The brain dissociates between different levels of prediction during language comprehension

Edward W. Wlotko[1], Margarita Zeitlin[1], Simone Riley[1], Maria Luiza Cuhna Lima[1], Gina Kuperberg[1,2,3];
[1]Tufts University, [2] Massachusetts General Hospital, [3]Harvard Medical School

Hierarchical generative frameworks of language comprehension propose that comprehenders constantly attempt to infer the underlying message they believe is being communicated. In turn, probabilistic predictions are generated at multiple lower level representations which are compared to the unfolding bottom-up input (Kuperberg & Jaeger, 2015). Here, we asked whether and how predictions at different levels of representation influence neural processing of incoming words. We used a partially-crossed design in which target nouns fulfilled or violated contextual predictions oat the level of specific lexical items and/or verb-argument event structure. METHOD: Event-related potentials (ERPs) were collected as participants read and judged the acceptability of five types of discourse scenarios (examples below). Contexts were either lexically constraining (average cloze predictions: 82%) or non-constraining (average cloze predictions: 26%). Following lexically constraining contexts, target nouns were (1) Lexically Expected, (2) Lexically Violating, or (3) Lexically and Animacy Violating (violating the preceding verb's animacy-based selection restrictions). Following non-constraining contexts, target nouns were (4) Lexically Unexpected or (5) Animacy Violating. Target nouns in conditions (2) through (5) were matched on semantic relatedness with their preceding content words. Discourse contexts appeared in full; a third sentence appeared word-by-word. RESULTS: We observed clear dissociable neural signatures of semantic facilitation, lexical prediction violations, and event structure prediction violations in the same participants. (A) Semantic predictions: The amplitude of the N400 was selectively reduced to the Lexically Expected nouns compared to all other conditions. (B) Lexical predictions: a Late Anteriorly-distributed Positivity was selectively enhanced to Lexically Violating nouns following lexically constraining contexts, but was not evoked by lexically violating nouns that additionally violated the animacy constraints of the preceding verb. (C) Event structure predictions: A late Posteriorly-distributed Positivity (the P600 effect) was selectively enhanced to Animacy Violating nouns; its amplitude was larger following lexically constraining that non-constraining contexts. DISCUSSION: Our N400 findings highlight the fact that this waveform primarily reflects the predictability of an incoming word's semantic features, rather than either its lexical predictability or its message-level coherence. Our findings on the late positivities indicate that the brain engages in prolonged neural processing upon encountering words that violate both lexical and event structure prediction, but by engaging distinct but partially interacting neural networks. Taken together, these findings support a hierarchical generative architecture in which unfolding bottom-up evidence that has not already been predicted at a given level of representational level manifests in the brain as distinct spatiotemporal neural signatures. EXAMPLE STIMULI. Constraining: The lifeguards received a report of sharks near the beach. Their immediate concern was to prevent any incidents in the sea. Hence they cautioned the (1) swimmers / (2) trainees / (3) drawer. Non-constraining: Eric and Grant received the news late in the day. They decided it was better to act sooner than later. Hence, they cautioned the (4) trainees / (5) drawer.