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Processing consequences of superfluous and missing prosodic breaks in auditory sentence comprehension

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ABSTRACT

This ERP study investigates whether a superfluous prosodic break (i.e., a prosodic break that does not coincide with a syntactic break) has more severe processing consequences during auditory sentence comprehension than a missing prosodic break (i.e., the absence of a prosodic break at the position of a syntactic break). Participants listened to temporarily ambiguous sentences involving a prosody–syntax match or mismatch. The disambiguation of these sentences was always lexical in nature in the present experiment. This contrasts with a related study by Pauker, Itzhak, Baum, and Steinhauer (2011), where the disambiguation was of a lexical type for missing PBs and of a prosodic type for superfluous PBs. Our results converge with those of Pauker et al. (2011): superfluous prosodic breaks lead to more severe processing problems than missing prosodic breaks. Importantly, the present results extend those of Pauker et al. (2011) showing that this holds when the disambiguation is always lexical in nature. Furthermore, our results show that the way listeners use prosody can change over the course of the experiment which bears consequences for future studies.

1. Introduction

To understand a sentence, listeners have to construct a representation of the syntactic and semantic structure of the sentence. To derive this representation, they need information about which words belong to the same syntactic constituent and which words belong to different syntactic constituents. In the auditory modality, a prosodic break (PB) or prosodic boundary can provide helpful information in this respect. A PB is usually realized as a pause in the speech signal, preceded by articulatory lengthening of the word preceding the pause and a boundary tone on this word. ERP research on the role of prosody in auditory sentence comprehension is still relatively scarce. The available ERP research has shown that listeners take a PB as an indication of a syntactic break in a sentence, that is, the position where a new syntactic constituent starts (e.g., Bögels, Schriefers, Vonk, & Chwilla, 2011a; Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs, 2010; Steinhauer, Alter, & Friederici, 1999; see Bögels, Schriefers, Vonk, & Chwilla, 2011b, for a review of ERP studies on the role of PBs in sentence processing). Conversely, one could hypothesize that the absence of a PB can indicate the opposite, a possibility that has been studied much less. When no PB is present (i.e., no pause, lengthening, or boundary tone, but rather normal pitch accents on the content words), listeners might infer that the syntactic constituent is not yet completed, that is, the absence of a PB would signal syntactic cohesion (see Cutler, Dahan, & van Donselaar, 1997, p. 169). The present study investigates the relative processing consequences of the presence versus absence of a PB, and is in this respect similar to a recent study by Pauker, Itzhak, Baum, and Steinhauer (2011).

Pauker et al. (2011) propose the Boundary Deletion Hypothesis. According to this hypothesis, the presence of a PB is a stronger cue than the absence of a PB. As Pauker et al. (2011) argue, it is costly to mentally delete a PB from the sentence when it turns out not to coincide with a syntactic break. By contrast, it should be less costly to mentally insert a PB into a certain position in the sentence, when this position turns out to correspond with a syntactic break. According to Pauker et al. (2011), this might be the case because a PB is a rather salient prosodic cue, and it would therefore be hard for a listener to imagine it to be produced 'by mistake'. Conversely, it would be more likely that a listener considers the absence of a PB as a potential PB that has not been produced to its full extent. The Boundary Deletion Hypothesis thereby assumes a prosodic repair of the sentence (mentally deleting or inserting a PB) after the prosody–syntax mismatch has been noticed. In the present paper we will stick to the term Boundary Deletion Hypothesis. However, we would like to stress that, with using this term, we do not imply any commitment as to the type of revision that is needed in the case of a superfluous (or missing) PB (i.e., whether

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the revision takes place at the prosodic level, as proposed by Pauker et al., 2011, or, for example, at the syntactic level).

Pauker et al. (2011) used sentences with a late versus early closure ambiguity, as in examples (1) and (2) (a PB is indicated by ♯).

(1) When a bear is approaching the people ♯ the dogs come running.
(2) When a bear is approaching ♯ the people come running.

These sentences are syntactically ambiguous up to *the people*. In (1), *the people* is the direct object of *approaching*. This is called a 'late closure' analysis because the current constituent (i.e., the verb phrase *is approaching*) is left open to incorporate *the people* as the verb's direct object. Reading studies have shown that this is the preferred syntactic analysis of these sentences (e.g., Kjelgaard & Speer, 1999). In contrast, in (2) the verb phrase is closed early ('early closure') and *the people* is the subject of a new clause, starting a new syntactic constituent. These different syntactic structures can be indicated by PBs at different places. In (1) and (2), the PB coincides with a syntactic break.

Via cross-splicing, Pauker et al. (2011) also created sentences like (3) and (4).

(3) When a bear is approaching the people come running.
(4) When a bear is approaching ♯ the people ♯ the dogs come running.

According to Pauker et al. (2011), sentences without PBs like (3), where a PB is missing after *approaching*, require listeners to mentally insert a PB in retrospect (i.e., when hearing *come*). Sentences with two PBs like (4), of which one is superfluous (the PB after *approaching*), require listeners to mentally delete this PB. Thus, sentences like (4) should lead to more severe processing difficulties than sentences like (3). Note that in (3) and (4) the late closure preference works against this prediction, since this preference is in accordance with the eventual disambiguation in (4) and not with the disambiguation in (3). Despite this fact, the results of Pauker et al. (2011) support the Boundary Deletion Hypothesis. In (4) as compared to (1), the ERPs yielded a biphasic N400/P600 pattern. These effects were observed at *the people*. In (3) as compared to (2), an apparently smaller P600 effect was elicited at the disambiguating verb (*come*) but no N400 effect was observed. Next to the ERP results, an acceptability judgment task administered during the EEG experiment, showed that sentences with a superfluous PB (like (4)) were judged less acceptable than sentences with a missing PB (like (3); but both were judged less acceptable than (1) and (2)). From these results, the authors conclude that mentally deleting a PB is indeed more costly than mentally inserting one.

However, a potential confound of this study is that these effects are elicited by different types of events. The P600 effect in (3) is elicited by the lexical disambiguation of the sentence (*come*), which reveals the syntactic structure (*the people* starts a new clause). In contrast, the biphasic effect in (4) is not elicited by the lexical disambiguation of the sentence (*the dogs*), but earlier, by *the people*. Since *the people* contains information about the upcoming second PB (lengthening and a boundary tone), the biphasic effect in (4) appears to be elicited by a prosodic disambiguation. According to Pauker et al. (2011), at this point *the people* was prosodically separated from both the preceding verb and the subsequent clause and therefore could not receive a theta role, leading to the N400 effect (p. 2748). Alternatively, two PBs this close after each other might sound like a prosodic anomaly. In any case, sentences (3) and (4) are disambiguated by different types of information: lexical information in (3) and prosodic information in (4). This might have had an influence on the strength and/or type of the processing difficulty.

Thus, it is an open issue whether these results also hold if the disambiguation in both cases is similar in nature. The present study addresses this question by using an early versus late closure ambiguity,[1] which is always disambiguated in a lexical way. The materials were adopted from an ERP study by Kerkhofs, Vonk, Schriefers, and Chwilla (2008) See sentences (5) to (7) for examples.

(5) The traveler followed the carrier and the guide through the mountain-like area.
(6) The model kissed the designer and the photographer took a bottle of champagne.
(7) The model kissed the designer ♯ and the photographer took a bottle of champagne.

In (5), the third NP *the guide* is coordinated by *and* with the preceding NP, *the carrier*. Together, the two NPs form a complex NP which is the direct object of *followed* (hereafter referred to as NP-coordination). This becomes clear when the listener encounters the prepositional phrase (*through*…). Sentences (6) and (7) contain words of the same syntactic categories as (5) up to and including the third NP. However, in (6) and (7) the third NP *the photographer* is the subject of a new sentence, coordinated with the preceding sentence by *and* (hereafter referred to as S-coordination). This becomes clear at the verb (*took*) following the third NP (*the photographer*). Reading studies (e.g., Hoeks, Vonk, & Schriefers, 2002) have shown that the NP-coordination analysis in (5) (late closure) is the preferred analysis. However, a PB between the second and third NP (as in (7), between *the designer* and *the photographer*) can indicate a syntactic break, acting against the late closure preference. Kerkhofs et al. (2008) focused on S-coordination sentences with a PB, like (7), and without a PB, like (6) (including NP-coordination sentences like (5), without a PB, only as filler sentences). S-coordination sentences with a missing PB (6) led to processing difficulties at the disambiguating verb (*took*) relative to the same sentences with a PB after the second NP (*the designer*) (7). These difficulties took a different form in the first and second half of the experiment; a Left Anterior Negativity (LAN) effect was found in the first half of the experiment and a P600 effect in the second half.

In the present study, we use the same locally ambiguous constructions as Kerkhofs et al. (2008). Like these authors, we compare S-coordination sentences with a missing PB as in (6), with S-coordination sentences with a PB as in (7). However, in the present study, we also compare NP-coordination sentences with a superfluous PB as in (8), with NP-coordination sentences without a PB as in (5).

(8) The traveler followed the carrier ♯ and the guide through the mountain-like area.

Put differently, in the present study, the presence or absence of a PB is fully crossed with the eventual disambiguation (as an NP-coordination or as an S-coordination). In our experiment, as in the examples given above, we used different sets of sentences for the NP-coordination and the S-coordination conditions. This made it easier (a) to create sentences that fit the NP- or S-coordination

[1] We believe the described ambiguity can be accounted for both by the late closure principle and the minimal attachment principle of the garden path model (Frazier, 1987). See also Pauker et al. (2011), note 3, for a similar account for a different type of locally ambiguous sentences. For simplicity, we refer to the ambiguities described here as late/early closure ambiguities.