattern. Each object was filmed with each action, using an analog video camera, NEC Model V5OU. Clips were selected, digitized, and then edited using Final Cut Pro.

Two clips were used for the familiarization phase, one with the round object and the zig-zag action, and one with the square object and the flip action. Each clip was cropped so that it could be placed on the right or left side of the screen. Each clip lasted 5 seconds with the action beginning 2 seconds into the presentation. Audio files were inserted at the beginning of these clips, so that sentences were completed before the beginning of the action. The timing is shown in Figure 2.2.

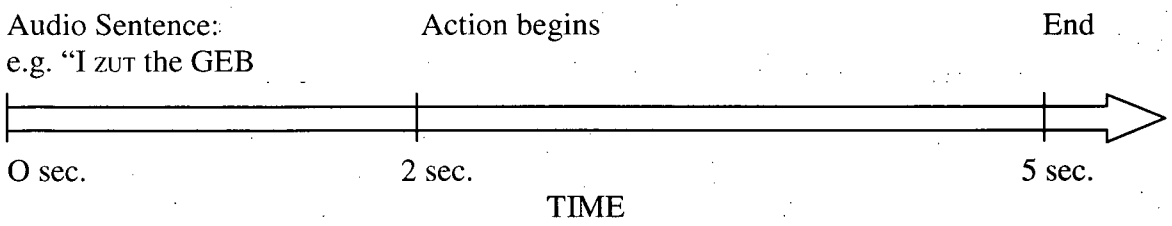

Figure 2.2 *Time line for individual familiarization clip*

Longer movies were created showing the same clip twice on the left, twice on the right, and twice on both sides. Following each of the six clips, one second of a black screen was inserted. These six presentations of a sentence and an object/action pair constituted the familiarization phase. Movies for the complete familiarization phase were exported from Final Cut Pro into Quick Time movies.

The two other clips were used for the test phase, this time presenting both sequences simultaneously, one on each side. These clips were also cropped. The clip with the round object and the flip action was placed on the right side and the clip with the square object and the ziz-zag action was placed on the left side. Each test clip was 4 seconds long with the action beginning 1 second into the presentation. Actions were similar in duration, so that, when two clips were presented simultaneously, there would

be no point in time when one object was moving and the other was not. The timing is shown in Figure 2.3.

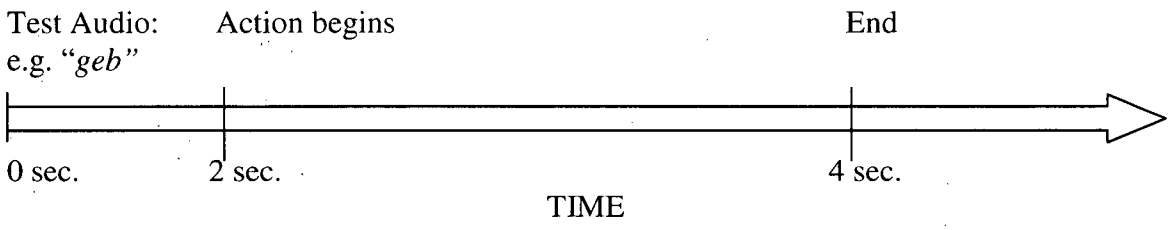

Figure2.3 *Time line for individual test clip*

A longer movie was created showing these simultaneous clips six times. Of these six test presentations, the first two were presented without audio, so that infants would have a chance to learn what was on each screen. For the final four presentations, a single test word was inserted at the beginning of each clip. Movies for the complete test phase were exported from Final Cut Pro into Quick Time movies.

Movies of a colourful ball, used as an attention getter, were combined with familiarization and test movies as shown in Figure 2.4.

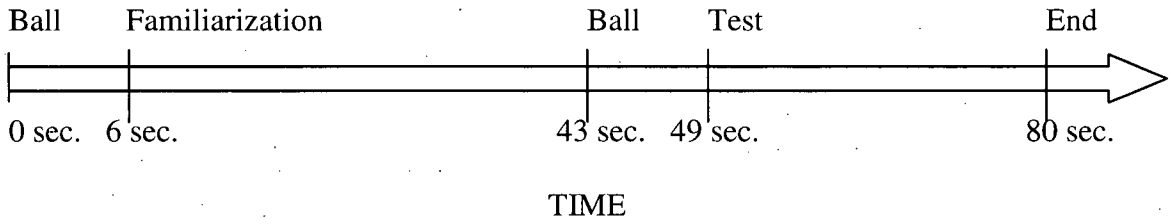

Figure 2.4. *Time line for video sequence*

2.3 Procedure

Infants were familiarized with one sentence while viewing a scene of a novel object and a novel action. This familiarization phase allowed the infants an opportunity

to develop an interpretation for one or both of the novel words. It also demonstrated to infants that information could be presented on either screen. In the test phase, the infants saw a new object paired with the original action on one screen and the original object paired with the new action on the other screen.

For all test presentations, the round object was consistently shown on the right at test. However, because infants were familiarized with both objects, the round object was the familiar object in only half of the conditions. Prior to the familiarization and test phase, a video with an interesting ball moving was presented on both screens to draw infants' attention to the monitor. The entire presentation of familiarization and test was 1 minute, 20 seconds, and is shown in Table 2.3.

Table 2.3

Familiarization and test sequence

Familiarization

Left Screen	*Audio*	*Right Screen*
Hand making round creature move in zig zag	I ZUT the GEB	
Hand making round creature move in zig zag	I ZUT the GEB	
	I ZUT the GEB	Hand making round creature move in zig zag
	I ZUT the GEB	Hand making round creature move in zig zag
Hand making round creature move in zig zag	I ZUT the GEB	Hand making round creature move in zig zag
Hand making round creature move in zig zag	I ZUT the GEB	Hand making round creature move in zig zag

Test

Left Screen	*Audio*	*Right Screen*
Hand making square creature move in zig zag		Hand making round creature flip forward and back
Hand making square creature move in zig zag		Hand making round creature flip forward and back
Hand making square creature move in zig zag	Geb	Hand making round creature flip forward and back
Hand making square creature move in zig zag	Geb	Hand making round creature flip forward and back
Hand making square creature move in zig zag	Geb	Hand making round creature flip forward and back
Hand making square creature move in zig zag	Geb	Hand making round creature flip forward and back

This design was intended to be used as a between subjects design, with each infant being tested on only one of the two test words. However, following the presentation of this sequence, a second presentation of the whole sequence was shown to all infants, this time

testing infants with the word they had not been tested on. This was included in case more could be learned by testing each infant with both test words. However, results from this second presentation were intended to be used with caution in case of test-retest effects. If no test-retest effects were revealed, the results could be used to increase power. A checkerboard pattern was presented for 10 seconds between these two sequences.

Infants were seated on a parent's lap, facing a 50 inch NEC PlasmaSync PX-50XM4A monitor. Parents were given headphones with music playing, and were instructed not to talk or point. Infants were recorded with a Sony DV Digital Handycam video camera, placed below the video monitor, peeking through a hole in a black cloth. There were equal numbers of boys and girls assigned to each of four conditions. The first four girls and four boys were randomly assigned to one of the first two conditions, and the next four girls and four boys were randomly assigned to one of the third or fourth condition. The final eight boys and eight girls were alternately randomly assigned to one of the first two conditions and one of the last two conditions.

The four conditions are based on the number of noun cues that the test word had in the familiarization sentence. Condition 1 had both distributional and position/stress cues, Condition 2 had no cues, Condition 3 had distributional cues only, and Condition 4 had position stress cues only. It is important to note that all test words had distributional cues, but only Conditions 1 and 3 had noun distributional cues, i.e. a word preceded by *the*. Therefore, in the current study, which focuses on noun cues, the presence or absence of a distributional cue is used to mean the presence or absence of a noun distributional cue, i.e. an article. Table 2.4 shows details of the four conditions. Within each condition, the novel

words were counterbalanced, so that half of the infants heard *zut* in final position and half of the infants heard *geb* in final position.

Table 2.4

Conditions

Condition	Number of Infants	Familiarization	Test word	Noun Cues
Condition 1 Final/Stressed Noun	4	I zut the geb	Geb	Both Distributional and Position/Stress Cues
	4	I geb the zut	Zut	
Condition 2 Medial Verb	4	I zut the geb	Zut	No cues
	4	I geb the zut	Geb	
Condition 3 Medial Noun	4	The zut can geb	Zut	Distributional Cue only
	4	The geb can zut	Geb	
Condition 4 Final/Stressed Verb	4	The zut can geb	Geb	Position/Stress cues only
	4	The geb can zut	Zut	

2.4 Coding

The video recordings of the infants' faces during testing were digitized using Final Cut Pro, so that the movies could be viewed, frame by frame, with 30 frames per second. Markers were added to indicate the onset of each test word. The digitized movies were exported into Quick Time movies, and coded, measuring infants' looking time, frame by frame, to the two screens. Beginning with the onset of each test word, each frame was coded as a look to the right, left or away. Coding away included blinks, unless the infant was looking at the same screen before and after the blink. The experimenter digitized and coded all of the subjects. After the first five infants had participated, it was noted that the first two presentations of the test word appeared to show differing responses according to condition. Meanwhile, the final two presentations showed more random results. After hearing the word

twice, infants may have become more interested in other differences between the two screens besides which one matched the audio. Therefore, based on data from the first 5 infants, the decision was made, at that time, to use only the first two presentations of the test word in the main analysis of results. For the first two presentations of the test word, infants' looking time to either screen was coded from 367ms to 1500ms after the onset of the test word. According to Swingley and Aslin (2000), 367ms is an educated guess of the minimum time to initiate a shift in eye gaze to a picture in response to the presentation of a word. The end point, 1500 ms after the onset of the test word, was chosen because, for the first five infants tested, looking appeared to become more random after this point. Swingley and Aslin (2000) used a similar logic in choosing an end point for coding, but found that for their stimuli, this occurred at 2000 ms. Similarly, for the first 6 infants, looking appeared to become more random after the first two presentations of the test word. Therefore, only responses to the first two presentations were coded. A second coder independently coded all presentations of the test word for 11 randomly selected subjects. Agreement between coders on whether infants looked left, right or away was 99.8%.

2.5 Analysis

The following analyses were undertaken for the current study.

1. Analysis of data in terms of procedural methods, including preference for object, side, or test word.
2. A comparison of looking time to the two screens before the infants could respond to the test word, to examine the effects of a preference for familiarity or novelty.

3. A comparison of looking time to the same object in the four conditions, in terms of an effect of distributional cues, prosodic cues, or both.
4. Analysis of data in terms of participant characteristics, including gender, vocabulary production and comprehension.
5. Analysis of correlations between CDI scores and looking time within each condition.

Results

During the entire first sequence of familiarization and test, infants appeared interested and engaged in the videos. Coding revealed that, during the window of analysis, infants were looking at one of the screens 97.6% of the time. Looks away were predominantly the time switching gaze from one screen to the other.

The first analysis involved ensuring that procedural methods such as test word, object, and screen side did not account for the results. The test words, *zut* and *geb*, were counterbalanced within each condition. However, an Analysis of Variance, was used to confirm that there were no main effects of test word. The between subject factors were test word and gender and the dependent variable was looking time to the same object. No main effects and no significant interactions were found. Object and side were also counterbalanced within each condition. However, they were counterbalanced as a set, such that the round object was always on the right at test. Because half of the infants were familiarized to each object, the round object was the familiar object for only half of the infants in each condition. An Analysis of Variance, with between subject factors of object and gender and the dependent variable as looking time to the same object, revealed no main effects and no significant interactions.

The second analysis was done in order to rule out the possibility that looking time was determined by a preference for familiarity or novelty. Looking time for the first 5 frames (166ms) from the onset of the first test word were scored as a baseline measure. Since we did not expect infants to be able to initiate a change in eye gaze in response to a word for 367ms (Swingley & Aslin, 2000), these first 166ms safely show infants' looking without influence from the test word. Percentage of looking to the same object was balanced

across conditions with no significant differences (Condition 1=38%, Condition 2=38%, Condition 3=39%, and Condition 4=47%).

The third analysis was the main analysis for the current study, comparing looking time to the same object in each condition. The dependent variable was the percentage of looking time to the same object out of total looking time to either screen. The independent variables were distributional cues (whether or not the test word had distributional cues suggesting that it was a noun) and position/stress cues (whether or not the test word had position/stress cues suggesting that it was a noun). Note that both novel words in each sentence were stressed, but the final word in each sentence was given extra stress. The final word in each sentence is therefore the word with position/stress cues suggesting a noun.

Looking time to the same object was compared across conditions because it indicates that the infant treated the word as an object label. Since looking to the same object was measured as percentage of total looking time, looking to the other object is simply the remaining percentage. For example, if an infant looked 70% to the same object, we know that the infant looked 30% to the unfamiliar object.

In Condition 1 (final noun) infants looked more to the same object than they did to an unfamiliar object. Average looking time to the same object was 69% of total looking time. In Condition 2 (medial verb), infants looked less to the same object than they did to an unfamiliar object. Average looking time to the same object was 18% of total looking time. Conditions 3 and 4 were particularly interesting because the cues conflicted. For each condition, only one cue suggested that the word was a noun, and the other cue suggested otherwise. In Condition 3 (medial noun), infants looked more to the same object. Average looking time to the same object was 71% of total looking time. In Condition 4, with

position/stress cues suggesting the word was a noun, and distributional cues suggesting the word was a verb, infants again looked more to the same object. Average looking time to the same object was 75% of total looking time.

An Analysis of Variance was performed, with between subject factors of distributional cue (+/-), position/stress cue (+/-) and gender (M/F), and the dependent variable of looking time to the same object. Looking time to the same object was measured as percentage of time looking at the familiar object compared to total time looking at either object. Greater looking times to the same object suggest that, during the familiarization phase, infants learned the test word as an object label. This analysis revealed main effects of both distributional cues $F(1,31)=5.487$; $P=.028$, and position/stress cues $F(1,31)=7.098$; $P=.014$, and a significant interaction between distributional and position/stress cues $F(1,31)=8.765$; $P=.007$. There was no main effect of gender, and there were no significant interactions between gender and either of the other factors.

To probe the source of the significant interaction effect a Fisher Hayter Test was used. The critical value was calculated to be 35.8, and the means were as follows: Condition 1=69 (Minimum 40, Maximum 100), Condition 2=18 (Minimum 0, Maximum 60),Condition 3=71 (Minimum 0, Maximum 100), Condition 4=75 (Minimum 36, Maximum 100). Therefore, in Condition 2, with no cues suggesting the word was a noun, looking time to the same object was significantly lower than in all other conditions. The other 3 conditions did not differ significantly from each other. Looking time to the same object is shown in Figure 3.1.

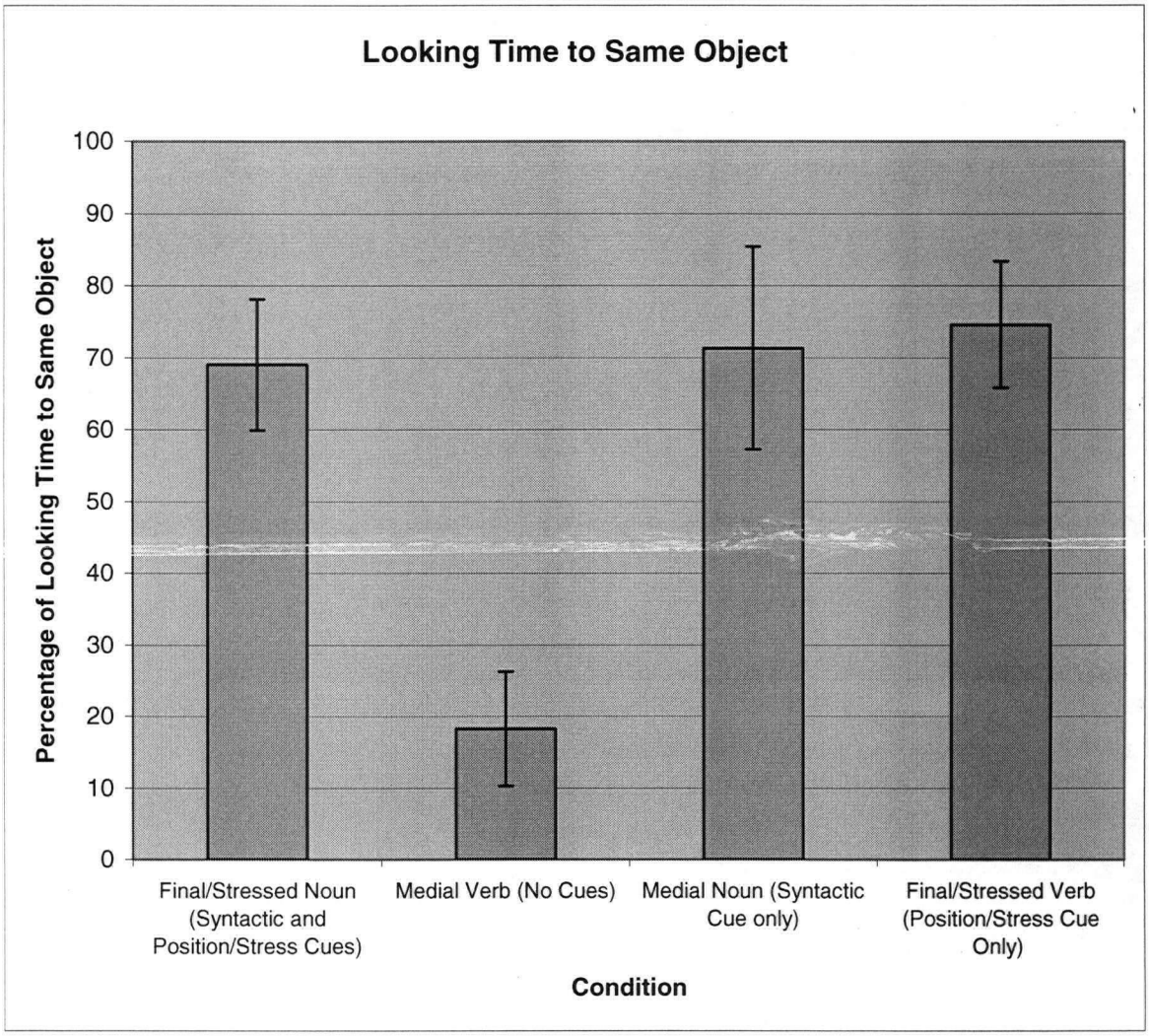

Figure 3.1 *Looking time to the same object in each condition*

For the fourth analysis, comprehension and production scores from the MacArthur Communicative Development Inventory (CDI) were tallied and are shown in Tables 3.1 and 3.2. Comprehension and production scores, of infants in different conditions, did not differ significantly.

Table 3.1

Comprehension scores

Comprehension Scores				
Condition	*Minimum*	*Maximum*	*Mean*	*Standard Deviation*
Condition 1 (Final/Stressed Noun)	81	311	248	84
Condition 2 (Medial Verb)	47	365	199	112
Condition 3 (Medial Noun)	55	267	176	79
Condition 4 (Final/Stressed Verb)	69	312	183	83

Table 3.2

Production scores

Production Scores				
Condition	*Minimum*	*Maximum*	*Mean*	*Standard Deviation*
Condition 1 (Final/Stressed Noun)	5	174	80	64
Condition 2 (Medial Verb)	9	155	60	55
Condition 3 (Medial Noun)	2	86	30	30
Condition 4 (Final/Stressed Verb)	0	115	48	44

A correlation analysis was used to compare looking time to the same object within each condition to comprehension and production scores from the CDI. In condition 4 (position/stress cues only), a significant negative correlation of -.945 (two tailed, p=.000) was found between looking to the same object and CDI Comprehension scores, and can be seen in Figure 3.2. Also in Condition 4, a significant negative correlation of -.871 (two tailed, p=.005) was found between looking time to the same object and CDI Production scores, and can be seen in Figure 3.3. In the other three conditions, there were no significant correlations between looking to the same object and CDI scores.

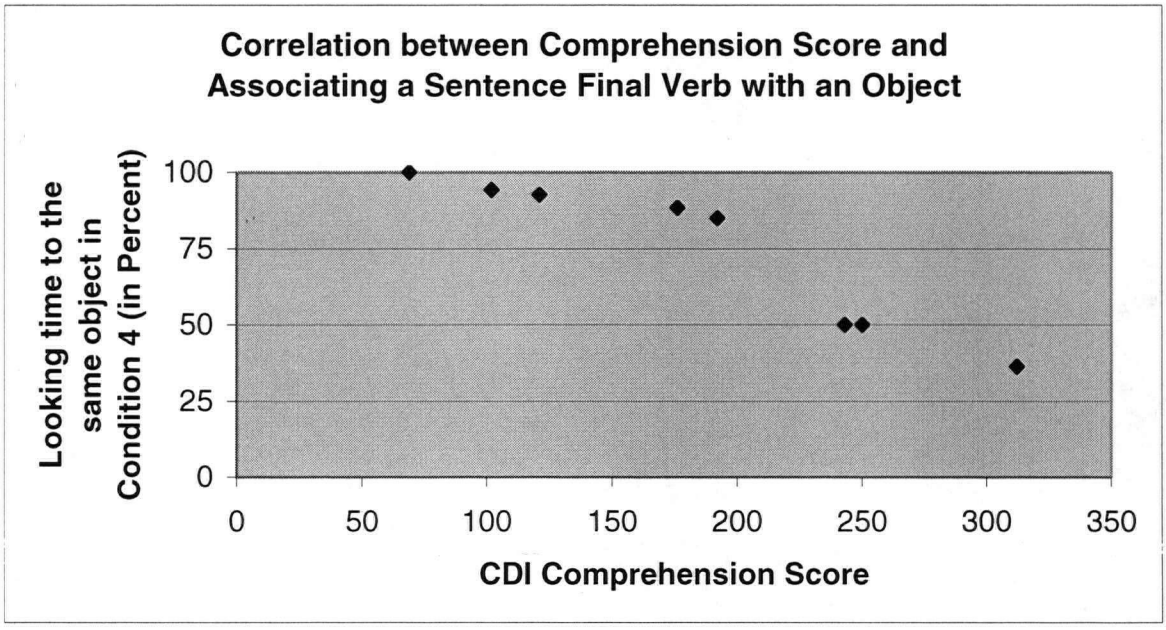

Figure 3.2 Correlation between comprehension score and associating a sentence-final verb with an object

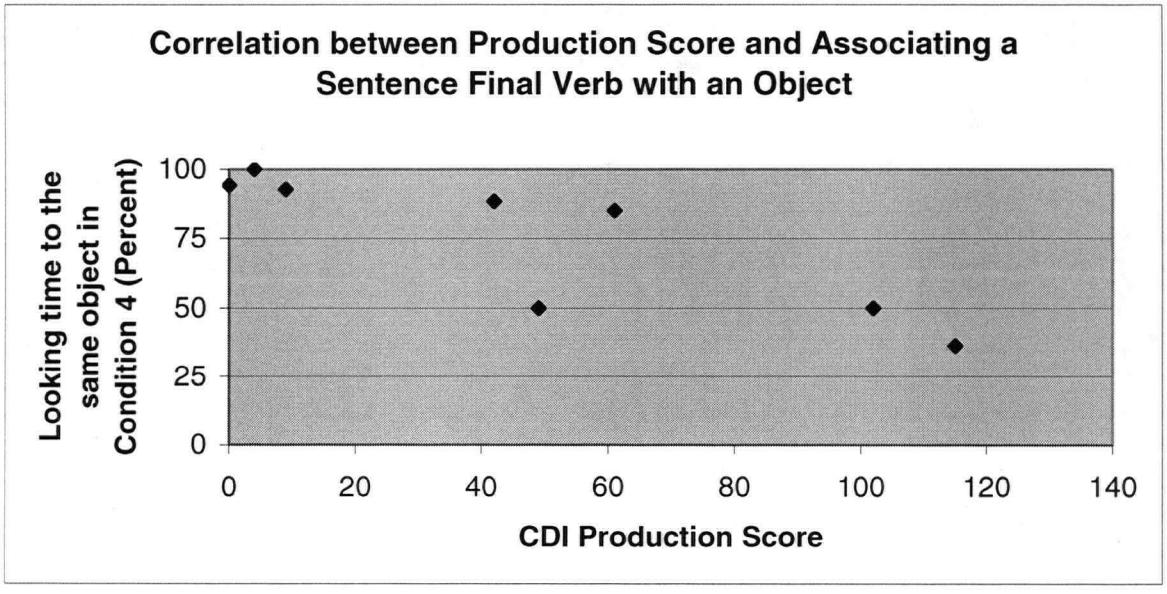

Figure 3.3 *Correlation between production score and associating a sentence-final verb with an object*

A correlation analysis was used to compare looking time to the same object with age in each condition. No significant correlations were found.

The second presentation of the familiarization and test sequence tested infants on the second test word. This presentation was not intended to be included in the main analysis above because of the likelihood of test-retest effects and infant fatigue. However, it was thought that something interesting might be gained by adding the second sequence to the procedure. During the second sequence, infants appeared less interested, and during the window of analysis, infants looked away more than they had in the first sequence; 15% of looks were away from either screen in the second sequence, compared to 2% of looks away in the first sequence. This confirms the impression that infants were less interested. An Analysis of Variance was performed on this second sequence, with between subject factors of Distributional Cue, Position/Stress Cue and Gender, and the dependent variable of looking time to the same object. In this second sequence, there were no main effects and no significant interactions.

Discussion

This study asked whether 16-month-old infants make use of distributional and/or prosodic cues when assigning grammatical class. The results clearly show that infants respond to both distributional and prosodic cues when learning an object label. Not only do they learn an object label when both types of cues line up, but they also assign an object label equally well when either type of cue is present. In other words, the presence of either a distributional cue or a prosodic cue is enough to signal that a word labels an object. In three of the four experimental conditions, this approach led infants to the correct conclusions. Infants linked the nouns in both medial and final/stressed positions to an object, and infants did not link a verb in medial position to an object. However, in one condition, this approach brought infants to the wrong conclusion. They mistakenly thought that an utterance-final verb labeled an object. While it was expected that infants would perform the best in the condition in which both distributional and prosodic cues suggested that the word was a noun, they actually performed similarly in the three conditions that provided any cue that the word was a noun. In other words, either a distributional cue or a prosodic cue was equally as helpful as both cues together.

The first analysis involved ensuring that procedural methods such as test word, object, and screen side did not account for the results. Results showing that there were no main effects of test word, object and screen side imply that these procedural details did not significantly influence infant performance.

The second analysis was done in order to rule out the possibility that looking time was determined by a preference for familiarity or novelty. Results showed that looking time

to the same object, before the influence of the test word, was not significantly different between the four conditions. While looking time slightly favoured the novel object, it did so for all four conditions. This implies that differences in looking time between the conditions, after the infants had a chance to respond to the test word, can be attributed to differences in the conditions and not differences in preference for familiarity or novelty. Specifically, the significantly different performance of children in Condition 2, i.e. looking less to the same object when tested on a medial verb, cannot be consistent with a familiarity or novelty response. This differences noted between Condition 2 and the three other conditions only occurred after infants had a chance to respond to the test word.

The third and main analysis for the current study compared looking time to the same object in each condition. Results from this analysis address the main questions of the current study. Do infants use prosodic bootstrapping, distributional learning, or both when learning object labels? In terms of prosodic bootstrapping, the findings of this study show for the first time that infants as young as 16 months use prosodic cues to assign grammatical class. Infants looked longer to the same object when tested with a noun or a verb in final/stressed position. In terms of distributional learning, results of this study show that infants can use distributional cues provided by syntax to assign grammatical class as early as 16 months. For both the medial noun and the final noun (both words preceded by *the*) infants looked longer to the same object. This can be seen as an early attempt at syntactic bootstrapping. Infants use the patterns provided by syntax to learn more about the meanings of words. While Echols and Marti's 1999 study (as cited in Echols & Marti, 2004) showed use of syntactic cues to distinguish nouns and verbs at 18 months, and Booth and Waxman (2003) showed use of syntactic cues to distinguish nouns and adjectives, it was not clear from these studies

whether prosody may have been a confounding factor. The results of the current study unconfound these factors, showing that 16-month-olds can use the distributional cues that syntax provides independently from prosody.

We began the current paper discussing a challenge infants face. When learning a language, infants need semantic knowledge in order to learn syntax, and they need syntactic knowledge in order to learn semantics. Use of prosodic and distributional cues allows infants to get a rough start at using sentence level cues to learn word meanings. Prosodic and distributional cues provide an imperfect strategy for assigning grammatical class. As seen in this study, assuming that a final stressed word labels an object can lead infants to learn a final verb as an object label. Similarly, assuming that a word preceded by an article is a noun could also lead infants to think that an adjective is a noun. For example, in the sentence, "The crazy car drove by," infants might think that the adjective *crazy* labels an object. However, even getting the wrong answer can be part of a brilliant strategy. Infants start out not knowing syntax or word meanings. A naïve theory of syntax, based on prosodic and distributional cues, can provide the perfect start to syntactic bootstrapping. It is reasonable to expect that as infants learn more word meanings they can then refine their knowledge of syntax.

Another main finding of this study is that at around 16 months, as vocabulary comprehension and production grow, infants appear to be less and less convinced that an utterance-final verb labels an object label. This was shown by the negative correlation in condition 4 showing that as infants' production and comprehension vocabularies increased, they were less likely to treat a verb in final/stressed position as a noun. Since this is the condition in which infants' responses were opposite to those we expect of adults, a negative

correlation implies a move towards adult competence. In other words, as vocabulary increases, infants treat a final verb in a more adult manner.

What exactly is changing for these infants? Two main possibilities could account for the change. First, as vocabulary increases, infants may be more certain that the other word in the sentence (the medial noun, *zut* in "The ZUT can GEB") labels an object. This increased certainty may allow them to use mutual exclusivity to reason that the final verb, *geb* could not also label the same object. Some evidence pointing toward this possibility would include a positive correlation between CDI comprehension scores and looking to the same object in the medial noun condition. Such a correlation is not indicated by the small sample of children in the medial noun condition in this study. The correlation between looking time and comprehension in the medial noun condition is negative and not significant. A larger sample may show this relationship more clearly.

A second possible account for the change toward a more adult interpretation of a final verb could be that as vocabulary increases, infants become more sensitive to the distributional cues to verbs. In other words, 16-month-old infants may be becoming more sensitive to the regularity with which the modal *can* precedes a verb. This is consistent with the idea of using cues positively. Perhaps, once infants learn a specific distributional cue for a verb, it overrides the prosodic cue.

A surprising result of the current study was that infants associated two different words in the same sentence with an object label. The design of using two novel words in one sentence was intended to shed light on which type of cue was stronger, distributional or prosodic. It was expected that infants would assign only one word in a sentence as an object label. Surprisingly, infants were willing to assign both words in one sentence as labels for a

single object. Mutual exclusivity would suggest that one object could not have two different labels. Is there a reason why infants should not use mutual exclusivity? Perhaps when infants first make an association between a label and an object, they are open to the idea that more than one possible word could label the object. This would prevent them from getting stuck on an association with an incorrect label. It is of some relief to me knowing that the infants in this study will not go through the rest of their lives insisting that a blue painted trombone mute with big eyes can only be called a *zut*.

4.1 Limitations

One limitation of the current study is that there is a possible alternative explanation for what appears to be an effect of distributional cues. The two sentence types were chosen to match as closely in rhythm as possible. However, in the first sentence, "The ZUT can GEB," *zut* is the final word in the noun phrase; and in the second sentence, "I ZUT the GEB", *zut* is in the middle of a verb phrase. Therefore, while the obvious difference between, "The zut" and "I zut" is the distributional cue, i.e. an article or a modal preceding the word, it is possible that there are prosodic differences between these two words, based on their position in phrase structure. Therefore, while the intention was to look at the effect of distributional cues without influence from prosodic cues, the possibility of prosodic differences between the two syntactic frames cannot be entirely ruled out.

A second limitation of the current study is that, for each condition, there were only two tokens of the sentence. For example, in Condition 1, infants heard one of two sentence tokens, "I ZUT the GEB" or "I GEB the ZUT." The possibility of idiosyncrasies in individual

sentence tokens affecting results could be minimized if more tokens were used, with a variety of novel words.

A third limitation of the current study is the small sample size. While the results appear clear with only 8 infants in each condition, doubling the sample size would allow even more confidence in results.

A final limitation of this study is that there are different ways to interpret infants' responses in Condition 2, the no cues condition. Condition 2 was the only condition in which infants did not associate the label with an object. When infants looked at the new object, they were also looking at the same action they had seen in the familiarization phase. Therefore, they could have been looking to the new object because they did not learn an object label, or they could have been looking to the same action because they learned a verb label. Further discussion of these two possibilities follows.

The first possibility, that they did not look to the same object because there were no cues suggesting that the word was a noun, fits nicely with the idea that a cue is only used as positive evidence. This possibility parsimoniously accounts for results in all conditions. Infants looked to the same object in all conditions with the presence of a noun cue. The second possibility, that the response to the medial verb was a result of a distributional cue to the word being a verb can also fit with results. However, in this case, we have to account for infants responding to the distributional cue of a medial verb preceded by *I* and not responding to the distributional cue of a final verb preceded by *can*. This could be accounted for in terms of lexical frequency. As reported in Greenberg (1997), in a large corpus of adult telephone conversations, the word, *I*, is the most frequent word. *The* is the third most common word, and *can* is the 50th most common. Although we do not know how well these

frequencies hold in speech to infants, it is possible that differences in frequency could account for infants noticing the distributional pattern associated with *I* and not with *can*. We know that for highly frequent words, adults do not show a differential effect of frequency in their reactions times (Gordon & Caramazza, 1982). However, it is possible that frequency has an effect for infants even within the most frequent 50 words. Interestingly, in Santelman and Jusczyk's study (1998), 15-month-olds were not sensitive to the difference between the sentences, "everybody is baking bread" and "everybody can baking bread." Perhaps the 16-month-olds in the current study were also not sensitive to the co-occurrence patterns of "can", and so they did not realize a word following *can* labelled an action. Because of these two possible interpretations of infants' responses in Condition 2 (medial verb), the current study does not attempt to make conclusions about verb learning. This is an area for future research.

4.2 Future research

An important implication for future studies is that vocabulary measures may be more useful than age when grouping children in studies. By 16 months of age, infants show a large range of vocabulary scores in both comprehension and production. In the current study, while the age range was only 18 days, production scores ranged from 0-81 words, and comprehension scores ranged from 86-365 words. When studying language development, it may be that more precise data can be gathered from groups matching in CDI scores than from those matching in age.

While this study begins to provide details on infants use of prosodic and distributional cues in learning an object label, several important questions remain, suggesting directions for

future research. First, is the effect of prosodic cues due to utterance-position, stress, or both? These two cues tend to co-occur, so they have been treated as a set of cues in this study. However, this study was intended to be part of a larger design meant to tease apart position and stress. Two additional sentence types were recorded that would allow us to look at the effects of heightened stress and utterance position as separate cues. The sentences are as follows (the word with heightened stress is shown in capitals):

1. I ZUT the GEB.
2. I GEB the ZUT.
3. The ZUT can GEB.
4. The GEB can ZUT.

When these sentences were recorded, the speaker was instructed to give extra emphasis (contrastive stress) to the second word in each sentence. While this stress pattern is less common in English, it does occur when a speaker intends to give focus to a word in the middle of a sentence. The conditions of interest would be the utterance-medial verb with heightened stress, e.g. *zut* in "I ZUT the GEB," and the utterance-final verb without heightened stress, e.g. *geb* in "The ZUT can GEB." Would either the position cue alone, or the heightened stress cue alone have the effect of overriding verb syntax in the same way that the combination of prosodic cues can?

There is reason to believe that each of these cues, position and stress, plays a role. We know from Childers and Echols' study (as cited by Echols & Marti, 2004) that 9-month-old infants show sensitivity to both position and stress. We also know from Shady & Gerken (1999) that both stress and final position affect comprehension in 23 month-olds. This suggests that both position and stress cues are important. Therefore, it is reasonable to predict that both cues would influence 16 month-olds in picking object labels out of sentences.

4.3 Clinical implications

The result that 16-month-infants assume that a final verb labels an object raises an interesting question. When teaching new verbs, is there a stage of language development when it would be better to avoid placing the verb in final position? There is evidence that mothers use final position as a strategic position for teaching new words. Aslin, Woodward, LaMendola, and Bever (1996) found that, when asked to teach their 12-month-infants novel nouns, mothers placed the target words in utterance-final position 89% of the time. Following up on this result, Aslin et al. asked mothers to teach their 12-month-olds transitive verbs, which would be ungrammatical in utterance-final position. Mothers placed most transitive verbs in medial position, however, 15% of the time, they placed the verbs in final position even though this resulted in ungrammatical phrases. This suggests that mothers see final position as a salient spot for teaching a new word, regardless of grammar.. Aslin et al. suggest that this strategy may be helpful even though it violates grammaticality. However, the results of the current study bring into question whether such a strategy is helpful in verb learning. For early word learners, verb learning may be hindered by placing a verb in utterance-final position. Since mothers make use of final position, even when teaching transitive verbs, it would be valuable to know whether this helps or hinders verb learning.

Although the results of this study suggest that placing a verb in final position may hinder verb learning for a period of time, there are some important differences between word learning in this experiment and word learning in the real world. It is possible that when learning words in the real world, infants have enough context to learn verbs even in final position. In this experiment, infants heard a novel verb only six times in a sentence with a novel noun. However, in real life infants may hear a novel verb many times, in sentences

with familiar nouns, and in a variety of sentences. Therefore more research is needed before making any conclusions about whether final position hinders or helps in verb learning. It is also possible that the salience of final position has a facilitative effect for verb learning. Some verbs occur very naturally in sentence final position, and some of these verbs are among infants' early verbs. In the MacArthur CDI Words and Gestures form, of the 55 action words, 14 can be used as intransitive verbs and placed grammatically in sentence-final position. *Eat* and *go* are examples of verbs that infants likely hear in final position. The fact that infants learn these two verbs early suggests that final-position may not hinder verb learning. It would be interesting to compare verb learning in utterance-medial and utterance-final position to see if one position showed an advantage.

4.4 Conclusion

In summary, this study has shown that 16-month-old infants are able to use information from two different types of cues to pick object labels out of a sentence. The presence of either a distributional cue or a position/stress cue leads infants to associate a word with an object. In the absence of either cue, infants do not associate a word with an object. Using prosodic cues to pick out object labels can lead to mistaking a final verb for a noun. However, at 16 months, this mistaken assumption appears to be declining. This decline could occur either because infants learn specific function words that occur before verbs, or because they become able to use mutual exclusivity to rule out the possibility that a second word could label an object.

This new design has proven useful. It shows that infants are able to learn a word label when presented with two novel words in a sentence. It also provides a promising

method for more studies on noun cues, as well as studies on verb learning and mutual exclusivity.

We began this exploration of infants' use of cues to grammatical class knowing that both prosodic and distributional cues to grammatical class exist in the input to infants. We also began knowing that infants are sensitive to both distributional and prosodic information. Therefore, we asked the question whether 16-month-old infants make use of prosodic bootstrapping and/or distributional learning when pulling object labels out of a sentence. The results of the current study clearly show that infants can use both prosodic and distributional cues when linking a novel word with a novel object.

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