Original Articles

Phrasal prosody constrains syntactic analysis in toddlers

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ABSTRACT

This study examined whether phrasal prosody can impact toddlers' syntactic analysis. French noun-verb homophones were used to create locally ambiguous test sentences (e.g., using the homophone as a noun: [*le bébé* **souris**] [*a bien mangé*] - [the baby **mouse**] [ate well] or using it as a verb: [*le bébé*] [**sourit** *à sa maman*] - [the baby] [**smiles** to his mother], where brackets indicate prosodic phrase boundaries). Although both sentences start with the same words (le-bebe-/suʁi/), they can be disambiguated by the prosodic boundary that either directly precedes the critical word /suʁi/ when it is a verb, or directly follows it when it is a noun. Across two experiments using an intermodal preferential looking procedure, 28-month-olds (Exp. 1 and 2) and 20-month-olds (Exp. 2) listened to the beginnings of these test sentences while watching two images displayed side-by-side on a TV-screen: one associated with the noun interpretation of the ambiguous word (e.g., a mouse) and the other with the verb interpretation (e.g., a baby smiling). The results show that upon hearing the first words of these sentences, toddlers were able to correctly exploit prosodic information to access the syntactic structure of sentences, which in turn helped them to determine the syntactic category of the ambiguous word and to correctly identify its intended meaning: participants switched their eye-gaze toward the correct image based on the prosodic condition in which they heard the ambiguous target word. This provides evidence that during the first steps of language acquisition, toddlers are already able to exploit the prosodic structure of sentences to recover their syntactic structure and predict the syntactic category of upcoming words, an ability which would be extremely useful to discover the meaning of novel words.

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1. Introduction

Learning word meanings can be a very complex task for toddlers during language acquisition. In their daily life, toddlers need to extract word forms from the speech stream and associate them with possible meanings in their environment. But what kind of information can children use when they need to identify the meaning of a novel word? The *syntactic bootstrapping hypothesis* (Gleitman, 1990; Landau & Gleitman, 1985; see also Fisher, Hall, Rakowitz, & Gleitman, 1994; Fisher, 1996) proposes that having access to the syntactic structure of sentences can help children to discover the meaning of novel words. According to this hypothesis, syntax can serve as a "zoom lens" to help learners figure out which part of the world is being talked about, and hence to identify candidate meanings for novel words. In other words, the range of syntactic environments in which a given word occurs can be informative about its meaning (see Gillette, Gleitman, Gleitman, & Lederer, 1999).

In the simplest case to illustrate this idea, it has been shown that around the age of two, children are able to learn that a novel word such as "*larp*" refers to an action, when listening to sentences in which it appears as a verb, as in "*He is larping that*"; but when exposed to sentences like "*This is a larp*" in which "*larp*" appears in a noun position, they learn that "*larp*" refers to an object (e.g., Bernal, Lidz, Millotte, & Christophe, 2007; Waxman, Lidz, Braun, & Lavin, 2009). This suggests that children exploit the syntactic frames in which novel words occur to infer their possible referent. Going further, it has been shown that toddlers can also learn that a novel verb such as "*blicking*" refers to a causal action between two participants when listening to transitive sentences such as "*She is blicking the baby*", but they do not make the same inference when listening to intransitive sentences such as "*She is blicking*" (Yuan & Fisher, 2009; Yuan, Fisher, & Snedeker, 2012). In Ferguson, Graf, and Waxman (2014), 19-month-olds exposed to sentences like

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"*The dax is crying*" were able to infer that "*dax*" referred to an animate entity (i.e., a novel animal), because it appeared in the subject position of a verb that requires an animate agent; but when exposed to sentences like "*The dax is right here*", they did not show any preference for the animate entity at test. Taken together, these studies show the important role played by syntactic structure to assist language acquisition: at an age when toddlers do not have an extensive vocabulary yet, the syntactic structure of sentences helps them to discover the meaning of novel words. The question that arises is how toddlers manage to access the syntactic structure of sentences before acquiring an extensive vocabulary.

A potential cue that has triggered a great deal of interest is phrasal prosody: the rhythm and melody of speech. Across the world's languages, the prosodic organization of speech is such that every prosodic phrase boundary is always aligned with a syntactic constituent boundary (Nespor & Vogel, 1986; Shattuck-Hufnagel & Turk, 1996), although the reverse is not true, since many syntactic boundaries are not marked prosodically. Crucially, however, prosodic information such as phrase-final lengthening, pitch contour variations and pauses between prosodic units may allow young listeners to find the boundaries between some of the syntactic constituents of a sentence, even in the absence of a very extensive vocabulary (Christophe, Millotte, Bernal, & Lidz, 2008; Morgan & Demuth, 1996; Morgan, 1986). This ability to exploit phrasal prosody to identify syntactic constituent boundaries, in addition to the perception of function words (Hallé, Durand, & de Boysson-Bardies, 2008; Höhle, Weissenborn, Kiefer, Schulz, & Schmitz, 2004; Höhle & Weissenborn, 2003; Shafer, Shucard, Shucard, & Gerken, 1998; Shi, Werker, & Cutler, 2006; Shi & Melançon, 2010), has been proposed to be potentially important for infants to bootstrap their way into syntactic acquisition, because phrasal prosody would allow them to identify some of the syntactic constituents in a sentence, while function words would allow them to determine the syntactic nature of these constituents (Christophe et al., 2008; Shi, 2014).

Supporting this hypothesis, several studies have shown that the perception of prosodic boundaries can indeed help adults and preschoolers to constrain their syntactic analysis and resolve syntactic ambiguities (in English: de Carvalho, Lidz, Tieu, Bleam, & Christophe, 2016; Kjelgaard & Speer, 1999; Snedeker & Yuan, 2008 and in French: de Carvalho, Dautriche, & Christophe, 2016; Millotte, René, Wales, & Christophe, 2008; Millotte, Wales, & Christophe, 2007). However, little is known about young children who are still in the process of acquiring the words of their language: can they exploit the prosodic structure of sentences as a cue to access their syntactic structure? Such an ability would be extremely important during the first steps of syntactic acquisition, since accessing the syntactic structure of sentences may allow children to determine the syntactic category of unknown words and therefore constrain their meaning.

A long series of studies shows that infants develop an impressive expertise with prosody from their first days of life. Newborns are able to exploit rhythmic information to discriminate between languages (Mehler et al., 1988; Nazzi, Bertoncini, & Mehler, 1998); from 4.5 months onwards, infants are sensitive to the coherence of prosodic constituents (Gerken, Jusczyk, & Mandel, 1994; Hirsh-Pasek et al., 1987; Jusczyk, Hohne, & Mandel, 1995; Männel & Friederici, 2009; Soderstrom, Seidl, Nelson, & Jusczyk, 2003), they show better recognition and memory for segments that correspond to whole prosodic units than for those which span prosodic boundaries (Mandel, Jusczyk, & Nelson, 1994; Nazzi, Iakimova, Bertoncini, Frédonie, & Alcantara, 2006) and they can rely on prosodic cues to segment the speech stream into words and constrain their lexical access (Gout, Christophe, & Morgan, 2004; Johnson, 2008; Millotte et al., 2010; Shukla, White, & Aslin, 2011). All of these findings, together with the reliable relationship

between prosodic and syntactic structures, suggest that toddlers might be able to use phrasal prosody, not only to facilitate memory and lexical access, but also to constrain their syntactic analysis (see Christophe et al., 2008; Hawthorne & Gerken, 2014; Massicotte-Laforge & Shi, 2015; Morgan & Demuth, 1996; Morgan, 1986; Shi, 2014).

In the experiments that follow, we directly examined whether toddlers, who are still in the process of learning the syntax and the lexicon of their language, exploit phrasal prosody to constrain their syntactic analysis.

2. Experiment 1

We tested toddlers' ability to use phrasal prosody as a cue to access the syntactic structure of sentences and to constrain their interpretation of an ambiguous word. Pairs of French noun-verb homophones were used to create locally ambiguous sentences. For instance, the word-form "/suʁi/" was used as a noun in: [*Le bébé*$_{ADJ}$ ***souris***$_{NOUN}$][*a bien mangé*] 'The baby$_{ADJ}$ **mouse**$_{NOUN}$ ate well' (hereafter the noun prosody condition), and it was used as a verb in: [*Le bébé*$_{NOUN}$][***sourit***$_{VERB}$ *à sa maman*] 'The baby$_{NOUN}$ **smiles**$_{VERB}$ to his mom' (hereafter the verb prosody condition) – brackets indicate prosodic boundaries. Although these two sentences start with the same three words (e.g., le-bébé-/suʁi/), they are disambiguated by their prosodic structures, reflecting their different syntactic structures. When the ambiguous word was used as a verb, there was a prosodic boundary just before it, corresponding to the boundary between the subject noun phrase and the verb phrase (i.e., [*Le bébé*] [***sourit***.. - [The baby] [smiles...). However, when the homophone was used as a noun, the prosodic boundary appeared just after it, because in this case all three words belonged to a single prosodic unit, corresponding to the subject noun phrase (e.g., [*Le bébé* ***souris***] ... - [The baby mouse] ...).[1] Crucially, all words following the homophone were masked with babble noise, such that prosodic cues were the only disambiguating information.

To examine whether 28-month-olds exploit phrasal prosody to constrain their syntactic analysis, an intermodal preferential looking task with an eye-tracker was designed. Toddlers listened to the beginnings of these ambiguous sentences while watching two images displayed side-by-side on a TV screen: one associated with the noun interpretation of the ambiguous target word (e.g., a mouse) and the other one with the verb interpretation (e.g., a baby smiling). Their looking behavior was measured with an eye-tracker. If toddlers are able to take into account the prosodic structure of these sentences when conducting their syntactic computations, we expect them to look more often toward the noun picture when listening to sentences in the *noun prosody condition* than to sentences in the *verb prosody condition*.

2.1. Method

The stimuli, data and analyses of the experiments reported in this paper are accessible to readers on the OSF (Open Science Framework) database through the following link: https://osf.io/744pq/?view_only=c50cd5300feb4832ad58d3566dd041ee.

2.1.1. Participants

Forty toddlers, from 27.6 (months.days) to 28.28, with a mean of 27.26 (*SD* = 0.5, 19 girls) participated in this experiment. An additional four children participated in the study but were not included in the final analysis because of fussiness during the

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[1] Note that in French there is no difference in pronunciation between "*souris*" and "*sourit*", the final 's' and 't' are not pronounced, and both words are pronounced as /suʁi/.