

Low predictability: An empirical comparison of paradigms used for sentence comprehension

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Contexts that constrain upcoming words to some higher or lower extent can be composed differently but are typically all evaluated using cloze-probability (Rayner & Well, 1996). Less predicted words were found to correlate with more negative N400 (e.g., Frank et al., 2015; Kutas & Hillyard, 1984) and longer reading times (Rayner & Well, 1996; Smith & Levy, 2013). Recently, however, it has been suggested that predictability, as in cloze-probability, is only one influence on processing cost (e.g., DeLong et al., 2014). As DeLong et al. show, differences in plausibility of words with similar cloze-probability also affect processing of such words, reflected in different ERP components. This hints at a difference between frequency-based and deeper semantic processing. Moreover, a relatively novel measure, the Index of Cognitive Activity (ICA) capturing pupil jitter, has been linked to cognitive load and predictability (Demberg et al., 2013).

We examined the plausibility effect using different experimental methods. We manipulate plausibility, similar to DeLong et al. (2014), but importantly, we try to divorce the high plausibility effect from the effects of high cloze-probability and word frequency. Our German stimuli use restrictive (1) and non-restrictive verbs (2) to create low- and no-constraint contexts paired with three nouns of approximately same frequency. This manipulation results in a highly plausible (1a), semi-plausible (1b) and an anomalous object (1c). All three objects are equally unpredictable in the no-constraint context (2). Two offline tests confirmed our manipulation. Target nouns were rated as anomalous (1c), semi- (1b), or highly plausible (1a) while having low cloze-probability (1b & 1c: < .01; 1a: < .20). Even though our manipulation does not entirely exclude the effect of cloze-probability, it may be low enough to not override the plausibility effect.

Example: Die Frau (1) bügelt / (2) beschreibt gleich (a) das T-Shirt / (b) die Socke / (c) den Sessel. (*The woman irons / describes soon the t-shirt / the sock / the armchair.*)

Four online studies tested the stimuli in different modalities, using the reading paradigm (self-paced and eye-tracking), auditory stimulus presentation during a lexical decision task (LDT), and an auditory ICA study. A word less plausible and/or less predicted in a given context is expected to lead to higher cognitive effort, evident in longer reading and reaction times and higher ICA values. Specifically, the no-constraint context (2) makes all target nouns equally plausible and equally unexpected, predicting similar processing cost. In the low-constraint context in (1), in contrast, we expected to see a higher cognitive load for anomalous nouns compared to semi-plausible nouns (1c vs 1b) despite their equally low cloze-probability. This would be consistent with DeLong et al.'s (2014) results. We further predicted that highly plausible nouns would be processed more easily than semi-plausible nouns, in particular since the increase in plausibility is also reflected in a (moderate) increase in cloze-probability.

The self-paced reading study (30 participants) showed no significant results. The disruption effect of the semantic anomaly (1c vs. 2c; 1c vs. 1a/b) was then found in the eye-tracking reading study (24 part.) and the auditory LDT study (24 part.). The ICA study (36 part.) did not include the anomalous object (c). No difference between (1a) and (2a) or between (1a) and (1b) was found in either reading study. However, results from the auditory LDT and the ICA study do confirm the plausibility effect: here (1b) induces higher reaction times and ICA values than (1a).

To conclude, we replicated the effect of plausibility on unexpected nouns found by DeLong et al. (2014). Studies with auditory stimulus presentation further show that different plausibility levels do induce significant changes in cognitive load. However, this effect was not observed in our reading data, potentially because of the overall low cloze-probability in our stimuli. It remains unclear whether the different results across different paradigms can be attributed to the presentation mode (auditory vs. written), measure sensitivity, or different mechanisms involved in processing plausibility as opposed to cloze-based expectancy.