Differences in lexical retrieval and reintegration processes between foveal and parafoveal processing during reading: Evidence from event related potentials

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Electrical brain potentials in response to violation of expectations in language processing have revealed that people use sentence context to facilitate word recognition and integration. The N400 is a robust language-related event-related potential (ERP) that is modulated by the semantic fit between a word and its preceding sentence context and is suggested to reflect retrieval of lexical information from semantic memory (Kutas & Hillyard, 1980; Kutas & Federmeier, 2000). In contrast, the late positive complex (LPC) which is assumed to reflect a later stage of processing, follows the N400 for unexpected word forms and is believed to reflect further integration of the lexical information with the surrounding context (Brouwer et al., 2017). Despite reflecting different processes, the N400 and the LPC are both not only influenced by top-down contextual expectations, but also bottom-up perceptual information (Laszlo & Federmeier, 2009). However, the majority of research on the N400 and the LPC uses rapid serial visual presentation (RSVP) of words in high-acuity foveal vision. In contrast, word recognition in normal reading often begins in low-acuity parafoveal vision before a word is fixated. Thus, less is known about how the quality of the bottom-up visual information interacts with top-down contextual expectations to impact the processes of lexical retrieval and semantic integration that are reflected by ERP responses such as the N400 and LPC, respectively.

To investigate this question, we recorded ERPs from participants (n = 38) as they read sentences (n per condition = 29) via RSVP, but the sentence-final word was presented either in the foveal or parafoveal visual field. The sentence context was manipulated to include conditions in which it (1) constrained to the target word, (2) constrained to a visually similar orthographic neighbor, or (3) had a neutral context that did not constrain to any particular word (see Table 1). After the target word, participants were prompted to select which letter (i.e., one from the target, the other from the orthographic neighbor) appeared in a particular location of the word (see Figure 1).

Table 1: Examples of Sentence Stimuli (targets in boldface)

Sentence Constraint	Example
Constrained to Target	James used some cheese to attract and catch all the **mice**.
Constrained to Neighbor	Chinese food dishes come with white or brown **mice**.
Neutral	James realized there wasn't enough water for all the **mice**.

Results from LMER models (Table 2) revealed that visual field did not interact with the N400 effects but did interact with the LPC effects (see below). In the N400 ROI, amplitudes were more negative in the constrained to neighbor and neutral condition than in the constrained to target condition in both visual fields. In the LPC ROI, amplitudes were more negative in the neutral and more positive in the constrained to neighbor condition compared to the constrained to target condition. The interactions suggest that, in the parafovea, the difference for the neutral condition was reduced (but not significantly), and the difference for the constrained to neighbor condition was completely eliminated.

Thus, the earlier stage of semantic retrieval indexed by the N400 is resilient to the degradation of visual information associated with eccentricity. However later reintegration processes indexed by the LPC may depend on clear foveal visual information. We propose that a certain threshold of bottom-up input must be reached for a reintegration process to occur. These findings have implications for parafoveal processing during natural reading and suggest that parafoveal processing may be sufficient for lexical retrieval, but not for full semantic integration, particularly when the incoming information is unexpected or requires reanalysis.

References

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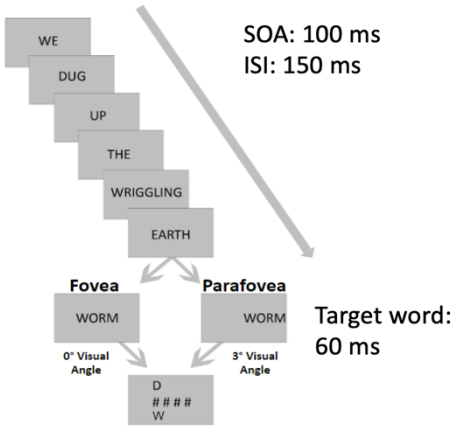

Figure 1. Illustration of trial procedure

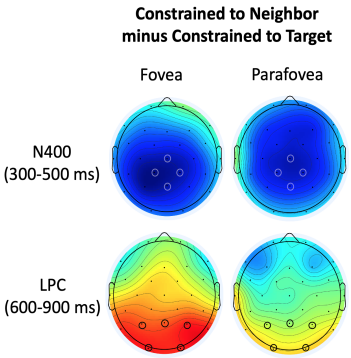

Figure 2. Topographic scalp maps of constrained to neighbor minus constrained to target conditions for N400 and LPC, in foveal and parafoveal visual fields

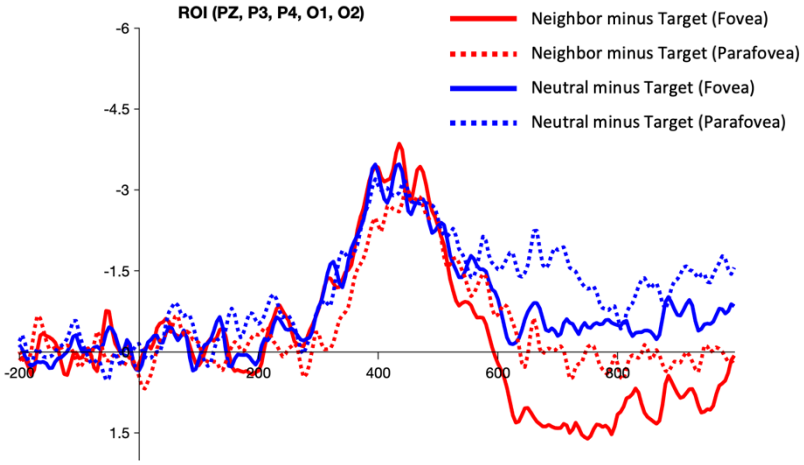

Figure 3. Difference ERP waves subtracting out the constrained to target condition from other constraint conditions at posterior ROI

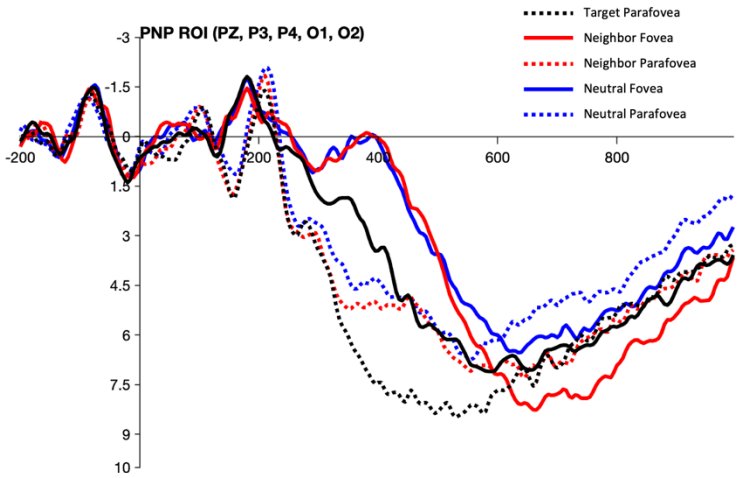

Figure 4. ERP waveforms by constraint and visual field conditions at posterior ROI

Table 2. Result of linear mixed effects models predicting LPC and N400 amplitude by sentence constraint condition and visual field presentation (foveal vs. parafoveal)

	LPC		N400	
	Estimate	t-value	Estimate	t-value
(Intercept)	6.25	**11.64**	4.26	**8.26**
Visual Field	-0.63	**-3.35**	2.62	**12.33**
Constraint (Target vs. Neutral)	0.98	**4.30**	3.03	**11.66**
Constraint (Alternative vs.Target)	0.58	**2.54**	-2.67	**-10.26**
Visual Field:Constraint (Target vs. Neutral)	1.00	**2.18**	-0.11	-0.21
Visual Field:Constraint (Alternative vs.Target)	-1.44	**-3.14**	0.16	0.31