**Lexical activation dynamics and interference in sentence processing: the effect of time**

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Speech is characterized as a transient acoustic signal rapidly unfolding to convey a message. During auditory sentence processing, the listener must analyze, segment, and process the input to build a syntactic structure and arrive at the correct meaning. As sentences become more complex, more demands are placed on the system. Processing object-relative sentence constructions, for example, requires the listener to link non-adjacent but linguistically dependent information within the temporal constraints of the auditory input. This process may be further complicated by interference arising from similarity between competing constituents which has been shown to lead to longer and more costly processing[1,2]. In this study we ask if manipulating a temporal aspect of speech input affects lexical and syntactic processing (including interference resolution). Here we show that the addition of time via focal rate manipulation (~460ms) after the direct object noun (N1) changes its lexical activation dynamics with a downstream effect on the subsequent subject noun (N2), dependency linking, and interference resolution.

**METHODS: Design**. We use eye-tracking-while-listening to examine the time course of lexical level processing (activation and deactivation) and dependency linking (reactivation) during the processing of object-relative sentence constructions (see control example in Figure 1A). We explore how manipulating temporal aspects of the direct object noun affects these processes using three manipulations (see Figure 1A). A natural recording served as the control condition with an average rate of speech (4.94 syllables/ second). These sentences served as the base to which the time manipulations were made. The stretch condition was created by increasing the duration of the direct object noun (+260ms). In the disfluent condition, the disfluency *uh* was inserted after the noun (+460ms), and in the silent condition the disfluency was replaced with a silent pause (+460ms). **Procedure**. During the experiment, the participants (n=24; $M_{age}$= 21, SD = 3.3) listened to sentences while presented with an array of four pictures on a computer screen (two depict referents in the sentence and two are distractors, Figure 1B). It is hypothesized that increased looks towards the picture of the referent recently processed indicates lexical activation, looks away from a referent indicate deactivation and looks back to the displaced noun after processing the verb indicate reactivation (i.e., syntactic dependency linking)[3,4,5]. Interference can occur as a result of competition between the subject noun (N2 *clown*) and reactivation of the direct object noun (N1 *elf*) at verb offset. We link this to eye-tracking data as overlapping activation of both nouns during the post-verb portion of the sentence[4]. To ensure attention to each sentence, participants were instructed to respond to a yes/no comprehension question (e.g., “Did the clown push someone?”) at the end of each trial. **Data analysis**. To explore the time-course of lexical activation and the effects of the temporal manipulations, we employed growth curve analyses[6,7]. Separate analyses were conducted on the three time windows [TW] of interest to explore aspects of sentence processing at hypothesized points: TW1 [lexical] encompassed the full time course of processing N1, TW2 [lexical] captured processing of the N2, and TW3 [syntax] captured reactivation of N1 and resolution of interference post-verb (see Figure 2).

**RESULTS**: In TW1, the temporal manipulations of disfluencies and silent pauses increased the overall magnitude of activation of N1 and increased the rate of activation and deactivation (see Figure 3A). Similar effects of these manipulations were found on the subsequent noun (N2) in TW2. In TW3, disfluent and silence conditions also resulted in increased rates of reactivation of the direct object (see Figure 3B). Interestingly, all three manipulations enhanced the deactivation of the competing N2 when compared to the control condition and resulted in a more rapid resolution of interference.

**CONCLUSION**: Additional time modulated the activation dynamics of lexical items and syntactic reactivation, possibly through enhanced lexical focus/attention. We argue that deactivation may play an important, beneficial role by mitigating interference during dependency linking.

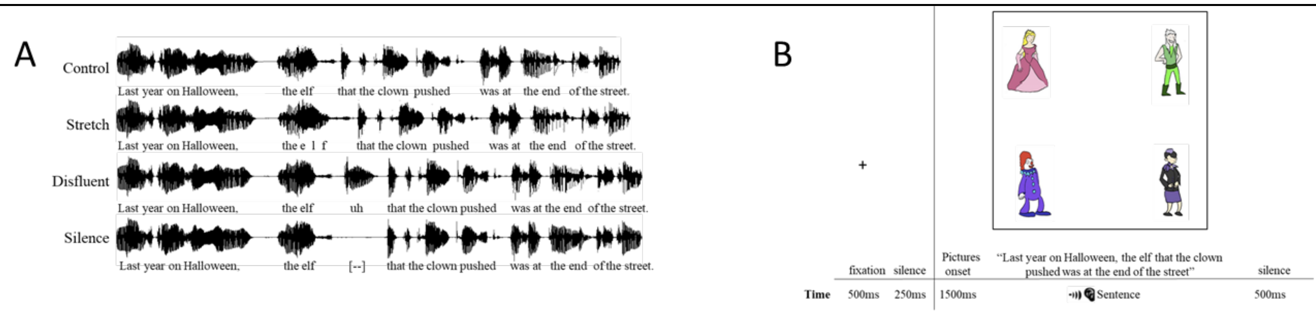


**Figure 1**. A) Examples of time manipulations. B) Eye-tracking while listening paradigm.

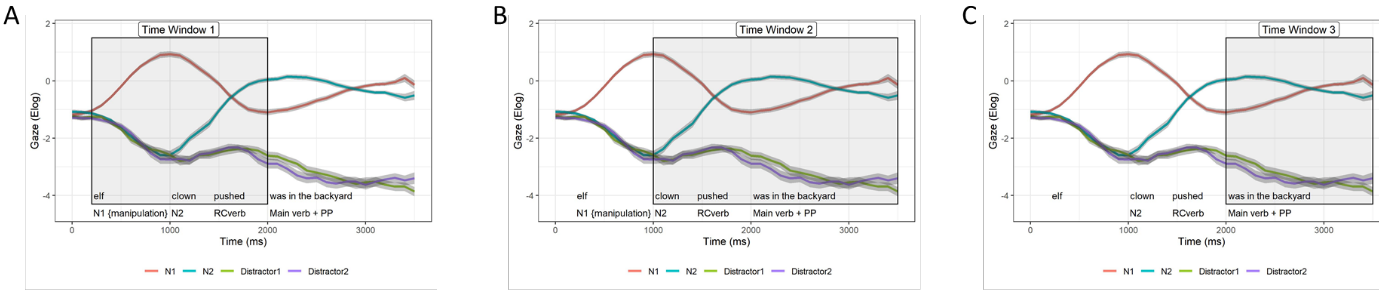


**Figure 2**. Mean gaze to N1 (the first noun, red line), N2 (second noun, blue line), and two distractor images averaged across condition as a function of time beginning at the auditory onset of N1. Windows of interest are outlined in black- **A**) Time window 1 (lexical, N1); **B**) Time window 2 (lexical, N2); **C**) Time window 3 (syntax). Error bars (shaded areas) are within-subject 95% confidence intervals.

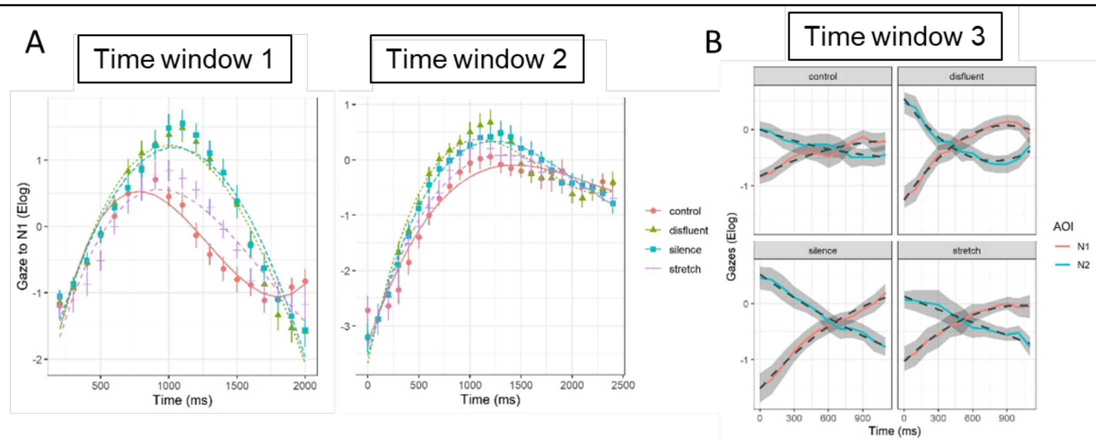


**Figure 3. A**) Growth curve analyses for time window 1: Initial lexical processing of the direct object (N1) and time window 2: lexical processing of the subject noun (N2). Model fit (lines) of the gaze data (shapes = means for the 4 conditions; error bars = standard errors) from the onset of N1 (left) and onset of N2 (right). **B**) Time window 3: deactivation of N2 and syntactic reactivation of the displaced object (N1). Model fit (dashed lines) of the observed gaze data (colored lines = means; shaded ribbons = standard errors) from the onset of the main verb.

**References**


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