

Can Attention Modulate Predictive Eye-Movements in Sentence Processing?

¹Edith Kaan, ¹Hannah Treadway, ¹Jude Singleton, ¹Amy Kessler, ¹Claire Kuntz, ¹Jorge Valdés Kroff, and ²Theres Grüter

¹University of Florida, ²University of Hawai'i at Mānoa

Language processing is an incremental and highly predictive process; parsers rely on contextual information to pre-activate upcoming linguistic input. According to some proposals (Pickering & Gambi, 2018), part of predictive processing (spreading activation) is largely automatic, followed by slower, more controlled and effortful processes. These models predict that attention mainly affects the latter but not the former stages. Prior studies using a visual world paradigm (VWP) report a delay of predictive eye-movements with passive listening compared to a target identification task (Altmann & Kamide, 1999) or under additional working memory load (Ito et al., 2018), suggesting that attention and resources affect the early time-course of prediction. However these studies used a rather slow presentation rate (1.3 syllable per second).

In this study, we investigated how attention modulates prediction as measured by predictive eye movements in a VWP paradigm with a more naturalistic speech rate (2.9 syllables/sec). We varied attention by manipulating the task-relevance of the predicted information. Young adults with English as their first language listened to English sentences and were instructed to attend to the actions of either masculine or feminine actors (between-group manipulation). Sentences consisted of two clauses. The first clause contained a verb that was either predictive of the target noun (After John *answered* his phone, Mary sighed and produced her wallet) or non-predictive (After John *lost* his phone, Mary...) (16 items/condition, see Table 1). All critical sentences had a masculine actor in the first clause and a feminine actor in the second clause, hence, the predicted information was task-relevant for those in the attention-to-masculine group. To reduce strategizing, the order of actors was reversed in filler sentences (50% of items). While listening, participants viewed three images: the target noun (phone), the second-clause noun (wallet), and a distractor. Participants fixated freely on the images during auditory presentation and then responded to comprehension questions via a mouse click (Fig. 1). The group that was instructed to attend to the masculine characters received questions only about the masculine characters; the group attending to feminine actors only received questions about these. If task-relevance has an immediate effect on prediction, we expected participants to make predictive eye-movements to the target image later and to a lesser extent when the target information was not relevant to the task (attention-to-feminine group) than when it was (attention-to-masculine group).

Thus far, we have collected 21 datasets in the attention-to-masculine group; 22 in the attention-to-feminine group. Preliminary analyses of the predictive time window (from 550 ms before target noun onset to 200 ms after) showed more anticipatory target fixations in the predictive than in the non-predictive conditions, as expected (Fig 2), [$b=0.55$, $SE=0.23$, $z=2.36$, $p<.05$]. Numerically the prediction effect was smaller when the predicted information was not task-relevant, however this failed to reach significance [$b=0.64$, $SE=0.38$, $z=1.68$, $p=.09$]. In the 200-1000 ms window relative to the onset of the target noun, the target was fixated more when it was task-relevant [$b=0.63$, $SE=0.28$, $z=2.22$, $p<.05$] in both predictive and non-predictive conditions. A divergence point analysis by bootstrapping suggested no difference in the onset of the prediction effect between the two attention groups [difference of -3ms for the attention-to-masculine vs. attention-to-feminine group, 95% CI: -11 to 5ms]. Although data collection is still in progress, our current results suggest that the onset of predictive eye movements is not much affected by attention, whereas the extent of target fixations is. This supports models in which initial stages of prediction are not affected by attention, but later stages of processing are.

References: Altmann & Kamide (1999), *Cognition*; Ito et al. (2018), *Bil. Lang. Cogn.*; Pickering & Gambi (2018) *Psych. Bulletin*

Predictive/non-predictive verb	Objects in display		
	Target (1st clause object)	2 nd clause object	distractor
After John <i>answered/lost</i> his <u>phone</u> , Mary sighed and produced her wallet.	phone	wallet	glasses
Q: Attention-to-masculine group (predicted info is task-relevant)	What did John answer/lose?		
Q: Attention-to-feminine group (predicted info is not task-relevant)	What did Mary produce?		

Table 1. Examples of the experimental conditions. Critical verb in *italics*, target noun underscored

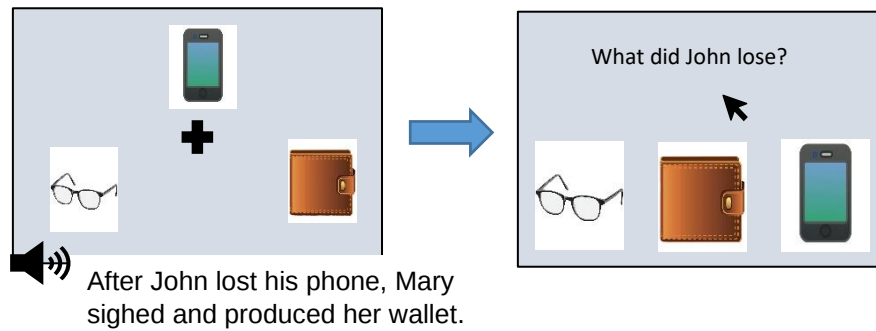


Fig. 1 Example trial (non-predictive condition, attention-to-masculine group)

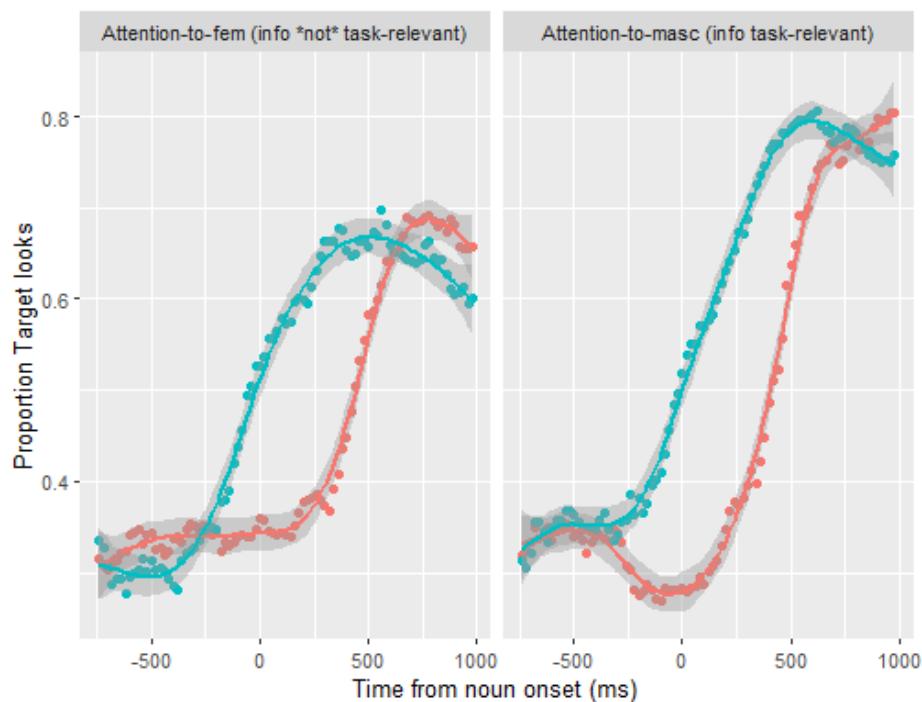


Fig. 2 Proportion of target looks in the four conditions. Target noun starts at 0 ms.