Segmentation of verb forms in preverbal infants

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Abstract: It has been observed that children’s early vocabulary is dominated by nouns, with verbs being much delayed. The current study investigated if this delay is related to infants’ failure to segment verb forms. Using a preferential looking procedure, French-learning preverbal infants were tested on novel verbs segmentation. Infants at the onset of vocabulary learning (11-month-olds) succeeded in segmenting the targets: they listened longer to test sentences containing previously familiarized verbs versus those containing nonfamiliarized verbs, suggesting that the delay in verb learning is not due to segmentation difficulty. Semantic and syntactic complexities of verbs could be among the underlying factors.

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1. Introduction

Infants begin to develop a vocabulary around the age of one year. A prerequisite for word learning is the capacity to segment word forms from continuous speech. Unlike printed texts, words in utterances are not separated by obvious acoustic cues. Moreover, speech addressed to infants contains mostly multword utterances rather than isolated words. In addition to finding word boundaries, infants also face the variability problem. That is, the same word type is realized in variable forms due to factors such as phonetic contexts, intonation, speech rate, etc.

Most studies thus far have focused on English-learning infants’ strategies and biases, showing that they can use prosodic cues, phonotactic cues, statistical cues, and coarticulation cues during word segmentation. Little work has examined infants learning other languages. The existing evidence suggests that properties of the input language affect infants’ strategies. English-learning infants use strong stress to determine word boundaries at an early age. French-learning infants, on the other hand, segment nouns based on syllables: Infants around 12 months of age interpret a disyllabic word as two separate forms rather than one single word, and they only succeed in extracting disyllabic forms by 16 months of age. The differential response patterns between the two languages reflect the fact that English is stress-timed and French is syllable-timed. Segmentation studies with infants learning distinct languages thus contribute to the understanding of the role of experience and infants’ perceptual biases.

Most infant word segmentation studies that used natural language have focused on nouns. It is interesting to extend this work to other grammatical classes as this may reveal how infants learn linguistic structures. Different grammatical classes assume different roles in the grammar. Language acquisition literature indicates that certain grammatical categories emerge later than others in children’s production. For example, early speech typically lacks function words/morphemes. Is this because these items are semantically and syntactically complex and therefore harder to learn? Or is it because infants fail to segment functional items due to their weak, and perhaps less perceptually salient acoustic forms? Is it also possible that infants segment and store these items in memory but fail to produce them due to other constraints? Studies testing infants’ initial segmentation of function words help narrow down these factors.

Recent work showed that preverbal infants already segment function words in English, German, and French, even though function words are generally reduced in the input. Furthermore, frequent function words assist infants in segmenting adjacent nouns by 8 months of age and in syntactic categorization of content words after 1 year of age, and in language comprehension at a later stage. Therefore, the lack of functional elements in early
speech production does not imply an inability to segment and represent these words. On the contrary, these elements are an essential part of infants’ early linguistic representations, and directly impact the acquisition of many aspects of the grammar.

The comparison of nouns and verbs represents another important issue. It is widely observed that children’s early speech is dominated by nouns, with verbs much delayed. The delay may be because verbs are conceptually more complex and difficult for word-meaning mapping. But could this delay also be because infants fail to segment verb forms? Few studies on infants’ verb segmentation exist. It is known that nouns in English are largely trochaic in stress, and verbs tend to be iambic. Given that English-learning infants use strong syllables to find word onset, nouns would be more favorable for segmentation. However, infants segment strong–weak verbs later than strong–weak nouns, suggesting that more subtle acoustic/prosodic properties of verbs may be responsible for the delay. In fact, verbs are typically shorter than nouns in vowel duration in French and English, and therefore may be less perceptually salient. Interestingly, function words, which are segmented as early as initial segmentation of nouns (at the preverbal stage) as discussed earlier, are acoustically and prosodically weaker than nouns and verbs. It was shown that frequency was a dominant factor for infants’ segmentation of function words. The high frequency of function words seems to offset their less favorable acoustic/prosodic properties. Thus, multiple factors seem to be involved in word segmentation. There is a need in the field to determine how various factors interact in segmentation, what infants’ perceptual biases are, and how the properties of the input language may affect segmentation strategies. Empirical data from different languages and across grammatical categories can give us valuable insight into these issues.

This study extends previous work on word segmentation to verbs in French. As in many languages, verbs in French emerge much later than nouns in early production. It is unknown whether this delay is due to infants’ difficulty handling semantic/conceptual complexity associated with verbs, or to an inability to segment verb forms. Hence, we aimed to determine if infants can segment some verb forms at the preverbal stage before word learning begins.

In Nazzi et al., disyllabic verbs were only segmented at 13 months of age by English-learning infants. Monosyllabic verbs were not examined, but are likely to be segmented earlier. In noun studies with French-learning infants, only monosyllabic forms appeared to be reliably segmented before 1 year of age: 8-month-old French learners segmented monosyllabic nouns. With disyllabic nouns used as targets, infants listened longer to passages containing the targets. These results were interpreted as suggesting that infants segmented the disyllabic forms. However, another interpretation is equally possible: Infants may have used a syllabic strategy and only segmented one of the two syllables of the targets. These possibilities were fully tested using disyllables and each of the two syllables of the disyllables as targets across experiments: Infants at 1-year of age interpreted disyllabic nouns as separate monosyllabic forms. In light of these results, we decided to test 11- and 8-month-old infants and used monosyllabic verbs, to determine the initial verb segmentation ability.

2. Method

Monolingual French-learning infants (sixteen aged 11 months, and sixteen aged 8 months) completed the experiment. Sixteen additional infants were tested but their data were excluded due to parental interference (3), crying (7), experimenter error (1), and refusal to finish the task (5).

The verbs chosen for the task were /bif/ (to cross-out) and /tar/ (to weigh). They are rare in spoken French, thus allowing us to assess infants’ ability to segment novel verbs. The verbs belong to the most frequent conjugation group of French verbs. The CVC form is the variant of these verbs (infinitives: biffer, tarer) for the first/second/third person singular and the third person plural in the present tense, and the second person singular imperative. It is also the form used with the subject pronoun on, which is an indefinite pronoun that can refer to any person. In fact, on is nearly always used in informal speech. Based on our analysis of the speech of four mothers to their preverbal French-learning infants, 62% of verb forms were monosyllabic, 53% present tense, and 16% imperatives. Thus, our target verbs correspond well with the
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The stimuli were recorded by a native French female speaker, using an infant-directed register, in an IAC sound chamber. The final stimulus set (see Table 1) consisted of one version of the two passages, and six tokens of each verb in citation forms. The prosodic measures for the targets are in Table 1. The six isolated tokens of each verb were doubled and strung together in the general verb pattern in the input speech. Two passages were constructed, one with /bif/ and the other with /tar/ in sentences across various positions.

The stimuli were recorded by a native French female speaker, using an infant-directed register, in an IAC sound chamber. The final stimulus set (see Table 1) consisted of one version of the two passages, and six tokens of each verb in citation forms. The prosodic measures for the targets are in Table 1. The six isolated tokens of each verb were doubled and strung together in a random order to create a /bif/ file and a /tar/ file. The interstimulus interval was 435 ms, with minor adjustments to ensure that a length of 13.5 s was maintained for both target files. The duration of the two passage files were each 17.5 s. The sentences ranged from 1.66 to 2.67 s for the /bif/ passage, and from 1.40 to 2.90 s for the /tar/ passage, with an average of 250 ms of between-sentence interval. Two visual files were used, a picture of a black-and-white checkerboard and a video of a flashing light.

Infants were randomly assigned to one of the two familiarization groups, /bif/ or /tar/. One target file was presented repeatedly during the familiarization phase, until infants reached 30 s of total looking time. Infants were then tested with alternating trials of the /bif/ passage versus the /tar/ passage, for a total of 10 trials. The first test trial was either the /bif/ or /tar/ passage type, counterbalanced across infants. Boys and girls were assigned equally in all conditions.

In the testing room the infant sat on the caregiver’s lap, facing a display monitor and a loudspeaker. The caregiver wore headphones hearing masking music. The researcher in the adjacent room, who was blind to the stimuli, controlled the experiment using a computer program, observed the infant’s eye movements through a closed-circuit TV, and pressed down a computer key whenever the infant looked at the monitor. Each trial was initiated by the infant’s look to the monitor, and continued until the end of the trial. When the infant accumulated 30 s of looking time during familiarization, the experiment moved automatically to the test phase. The software recorded all looks to the TV and calculated online the total looking time for each trial.

The checkerboard was displayed during each trial, accompanying the auditory stimuli. Between trials, the flashing light was presented to attract the infant’s attention.

### 3. Results

Total looking times during the test phase were analyzed in a 2 × 2 mixed analysis of variance, with familiarity (passage containing the familiarized target verb versus the nonfamiliarized verb) as the within-subject factor, and age (8 versus 11 months) as the between-subject factor. Across all trials, there was a familiarity × age interaction \([F(1, 30) = 5.25, \ p = 0.029]\), but no main effect of familiarity \([F(1, 30) = 0.562, \ p = 0.459]\) or age \([F(1, 30) = 0.62, \ p = 0.437]\). As is

| Table 1. Mean acoustic values and standard deviations (s.d.) of the vowels of the target words. |
|---------------------------------|--------------|-----------|---------------|
| **Duration (ms)**               | **Mean F0 (Hz)** | **Mean amplitude (dB)** |
| /bif/ (6 citation tokens)       | 704.69 (116.40) | 339.42 (91.07) | 74.74 (2.69) |
| /tar/ (6 citation tokens)       | 575.98 (129.34) | 324.17 (122.70) | 70.9 (1.64)  |
| /bif/ (7 tokens in sentences)²  | 382.14 (162.40) | 335.76 (144.55) | 77.77 (2.07) |
| /tar/ (7 tokens in sentences)²  | 495.08 (228.06) | 182.11 (33.48)  | 73.69 (3.16) |

²La jolie maman biffe les poèmes. Elle biffe les verbes. Évidemment on biffe la virgule. C’est le juron qu’il biffe. Le petit bébé biffe le graffiti. La syllabe je biffe. Biffes-tu le calembour? (The pretty mommy crosses the poems out. She crosses the verbs out. Obviously we cross the comma out. It’s the curse that he crosses out. The little baby crosses the graffiti out. The syllable I cross out. Do you cross the pun out?)

bLa nouvelle maman tare le magot. Il tare les grappes. Visiblement je tare la parcelle. C’est le lot qu’elle tare. Le gentil bébé tare les gondoles. Les rouets je tare. Tares-tu la coquille? (The new mommy weighs the pile. He weighs the clusters. Visibly I weigh the fragment. It’s the share that she weighs. The nice baby weighs the gondola. The spinning wheels I weigh. Do you weigh the shell?)
standard with this procedure, another analysis was done with the first (often unstable) test trial of each type removed. We obtained the same results: only a familiarity $\times$ age interaction $[F(1, 30) = 6.41, p = 0.017]$, indicating that the two age groups differ statistically. Follow-up analyses of each age were conducted. For the 11-month-olds, looking times across all trials tended to be longer for the passage containing the target $[t(15) = 1.821, p = 0.089, \text{two-tailed}]$. The analysis with the first trials removed yielded significantly longer looking times for the target trials [mean = 38.88 s, SE = 2.74 s] than for the nontarget trials [mean = 32.66 s, SE = 2.5 s; $t(15) = 2.284, p = 0.037, \text{two-tailed}$; see Fig. 1]. These results show that 11-month-olds recognized the targets. For the 8-month-olds, total looking times during the two types of passage trials did not differ significantly [all trials, $t(15) = 1.401, p = 0.182, \text{two-tailed}$; excluding the first test trials, $t(15) = 1.147, p = 0.269, \text{two-tailed}$].

4. General discussion

This study shows that French-learning infants can segment verbs by 11 months of age, younger than the age shown in English-learning infants. However, given that monosyllabic nouns are segmented earlier than disyllabic nouns, the earlier segmentation in our study is reasonable since we used monosyllabic verbs, whereas Nazzi et al. used disyllabic verbs. Note that the 8-month-olds in our study failed to segment verbs. This contrasts with the results that infants of the same age segmented nouns in French. Thus, verb segmentation seems somewhat delayed. It is possible that the less salient acoustic forms of verbs (e.g., shorter vowel duration) contributed to the difficulty in segmenting verbs at 8 months. Our target verbs in the passages often appeared adjacent to function words. Such contextual support may have contributed to the 11-month-olds’ success in verb segmentation. But it was obviously not enough for the 8-month-olds. Previous work showed that frequent function words, but not infrequent ones, assist the segmentation of adjacent nouns in 8-month-olds. The present study contained both high- and lower-frequency function words adjacent to the target verbs. It is possible that if all contextual words are highly frequent, infants younger than 11 months may segment verbs. Future studies can test this effect by manipulating contextual words.

As discussed earlier, verbs appear much later than nouns in children’s early speech. The present study shows that this delay is not related to an inability to segment verb forms. Although verb segmentation may occur somewhat later than noun segmentation due to their weaker forms than nouns, the ability is still present at 11 months, the age when speech production begins. The fact that infants in this study segmented rare verbs indicates that they are able to extract novel verb forms from the input. Note also that 62% of verb forms in parental speech in French are monosyllabic, while 46.4% of nouns are monosyllabic. Given the syllable based segmentation in French-learning infants shown in Nazzi et al., it is plausible that monosyllabic verb forms can be segmented at the preverbal stage and are available for learning meaning. The delay in the production of verbs must be due to other reasons, such as the difficulty in mapping verb concepts to word forms. That is, the phonological forms of at least some verbs may be

Fig. 1. French-learning infants’ mean looking times (with SEs) during the test phase for the passage containing the target verb and the passage containing the nontarget verb.
segmented and represented in the system very early, but their semantic and syntactic representations require a much longer period of learning in comparison to the development of nouns.

In conclusion, this study extends the existing literature on word segmentation to the verb category. We demonstrated that French-learning infants can segment novel verb forms from continuous speech by 11 months of age (i.e., around the time when they begin to learn word meaning). This ability prepares them for the subsequent acquisition of syntactic and semantic properties associated with verb forms.

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References and links

32Differential listening times to the target passage versus nontarget passage are standardly viewed in the field as evidence of word recognition (e.g., Refs. 2, 7, 8, 12, 23, 28, and 33). Indeed, previous work showed that infants only accept word forms during the test phase that are identical to the familiarized targets, and reject forms that are altered in one segment [e.g., P. W. Jusczyk and R. N. Aslin, “Infants’ detection of the sound patterns of words in fluent speech,” Cogn. Psychol. 29, 1–23 (1995)], suggesting that segmentation occurs for the whole word forms in this type of task.