

## Dissociating Effects of Predictability, Preview and Visual Contrast on Eye Movements and ERPs

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A predictable word receives shorter eye fixations in reading [1] and reduced N400 amplitudes in ERP experiments [2]. The effect on eye fixation durations appears to be dependent on valid parafoveal preview [3]; when a reader is provided with an invalid preview of the target word using the boundary paradigm [4] the predictability of the target no longer influences fixation durations. Nevertheless, predictability modulates the N400 in ERP experiments using the RSVP paradigm, in which there is no preview of upcoming words. We utilized a coregistration [5] paradigm where participants' eye movements and EEG are simultaneously recorded. Based on previous results, we predicted that the predictability effect on the N400 should persist with invalid preview, but the predictability effect on fixation durations should not. In a second experiment, we manipulated predictability and visual contrast, to further explore how low-level properties of the text may differentially influence eye movements and the N400 in normal reading. In [6] these variables demonstrated additive effects on eye fixations durations. We expected to replicate this pattern, while assessing whether contrast influences the amplitude or latency of the N400 [cf. 7].

In Experiment 1 participants ( $N_{\text{subjects}}=33$ ) read sentences ( $N_{\text{items}}=180$ ) distributed in a 2x2 design crossing the predictability of the target word (mean cloze = .93 vs mean cloze = .004) and target preview validity (Table 1). A linear mixed effects model (LMEM) of first fixation durations (Figure 5) revealed a significant interaction between predictability and preview validity, replicating [3]. Two sets of fixation-related potentials (FRPs) were created by time-locking the EEG to the onset of fixation on the target word, and the onset of the immediately preceding fixation (typically on the previous word) (Figures 1 and 2). These FRPs collapse across centro-parietal electrodes. The FRPs were analyzed using a standard N400-window (250-500ms) ANOVA; trial-level mixed effects models [8] revealed similar statistical patterns. Predictability reduced N400 amplitude on the target word FRP ( $p < .001$ ), while preview did not have a significant effect ( $p=.1$ ). There was a marginal interaction ( $p=.06$ ). To assess differences in N400 latency, we also conducted ANOVAs in 50ms bins, as in [5], which revealed that the predictability effect began as expected at 350ms. This analysis also revealed an interaction ( $p = .01$ ) in the 500 to 600ms interval; the predictability effect was larger with invalid preview, driven by a positivity in the invalid predictable condition. For the previous fixation FRP, there was a significant effect of preview ( $p=.008$ ) and a significant interaction ( $p=.007$ ), driven by a predictability effect in the valid preview conditions but not the invalid conditions. In sum, the reduced negativity associated with a predictable word appears earlier with valid preview than with invalid preview, but is present in both cases.

Experiment 2 ( $N_{\text{subjects}}=25$ ) used the same procedure and same items, now crossing predictability with visual contrast (Table 2). The eye tracking data are shown in Figure 6; a LMEM confirmed [6] in showing significant and additive effects of predictability and contrast ( $ps < .001$ ). FRPs are in Figures 3 and 4. Analyses of the target word FRP revealed that predictability significantly reduced N400 amplitude ( $p=.001$ ), with stimulus quality showing no significant effect on amplitude or latency. A series of analyses of sequential 50ms bins revealed no evidence that the N400 was delayed in the faint text conditions [7]. There were no significant effects on the FRP for the previous fixation in the N400 window, though qualitatively the patterns for clear text are similar to the patterns for valid preview in Experiment 1 (Figures 1 and 3).

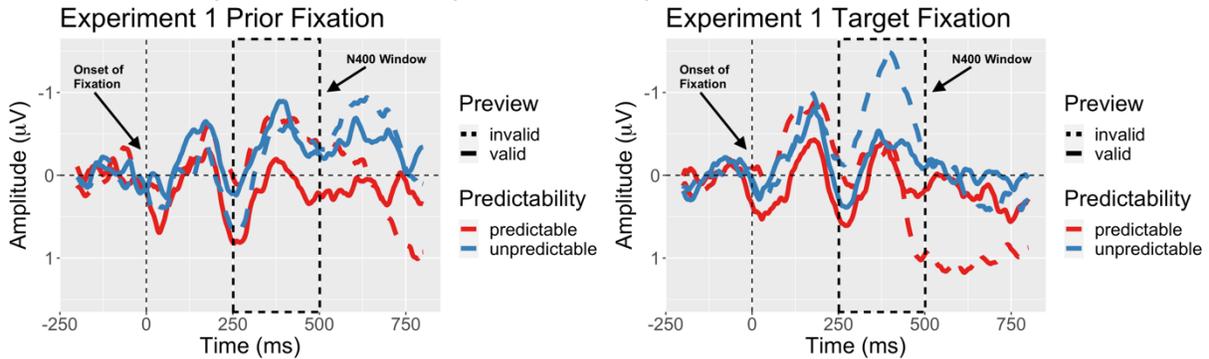
In sum, the usual predictability effect on eye movements in reading is eliminated when parafoveal preview is absent, while the predictability effect on the (foveal) N400 is not. Furthermore, the amplitude and latency of the N400 appears not to be influenced by visual contrast, while eye fixation durations are. These dissociations emphasize that distinct processing events determine eye fixation durations and N400 amplitude and latency. We are in need of a more explicit model of how each of these measures indexes specific stages of lexical processing.

	<b>valid preview</b> (mail → mail)	<b>invalid preview</b> (exit → mail)
<b>predictable target</b>	The package was sent through the {mail  <u>mail</u> } two weeks ago.	The package was sent through the {exit  <u>mail</u> } two weeks ago.
<b>unpredictable target</b>	If nobody claims the {mail  <u>mail</u> } then it will be thrown away.	If nobody claims the {exit  <u>mail</u> } then it will be thrown away.

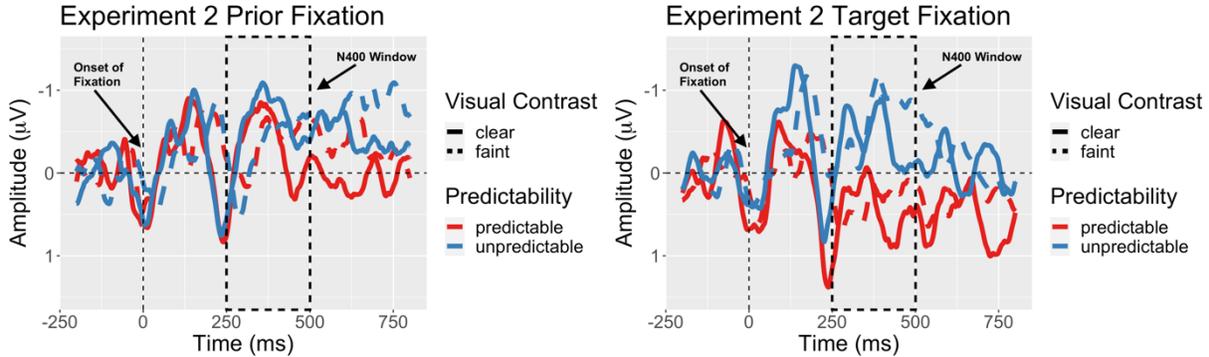
**Table 1:** Example stimuli from Experiment 1. Previews are to the left of the “|”. The display would show the preview until fixated, at which point the target word “mail” would be displayed.

	<b>clear text</b>	<b>faint text</b>
<b>predictable target</b>	The package was sent through the <u>mail</u> two weeks ago.	The package was sent through the <u>mail</u> two weeks ago.

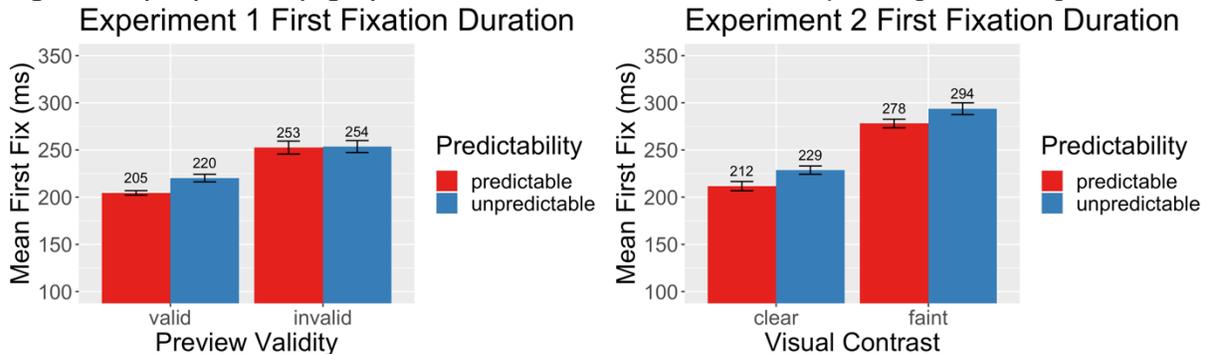
**Table 2:** Example stimuli from Experiment 2. Unpredictable contexts were used in addition.



**Figures 1 (left) and 2 (right):** Baseline-Corrected FRPs for the pre-target and target fixations.



**Figures 3 (left) and 4 (right):** Baseline-Corrected FRPs for the pre-target and target fixations.



**Figures 5 (left) and 6 (right):** First Fixation Durations on the critical target word by condition.

[1] Staub (2015), [2] Kutas & Federmeier (2011), [3] Staub & Goddard (2019), [4] Rayner (1975), [5] Kretschmar et al. (2015), [6] Staub (2020), [7] Holcomb (1993), [8] Alday (2019)