

Employing event-based eye-blink rate to study adaptation of prediction

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Pre-updating and disconfirmation of predictions. In the study of prediction during sentence processing, a distinction was made between “pre-activation” of representations in long term memory, and “pre-updating” of a prediction [1]. Pre-updating is a stronger form of prediction, which occurs only if a certain prediction is highly activated, and it involves integration of the predicted word into the sentence’s working memory (WM) representation. Evidence for pre-updating was shown in an event-related potentials (ERP) study [2], in which the pre-updating effect was greater for participants with higher WM capacity.

Several studies showed that disconfirmation of strong predictions entails processing costs, commonly observed in the frontal post-N400 positivity ERP component [3]. These costs were suggested to stem specifically from the disconfirmation of pre-updated predictions. Since such predictions are integrated into the sentence’s representation, they need to be inhibited in order to allow integration of another word [2,4].

Eye-blink rate. Extensive research indicates that spontaneous eye-blink rate (EBR) is an effective indirect measure of dopamine (DA) activity in the striatum [5]. Additional work suggests that phasic DA signals drive gating and updating of WM, in line with the prefrontal cortex basal ganglia WM model [6,7]. Recent event-based EBR (ebEBR) experiments have shown that EBR increases when WM is updated, in a non-linguistic reference-back task [8]. A recent study employed ebEBR to provide additional evidence for pre-updating [9]. Two-word phrases were presented word-by-word. The first word was either highly predictive of the second, i.e. had high constraint (e.g. “climate change”) or not (e.g. “vegetable soup”). In high constraint pairs, upon updating the first word into WM, if pre-updating occurs then the predicted second word should also be updated, and no gating or updating is expected upon presentation of the second word. Indeed, reduced EBR was observed following the second word in the high constraint vs. low constraint condition. This effect was also correlated with WM capacity, in line with the ERP results [2].

The current study aims to replicate the previous ebEBR findings [9], as well as use ebEBR to study adaptation of prediction. We hypothesize that since the disconfirmation of pre-updated predictions incurs processing costs, repeated disconfirmation of strong predictions would result in a lower tendency to pre-update.

Methods. The materials include 100 two-word phrases in Hebrew, half with high constraint and half with low constraint. The second word is always the most predictable word for that item (see Table 1). The phrases are presented word by word (SOA=1000ms), and participants are instructed to press a button as quickly as possible if the phrase is anomalous (i.e. no response is needed in the experimental trials; 50 anomalous filler trials are included). The experiment also includes 50 high constraint fillers that are used in order to create a between-participants manipulation: half of the participants see these items with their most predictable completion (i.e. they do not experience disconfirmation of strong predictions throughout the experiment), and half see them with a congruent but unexpected completion (i.e. disconfirmation of strong predictions). Participants’ WM capacity is assessed via a reading span (RS) task. EBR is measured using EOG electrodes above and below the eye. Due to the coronavirus situation, data collection was temporarily halted (at 23 participants); however, the experiment will include 60 participants (30 per group, matched for RS).

Predictions and discussion. We expect to replicate the reduction in EBR in the high relative to low constraint experimental trials, reflecting pre-updating. We predict this effect to be smaller for participants who were presented with unexpected words in the filler trials, reflecting adaptation to the disconfirmation of strong predictions by lowering the tendency to pre-update. If the previous results replicate, this will indicate that ebEBR is a reliable measure of pre-updating. If the expected between-group results will be obtained, this will also provide evidence for adaptation of the tendency to pre-update. Importantly, we hope the current study will help establish this technique as a valuable tool to study other linguistic phenomena.

Table 1: Example set

Type	Phrase	
High constraint condition	<i>ptitey šeleg</i> flakes snow 'Snow flakes'	
Low constraint condition	<i>marak yerakot</i> soup vegetable 'Vegetable soup'	
Anomalous fillers	<i>ugat garbayim</i> cake socks 'Socks cake'	
High constraint fillers (between groups manipulation)	<u>Predictable:</u> <i>zihum avir</i> pollution air 'Air pollution'	<u>Unexpected:</u> <i>zihum svivaty</i> pollution environmental 'Environmental pollution'

* The materials were presented in Hebrew. Constraint was determined based on a cloze pre-test (sentence completion questionnaire).

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