Homographs Revisited: ERP Insights Into the Dynamic Interplay Between Top-down Predictive and Bottom-up Reactive Processes

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Introduction. A fundamental question in psycholinguistics is whether top-down constraints from a prior context can override bottom-up lexico-semantic access during word-by-word sentence comprehension. To address this question, psycholinguists have long examined homographs—semantically ambiguous words whose interpretation often relies on the context (e.g. *bank*-finance vs. *bank*-river). In contexts with weak top-down constraints, both meanings of a homograph are accessed from the bottom-up input.[1] In contexts with strong top-down constraints for a homograph's dominant meaning, only that meaning is accessed (e.g. 1a, Table 1). What remains unclear is what happens when a homograph appears in a context that constrains for its subordinate meaning (e.g. 2a, Table 1): There is some evidence in subordinate constraining contexts for facilitated processing of targets that are related to the subordinate meaning,[2,3] suggesting that top-down constraints can override bottom-up constraints. However, other studies reported that it takes longer to process homographs appearing in subordinate- versus dominant-constraining contexts,[4] suggesting limited contextual constraints on bottom-up lexico-semantic access of the dominant meaning. We propose that this apparent contradiction can be resolved by assuming that lexico-semantic access is not a single, static stage of processing. Rather, we argue that top-down constraints pre-activate the homograph's subordinate meaning, facilitating initial access to its lexico-semantic features. Then, during bottom-up processing of the homograph, the dominant meaning also becomes activated despite its contextual irrelevance. The system must then work to "clean-up" these irrelevant dominant features and enhance activity over the relevant, subordinate features. In the present study, we explore these dynamics using ERPs, mapping top-down predictive facilitation onto the N400 (a measure of the ease of lexico-semantic processing),[5] and this later "clean-up" process onto a late frontal positivity (LFP) that has also been associated with the top-down selection of unexpected (but plausible) words that violated comprehenders' strong lexico-semantic predictions.[6,7]

Design. We measured ERPs as English-speaking adults (N = 33) read sentences word-by-word (SOA = 700ms) that constrained either for a homograph's dominant or subordinate meaning (*Mean Constraint*: 88%). In the *Expected* conditions (1a, 2a), the homograph confirmed prior expectations. In *Unexpected* conditions (1b, 2b), non-homographs violated expectations. For statistical analyses, we carried out planned pairwise comparisons using a mass univariate approach—i.e., cluster-based permutation tests of mean amplitudes (μV) between 300-500ms (the N400) and 600-1000ms (the LFP), which allowed us to remain agnostic about the precise scalp topography of effects, while correcting for multiple comparisons.

Results and Discussion. As expected, the comparison between *Expected* and *Unexpected* words in dominant-constraining contexts (1a vs. 1b) revealed significant effects on both the N400 and the LFP. In contrast, when comparing the two expected homographs (1a vs. 2a), there was no difference in the N400, indicating that initial access of the homograph's subordinate meaning was facilitated (to the same degree as the dominant meaning). We did see, however, a larger LFP to the expected homograph in the subordinate-constraining context relative to the dominant-constraining context. The LFP in (2a) was smaller in magnitude than the LFPs produced by prediction violations in (1b) and (2b), but remarkably similar in its timing and scalp distribution. We interpret these findings within a predictive, generative framework of language comprehension[8] where continuous, dynamic interactions between feedback and feedforward processes work to select the correct meaning through mutual constraint satisfaction.[9] Within this framework, top-down, predictive processing in subordinate-constraining contexts can constrain activity over an expected lexico-semantic representation before bottom-up input is encountered. However, in these situations, top-down prediction cannot fully override the strong bottom-up constraints, which activate the irrelevant dominant features. Then, in the presence of inconsistent top-down and bottom-up information, later top-down processes are engaged (seen on the LFP) to "clean-up" irrelevant information and "sharpen" activity over the appropriate lexico-semantic representation.

Table 1. Example stimuli from the ERP study.

Constraint	Stimuli
Dominant	1a) I went to deposit the check at the **bank**. **(Expected, Dominant)** 1b) I went to deposit the check at the **ATM**. **(Unexpected, Dominant)**
Subordinate	2a) The muddy sides of the river are called the river **bank**. **(Expected, Subordinate)** 2b) The muddy sides of the river are called the river **slope**. **(Unexpected, Subordinate)**

Figure 1. ERP waveforms at a centroparietal electrode site (Cz) for the N400 effect in **(A)** and frontal site (Fz) for the LFP in **(B)**; Topographic plots of electrode sites that showed significant differences across our contrasts of interest for both the N400 (left) and LFP (right) in **(C).**

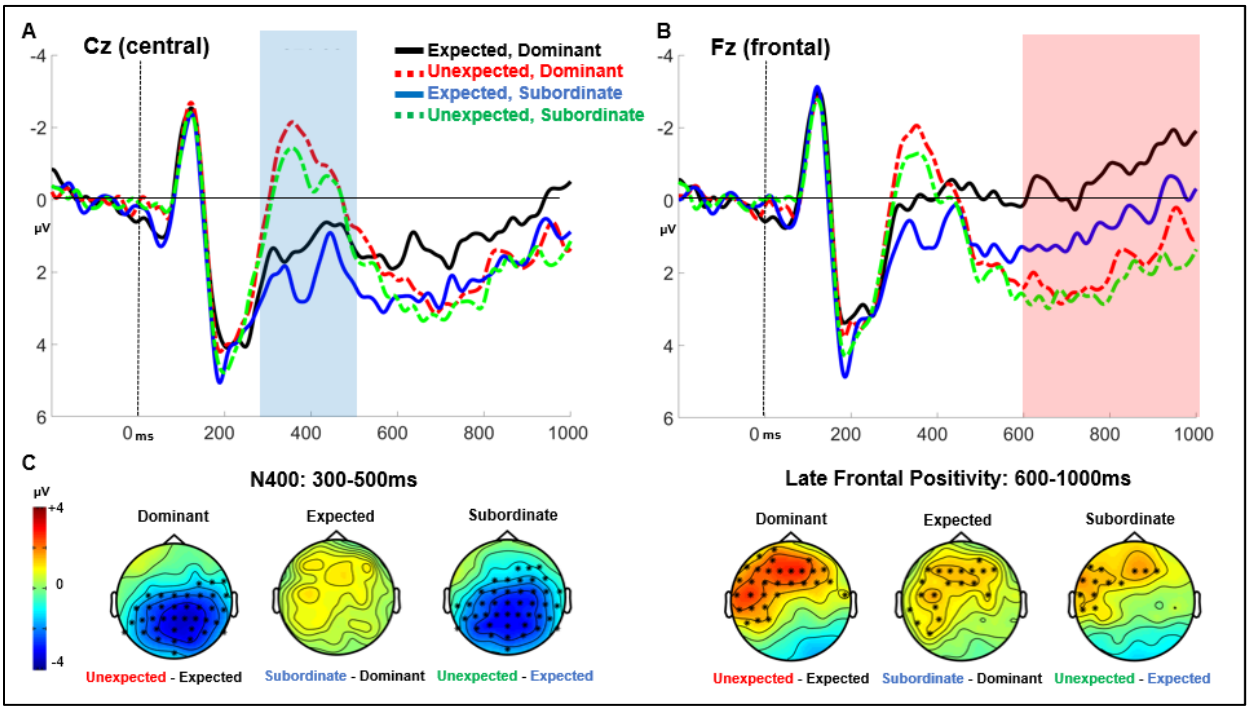

Table 2. Results from statistical comparisons of interest for N400 and LFP effects.

Pairwise Comparisons (Cluster-mass Permutations Tests)	N400	LFP
Expected, Dominant (1a) vs. **Unexpected, Dominant** (1b)	p = 0.002 **	p = 0.002 **
Expected, Subordinate (2a) vs. **Expected, Dominant** (1a)	p = 0.102	p = 0.012 *
Expected, Subordinate (2a) vs. Unexpected, Subordinate (2b)	p = 0.002 **	p = 0.014 *

References: [1] Simpson (1984). *Psychological bulletin*. [2] Glucksberg, Kreuz, & Rho (1986). *JEP: Learning, Memory, and Cognition* [3] Van Petten & Kutas (1987). *JML*. [4] Duffy, Morris, & Rayner (1988). *JML*. [5] Kutas & Federmeier (2011). *Annual Review of Psychology* [6] Kuperberg, Brothers, & Wlotko (2020). *JCN*. [7] Federmeier, Wlotko, De Ochoa-Dewald, & Kutas (2007). *Brain research.* [8] Kuperberg & Jaeger (2016). *LCN*. [9] Lee & Mumford (2003). JOSA A.