

Prediction is a processing default in spoken language comprehension

Margaret Kandel (Harvard), Danielle Novak (Johns Hopkins U.), Jesse Snedeker (Harvard)

Comprehenders use contextual information to pre-activate, or predict, upcoming words before they appear in the input, facilitating later word recognition and processing. This phenomenon is illustrated in EEG studies, which find reduced neural responses (N400s) to words that appear in supportive contexts (1–2). There is evidence that predictive pre-activation can occur both through the passive spread of activation between long-term memory representations as well as through the generation of specific predictions (a process we call *generative prediction*) (3–4). Prior reading studies have shown that generative prediction is flexible and strategic, with comprehenders generating more robust predictions when the context contains valid predictive cues than when it does not (3–4). This finding is compatible with two possibilities: 1) Generative prediction could initially be active by default but then disengaged strategically when predictions are violated. 2) Generative prediction may not be the default and may be engaged only in supportive contexts. The present study explores these two possibilities by comparing how the effect of cue validity on prediction unfolds over time, providing insight into comprehenders' default predictive mechanisms and how they are modulated by context. Here we focus on spoken language comprehension, both to explore whether prediction in this modality is flexible, similar to reading, and to pave the way for a developmental study.

Method. We conducted an EEG study with a relatedness proportion semantic priming manipulation (modeled after 3). The study was conducted in American English; participants were monolingual native speakers ($N = 66$). Participants listened to 120 prime–target pairs (Fig. 1). We manipulated the target's relation to the prime (related vs. unrelated; within- subject) and the proportion of related trials in the presentation list (low = 20% vs. high = 80%; between-subject). Across presentation lists, 48 critical items appeared in each cell of the 2×2 manipulation (24 related/unrelated in each list); this design allowed us to avoid item-specific effects. To ensure that participants attended to the meanings of the prime–target pairs, we included a picture matching task: After each word pair, participants were presented with an image and were asked to state whether it matched a word they had heard in the trial. We analyzed N400 responses to the critical target words. We compared N400 amplitudes to related and unrelated targets (the N400 effect) in the low and high relatedness conditions. If prediction is strategically flexible, we would expect greater semantic priming (a larger N400 effect) in the high relatedness condition, when primes tend to be related to targets and are thus valid predictive cues, than in the low relatedness condition, when primes are not reliable cues. To address whether generative prediction is the default, we investigated how the N400 effect differed between relatedness conditions in the first and second half of the experiment.

Results & Discussion. We observed semantic priming in both the low and high relatedness conditions (more negative N400 amplitudes for unrelated targets); the N400 effect was larger and appeared earlier in the high relatedness condition (replicating 3; Fig. 2a–b). These results indicate that participants generated more predictions in the presence of valid predictive cues, revealing that comprehenders apply the same flexible predictive strategies when parsing spoken language input (which unfolds temporally over time) as they do while reading (when word input is presented and accessed all at once). The early N400 effect in the high relatedness condition could reflect form-based prediction (see 4), further suggesting that generated predictions are robust and specific when supported by context. Critically, while we observed comparably large N400 effects in both relatedness conditions in the first half of the experiment, in the second half of the experiment, the N400 effect decreased in the low relatedness condition but remained stable in the high condition (Fig. 2c). The N400 responses to the picture matching task did not change by experiment half, indicating that the reduced prediction in the low relatedness condition did not result from reduction of attention. The results imply that participants initially generated predictions by default in both conditions but then stopped doing so in the low relatedness condition in response to prediction violation. In ongoing work, we are investigating how this ability develops, testing 4–6yo children (Fig. 2d).

Figure 1. Trial structure schematic. Related prime–target pairs were derived from forward association norms (5). Unrelated pairs were created by reshuffling primes between targets. In each presentation list, 50% of images matched and 50% mismatched. Mismatch images were assigned by reshuffling between targets; across presentation lists, images appeared in all possible conditions.

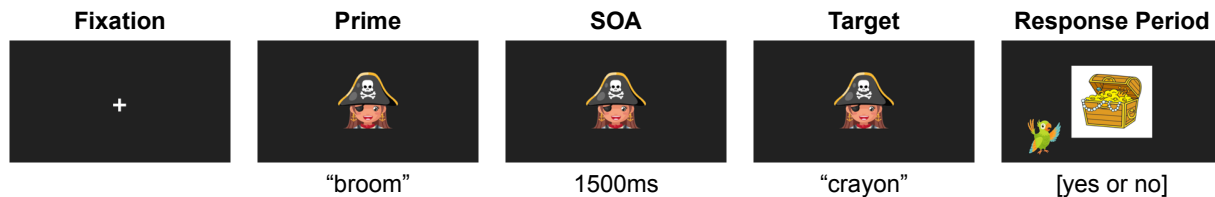
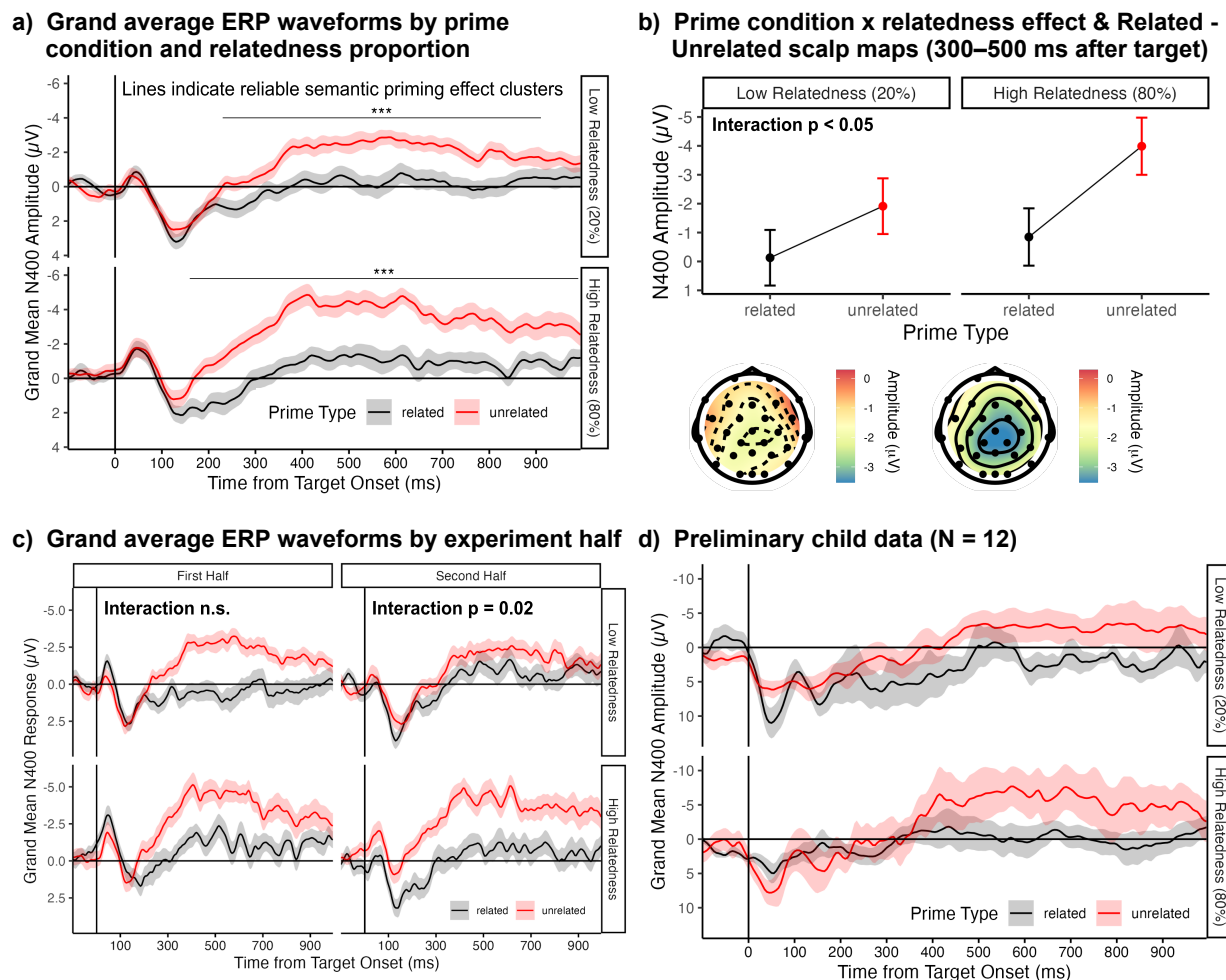


Figure 2. N400 electrodes: Fz, Cz, C3, C4, CP1, CP2, Pz, P3, P4, FC1, FC2.



In the first half, the semantic priming effect was reliable in both low and high relatedness conditions (p 's < 0.001). In the second half, the priming effect was reliable in the high relatedness condition only (p < 0.0001). Analyses were performed in the window 300–500 ms after target onset.

Grand average ERP waveforms for all trials (critical + filler) by prime condition and relatedness proportion.

References. (1) Kuperberg & Jaeger (2016); (2) Kutas & Federmeier (2011); (3) Lau, Holcomb, & Kuperberg (2013); (4) Lau, Weber, Gramfort, Härmäläinen, & Kuperberg (2016); (5) Nelson, McEvoy, & Schreiber (2004)