



# From pauses to clauses: Prosody facilitates learning of syntactic constituency



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## ABSTRACT

Learning to parse the speech stream into syntactic constituents is a crucial prerequisite to adult-like sentence comprehension, and prosody is one source of information that could be used for this task. To test the role of prosody in facilitating constituent learning, 19-month-olds were familiarized with non-word sentences with 1-clause (ABCDEF) or 2-clause (ABC, DEF) prosody and were then tested on sentences that represent a grammatical (DEF, ABC) or ungrammatical (EFA, BCD) 'movement' of the clauses from the 2-clause familiarization sentences. If infants in the 2-clause group are able to use prosody to group words into cohesive chunks, they should discriminate between grammatical and ungrammatical movements in the test items, even though the test sentences have a new prosodic contour. The 1-clause, control, group should not discriminate. Results support these predictions and suggest that infants treat prosodically-grouped words as more cohesive and constituent-like than words that straddle a prosodic boundary. A follow-up experiment suggests that these results do not merely reflect recognition of words in boundary positions or acoustic similarity of words across the familiarization and test phases.

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## 1. Introduction

Superficially, language takes the form of a linear string of words, but that linear string is the result of syntactic phenomena operating over hierarchically-organized constituents. Syntactic constituents – minimally defined as groups of words that function as cohesive units in sentences – form the building blocks upon which natural language grammar is organized. Constituency is an important concept even at the early stages of syntax acquisition. A rudimentary appreciation of constituency is necessary to

understand the subject-predicate distinction, which underlies comprehension of who did what to whom. For more advanced learners, constituency is important for interpreting phenomena such as proform replacement (e.g., *it* can replace noun phrases) and syntactic movement (e.g., the clauses “when Grandma gets here” and “we’ll go to the zoo” can appear in either order). Correctly parsing a sentence into constituents is also crucial for interpreting syntactically-ambiguous strings, such as “old men and women” ([old [men and women]] versus [[old men] and women]).

Given the critical role that constituents play in syntax, it follows that a learner who can parse constituents from the speech stream will be advantaged in her language development. There are many potential sources of information about constituency, including frequently-occurring function morphemes (Gervain, Nespor, Mazuka, Horie, &

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Mehler, 2008; Morgan, Meier, & Newport, 1987), cross-sentential comparisons (Morgan, Meier, & Newport, 1989), transitional probabilities between syllables (Takahashi & Lidz, 2007; Thompson & Newport, 2007), and semantics (Pinker, 1984). However, with the exception of transitional probabilities, these cues rely on prior learning and may not be helpful at the earliest stages of acquisition.

Prosody, the rhythmic and melodic aspects of speech, is one aspect of the input that may serve as a stepping-stone for early constituent learning. The prosodic bootstrapping hypothesis (Gleitman & Wanner, 1982; Morgan, 1986; Peters, 1983) proposes that infants use prosody to identify word, phrase, and clause boundaries and possibly even to infer constituency and hierarchical syntactic structure. This is a promising hypothesis, since infants have demonstrated sensitivity to a broad variety of prosodic information from the very earliest ages in both perception (e.g., Nazzi, Bertoncini, & Mehler, 1998) and production (Halle, de Boysson-Bardies, & Vihman, 1991; Mampe, Friederici, Christophe, & Wermke, 2009). Prosody is also a powerful cue for word segmentation (Johnson & Seidl, 2009; Jusczyk, Cutler, & Redanz, 1993), and larger prosodic groupings constrain the domain over which infants look for words (Gout, Christophe, & Morgan, 2004; Shukla, White, & Aslin, 2011), suggesting that infants are adept at extracting prosodic regularities from the input.

There is a large body of work examining prosodic cues at the boundaries of major syntactic constituents. Clauses typically correspond to the Intonational Phrase level of the prosodic hierarchy (Nespor & Vogel, 1986; Selkirk, 1984) and, as such, are marked with a pause, pitch resets, and final syllable-lengthening (Beckman & Edwards, 1990; Beckman & Pierrehumbert, 1986; Cooper & Paccia-Cooper, 1980; Cruttenden, 1986). These prosodic features are exaggerated and occur more reliably in infant-directed speech (IDS) (Broen, 1972; Fernald et al., 1989; Garnica, 1977; Morgan, 1986). Infants are able to perceive these cues, preferring to listen to speech that does not violate typical correlations of clause-final prosodic cues (Hirsh-Pasek et al., 1987; Jusczyk, 1989).

To examine the role of prosody on infants' memory for strings of words, Nazzi, Kemler Nelson, Jusczyk, and Jusczyk (2000; c.f. Seidl, 2007; Soderstrom, Seidl, Kemler Nelson, & Jusczyk, 2003) familiarized 6-month-olds with strings of words that formed a prosodic constituent (e.g., "Rabbits eat leafy vegetables") or straddled a prosodic boundary (e.g., "...rabbits eat. Leafy vegetables...") and found that words that form a prosodic constituent were better remembered and recognized when embedded in a passage of fluent speech at test. Soderstrom, Kemler Nelson, and Jusczyk (2005) extended these results by placing the familiarization (as well as test items) in a short passage of fluent speech. They found that infants used prosody to pull substrings out of fluent speech and then recognize them during testing. However, there was also an effect of acoustic similarity: infants preferred to listen to a test passage in which the target string had the same prosodic features – either comprising a prosodic constituent or straddling a prosodic boundary – as it did during familiarization.

Together, these studies offer evidence that prosody influences how infants remember linguistic stimuli and

even helps with extracting groups of words from continuous speech. However, while parsing speech into substrings is an important prerequisite to syntax acquisition, constituents are crucially not just substrings pulled from the speech stream. Constituents are hierarchically-organized groupings that are cohesive, rule-abiding units of grammar and are independent of a particular acoustic manifestation. Recent work by Langus, Marchetto, Bion, and Nespor (2012) demonstrates that adults can use prosody to segment speech into phrases embedded into sentences, but their work does not address the developmental question of whether infants treat prosodically-grouped words like syntactic constituents – for example, by recognizing the grouping when the non-segmental acoustic features have changed.

To test whether infants can use prosody to chunk sentences into constituent-like units, we examine infants' ability to not only parse the speech stream into substrings, but to recognize those substrings when they behave like cohesive constituent-like chunks and 'move' to a new position in the utterance. Nineteen-month-olds were familiarized with sentences with 1-clause (ABCDEF, where each letter represents a class of two nonsense words) or 2-clause (ABC, DEF) prosody and were then tested on sentences that represent a grammatical (DEF, ABC) or ungrammatical (EFA, BCD) 'movement' of the clauses that the 2-clause group heard during familiarization. If infants in the 2-clause group use prosody to locate groups of words that they treat like cohesive units, they should discriminate between the grammatical and ungrammatical movements in the test items, because the grammatical-movement items maintain the prosodically-cohesive groupings from familiarization, while the ungrammatical-movement items don't. The 1-clause group serves as a control, since their familiarization stimuli contain no internal prosodic boundaries.

Such a finding would not necessarily indicate that the infants were computing complex syntactic structures involving moved constituents. However, there are two reasons why movement is a useful test for investigating the underpinnings of constituency learning in an artificial grammar. First, since only words that are in the same constituent can 'move' together in natural languages,<sup>1</sup> a learner who recognizes a substring of a larger sentence when it appears in a transformed version of that sentence is going beyond grouping the speech stream into substrings. She is treating prosodically-marked strings of words as more cohesive than strings containing a prosodic break. Cohesiveness is an identifying property of within-constituent words, as seen through the movement of constituents, pro-form

<sup>1</sup> There are circumstances in which a non-constituent string of words appears to move as a single unit. Consider, for example, the sentence "Heidi saw Greg yesterday at the park." The constituents "yesterday" and "at the park" can both 'move' to the beginning of the sentence, leaving the transformed sentence "Yesterday, at the park, Heidi saw Greg." The string 'yesterday at the park' appears to have moved as a single unit, but it does not form a syntactic constituent. Often, it does not form a prosodic constituent either. For the purposes of this paper, we presume that infants are biased to infer that movement is, minimally, evidence for the cohesiveness of certain strings of words, which is a crucial feature of syntactic constituents. Thanks to the reviewer who pointed this out.

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