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Early segmentation of fluent speech by infants acquiring French: Emerging evidence for crosslinguistic differences

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Abstract

Four experiments explored French-learning infants' ability to segment words from fluent speech. The focus was on bisyllabic words to investigate whether infants segment them as whole words or segment each syllable individually. No segmentation effects were found in 8-month-olds. Twelve-month-olds segmented individually both the final syllables and, under appropriate test conditions, the initial syllables of these bisyllabic words, but failed to segment bisyllabic words as whole units. The opposite pattern was observed at 16 months: final syllables were not segmented, while there was evidence that the words were segmented as whole units. The present findings are consistent with the proposal that the syllable is a unit of prosodic segmentation in French, therefore introducing evidence from a syllable-based language in support of the more general hypothesis that the emergence of segmentation abilities differs crosslinguistically as a function of the rhythmic class of the language in acquisition.
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The segmentation of fluent speech into words constitutes a critical aspect of speech processing. It allows adults and infants to determine the sequence of lexical units that make up the utterances they hear. Moreover, because most speech to infants is fluent speech rather than isolated words, speech segmentation has to play a central role in the early acquisition of words by infants. The ability to segment fluent speech into word forms has been shown to emerge during the first year of life, around 8 months of age (Jusczyk & Aslin, 1995). However, the bulk of the research on this issue has been conducted in English. Therefore, determining the pattern of emergence of segmentation abilities in different languages has become a necessity. Because prosodic information, and more specifically rhythmic properties, appears to play a central role in early segmentation in English, the present paper focuses on the early segmentation abilities of infants growing up hearing a language with radically different rhythmic properties: French.

Learning the sound patterns of individual words is a requirement for the acquisition of both the lexicon (these sound patterns being associated to their meanings) and syntax (as theories of syntax acquisition assume that infants process sentences as sequences of individuated words). Therefore, it is crucial for infants to have the capacity to access the isolated forms of the words they

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hear. This issue would be trivial if the boundaries between the words spoken to infants were clearly marked at the acoustic level, or if words were (often) presented in isolation. However, there are no obvious pauses between words in connected speech, and no clear and systematic marking of word boundaries at the acoustic level (Cole & Jakimik, 1978, 1980; Klatt, 1979, 1989). Moreover, a few studies have evaluated the presence of isolated word forms in the input received by infants acquiring English (Aslin, 1993; Brent & Siskind, 2001) or in the input received by a Dutch/German bilingual infant (van de Weijer, 1998). The results of these studies suggest that most speech to infants consists of multiword utterances, words spoken in isolation accounting for no more than 10% of all the words present in the analyzed samples. These isolated forms might help infants' acquisition of these words, as supported by the finding that the frequency with which a word is presented in isolation (rather than the total frequency of that word) partly predicts whether it will be produced several months later (Brent & Siskind, 2001). However, the need for procedures to segment continuous speech remains given that not every type of word appears in isolation (e.g., grammatical words), and that many of the words that appear in isolation correspond to fillers ("yes," "hmm," ...), vocatives ("baby's name") and social expressions ("hi!,"...), as found by van de Weijer (1998).

Although there are no pauses between consecutive words in the signal, infants could rely on several subtle linguistic cues that signal boundaries between words and cohesion of consecutive sounds within words: prosodic cues (how stress and pitch information are affected by position within words), allophonic cues (the realization of some phonemes according to their position within words), phonotactic cues (constraints on phoneme order within words), and statistical/distributional information regarding consecutive syllables (higher transitional probabilities within words compared to between words). None of these cues systematically marks word boundaries, but it is possible that using them in conjunction may provide sufficient information for successful segmentation (Christiansen, Allen, & Seidenberg, 1998).

Several studies have established that young English-learning infants are sensitive to prosodic (Jusczyk, Cutler, & Redanz, 1993; Turk, Jusczyk, & Gerken, 1995), allophonic (Hohne & Jusczyk, 1994), and phonotactic (Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993; Jusczyk, Luce, & Charles-Luce, 1994; Mattys, Jusczyk, Luce, & Morgan, 1999; see also Friederici & Wessels, 1993, for Dutch; Sebastián-Gallés & Bosch, 2002, for Catalan) markers of word boundaries in their native language. Other studies have investigated infants' use of these various linguistic cues for segmentation by exploring whether and how they segment multisyllabic words from fluent speech. The methodology used for the majority of these studies is the same as what was used in the seminal study by Jusczyk and Aslin (1995), which established that English-learning infants start segmenting monosyllabic words between 6 and 7.5 months of age. The present study also uses the same methodology. In this paradigm, infants are first familiarized with whole words or syllables from these words, and then they are presented with passages containing the familiarized words and with passages that do not. Evidence for segmentation is demonstrated by longer orientation times to the passages containing the familiarized words.

From the studies on English-learning infants emerges the following developmental pattern. At about 7–8 months of age, infants use prosodic information to segment fluent speech into sequences of syllables that begin with a strong syllable, i.e., trochaic units (Jusczyk, Houston, & Newsome, 1999b; for further evidence, see also Curtin, Mintz, & Christiansen, 2005; Echols, Crowhurst, & Childers, 1997; Houston, Santelmann, & Jusczyk, 2004; Johnson & Jusczyk, 2001; Morgan & Saffran, 1995; Nazzi, Dilley, Jusczyk, Shattuck-Hufnagel, & Jusczyk, 2005). Given that most English bisyllablic words have a strong–weak stress pattern (Cassidy & Kelly, 1991; Cutler & Carter, 1987; Kelly & Bock, 1988), this prosodic segmentation procedure (similar to the metrical segmentation strategy used by adults, c.f. Cutler, Mehler, Norris, & Segui, 1986; Cutler & Norris, 1988; McQueen, Norris, & Cutler, 1994) would allow English-learning infants, from a very young age, to appropriately segment most bisyllabic words. Indeed, Jusczyk et al. (1999b) found that English-learning infants segment trochaic (strong–weak) nouns (e.g., *candle*) by 7.5 months of age, but missegment iambic (weak–strong) nouns (e.g., *guitar*) at that age, a boundary being placed between the initial/weak syllable and the final/strong syllable (e.g., *guil/tar*, c.f. Jusczyk et al., 1999b). Finally, note that the proposal of this prosodic segmentation procedure is compatible with the data on monosyllabic word segmentation (Jusczyk & Aslin, 1995) given that these words were strong syllables.

Distributional regularities of the order of syllables (henceforward, syllabic order information) in the speech signal were also found to be a crucial cue for early segmentation. For example, 7.5-month-olds tested on passages containing strong–weak words such as *doctor* were found to show a segmentation effect if familiarized with the whole words, but not if familiarized with their initial syllables, e.g., *doc* (Jusczyk et al., 1999b). Moreover, using an artificial language paradigm in which infants are presented with a continuous sequence made-up of randomly ordered repetitions of 4 trisyllabic pseudo-words, 8-month-olds were found to group syllables into cohesive word-like units on the basis of the transitional probabilities between consecutive syllables (Saffran, Aslin, & Newport, 1996; though see Perruchet & Vinter, 1998, for an alternative interpretation of these

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