

Contextual speech rate influences morphosyntactic prediction and integration

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The perception of vowel length can be substantially influenced by the rate of the surrounding context. This phenomenon may have wide ranging implications for how higher-level linguistic information can be perceived from speech [1]. For instance, when presented with temporally ambiguous sounds (e.g., German vowels midway between short /a/ and long /a:/), listeners' perception can be biased towards the longer phoneme (i.e., /a:/) by embedding it in a fast context (e.g., [2-4]). Previous studies have tested this effect, known as rate normalization, using minimal word pairs, explicitly asking participants to categorize targets as one of two semantically distinct words (e.g., German *bannen* /banən/ "to ban" vs. *Bahnen* /ba:nən/ "lanes"). It is unclear, however, whether these contextual rate effects can also be observed for phonemes carrying morphosyntactic information, thus potentially bearing implications for syntactic prediction and subsequent integration [5]. Moreover, previous studies have exclusively used paradigms in which participants were explicitly instructed to categorize the ambiguous sound. As such, it is unknown whether rate normalization effects are merely task-driven or also influence implicit online processing.

We used an eye-tracking experiment with the visual world paradigm. Thus, we obtained online measures of the influence of contextual rate on the perception of the presence or absence of the morphosyntactic inflectional suffix [-ə], marking gender on indefinite articles (feminine *eine* vs. neuter *ein*) in German. Spoken sentences (e.g., example 1) were manipulated to include tokens of the indefinite article *ein[?]* that were ambiguous between *ein* and *eine* (schwa manipulated between 40-52% original duration). Furthermore, we introduced rate manipulations (slow vs. fast) in the preceding context (underlined in example 1) using PSOLA in Praat. Participants ($N=35$, 26 F, $M_{age}=22$) were presented with two pictures on a screen (e.g., feminine *Katze*; neuter *Reh*), and were instructed to click on the picture corresponding to the sentence-final target word. As such, participants were *not* making explicit perceptual decisions about the indefinite article.

Eye fixations in a pre-target time window after the ambiguous indefinite article showed that slow contexts biased perception of the ambiguous *ein[?]* towards *ein*, marking neuter gender. Thus, slow (fast) contexts induced a greater proportion of looks to neuter (feminine) objects, crucially well before the onset of the disambiguating -s morpheme (Figure 1). This demonstrates that contextual speech rate effects can be observed for phonemes carrying morphosyntactic information, and as such influence prediction of upcoming referents.

Moreover, in a later time window after target disambiguation, we found that participants were slower to recognize the target word if the rate manipulation biased them towards the distractor. That is, participants were slower to look at a feminine (neuter) target when presented in a slow (fast) context (Figure 2). This indicates that rate effects are robust enough to influence the integration of following target information, thus affecting not only local perception, but also subsequent referential integration.

This study shows for the first time that rate effects also affect morphosyntactic contrasts, implying that rate normalization may be a component of perceptual inference when perceiving language from speech [1, 5]. These observations were made without explicit perceptual categorization judgments, suggesting that contextual rate effects influence implicit online processing, such as prediction (i.e., not task-driven). More importantly, we show that rate-induced perceptual biases are robust enough to impact morphosyntactic inference and integration further downstream, thus impacting higher-level linguistic processing.

(example 1) Schauen Sie jetzt sofort auf ein[?] außerordentlich schöne(s) Katze/Reh.
 Look you right now at a exceptionally beautiful cat/deer.
 Now look at an exceptionally beautiful cat/deer.

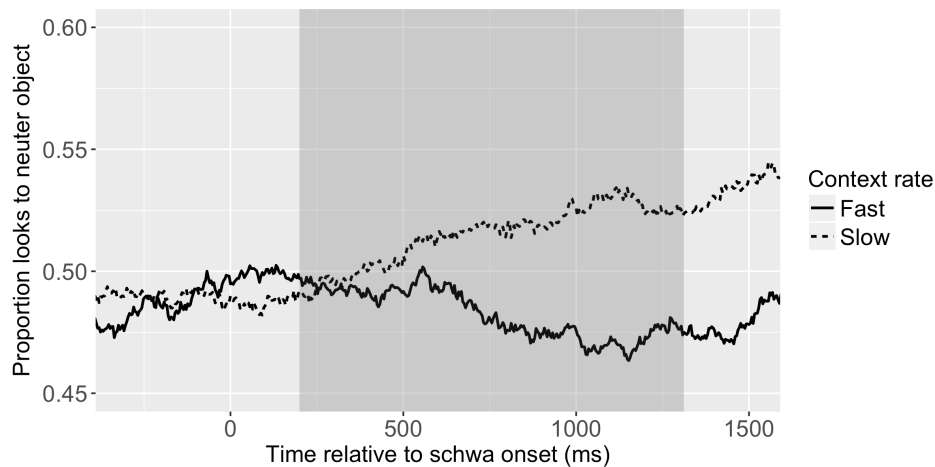


Figure 1. *Proportion of looks to neuter object across time in fast and slow contexts.* Time point 0 marks the onset of the ambiguous schwa phoneme. Shown in grey is the area of interest, spanning from 200 ms after schwa onset until the mean onset of the target word.

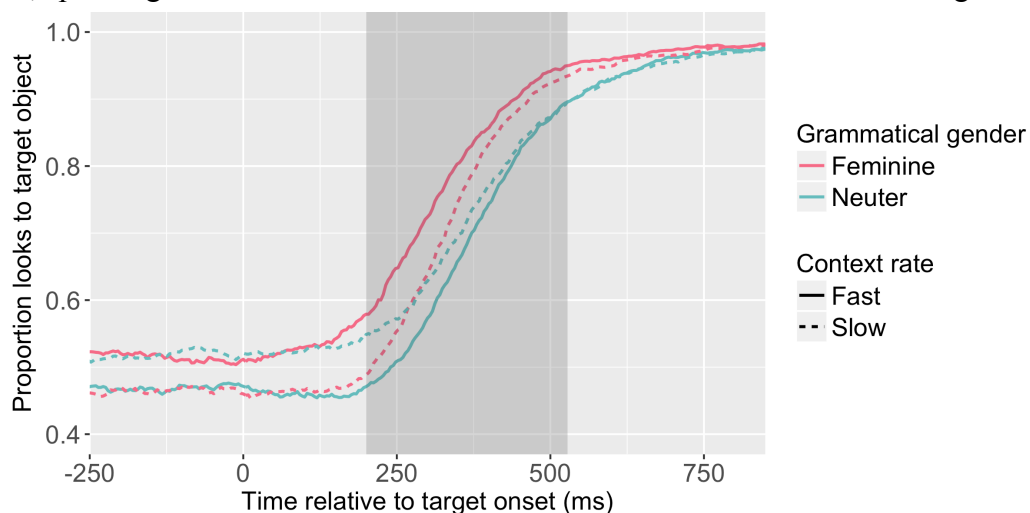


Figure 2. *Proportion of looks to target object across time for feminine and neuter target words in fast and slow contexts.* Time point 0 marks the onset of target word disambiguation (feminine: target onset; neuter: inflectional phoneme –s on adjective). Shown in grey is the area of interest, spanning from 200 ms after the point of disambiguation until 200 ms after the mean offset of the first syllable of the target word (328 ms).

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