The impact of auditory presentation speed on anticipatory eye movements in L2 speakers of English and older and younger L1 speakers of English

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During language processing the parser integrates information from multiple sources to generate grammatically accurate representations of the incoming linguistic input. Research has shown that the parser not only integrates each word into a preceding structure, but also actively constructs interpretations by generating expectations on the basis of information that it is integrating (e.g., Staub, 2015). This type of anticipatory behavior in sentence processing can be observed, for example, in eye movements to an object before it is explicitly referred to in the auditory input, as is often the case in the visual world paradigm (VWP). Spoken language provides additional suprasegemental information that can facilitate interpretations, and several VWP studies have found that these cues can be used in conjunction with visual context to generate expectations (Huettig et al., 2011). To date, only one study has investigated the impact of speech rate in the VWP (Huettig & Guerra, 2019). Across three studies, they found that participants made anticipatory eye movements when sentences were presented at a "slow" rate but only made anticipatory eye movements at a "normal" speech rate when the visual array was available for an extended period of time. In that study, and like most VWP research, the actual speech rate is somewhat unclear, and given that normal speech rates have been reported anywhere from 2-8 syllables per second (e.g. Hertrich et al., 2013; Wilshire, 1999) it is hard to quantify what is "slow" and "normal". In the present study, we test the impact of speech rate on anticipatory eye movements by systemically varying speech rate (using Praat), within the normal speech rate range, from 3.5 – 6 syllables per second (i.e., 3.5, 4.5, 5.5, 6.0 syllables per second), and we did so across groups that are likely to be differentially impacted by speech rate: older adults and L2 speakers. We use the VWP to test participants' anticipatory eye movements to wh-movement constructions; participants viewed 4 images and heard a short story (see Example 1), which was followed by a wh-movement question (1a).

We analyzed the weighted empirical logit (log-odds ratio of looks to the target object relative to looks to the non-targets) in a 1000ms time window from 200ms following the onset of the verb (e.g. *tickle* in 1a) using linear mixed effects models. In order to capture the potential non-linearity of fixation probability, models included a fixed effect of time to the polynomial order of two. As a result of the speech rate manipulation this 1000ms time window encompassed slightly different linguistic information; however, the time window captured the critical part of the utterance across all speeds. In the Experiment 1, younger (18-24 years of age, N=25) and older (40-75 years of age, N=31) adult native speakers of English were tested. Older adults show a greater increase in fixations to the target from 3.5 to 4.5 relative to younger adults, however younger adults showed an additional increase in fixations to the target up to 5.5, while older adults showed a decrease from 4.5 to 5.5, both groups showed a decrease from 5.5 to 6 (see Figure 1). In Experiment 2, we compared late second language speakers of English (L1 German, N=23) and young L1 English speakers. L2 speakers only make anticipatory eye-movements at the slowest speech rate (and do so later than L1), at the faster rates they made eye movements to the target only after the verb has been uttered, while L1 anticipatory eye movements increased up to 5.5, both groups again showed a decrease from 5.5 to 6 (see Figure 2).

These findings show differential patterns of anticipatory eye movements emerging across different speech rates, even within the normal (speech rate) range. The different speech rates used in the current study impacted eye movements in native speakers, across age groups, and in non-native speakers, suggesting that speech rate plays an important role in anticipatory eye movements. Future VWP research should, at the minimum, report speech rate and discuss the potential role of the speech rate within the context of our findings.

Example 1: One day a bride and groom were walking in the mall. The bride was feeling playful, so the bride tickled the groom. A clerk was amused.

a. Who$_i$ did the bride tickle t_i in the mall

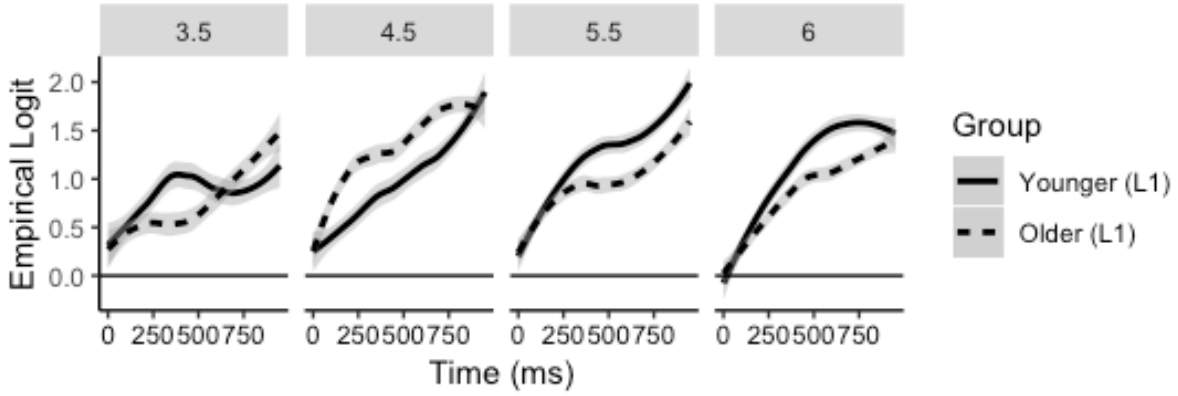

Figure 1. Empirical logit to the object across time for L1 speakers (logits above zero show that eye movements to the target were more likely to occur than looks to the non-targets)

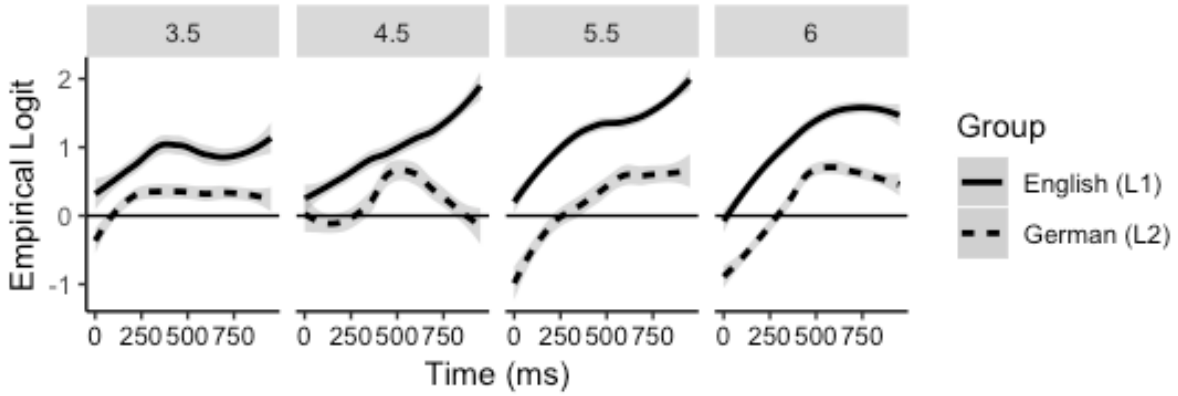

Figure 2. Empirical logit to the object across time for L1 and L2 speakers (logits above zero show that eye movements to the target were more likely to occur than looks to the non-targets)

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