Causal Inference and Language Comprehension: ERP Indices of Semantic Activation versus Updating and Integration

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Previous event-related potential (ERP) investigations of the role of causal inference in word processing have shown effects of causal relatedness limited to the N400 (Kuperberg, Paczynski & Ditman, 2011; Yang, Perfetti & Schmalhofer, 2007), suggesting the primary effect of causal relatedness is to modulate activation of a word's meaning (Kutas & Federmeier, 2011). By contrast, Burkhardt (2007) reports P600 effects, suggesting that causal relatedness can influence later processes of memory updating and semantic integration. However, Burkhardt's (2007) materials confounded lexical association and causal relatedness, clouding interpretation of their P600 effect. The present study seeks to clarify these issues by comparing the impact of lexical association and causal relatedness on word processing (Experiment 1), and by varying the time available for inferential activations to develop (Experiment 2).

In Experiment 1, EEG was recorded as native English speakers heard 160 short vignettes designed to promote a causal bridging inference. (e.g., "A stack of papers was sitting next to the open window. A moment later, the pages were fluttering into the yard.") ERPs were timelocked to one of four visual probe words presented 400ms after the end of each vignette: CAUSAL PROBE related to the inferred cause (WIND), LEXICAL PROBE related to the vignette's final word (GRASS), or one of two unrelated control conditions drawn from the causal and lexical probes for other vignettes (HUNTER, FLOOR). Relative to unrelated controls, causal probes elicited less negative N400, and more positive P600. Lexical probes elicited less negative N400 than unrelated controls, but similar amplitude in the P600 window. N400 priming effects were larger for causal than lexical probes, even though lexical probes were more associatively related to their entire associated vignettes, as assessed by Latent Semantic Analysis (Landauer & Dumais, 1997). Whereas lexical priming effects were observed on ERP components related to semantic memory activation, causal effects were also evident in later stages of processing indexed by the P600 component. Contrary to some prior work, these ERP data indicate that causal relatedness affects both semantic memory activation and later stages of processing.

In Experiment 2, we manipulated the amount of processing time before the participant encountered the probe. Consequently, the interstimulus interval (ISI) between the end of the vignette and probe word presentation was either 0ms (short) or 400ms (long), and only the causal related (WIND) and control (HUNTER) probes were used. Larger relatedness effects were observed at the short ISI, for both the N400 and the P600. In the N400 window, ERPs to unrelated probes were larger at the short ISI, while ERPs to related probes did not significantly differ. In the P600 interval, ERPs to unrelated probes show a standing difference approximately the same size as that observed during the N400 window; related probes elicited a marginally larger P600 over parietal sites at the long than the short ISI. Thus increasing the amount of processing time had minimal impact on semantic activation processes (N400) initiated by causally related probes, but led to larger P600 associated with memory updating and semantic integration.