

Prosodic Cues to Noun and Verb Categories in Infant-Directed Speech

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1. Introduction

Children begin to develop a vocabulary towards one year of age. While vocabulary items must be each learned and stored in memory, sentences do not need to be individually stored. An important aspect of language learning is to assign words to their appropriate grammatical categories (such as nouns, verbs, and prepositions) because these categories are the basic elements with which phrasal structures and rules are defined. Such knowledge enables native speakers of any language to comprehend and produce an infinite number of phrases and sentences, including those that they have never encountered. Learning grammatical categories is therefore crucial for children's subsequent acquisition of combinatorial organizations of categories.

It is, however, not obvious how grammatical category assignment is learned by infants. When adults learn a foreign language, they are often given grammatical category labels for new vocabulary items along with instructional sentences in which the new words are used. Infants receive no category labels, nor instruction. They must discover the category membership of each vocabulary item based on the input. How do they achieve this task?

Several theories have been proposed in the literature regarding the mechanisms underlying infants' initial learning of grammatical categories. One type of approach focuses on semantics as the means for infants to break into initial grammatical categories (e.g., Braine, 1976; Pinker, 1984). Infants may take advantage of their conceptual knowledge about objects and events in the world, and map object-denoting words as nouns, action-denoting words as verbs, and property-denoting words as adjectives. Grammatical categories, however, are abstract constructs defined in terms of their syntactic relations with one another in phrases and sentences, rather than straight-forward conceptual relations. For example, nouns can denote concepts other than objects (e.g., *sorrow*). Words like *sorrow* and *cheese* are nouns because they land in equivalent positions in the syntactic trees and are expressed in terms of their positions relative to other categories (such as verbs and adjectives) in the phrase structure. If infants' initial grammatical categories are semantically based, formal transition involving another mechanism is needed at a later developmental stage to enable the categories to reach an abstract syntactic level.

The distributional based theories are more direct in approaching the

problem of grammatical category learning. On this view, initial grammatical categories can be derived through direct, formal analyses of the co-occurrence patterns of words and morphemes in utterances (e.g., Levy, 1988; Maratsos & Chalkley, 1980). Accordingly, infants break into the syntactic system without the need of the mediation of semantic categories. Redington, Chater and Finch (1998) and Mintz (2003) examined the immediately preceding and following contextual words in parental speech to English-learning children. They showed that contextual distributional cues indeed exist and support the distinction of grammatical categories such as nouns and verbs. In the study by Monaghan, Chater and Christiansen (2005) preceding contextual words (i.e., bigram information) were sufficient to support grammatical categorization. The contextual words in these studies were nearly all function words. Function words are extremely frequent, as shown in studies of parental speech in different languages (e.g., Shi, Morgan, & Allopenna, 1998; van de Weijer, 1998), and infants at birth have the capacity to distinguish between words of lexical and functional categories (Shi, Werker, & Morgan, 1999). Recent work also suggests that preverbal infants not only recognize function word forms from continuous utterances (Höhle & Weissenborn, 2003; Shi, Werker, & Cutler, 2006), but also use them to segment adjacent lexical words (Höhle & Weissenborn, 2000; Shi, Cutler, Werker, & Cruickshank, 2006; Shi & Lepage, in press). The co-occurring pattern of function words with lexical words as demonstrated by “frequent frames” (Mintz, 2003) may be salient information for grammatical category formation. In artificial language experiments adults (e.g., Valian & Coulson, 1988) and children (e.g., Gomez, 2002; Saffran, 2001) learned the co-occurrence patterns of the function-word-like and lexical-word-like categories. In the learning of structures involving bigrams, an increase in the token frequency of a function-word-like item led to better detection of its co-occurrence pattern with a lexical-word-like item (Valian & Coulson, 1988). The structure resembles the fact that functors in natural languages are a small set of elements each occurring with high token frequency. Also, the learning of non-adjacent dependencies of functor-like items relied on the increased variability of the intervening lexical-word-like items (Gomez, 2002) – such structures are comparable to the case of natural languages (e.g., noun being a class of many word types surrounded by function words of a few word types).

Distributionally-based grammatical categorization has been studied in infant experiments using natural language stimuli (Höhle, et al., 2004; Mintz, 2006). German-learning infants aged 14-16 months categorized non-words into nouns when they were preceded by a determiner (Höhle, et al., 2004). English-learning infants, on the other hand, showed evidence of first categorizing verbs in the context of appropriate function items (Mintz, 2006).

Another approach for understanding initial grammatical categorization concerns the idea of phonology-syntax correspondence. Based on the classic view of natural language (e.g., Saussure, 1916/1959; Hockett, 1966), phonology, syntax and semantics are independent levels of representations. One of the design features of human languages described by Hockett (Hockett, 1966) is that

the sound forms of words are arbitrary. This view has been challenged by empirical evidence in psycholinguistics. Cooper and colleagues (Cooper & Paccia-Cooper, 1980; Cooper & Sorensen, 1981) showed that in speech production major syntactic units are marked with distinct prosodic cues such as final vowel lengthening, pause and fundamental frequency declination. Adult listeners use boundary prosodic cues to resolve syntactically ambiguous structures and make the correct interpretations about the phrasal units intended by speakers (Millotte, Wales, & Christophe, 2007), e.g., [*les pommes dures*] versus [*les pommes*][*durent ...*] (“hard apples” versus “apples last ...”). Developmental studies showed that cues marking major syntactic boundaries are available in infant-directed speech (e.g., Bernstein Ratner, 1986; Morgan, 1986). Furthermore, preverbal infants are sensitive to these cues and use them to parse and encode major syntactic units (e.g., Soderstrom, Seidl, Kemler Nelson, & Jusczyk, 2003; Nazzi, Kemler Nelson, Jusczyk, & Jusczyk, 2000).

In addition, phonological and prosodic cues have been identified for grammatical categories. Grammatical categories can be divided into two broad classes: lexical and functional categories. The former includes nouns, verbs, adjectives and adverbs, and the latter includes closed-class items such as auxiliaries, determiners, complementizers, etc. These two classes are distinguished by phonological and prosodic cues, as shown in adult- (e.g., Cutler, 1993) and infant-directed speech (e.g., Shi, Morgan, & Allopenna, 1998). In comparison with lexical words, functional items are universally reduced. Prosodically, function words have shorter duration, weaker intensity, and are more centralized on the format (F1-F2) space. Phonological characteristics include simpler syllabic structures, minimal number of syllables and underspecified representations. Certain language-specific phonological rules (e.g., consonant assimilation and vowel harmony) tend to occur for function words (Shi, Gick, Kanwischer, & Wilson, 2005; Shi, Morgan, & Allopenna, 1998). These cues allow infants to make the initial bifurcation of words into two basic categories (Shi, Werker, & Morgan, 1999). This initial categorization can optimize the subsequent learning of more specific grammatical categories (such as nouns and verbs) by limiting the scope of the analyses which infants perform.

Nouns and verbs are also marked by phonological and prosodic cues. For example, in a corpus study Soreno and Jongman (1990) found that for high frequency words in English nouns tend to contain back vowels whereas verbs tend to contain front vowels, and that adult listeners are sensitive to the cues. Nouns are more likely to contain nasals and to have more syllables than do verbs (Cassidy & Kelly, 1991; Kelly, 1992). The final consonant of nouns is more likely to be voiced in comparison to the case of verbs (Kelly, 1992). Nouns and verbs in English also tend to have different stress patterns, with disyllabic nouns largely strong-weak and disyllabic verbs weak-strong (e.g., Kelly, 1992). There is evidence that infants around nine months of age begin to attend to native-language stress patterns (Jusczyk, Cutler, & Redanz, 1993). In simulations using natural language materials, phonological and prosodic cues were shown to be effective for a naïve learning system to derive lexical and functional categories

(Shi, Morgan, & Allopenna, 1998). The simulations of Monaghan, Chater and Christiansen (2005) included the use of phonological cues for the categorization of lexical versus functional categories as well as nouns versus verbs, and they found that phonological cues weighed more than distributional cues particularly for the categorization of lower-frequency nouns and verbs.

Little work exists on infants' sensitivity to phonological and prosodic cues to nouns and verbs. Conwell and Morgan (submitted) recently examined homophone nouns and verbs (e.g., *walk* as a noun and verb) in parental speech corpora in English, and found that nouns are longer than their verb homophones. Moreover, 13-month-old English-learning infants were able to categorically discriminate the noun-verb homophones extracted from the natural parental speech, suggesting that such cues may potentially assist infants in assigning the tokens into nouns and verbs respectively.

Our interest is to understand what mechanism or combination of mechanisms underlies infants' initial derivation of grammatical categories. To do so, we need to fully explore what cues parental speech reliably contains in support of category distinctions. Whereas previous studies primarily examined distributional and phonological cues in natural speech input, little has been done with respect to potential prosodic cues to grammatical categories. The goal of this study was to examine the prosodic properties of nouns and verbs.

Many factors may influence the prosodic realizations of a word. For example, a word form can be strongly affected by its sentential position, word frequency, number syllables and words within an utterance, etc. Studies that control these factors are necessary. Furthermore, since existing work in this area is dominantly on English, cross-language studies are needed if generalizations are to be made about the categorization mechanism(s) in infants. The present study aimed to examine prosodic characteristics of nouns and verbs in parental speech in French, using well-controlled stimuli and procedures to balance all potential extraneous factors that may affect prosody. Rhythmically, French has no contrastive lexical stress, unlike English. Related to this issue, even nouns and verbs that share the same stress patterns in English seem to differ subtly in acoustic characteristics. This can be inferred from segmentation studies in which English-learning infants begin to segment strong-weak and weak-strong disyllabic nouns about five months before they can segment verbs sharing the same stress patterns (Jusczyk, Houston, & Newsome, 1999; Nazzi et al, 2005). It is thus also possible that a non-stress language like French may exhibit prosodic differences for nouns and verbs.

The final question that interests us concerns whether the prosodic marking in input speech, if there is any, exists only when infants are at the stage of learning noun and verb categories. In previous work (Bernstein Ratner, 1984) acoustic cues to lexical versus function words occurred in speech to infants when they were learning these categories, with vowels reduced in formants for function words and exaggerated for lexical words; but at a later stage when infants already learned this category difference and needed to focus on individual function words, function words showed the same vowel clarification

patterns as did lexical words. We therefore examined speech to infants at the onset of noun-verb category learning and months before they enter this stage.

2. Methods

2.1.1. Participants

Participants were eight mother-infant dyads. Four infants were four months of age, and the other four infants were 11 months of age. The eight mothers were all monolingual Quebec-French speakers. Given that receptive vocabulary learning begins at about eight to nine months (Fenson, et al., 1994) and that noun-verb categorization begins to emerge around 12 months of age (Mintz, 2006), we decided to compare parental speech to infants at 11 months of age with speech to much younger infants.

2.1.2. Stimuli and Design

Stimuli included sentences containing four nonsense target words, each used as nouns and verbs. The decision to use non-words was based on a number of methodological considerations. Firstly, real words of different frequencies may lead to different prosodic realizations in speech production. The use of non-words is a way to eliminate this concern. Secondly, words of different syllabic structures and segmental types may have different prosodic characteristics. For example, high vowels and low vowels are inherently different in pitch level (Whalen & Levitt, 1995) and in duration (Lehiste, 1970). The ideal control for such factors is to use noun-verb real-word homophones. However, noun-verb homophones usually do not occur with equal frequencies in natural speech. Parents typically use the homophones more in one of the two categories (Conwell & Morgan, submitted; Nelson, 1995). Such an imbalance may affect the prosody of noun versus verb uses for a given word type. Creating non-words and use each in both categories can ensure reliable control over these variables.

The four target non-words were all of CVCVC syllabic structure: *cagère*, *noupole*, *docasse*, *bacotte*. Each of the four words was judged by native French speakers as equally likely to be a noun and a verb. The verb use was the form of the present indicative tense (the first, second and third person singular, third person plural, and the first person plural used with the pronoun *on* in informal speech), as well as the singular imperative and present subjunctives. This form represents the majority of verb usage in speech to preverbal French-learning infants (based on the corpus of Cécylre and Shi, 2005).

Sentences in French were created, each including a target in the early, medial or final position. Each target appeared as a noun and a verb in the same position in separate sentences. Note that there was no “initial” condition because common nouns in French cannot occur utterance initially, unlike in English. A function word or a numeral must precede a noun, e.g., *des livres* (books), *du sable* (sand), *trois livres* (three books). Therefore, for the early position sentences, the target appeared as the second word. Although verbs in French can

occur utterance initially, this was avoided in order to create the exact comparison for nouns and verbs.

In addition, the number of words and syllables for comparison sentences in a noun-verb homophone pair was controlled as closely as possible, since these may be factors affecting the prosody of the targets. Moreover, even though French is a syllabic timing language, words do not have equal prosodic weight in continuous speech. Function words/morphemes, for example, are universally weaker in spoken forms than lexical words. We controlled for the alternations of lexical and functional elements in comparison pairs. Prosodic phrasal groupings were balanced as much as possible. Finally, the preceding and following phonetic segments were controlled for to some extent. The sentences containing the targets are listed in the Appendix.

2.1.3. Recording Procedure and Acoustical Analyses

Each mother-infant dyad participated in a recording session. The mother and her infant were left alone in a sound-attenuated acoustic chamber. The four-month-old infant was placed in a car seat on the floor. The 11-month-old infant sat on the floor. Soft, quiet toys were provided for the infant. In both cases the mother sat on the floor, facing her infant. The mother was instructed to read the sentences to her infant in the style which she would normally use at home when reading books to her infant. A microphone was placed by the mother's mouth. The researcher monitored the audio recording in the adjacent control room without interfering with the participants. The speech was recorded to a digital audio tape using a Tascam audio recorder.

To avoid possible repetition effect, we avoided placing the noun use and the verb use of the same target in adjacent order. That is, a sentence containing a target was preceded and followed by sentences containing different targets.

The audio tape of each session was then transferred digital-to-digital to the computer. Acoustical analyses were performed with the use of the software Praat. For each token of the target non-words, the following measures were conducted for each of the two vowels: vowel duration, mean fundamental frequency (F0) and mean amplitude. We inquired whether noun and verb uses of the target words differed globally (e.g., overall duration, overall pitch), and whether nouns and verbs differed in the rhythmic patterns of the first and second vowels of the disyllabic forms. We predicted that if prosodic cues to noun and verb categories existed, the cues should be stronger in speech addressed to 11-month-old infants than to four-month-olds, as the former age is at the onset of vocabulary learning and soon to begin grammatical category learning.

2.2. Results

For each mother's speech, there were a total of 12 noun tokens (four target non-words each occurring in three utterance positions) and 12 verb tokens (also four targets each in three positions). For each subject, two means for each

acoustic measure (duration, F0 and amplitude) were calculated respectively for the first and the second vowels of all the noun targets. The means for each acoustic measure were also calculated respectively for the two vowels of all the verb targets. These means were then analyzed in 2x2x2 mixed ANOVA for each acoustic measure, with Age (four versus 11 months) as the between-subject factor, Vowel (Vowel 1 versus Vowel 2) as the first within-subject factor, and Category (noun versus verb) as the second within-subject factor.

The results of the vowel duration measure showed an overall marginally significant main effect of Category, $F(1,6) = 4.807$; $p = .07$. There was no main effect of Age, $F(1,6) = 1.56$; $p = .258$, and no interaction of Category x Age, $F(1,6) = .132$; $p = .729$. Nouns tended to be longer than verbs across all mothers of both ages (see Figure 1). This pattern is consistent with Conwell and Morgan's (submitted) finding on noun-verb homophones in infant-directed spontaneous speech in English.

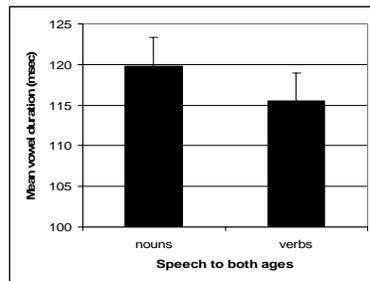


Fig. 1. Mean vowel duration (and SEs) of nouns and verbs in parental speech to infants of both ages (four- & 11-month-old).

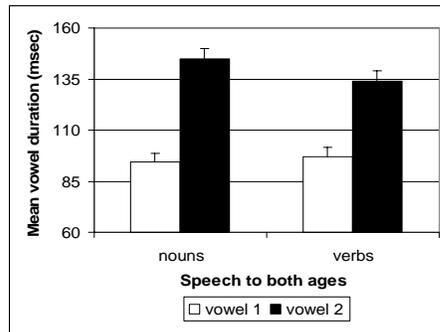


Fig. 2. Mean duration (and SEs) of the first and second vowels for nouns and verbs in parental speech to infants of both ages (four- & 11-month-old).

Regarding the comparison of the duration of the first and second vowels within a target word, we found that Vowel 2 was significantly longer than Vowel 1, $F(1,6) = 63.535$; $p = .000$. More interestingly, there was a significant Vowel x Category interaction, $F(1,6) = 9.345$; $p = .022$. Thus, while all targets

exhibited a short-long within-word durational pattern, the difference between the two vowels was significantly greater for nouns than for verbs (see Figure 2). Furthermore, there was neither a Vowel x Age interaction ($F(1,6) = .048$; $p = .833$), nor a Category x Vowel x Age interaction ($F(1,6) = .918$; $p = .375$), suggesting that the distinctive patterns for nouns versus for verbs hold for parental speech to both four- and 11-month-olds.

For the second acoustic measure, mean F0 of each vowel of targets, there was a significant main effect of Vowel, $F(1,6) = 38.738$; $p = .001$, a significant Category x Vowel interaction, $F(1,6) = 16.897$; $p = .006$, but crucially, a significant Category x Vowel x Age interaction, $F(1,6) = 14.406$; $p = .009$. No other main effect or interaction was found. These results indicate that the F0 characteristics in the speech directed to the two age groups were different. More specifically, the speech to four-month-olds showed the same F0 pattern for noun and verb categories, i.e., no Category x Vowel interaction ($F(1,3) = .172$; $p = .706$). The pitch was low-high across the two vowels within all targets. However, the F0 patterns were drastically different for the two categories in the speech to 11-month-old infants (Category x Vowel interaction: $F(1,3) = 18.256$; $p = .024$), with nouns showing a large low-high F0 difference across the two vowels ($t(3) = 6.895$; $p = .001$) but verbs showing no F0 difference across the two vowels ($t(3) = -.388$; $p = .724$). These results are illustrated in Figure 3.

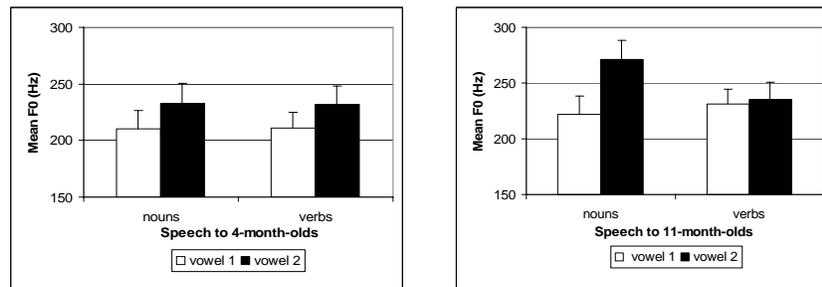


Fig. 3. Mean F0 (and SEs) of the first and second vowels for nouns and verbs in parental speech to four-month-olds and to 11-month-olds.

Finally, the results of the mean amplitude showed only a main effect of Vowel, $F(1,6) = 11.788$; $p = .014$, with the first vowel (Mean= 65.835 dB; SE= 1.68) being greater in amplitude than the second vowel (Mean= 64.556 dB; SE= 1.615) for all targets. No other main effect (Age, Category) and no interaction of any factors was found. Thus, unlike vowel duration and F0, amplitude did not show any difference for nouns and verbs in the speech to infants of both ages.

3. General Discussion

This study demonstrates that input speech in French contains prosodic cues that distinguish noun and verb categories. Nouns are overall longer in vowel duration than verbs, as in the case of English (Conwell & Morgan, submitted).

The disyllabic targets in our experiment were all produced with an iambic durational pattern, with the first vowel being short and the second long. Crucially, the short-long difference was much greater in noun than in verb production. This category distinction was present in parental speech to both four- and 11-month-old groups. Another prosodic cue, mean F0, also supported the noun-verb category distinction. But interestingly, the category difference was only present in the speech to 11-month-old infants, with the nouns showing a major low-high pitch change and the verb pitch being equal across the two vowels. No category difference was observed for the F0 measure in the speech to four-month-olds. These results confirmed our hypothesis that prosodic cues are available in parental speech for the noun-verb distinction, and that the cues are particularly strong in speech directed to infants at the onset of grammatical category learning.

The prosodic cues shown in this study can potentially assist infants in deriving the rudimentary categories of nouns and verbs. A large body of research has revealed infants' remarkable capabilities in processing acoustic/prosodic, phonological, and distributional information in various speech perception tasks (e.g., word segmentation, phonetic discrimination, etc.) during the first year of life. These capabilities are likely to be recruited for the derivation of rudimentary grammatical categories. It is, however, an empirical question what information infants rely on to discover grammatical categories. It has been argued that individual perceptual cues each typically involve a great deal of overlap between categories in natural speech, so even if infants successfully apply the optimal cut-off point, categorization errors would still be substantial (Shi, Morgan, & Allopenna, 1998). Combined prosodic, phonological and distributional cues have been shown in simulation studies to yield reliable categorization of lexical and function words (Monaghan, Chater, & Christiansen, 2005; Shi, Morgan, & Allopenna, 1998) and of nouns and verbs (Monaghan, Chater, & Christiansen, 2005). Whereas using multiple phonological cues provides quite good categorization, adding distributional cues leads to even better categorization (Monaghan, Chater, & Christiansen, 2005). Combination of cues for categorization has also been studied in recent infant experiments. Gerken, Wilson and Lewis (2005) familiarized English-learning infants with Russian nouns of masculine and feminine gender categories, thus removing semantic information. Infants aged 17 months were able to categorize nouns into correct gender classes only when the training materials contained double morphemic cues, but not when the training presented only one cue. In an artificial language experiment (Gomez & Lakusta, 2004) infants as young as 12 months of age could generalize novel words to appropriate categories after a brief training to bigram materials (i.e., *aX*, *bY*) containing contextual distributional information (i.e., *a* and *b*) correlated with phonological cues (e.g., the number of syllables differed for *X* versus *Y*). These studies suggest that combinations of cues are indeed important for grammatical category formation. Future work needs to examine how prosodic cues such as those shown in the present study may contribute to the learning of noun and verb categories.

In conclusion, using a well controlled procedure, we showed that nouns and verbs in French are marked with distinctive vowel durational and fundamental frequency cues in parental speech input, and that the prosodic marking is more salient when infants begin to develop a lexicon. These prosodic cues may play an essential role in the initial categorization of nouns and verbs.

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Appendix: Sentences containing the target non-words (the category and the utterance position of the targets are indicated after the sentences, i.e., N: noun, V: verb, e: early, m: medial, f: final)

La <u>cagère</u> est peu convenable. N-e	Le <u>docasse</u> dort dans le grenier. N-e
Je <u>noupole</u> le tout petit chat. V-e	Elle <u>bacotte</u> fort pour ses enfants. V-e
La <u>noupole</u> sent fort le muguet. N-e	Le <u>bacotte</u> traînait sur la table. N-e
Elle <u>cagère</u> mais vend la maison. V-e	Elle <u>docasse</u> parfois sur les roches. V-e
Tu le posais dans la <u>cagère</u> . N-f	La fillette vendait le <u>bacotte</u> . N-f
Il lui tentait qu'elle la <u>noupole</u> . V-f	Je préfère ton chien qui <u>docasse</u> . V-f
Le rat le met dans la <u>noupole</u> . N-f	Nous allons chasser le <u>docasse</u> . N-f
La mère la voit et la <u>cagère</u> . V-f	Les bruits de la rue le <u>bacotte</u> . V-f
Tes parents prennent la <u>noupole</u> vert et bleu. N-m	Ton petit frère mange le <u>docasse</u> sans se salir. N-m
Ton beau grand chien la <u>cagère</u> vite et bien. V-m	Ma belle grande sœur le <u>bacotte</u> moins bien. V-m
Le beau canard vole la <u>cagère</u> rouge et blanc. N-m	Le vieux canard voit le <u>bacotte</u> se baigner. N-m
La grande sirène la <u>noupole</u> plus que ça. V-m	Le jeune danseur voilé <u>docasse</u> sur lui-même. V-m

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