Event-related potentials reveal rapid positive and negative updating of message-level representations

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Rationale. Can a single adjective immediately influence message-building during sentence processing? If so, does this influence only increase the activation of the upcoming noun's meaning (as in simple spreading activation) or does it also involve decreasing activation of no longer compatible representations? The possibility that an adjective could decrease a noun's predictability (indexed by a change in cloze probability) but not immediately reduce the noun's on-line semantic activation (indexed by the N400 to the noun) is supported by research showing that activating a word does not inhibit its semantic competitors (Federmeier et al., 2007), findings that negations and quantifiers often lead to no immediate updating on the N400 (e.g. Fischler & Bloom; 1983), and that semantic activations can linger even when they are no longer relevant (Rommers & Federmeier, 2018). Assuming that local lexico-semantic information can induce rapid updating, it is also of interest to assess the relative strength of this local information compared to that of the global predictive context during online reading.

Methods. We presented 32 participants with 168 English sentences displayed word-by-word. For each sentence, we selected, based on cloze probability (CP) norms, a very likely noun completion and a low probability noun completion. Each noun was preceded by an adjective that increased CP of that noun at the expense of the other noun (Figure 1). For example, "The other driver was so angry he threatened him with a LOADED/CIVIL gun/lawsuit." We measured ERPs to the adjective and the noun to investigate whether the adjective led to updates in the activations of possible nouns, or whether the originally most likely noun remained most activated. At the adjective, we conducted exploratory cluster-based permutation tests looking for ERP modulations triggered by the extent to which an adjective changes the activations within the set of predictable nouns (quantified as the Kullback-Leibler divergence over the noun distribution before vs. after the adjective). At the noun, we looked at the amplitude of the N400 component, with its post-adjectival CP decomposed into 2 predictors (N400 ~ pre-adjectival CP + update in CP induced by the adjective). We constructed the materials such that across items, adjectives, and nouns, both the initial CP, as well as the CP update size, varied in the range 0-100% (Figure 2). Data were analyzed using linear mixed effects models.

Results. Patterns of N400 amplitude at the noun revealed that adjectives succeeded in updating noun's activation, and did so symmetrically, both toward information that fit the adjective and away from information that did not (CP update slope=2.1; t=6.7). However, the updating was not as potent as the global context in determining N400 amplitude (pre-adjectival CP slope=3.2; t=6.9; see Figure 3). In other words, the adjective could not fully override the initial semantic context, leading to a discrepancy between the updated N400 and updated CP. An additional model including the interaction between CP updating and constraint strength showed that updating was the least effective in high-constraint contexts. On the adjective, the exploratory analysis of the ERPs showed that the updating was not associated with any discernible modulation (Figure 4). This replicates work using morphological cues, showing that within-set updates (i.e. updating the activation of words within a set already picked out by the context) are not detectable with ERPs (Szewczyk & Wodniecka, 2020).

Conclusions. Overall, these results show that message-level representations can be both strengthened and weakened when additional lexico-semantic information becomes available, and that such updating can occur very rapidly. However, local information does not fully override message-level representations. Finally, although the N400 is sensitive to the impact of updating, it does not appear to vary with prediction error itself (if construed as the amount of necessary updating).

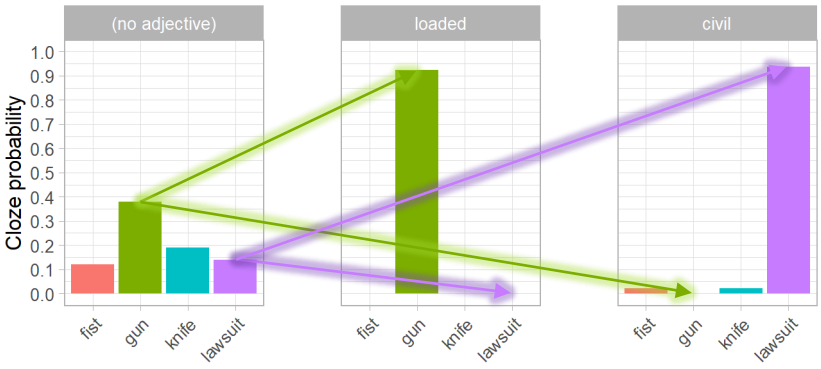

Figure 1. Cloze probabilities (CP) for an experimental item. Compared to when the noun was not preceded by any adjective, the adjective “loaded” increased the CP of “gun” and decreased the CP of “lawsuit”, while the adjective “civil” decreased the CP of “gun” and increased the CP of “lawsuit”.

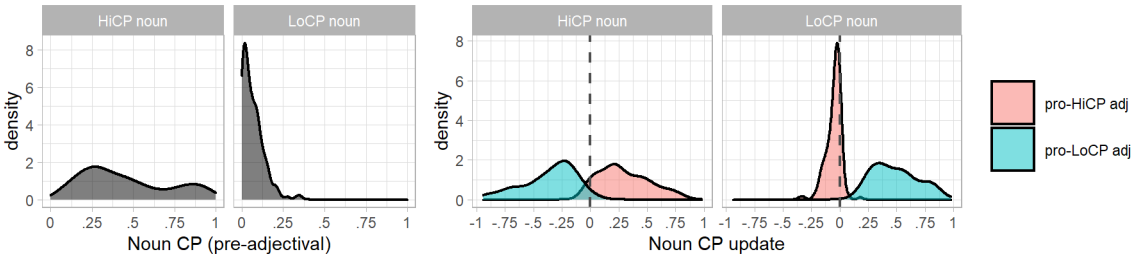

Figure 2. Left: CPs for the noun with the highest or near highest CP in a given sentence (HiCP noun) and a lower probability completion (LoCP noun), measured without the experimental adjective. Right: Changes in HiCP and LoCP noun’s CP induced by the adjectives. Pro-HiCP / Pro-LoCP corresponds to adjectives promoting the HiCP / LoCP noun.

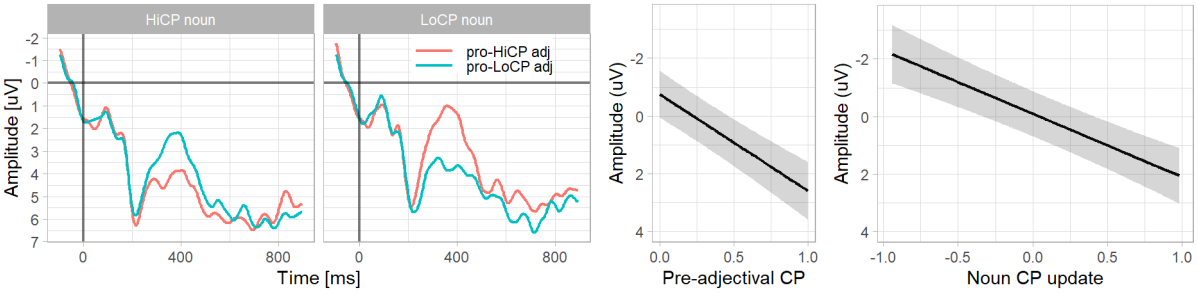

Figure 3. Left: ERPs to the noun (at a midline parietal electrode) evoked by HiCP and LoCP nouns, preceded by pro-HiCP and pro-LoCP adjectives. Middle: Model predictions for the effect of pre-adjectival cloze probability on the N400 amplitude to the noun. Right: Model predictions for the effect of adjectival updating on the N400 amplitude to the noun.

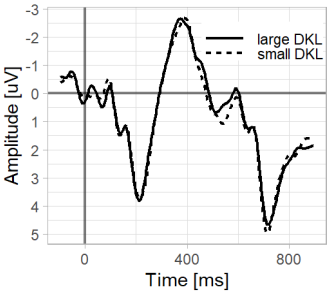

Figure 4. ERPs to the adjective (at a midline parietal electrode) split at the median into large/small Kullback-Leibler divergence over the noun CP distribution.

References: Federmeier et al., Brain Research, 2007; Fischler & Bloom, Psychophysiology, 1983; Nicenboim et al., Neuropsychologia, 2020; Rommers & Federmeier, NeuroImage, 2018; Szewczyk & Schriefers, JML, 2013; Szewczyk & Wodniecka, JEP:LMC, 2020