Chapter 21

EARLY SYNTACTIC CATEGORIES IN INFANTS' LANGUAGE

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Abstract

The theory outlined in this chapter proposes that infants' earliest syntactic categories correspond to the language-universal, superordinate binary distinction of content words vs. function words, and that these two categories can be derived by infants based on perceptual analysis of a constellation of acoustic/phonetic and phonological cues in the input. Function words are hypothesized to be universally minimized in spoken language. Furthermore, the theory predicts that this initial bifurcation facilitates or optimizes various important aspects of early language acquisition, including deriving refined grammatical categories, determining phrasal bracketing, segmenting words, and learning of word meanings. Data from cross-language studies of infant-directed speech, connectionist modeling, and infants' discrimination of the two categories support the function-word/content-word distinction. The chapter also discusses experimental results suggesting that function words do impact several aspects of language acquisition. It is proposed that high-frequency function words are stored in the emerging lexicon of preverbal infants, these stored function words have the primary role of assisting early language analysis.
1. Introduction

This chapter focuses on the question of how infants start acquiring language at the earliest stage, and in particular, how they establish their earliest syntactic categories, and how these initial categories may then affect their subsequent analyses of the language input. In Section 2, I will discuss my team’s theoretical proposal, arguing that infants tackle the system of grammatical categories by first making a binary, language-universal distinction between function and content words based on the cues in their spoken forms and distribution. In Section 3, I will present experimental evidence that speech input to infants across languages contains a range of acoustical/phonetic, phonological, and distributional cues that support these two superordinate categories, and that infants are capable of detecting such perceptual cues in deriving these two categories. The discussion in Section 4 will center on the argument that the early bifurcation of words into function and content words may have a direct impact on language acquisition; experimental data on the processing and early representation of function words by infants, as well as their roles for other language acquisition tasks will also be discussed.

2. The acquisition of grammatical categories and the earliest binary distinction of function words and content words

One of the most important tasks facing children during language development is the acquisition of grammatical categories such as nouns, verbs, prepositions, auxiliaries, etc. These categories are the fundamental primitives with which larger syntactic units are formed, such as phrases, clauses, and sentences. All contemporary syntactic theories embody the notion of grammatical categories. The organization of words into appropriate grammatical categories and the rule-governed property of category grouping into larger syntactic units capture the productive nature of human languages. Indeed, according to the generative framework, native speakers of any language possess implicit knowledge of syntactic categories and rules. Such knowledge enables them to produce and comprehend utterances that they have never heard before. Even young children’s syntactic errors demonstrate the rule-like productivity of an evolving grammar. Learning to assign words to grammatical categories is therefore not only logically necessary, it must also begin before any evidence can appear in children’s production.

Several theoretical approaches have attempted to address the question of grammatical category acquisition in children. One type of theory focuses on the role of semantics in deriving the initial word categories [e.g., Schlesinger (1974), Bates and MacWhinney (1979), Pinker (1984)]. On this view, initial grammatical categories are semantically based; for example, nouns typically denote concrete objects, verbs denote actions, and adjectives denote properties. Depending on specific theoretical assumptions, the infant is viewed as either mapping words to innate grammatical categories through their canonical semantic properties [e.g., Pinker (1984)] – i.e., a process of instantiation – or deriving the grammatical categories by discovering the semantic-syntactic mapping through
induction processes [e.g., Schlesinger (1974), Bates and MacWhinney (1979)]. Based on these theories, the co-occurrence patterns of grammatical categories in phrases and sentences play only a limited role compared with the importance of semantics or become important only later in the acquisition process; the prototypical semantic properties of grammatical categories provide the primary route toward the acquisition of these categories.

The semantically based theories contrast significantly with theories suggesting that grammatical categories can be bootstrapped by analyzing the distributional patterns among words [e.g., Maratsos and Chalkley (1980)]. Strictly distributional approaches are directly compatible with the concept that grammatical categories are abstract, formal categories defined in terms of their relative positions within utterances. For example, Maratsos and Chalkley (1980) showed that formal gender categories must be acquired on distributional grounds. Recent work suggests that parental speech input contains co-occurrence regularities that provide evidence of some grammatical categories, e.g., nouns and verbs [Mintz, Newport and Bever (2002)], and that the learner may derive these categories based on such regularities. Li (2003), for instance, using connectionist modeling, showed that the analysis of statistical regularities among words, such as between-word transitional probabilities, constitutes sufficient evidence to assign grammatical categories.

The theory that my team has proposed focuses on a putatively even more fundamental grammatical category distinction: the bifurcation of the two broad categories of function and content words [Morgan, Shi and Allopenna (1996), Shi (1996), Shi, Morgan and Allopenna (1998)]. Content words include nouns, verbs, adjectives, and adverbs. Function words are items including determiners, conjunctions, complementizers, auxiliary elements (such as tense/aspect/number affixes), etc. The term “words” in this chapter refers broadly to word-like chunks from the perspective of the child, which must be minimally syllabic since the syllable appears to be the minimal processing unit for the infant [Bijeljac-Babic, Bertoncini and Mehler (1993), Bertoncini et al. (1995)]. There is linguistic evidence that refined grammatical categories show considerable language-specific characteristics. For example, they may differ in terms of the grammatical categories included. Some languages use prepositions (such as English and French), whereas others use postpositions (such as Quechua), and some use both (such as Chinese). Languages often differ in the mapping between concepts and grammatical categories, as well as in their category boundaries. For example, the distinction between verbs and adjectives in Mandarin is not as clear as it is in some other languages. Further, languages also differ in the richness of their morphology, with some using many bound morphemes for function items (e.g., the Bantu languages and the Amerindian languages), while others use only free-standing morphemes (e.g., most West African languages and many Asian languages). The existence of such cross-linguistic variability suggests that assigning words to their appropriate grammatical categories is by no means a trivial task.

Despite the cross-language variations in refined grammatical categories, we note the basic, language-universal binary distinction between content words and function words.
We propose that the rough sorting of words into the two superordinate, language-universal classes occurs prior to the acquisition of specific grammatical categories. In other words, the initial binary categories feed into the process of discovering refined grammatical categories, regardless of whether the process is semantically or distributionally based. As will be discussed later in this chapter, this initial binary sorting is not only logically plausible, but may also have direct consequences for the efficacy of a number of important language acquisition tasks, including the bootstrapping into early syntax.

In our model, we consider the link between phonology and syntax, and in particular, the phonetic and phonological cues to the distinction between content and function words. This position departs from the classical view that the relationship between syntactic categories and their phonological forms is an arbitrary one, and that phonology and syntax are independent parts of the grammar [Hockett (1966)]. We hypothesize that the most frequent function words should show a universal tendency to be minimized in their spoken form when compared to content words. This minimalism may be a result of very frequent use [Zipf (1949)], low demand for meaning contrasts among function words since they make up a small set, or high degree of predictability since each syntactic position requiring a function word permits only a limited number of word choices. Although we consider the minimalism of function words to be universal, the manifestations of this minimalism are universal at some levels, but are subject to language-specific constraints at the more abstract phonological level (this will be discussed in more detail in Section 3). We further propose that the language learner can derive the basic distinction between function words and content words on the basis of the perceptual analysis of multiple phonetic, phonological, and distributional facts. We suggest that the rudimentary categories of function words and content words may assist the language learner in breaking into the syntactic system and performing tasks such as acquiring refined grammatical categories and phrasal bracketing, segmenting words, and determining initial word-meaning associations.

The fundamental distinction between content and function words agrees with both linguistic descriptions and psycholinguistic observations. These two classes have a number of key characteristics. First, content words carry the dominant semantic load of utterances; function words are more important in marking relationships among content words in the utterance. The importance of function words for syntactic structure is encompassed in most contemporary syntactic theories.

Second, in terms of their frequency of occurrence, content words as an open class have a very large number of types whereas function words constitute a very small closed-class set. New words can easily be added to the classes of nouns, verbs, adjectives, and adverbs. Function words, in contrast, are far more stable over a long period of time. However, the frequency of occurrence of each word type exhibits the opposite pattern. The type-token ratios of function words are much higher than those for content words. That is, on average, function word types occur far more frequently than content word types. For example, the majority of the most frequently occurring 100 word types in the Kucera and Francis database [Kucera and Francis (1967)] are function words. Thus, it is observable that phrases and sentences are constructed from a small number
of function word types which occur consistently among vastly different content word types. Content words carry the dominant weight of meaning, while function words appear to serve as the structural skeleton of utterances.

Third, function words and content words are processed differently by adults. Function word errors often fail to be detected during proofreading [Rosenberg et al. (1985)]. In a recent study [Shi et al. (in press)], we showed that certain phonological processes of deletion or assimilation (such as syllable-final /t/d/ deletion when preceded by a labial in English) are more likely to occur in function words, even when frequencies are controlled. Evidence from the X-ray analysis of schwa [Yamane-Tanaka, Gick and Bird (2004)] suggests that even though schwas in function words and content words are judged to be auditorily equivalent by an observer, only the schwa in function words was found to be truly neutral in the tongue configuration, while the schwa in content words in fact involved tongue root retraction.

Fourth, research into language acquisition has shown a different pattern for function words and content words [e.g., Brown (1973), Radford (1990)], with function words typically missing from children’s early production in many languages. As will be discussed later, the lack of function words in early production does not imply that these words are not represented and processed by infants. It does demonstrate, however, that the distinction between function words and content words exists at some level of psychological processes even in infants.

The idea that phonological characteristics may signal syntactic information has been suggested in adult language processing [Cooper and Paccia-Cooper (1980)], and was extended to the theory of prosodic bootstrapping in acquisition [Morgan (1986), see also discussions in Christophe et al. (1997)]. With respect to grammatical category distinctions per se, Kelly (1992) showed that nouns in English tend to be trochaic whereas verbs tend to be iambic, and that children are sensitive to these different sound patterns. Function words in English have been claimed to contain reduced vowels [Cutler and Carter (1987)] or described as unstressed [Gleitman and Wanner (1982)]. These arguments are primarily based on language-specific observations. Infants’ analysis of these properties likely involves a certain amount of experience with the native language so as to be able to discover the phonological cues to grammatical categories. Our model extends this idea to propose that the fundamental language-universal distinction between function words and content words is probably the first grammatical category distinction entertained by infants, and that this distinction is marked by a combination of acoustic, phonetic, phonological, and distributional cues, which exhibit a universal tendency to be reduced (although the exact manifestations of some cues must respect language-specific constraints). Furthermore, previous proposals concerning the phonological correlates of grammatical categories were largely based on the researchers’ linguistic intuitions or judgment. Our work on parental speech input therefore included systematic acoustic measures and detailed transcription analysis.

In sum, both linguistic descriptions and psycholinguistic evidence support the intuition that there is a broad, binary distinction between function and content words. Our theoretical model addresses several pertinent questions, namely, whether this distinction
is encoded in the spoken form of the input speech to infants, whether function words and content words are indeed the first two categories that the language learner derives, and if so, whether the division into two categories exerts an influence on the initial development of syntax and other aspects of language acquisition.

3. Input speech and the categorization of function words and content words

The first step in this approach was to verify whether there are acoustic and phonological cues in speech input to infants that mark the distinction between function words and content words. To test the hypothesis that function words are universally minimized in their spoken form, we recorded spontaneous maternal speech to preverbal and early verbal infants in three typologically distinct languages: English, Mandarin, and Turkish [Shi (1996), Shi et al. (1998)]. Whereas English uses limited inflections, Turkish is highly inflectional and uses rich, agglutinative functional morphemes. Mandarin, on the other hand, is an isolating language with no inflectional morphology. In our study, several types of cues were analyzed: distributional and phonological coding of the transcripts, and acoustical measures.

Based on our model, we predicted that, at the acoustic/phonetic level, all three languages should show shortened vowel duration, weaker vowel amplitude, and less pitch change for function words than for content words. Function words were expected to have a smaller number of syllables. The syllable structure was expected to be simplified such that the number of segments in the onset and coda positions is reduced or null, and the nucleus is less likely to be a diphthong. Whereas the acoustical properties of vowel duration and amplitude were expected to be language-universal in a straightforward way, the cues related to syllable number and syllable structure must respect the phonological constraints of the specific language. English, for example, permits consonant clusters in the onset and coda positions; the number of segments at these positions was expected to be reduced or null. Function words with clusters should be infrequent, although they may occur. Mandarin, on the other hand, does not permit consonant clusters in any syllable position. However, given that the syllable onset can be a consonant or null and that the coda can only be null or a nasal, function words were expected to have a tendency toward null segments in the onset and/or coda positions. The vowel F1–F2 space was also expected to be more centralized for function words than for content words. Although we only analyzed the vowel space for English (assuming that this cue might be particularly prominent because English is a stress-timing language), the reduced vowel space for function words was hypothesized to be present to some degree in all languages, as it is a property correlated with short vowel duration. Distributionally, we expected function words to be much more frequent than content words and to manifest an asymmetry with respect to whether they tended to occur in utterance-initial or -final positions.

Even though phonological properties at the syllable and word levels (e.g., number of syllables, syllable structure complexity) are subject to language-specific constraints, we
considered them to be sufficiently accessible by the infants’ perceptual system, and perhaps comparable to the language-general acoustical cues. This may not be the case for more abstract cues. That is, abstract cues may only be accessible to infants after they have learned a certain amount of the ambient language. For example, we hypothesized that the minimality of function words may be manifested in their tendency to contain unmarked segments. In our analysis, we examined whether vowels in Turkish function words were more likely to be underlyingly underspecified and thus more subject to being harmonized with the preceding vowel, and whether the tones in Mandarin function words were more likely to be unspecified and thus to exhibit the surface output of the neutral tone rule. Aside from being language-specific, such cues involve context-sensitive phonological rules and were expected to be less transparent and thus perhaps only perceptible to infants after a certain amount of experience.

The results of our analyses confirmed nearly all of the cues hypothesized for the three languages [for details, see Shi (1996), Shi et al. (1998)]. Input to preverbal infants did indeed exhibit shorter vowel duration and weaker amplitude for function words than for content words. Function words were found to consist of fewer syllables than content words; in fact, they tended to be monosyllabic. The syllabic structure of function words contained fewer segmental materials than that of content words in the onset, nucleus, and coda positions, within the constraints of the native language phonology. For function words, the syllable onset and coda tended to be reduced toward nullness, and the nucleus was rarely found to contain diphthongs in languages that have a repertoire of diphthongs (such as Mandarin and English). At the abstract phonological level, the tones of Mandarin function words were significantly more likely to be unspecified (underlyingly), and the vowels in Turkish function morphemes were observed to be mostly underspecified, obtaining the remaining features from the preceding vowel. The results of distributional analyses revealed that function words occurred significantly more frequently than content words.

Our results therefore confirmed that function words were minimized in the spoken form. However, for each cue for which we found a significant mean difference between function words and content words, the distributions of the two categories showed a sizable overlap. As we described in Shi et al. (1998), this means that none of these cues alone would suffice to reliably predict the two categories. However, our model hypothesized that the correlation of the multiple cues is necessary and would be sufficient to support the sorting of the two categories. Each individual token may not, and need not, have all of the distinctive cues; a subset of cues together would indicate the membership of a token.

Given that our analyses were performed on completely spontaneous speech with no control over the linguistic contexts of the words, the results we obtained were quite robust. A study by Church (2002) attempted to replicate our findings. Church examined both spontaneous and read speech, with the targets being carefully selected. She found that unstressed vowels in function words and content words were not equivalent even when their sentence positions were identical: on average, vowels in function words were shorter than those in content words. The difference in vowel duration would be
still greater if we considered the fact that the sentence-level stress of function words is more likely to be weak than that of content words.

Having established that input speech across languages contains acoustical, phonological, and distributional cues supporting the function-word/content-word distinction, we wondered whether a language learner can derive the two categories on the basis of these cues. We first examined this question using unsupervised neural network simulations [Shi (1996), Shi et al. (1998)]. After training with a random set of words (i.e., each represented by a vector of cues that had previously been analyzed), the networks successfully classified novel words in their appropriate categories (at about 85% accuracy, a level sufficient for initial entry into the system). To test whether the cues that were generally common across languages were sufficient to derive the categories, we removed the language-specific, abstract cues (i.e., the neutral tone rule in Mandarin and vowel harmony in Turkish) from the training. The networks learned to categorize new words with comparable success. More interestingly, we found that the networks not only generalized the learned categories to words uttered by new speakers, but also to another language which they had never previously been exposed to. In other words, networks trained with words from one language were able to categorize words from another language. This suggests that the learning of the fundamental categories of function words and content words can be driven by language-universal perceptual cues.

Subsequently, we conducted experiments with newborn infants to investigate whether they were capable of categorizing function words and content words on the basis of the perceptual cues found in the input [Shi, Werker and Morgan (1999)]. In a High Amplitude Sucking Paradigm, 1- to 3-day-old infants were habituated to English words\(^1\) from one of the two categories and tested on novel words from either the same category or the other category. Infants showed significantly greater recovery in their sucking responses when there was a category change, indicating that they were making a categorical discrimination. This result held even when the cues of frequency of occurrence and number of syllables were balanced across the two categories. Furthermore, we compared the performance of infants who heard English prenatally versus those who heard only other languages prenatally (in nearly all cases, an Asian language). Both groups of infants responded equivalently, showing a categorical discrimination. These results suggest that the categorization must have been based on language-universal distinctive cues. Either infants’ prenatal experience with certain universal cues led to their categorical responses, or humans possess innate perceptual mechanisms that allow them to respond to universal cues even at birth.

4. Function words and language acquisition

What significance does the initial bifurcation of words into the two broad universal categories of function words and content words have for language acquisition? Our model is concerned with a number of early language-learning tasks: bootstrapping into refined

\(^1\) The study with newborns was limited to the use of English stimuli.
grammatical categories and rudimentary phrase structure, optimizing word segmentation, and facilitating the learning of word meaning.

At the very least, the bifurcation of words into function words and content words may considerably lower the computational load in infants' analysis of input. It may significantly improve their learning efficacy by narrowing the scope of the analysis that they must perform. This initial division can assist with the discovery of refined grammatical categories such as nouns and verbs. Due to the high type/token ratio of function words and their regular positions in phrases and sentences, the same function word/morpheme is typically followed or preceded by many different content words of the same class, e.g., determiners are followed by different nouns. Mintz et al.'s (2002) work showed that such distributional regularities do indeed hold for nouns and verbs in input speech to English-learning children; function words play an important role in revealing the category membership of the neighboring word. Recent research with German infants [Hoehle et al. (in press)] showed that function words are involved in the early categorization of nouns.

If canonical semantic properties serve as the possible route to refined grammatical categories [Pinker (1984)], then having a rudimentary dichotomy of function words versus content words greatly constrains the possible mapping of meanings to the corresponding word forms. Indeed, we showed in a cross-linguistic study using a preference looking procedure [Shi and Werker (2001)] that infants of 6 months old selectively attended to content words [whereas the newborns described in Shi et al. (1999) did not], and that this preference was acoustically and phonologically based rather than a result of possible familiarity with specific content words [Shi and Werker (2003)]. Consistent with these results, the earliest word forms that infants are able to segment and memorize have been shown to be content words [e.g., Jusczyk and Aslin (1995), Mandel, Jusczyk and Pisoni (1995), Jusczyk and Hohne (1997), Tincoff and Jusczyk (1999)]; infants' initial mapping of meaning to word forms as evidenced in perceptual experiments typically involves content words [e.g., Werker et al. (1998)]; and their early comprehended and produced vocabulary contains primarily content words [e.g., Brown (1973), Fenson et al. (1994)]. The fact that early learning of word meaning tends to involve content words could be due to the more transparent meaning-to-word relation of these words [Gillette et al. (1999)]. Nevertheless, the acoustically and phonologically based attentional preference for content words over function words that we observed in 6-month-olds is likely to occur first, perhaps before the onset of associating meanings to individual words. In any case, the ability to focus on one category at a time helps constrain the mapping of meanings to a smaller set of words and may facilitate word learning.

Infants' ability to selectively attend to content words does not imply that they ignore function words. On the contrary, function words may play a crucial role in early language acquisition. In the case of word-meaning mappings, for instance, the occurrence of a determiner before a word may signal to infants that this word refers to an entity. Function words may also assist in the initial parsing of phrases. Although prosodic cues may serve as indicators of sentential and clausal boundaries [Cooper and Puccia-Copper
and infants are sensitive to such information [e.g., Hirsh-Pasek et al. (1987)], phrasal boundaries are not reliably marked by prosody. Given that any given phrase has two boundaries, the boundary that does not coincide with a clausal or sentential boundary is usually not marked prosodically. For example, the NP (noun phrase) the cat in the sentence The dog saw the cat is only prosodically marked at its end as this coincides with the end of the sentence. In this case, the function word may prove to be an important boundary marker to complement prosodic marking, potentially leading to successful bracketing of the phrase at both ends. This has been demonstrated in experiments with artificial language learning by adults [Morgan, Meier, and Newport (1987)]. Green (1979) showed that the grammar of an artificial language is unlearnable if no functional markers are present. Studies are being conducted in our laboratory to test the contribution of function words to phrasal parsing by infants.

There is evidence that infants are sensitive to function words in early language processing. Gerken and colleagues [Gerken, Landam and Remz (1990), Gerken and McIntosh (1993)] showed that 2-year-olds comprehended and produced utterances containing real, grammatical function words better than those either with function words replaced by nonsense function words or with ungrammatical function words. Using time-locked eye movement measures, Zangl and Fernald (2003) showed that English-learning infants as young as 18 months of age were sensitive to function morphemes in online sentence processing. Two-year-old Dutch-learning infants have been shown to have some knowledge of grammatical gender [Johnson (2004)]. Recent work from a few laboratories suggests that even preverbal infants are sensitive to function words [Shady (1996), Schafer et al. (1998), Hoehle and Weissenborn (2003), Shi, Werker and Cutler (2003, 2004a)].

In our recent work, we tested the hypothesis that function words, especially very frequent function words, may facilitate the segmentation of content words in continuous speech in early infancy. Word segmentation is necessary since most speech directed to infants is not in citation form. Approximately 90% of utterances in our recordings of motherese in Mandarin, English, and Turkish were multiword utterances. In a study of English infants [Shi et al. (2004b)], 11-month-olds segmented a monosyllabic content word preceded by the frequent functor the better than when a content word was preceded by a nonsense functor. After becoming familiar with the sequences “the + content word 1” versus “nonsense functor + content word 2,” infants listened significantly longer to isolated presentations of “content word 1” than to “content word 2” during the test phase. That is, they segmented the syllable better when it followed the than when it was preceded by a segmentally modified nonsense functor (it is therefore possible that they may have treated the sequence “nonsense functor + content word 2” as one single disyllabic word, with “content word 2” as the second syllable of the word). No such difference in segmentation was found for sequences including an infrequent functor versus a nonsense functor. This shows that only the function word the facilitated the segmentation of an adjacent content word.

The effects of function words on early language acquisition and processing discussed above imply the assumption of a prior segmentation of the word forms of function words
from continuous speech. This is an empirical question, but a highly plausible one. Given infants' remarkable ability to use statistical-distributional properties to segment the speech stream into word-like units [Saffran, Newport and Aslin (1996)]\(^2\), frequently occurring function words in highly varying contexts are likely to be segmented at quite an early age. Hoehle and Weissenborn (2003) showed that German-learning 7- to 9-month-old infants segmented function words in continuous speech. Behavioral experiments [Shady (1996)] and ERP measures [Schafer et al. (1998)] using synthetic speech revealed that English-learning 10.5- and 11-month-old infants can detect function words in utterances. In our experiments using a preference procedure [Shi et al. (2003, 2004a, under review)], we presented 8-, 11-, and 13-month-old infants with phrases containing real function words versus nonsense function words. We found that 11-month-old infants showed an emerging recognition of function words as a class, and 13-month-olds showed a robust recognition. Furthermore, because the nonsense function words in our stimuli were minimal modifications of the real functor counterparts (with prosody unchanged), our results also suggest that infants' representation of the functors they recognized was phonetically well specified.

In these studies on infants' perception of function words [Shi et al. (2003, 2004a, under review)], we considered the idea that the word forms of certain function words are stored in infants' memory, i.e., an emerging mental lexicon (so that they may exert an influence on the linguistic analyses discussed above), and that the function words with extremely high frequencies of occurrence are likely the earliest candidates in the initial lexicon. In our view, these items are unlikely to have any meaning in the early lexicon. Instead, they are stored only as pieces with phonetic representations. Our finding that segmentation of an adjacent content word was only facilitated in the context of a very frequent functor, but not in the context of an infrequent or nonsense functor [Shi et al. (2004b)], suggests that it was the very frequent functors previously stored in infants' emerging mental lexicon (or some prototypical phonological representation, e.g., a schwa, for certain function words) that exerted the facilitation effect. Note that every real versus nonsense functor was presented equally frequently during the experiments, indicating that the frequency effect observed must have been due to the unequal frequencies of occurrence in the natural input that the infant had heard.

Developing an early lexicon which includes at least some spoken forms of function words/morphemes, regardless of whether their phonetic representations are well specified, may impact on various important aspects of early language acquisition. The stored function words could facilitate infants' discovery of phrasal structures, the derivation of

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\(^2\) In the Saffran et al. study, infants were presented with a monotonic synthetic speech stream consisting of nonword syllables. Only information on transitional probabilities between syllables was kept and manipulated. A sequence of syllables with a high transitional probability was more likely to be a word-like unit than a sequence containing syllables with a low transitional probability. To illustrate with a real language, for the phrase *joli visage*, the transitional probability between *j*o and *li* would be higher than that between *li* and *vi*; this is because *li* can be followed by many different words such as *joli chat*, *joli jardin*, etc., while *j*o and *li* co-occur more consistently. Saffran et al. found that infants were able to rely on this statistical information to segment the "words" in the artificial language.
a refined set of grammatical categories, word segmentation, and the learning of word meanings, as discussed in this section.

5. Conclusions

In this chapter, I addressed the question of how infants initially break into language. In particular, I argued that infants may first establish the syntactic categories of function and content words, and that these initial categories may then assist them in their subsequent analyses of the language input.

In our model, we hypothesized that input speech to infants contains universal acoustic, phonetic, and phonological cues to the most fundamental, language-universal, superordinate distinction between function words and content words. More specifically, function words were hypothesized to be universally minimized in the spoken forms, although the manifestations of this minimality must respect language-specific constraints at the more abstract phonological level to some degree. We further proposed that infants are capable of categorizing function words and content words on the basis of these perceptual cues. As discussed in Section 3, data from cross-linguistic studies of infant-directed speech, neural network simulation of the categorization of the two categories, and newborn infants' categorical discrimination of the two categories all support the above hypotheses.

Another component of our model includes the hypothesis that the initial bifurcation of words into function words and content words may facilitate or optimize various important language-learning tasks, including the derivation of refined grammatical categories and phrasal structures, learning of word meanings, and word segmentation. This chapter presents arguments in favor of each of these aspects as well as the existing empirical results that support some of them.

Finally, the model was extended to consider the idea of an impoverished initial mental lexicon at the preverbal stage that includes highly frequent function words; it is these functors that first play a facilitation role in the language-learning tasks discussed above. The results of our recent experiments with 8- to 13-month-old infants support this proposal. It is argued in Section 4 that frequent function words in the emerging lexicon contain only phonetic forms. These stored function words, which contain no meaning, primarily play the role of assisting infants' early language analyses such as refined grammatical categories, rudimentary phrasal bracketing, word segmentation, and word-meaning mapping.

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