Gaze cue effect during language comprehension

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1 Introduction

Real-world eye-tracking results from 3 experiments suggest that people prefer to look at recently depicted over possible future events during spoken sentence comprehension. Participants (N=32) saw a videotaped actor performing an action (e.g. sugaring strawberries). Once the action was completed, they heard a German sentence (NP1-VERB-ADVERB-NP2) that referred either to that action (e.g., *Der Versuchsleiter zuckerte kürzlich die Erdbeeren* 'The experimenter recently sugared the strawberries', or an equally plausible action that the actor would perform in the near future (e.g., *Der Versuchsleiter zuckert demnächst die Pfannkuchen* 'The experimenter will soon sugar the pancakes'). People's eye movements to the objects were recorded while they heard the sentence (Fig. 1).

In Expt 1 by Knoeferle et al., (2011, Expt 1) participants only saw the past action being performed (see also Abashidze et al., 2011, Exp. 1; Knoeferle & Crocker, 2007, Exp. 3). The results showed that, although at the ADVERB the sentence becomes fully disambiguated towards the past or the future event, looks to the past (strawberries) and future (pancakes) objects only started to diverge late during the NP2 (i.e., the tense effect). Until then, listeners preferred to look at the recent object (strawberries). Crucially, throughout the sentence there was an overall preference to look at the past than the future object, irrespective of sentence tense (henceforth 'recent-event preference'). This recent-event preference was investigated further in two subsequent experiments. In Expt 2 by Knoeferle et al. (2011), participants saw both the past and future action performed equally often (50% frequency), while in Expt 3 (Abashidze et al., 2013) the frequency of the future action was increased to 75% of the trials (vs. 25% for the past action). As a result of these frequency manipulations, looks to the past and future object started to diverge earlier - in the later part of the AD-VERB region in Expt 2, and at the end of the verb region in Expt 3. However, the overall bias of looking more at the past vs. future object remained present throughout most of the sentence. Clearly, the recent-event inspection preference is robust and not easily overridden by frequency manipulations favoring a future event.

In our latest study the recent-event preference was pitted against a situational cue that seems to be very effective in directing visual attention, i.e. gaze. Gaze is important in communication and existing research has examined how a listener responds to a speaker's gaze during language comprehension. A study by Hanna and Brennan (2007) examined gaze cues in speaker/listener pairs during a simple target-matching task. They found that listeners used the gaze cues of speakers to identify correct targets before the point of linguistic disambiguation. A study by Knoeferle and Kreysa (2012) examined effects of a speaker's gaze on a listener's visual attention and language comprehension when the speaker did not directly face the listener. The results showed that even when the speaker was positioned at an angle to the listener, the listener followed the

speaker's gaze to the target objet before it was mentioned (see also Macdonald, & Tatler 2013).

With regard to the recent event preference and our experiments, we wanted to see whether and to which extent an actor's gaze towards the (past or future) object influences listeners' visual attention; in particular, we wanted to see whether a gaze towards the future object could overcome the preference for the recently acted upon object. The current study (*N*=32) used the same experimental materials as the previous studies (e.g., Knoeferle et al., 2011). In addition we created short 'gaze' video clips for every item, showing the experimenter gazing at the target object (e.g. past (strawberries) or future object (pancakes)).

As in the previous studies, the videotaped experimenter performed one action before the sentence – the recent action (e.g., sugaring the strawberries) and then after 700 ms the sentence was presented. In half of the trials the experimenter gazed at the target object from VERB onset and kept his gaze on the target until the end of the sentence. In the other half of the trials, participants saw a static picture of the experimenter looking straight ahead. The second (i.e. future) action was shown 700 ms after the end of the sentence. Thus, the experiment manipulated 2 factors: sentence tense (past vs future) and gaze to target object (gaze vs no gaze). Past and future events were shown equally often.
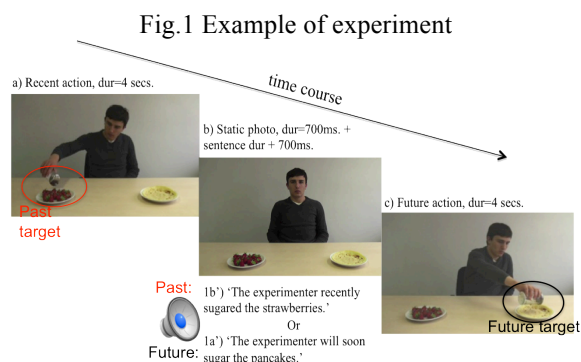
Fig.1 Example of experiment

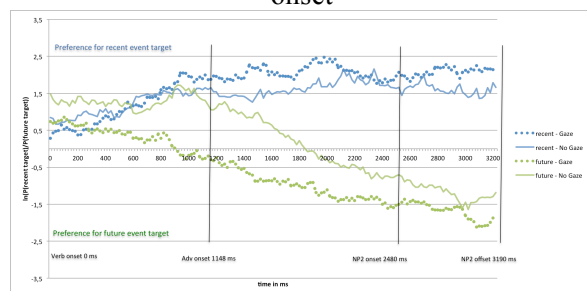Fig. 2 Mean log gaze probability ratios ($ln(P$(recent target)$/P$(future target)) from verb onset

Fig. 2 shows the time course of participants' eye fixations from verb onset. The dependent measure is the mean log gaze probability ratio ($ln(P$(recent target)$/P$(future target)).This ratio expresses the visual bias strength for the past target vs. the future one. A positive value means more looks to the past target, a negative one to the future. In the no-gaze conditions, we replicated the results of Expt 2 (Knoeferle et al., 2011), with the preference for looking at the past object reversing only during the adverb (where ratio values become negative). When gaze (vs. no gaze) was available, there were more and earlier looks to the target object. Importantly, gaze affected looks to the future object to a greater extent than the past object. With gaze (cf. green dotted line, Fig 2), looks to the future object increased faster than without gaze (solid green line), with the ratio becoming negative (showing a preference for the future target) 800ms earlier than with no gaze (1100 vs. 1900ms). In sum, by triggering more and earlier looks to the future target, gaze mitigated the recent event preference, however, it did not completely override it, as in the first 800 ms there was still an overall preference for the past target.

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