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# Priming Prosodic Boundaries Across Constructions

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Unlike perception studies, production studies have so far failed to prime intonational phrase structure. One reason for this might be syntactically-biased materials. This study aims to assess whether prosodic boundaries can be primed in production when their saliency is not reduced by a strong syntactic bias. We replicated the prosodic priming paradigm from Tooley et al. (2014, 2018) in an online production study testing two constructions: the original PP-attachment (transfer of location) sentences used by Tooley et al. and newly constructed relative clause attachment constructions. A norming study confirmed a strong syntactic bias in the original materials while showing more balanced preferences for RC attachment. Prosodic analyses revealed a priming effect for RC attachment constructions only, suggesting that intonational phrase structure can be primed in production in proper conditions.

## 1 Introduction

In the last decades, research in online sentence comprehension has pointed to the key role played by prosody in language processing (for a review, Pratt, 2017). In a series of perception studies, Jun and Bishop (2015) (see also Mills, 2020) have shown that by priming the intonational phrase structure (i.e., prosodic boundaries), it is possible to promote one interpretation of syntactically ambiguous sentences over the other. Surprisingly, the quite robust prosodic priming effect found in perception has not been replicated in production experiments, where intonational phrase boundaries were not primed (Tooley et al., 2014, 2018). One possible explanation to this asymmetry is that the production studies conducted so far tested the effect of prosodic boundaries under the hardest possible conditions – that is, when the intonational phrase structure is redundant to the internal structure of the sentence and/or when there is a strong syntactic preference boosting one interpretation of an ambiguous sentence over the other.

In light of these findings and their potential limitations, we replicated the prosodic priming paradigm from Tooley et al. in online studies testing two different structures which we normed for their underlying interpretational bias. The goal of the experiments was to assess whether prosodic boundaries can be primed in production, when the saliency of prosodic cues is not heavily reduced by strong syntactic biases. Our overall hypothesis was that, when addressing some methodological limitations in the design, it would be possible to see a priming effect of prosodic boundaries in production as well.

## 2 Experiment 1: Norming study

Experiment 1 was a norming study with the double purpose of (i) testing our hypothesis of a bias in the materials originally tested, and (ii) validating the ambiguity of newly-created materials. If our hypothesis is correct, we can expect a difference in the ratings for the two interpretations of the original sentences, but not for the new set of sentences.

### 2.1 Methods

*Participants:* Twenty-eight young adult (18-35 years old,  $M$  age = 26.86) English speakers from the same UK area were recruited online via Prolific. All participants had acquired the target language as (one of) their first language(s), had been exposed to it for the most part of their lives while growing up, and still has it as their strongest and dominant language (Cheng et al., 2021). Participants were controlled for gender, age, and educational level. All participants had normal or corrected-to-normal vision and no hearing impairments. No participants presented any known neurological, speech, or communication disorders at the time of testing. All procedures were performed in accordance with standard ethical guidelines and protocols, as approved by the Ethics Committee at the Université Paris Cité and the University of York. All participants provided informed consent prior to testing.

*Materials:* The experimental stimuli consisted of 80 ambiguous sentences: 40 sentences describing transfer-of-location events and 40 relative clause attachment sentences. For the transfer-of-location sentences, we used the same PP-attachment sentences from Tooley et al.'s (2018) second

experiment. An example of an ambiguous transfer sentence with its two alternative readings can be seen in (1a-b). For the relative clause attachment ambiguities (2a-b), we created globally-ambiguous sentences, controlled for length, semantic plausibility, and all adhering to a constant structure to avoid any preferences for low or high attachment (Grillo et al., 2015; Hemforth et al., 2013, 2015).

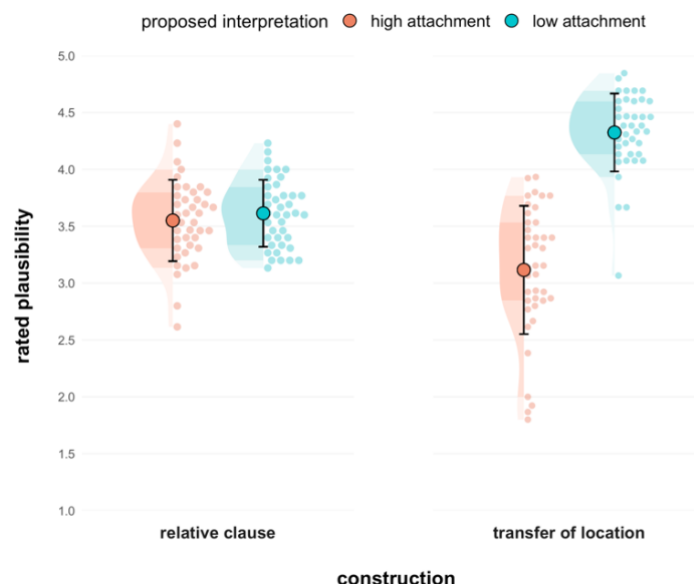
- (1) She put the money in the basket on the table.
  - a. *The money was in the basket and she put it on a table* (high attachment)
  - b. *She put money in the basket that is on the table* (low attachment)
- (2) She stayed with the patient of the doctor who waits for the blood results.
  - a. *The patient of the doctor waits for the blood results* (high attachment)
  - b. *The doctor waits for the blood results* (low attachment)

*Procedure:* The experiment consisted in an online acceptability judgement task created in PClbex (Zehr & Schwarz, 2018) and run on the university-hosted Ibex farm server. Participants were shown an ambiguous sentence and asked to rate on a 1-5 Likert scale the plausibility of one of its possible interpretations. The proposed interpretations (high vs. low attachment) were distributed across lists. A simple Y/N comprehension question followed roughly 25% of the experimental sentences. Filler sentences with either only a plausible reading or a totally implausible reading were added at the end of the task as a baseline for judgements.

## 2.2 Results

The plausibility ratings for the experimental materials were analyzed fitting a cumulative link mixed model, including main effects of construction and proposed attachment (both sum-coded), as well as the two-way interactions between them. Participant and item were entered as random effects. All analyses were performed in the R environment (R Core Team, 2021.09) using the ordinal package (Christensen, 2019). The interaction effect is plotted in Figure 1. In line with our initial prediction, the results of the model revealed a significant interaction between construction and proposed attachment ( $\beta = 0.49373$ ,  $z = 0.04046$ ,  $SE = 12.202$ ,  $p < 0.001$ ), with low-attachment interpretations of transfer-of-location sentences being preferred on average of 1.97 rating points to the alternative high-attachment interpretations. The results showed no effect of attachment on the plausibility of the relative clause sentences.

Figure 1. *Plausibility ratings on the interpretations of ambiguous sentences*



## 2.3 Discussion

The results of the norming study on the ambiguity of the materials showed a strong preference for one interpretation over the other in the transfer-of-location sentences but not in the relative clause attachment constructions. These findings substantiate the claim of a strong syntactic bias in the material originally tested (Tooley et al., 2014, 2018); whereas they confirm the more balanced ambiguity of the newly-created materials.

### 3 Experiment 2: Prosodic Priming

Experiment 2 replicated Tooley et al.'s prosodic priming paradigm with the two constructions to test whether there is a prosodic priming effect in production, when the saliency of prosodic cues is not heavily reduced by syntactic attachment preferences. If intonational phrase boundaries can be primed, we expect to see an effect of boundary location in the less biased materials – i.e., the relative clause attachments. Specifically, we expect sentences primed for an early boundary to lead speakers to produce longer NP1s than NP2s (presenting an early boundary as well) both in the repetition and in the production of a new relative clause; whereas we expected sentences primed in the late boundary to lead speakers to produce longer NP2s than NP1s (presenting a late boundary as well) both in repetition and in production.

#### 3.1 Methods

*Participants:* Forty participants with the same inclusion/exclusion criteria as the norming study were recruited online via Prolific. Seventeen participants were subsequently excluded from the final data analyses due to bad audio quality and/or production accuracy, resulting in a final sample of 23 participants and 1608 recorded sentences.

*Materials:* The experimental sentences were the same as tested in Experiment 1. Each item was manipulated to be either ambiguous or not, and to either include a prosodic boundary or not. Half of the sentences with boundaries presented an early boundary (after NP1); half a late boundary (after NP2). Following Tooley et al.'s (2014, 2018) procedure, the sentences in each of the sets (transfer-of-location and relative clauses) were paired two by two, to form prime-target pairs. The prime sentences were assigned by Latin square to one of the four experimental conditions (Y/N ambiguous by Y/N boundary); whereas the target sentences were always in the ambiguous condition, and always without boundary, being visual stimuli (see below). Ambiguity (present or absent), boundary (present or absent), and sentence position (prime or target) were counterbalanced across items and across participants. The two sets were then intertwined to alternate the two constructions. As in the original experiment, each participant was presented with 20 sentences of each set (five sentences per prime-condition), with no more than two sentences in the same condition in a row.

*Procedure:* Tooley et al.'s (2014, 2018) prosodic priming paradigm, the task consisted in repeating back out loud an auditorily or visually presented sentence. For each trial, participants listened to (and repeated) a prime sentence, and then silently read and then produced a novel target sentence. One or two filler sentences presenting various syntactic structures and intonational boundaries at various locations were added as audio or visual stimulus between each prime-target pair. The task was created in PClbex (Zehr & Schwarz, 2018) and run on the university-hosted lbex farm server.

*Data Processing and Analyses:* The audio-recorded data were transcribed, force-aligned using the Montreal Forced Aligner (McAuliffe et al., 2017), manually checked and analyzed offline using the Praat Software (Boersma & Weenink, 2021). For each repeated sentence, the 'word-and-pause' duration at the two critical regions (NP1 and NP2) was measured to assess whether or not a boundary was produced. Each absolute duration was hence normalized as a function of the noun length and the total duration of the sentence.

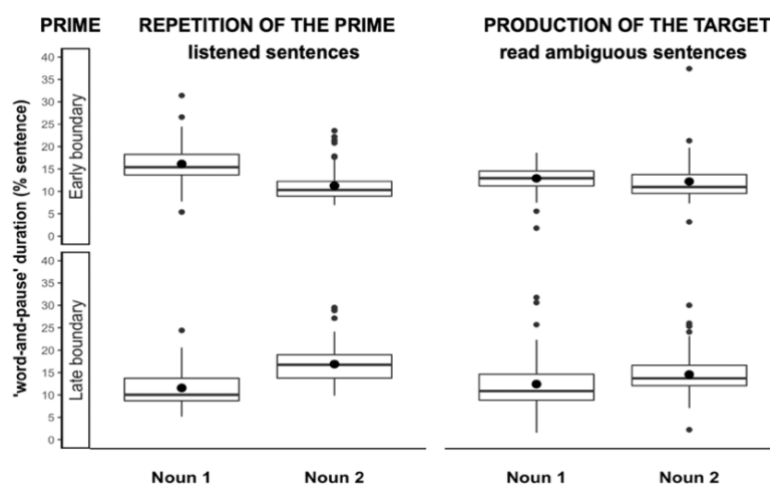
#### 3.2 Results

We used a Bayesian statistical approach to test our prediction of a prosodic priming effect depending on the boundary location. For the purpose of the current analysis, we only included items primed with a boundary (early vs. late), both in the ambiguous and unambiguous prime conditions. Since we expected a between-construction difference (relative clauses > transfer-of-location), supported by the findings of Experiment 1, we fitted separate models for each of the two constructions. The models were constructed and performed in the R environment (R Core Team, 2021.09) using the brms package (Bürkner, 2018), and using so-called weakly informative priors. Both models had the normalized duration of the nouns at the critical locations as DV, and included main effects of ambiguity condition of the prime, boundary location in the prime, prime/target position, noun phrase (NP1 vs. NP2), as well as all the interactions between them. A fixed effect of presentation order, as well as by-item and by-subject random intercepts were added to the models.

The effect of the boundary location in the primes on the duration of the noun phrases for the relative clause sentences is plotted in Figure 2. For these sentences, the estimated probability of an

interaction effect of boundary location and noun phrase on the critical noun duration is 0.13 with a 95% CI of [0.11,0.15], suggesting a rather clear effect of boundary location on the NP durations. Post-hoc analyses showed that this priming effect pattern is present in the repetition of the listened sentences ( $\hat{b} = 0.20$ , with a 95% CI of [0.17, 0.22]) and, more interestingly, it is carried over, to a lower extent, in the production of the target sentence as well ( $\hat{b} = 0.06$ , with a 95% CI of [0.03, 0.09]). So, the results of the model for the relative clause sentences revealed that speakers produced longer NP1 than the corresponding NP2 after hearing a sentence with an early boundary; whereas speakers produced longer NP2 than NP1 after hearing a sentence with a late boundary; and this was true for both the repeated sentences and the production of the new ambiguous read sentences. In line with previous production studies, and in line with our predictions, the model for the transfer-of-location sentences showed a repetition priming effect in the listened sentences ( $\hat{b} = 0.10$ , with a 95% CI of [0.07, 0.13]) but no prosodic priming effect in the production of the new sentences ( $\hat{b} = 0.00$ , with a 95% CI of [-0.03, 0.04])

Figure 2. *Duration of NPs at critical locations in relative clauses after hearing sentences with different boundaries*



### 3.3 Discussion

The results of the priming study showed that priming different intonational boundaries promotes the production of boundaries at the corresponding location, when repeating the primed sentence (repetition) as well as when reading a new target ambiguous sentence (production), when there is not a strong syntactic preference boosting one interpretation of the target sentence over the other and thus reducing the saliency of prosodic cues. These preliminary analyses extend previous work in perception and provide the first experimental evidence that, in proper conditions, intonational phrase structure can be primed in production as well. Our findings suggest that intonational phrase structure is not merely the result of semantic and syntactic processes, but indeed it affects the processing of new sentences. All this points out the relevant role of prosody in planning and facilitating language processing and production, and the need to further investigate how and what exactly are the mechanisms underlying these processes.

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