

## **Retrieval (N400) and Integration (P600) in Expectation-based Comprehension**

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Evidence for expectation-based theories of language processing (Levy, 2008, Venhuizen et al., 2019), such as Surprisal theory, comes from effects in both behavioural (Smith & Levy, 2013) and neurophysiological measures (Kutas et al., 1984, Frank et al., 2015). Online measures of language processing, however, are known to be influenced by factors such as lexical association that are distinct from – but often confounded with – expectancy. Indeed, there is evidence that association with the context can attenuate (Federmeier & Kutas, 1999) or even eliminate (Nieuwland & Van Berkum, 2005, Delogu et al., 2019) the N400 for unexpected targets. An open question therefore is whether a specific locus of expectancy related effects can be established in neural and behavioral processing correlates.

We address this question in an event-related potential experiment and a self-paced reading experiment that crossed expectancy and lexical association in a context manipulation design (Figure 1). Expectancy was manipulated by a violation of the selectional restriction of the main verb on the target word, whereas association was independently manipulated by an intervening adverbial clause. Adverbial clauses were created such that no structural or thematic dependency of the target word with the adverbial clause and critically no role-reversal reading was supported. Expectancy and lexical association were validated in offline norming studies, in which we collected Cloze probability and association ratings. Under the Retrieval-Integration account of language comprehension (Brouwer et al., 2012, 2017, 2021), we predicted that both expectancy and lexical association modulate the N400, while only expectancy modulates the P600. Further, we predict a slow-down of reading times in response to both low lexical association and low expectancy. Analyses of the event-related potentials revealed that the N400 is sensitive to both expectancy and lexical association, while the P600 is modulated only by expectancy. Reading times, in turn, reveal effects of both association and expectancy in the first spillover region, followed by effects of expectancy alone in the second spillover region.

Indeed, these findings are consistent with the Retrieval-Integration account of language comprehension, according to which lexical retrieval (N400) is facilitated for words that are both expected and associated, whereas integration difficulty (P600) will be greater for unexpected words alone. Under this interpretation, expectancy is a linguistic property of the stimulus that is relevant to two distinct cognitive processes – retrieval and integration – thus resulting in the modulation of two distinct electrophysiological processing indices. Further, in a post-hoc analysis, we find Cloze to be a predictor of the N400, the P600 and reading times in the subset of Condition A, i.e. the experimental sentences without any manipulation. Crucially, this exploratory analysis suggests that the P600 – just like reading times – is not merely sensitive to violations of expectancy, but rather, that it is a graded index of the degree of expectancy. That is, P600 amplitude could quantitatively index the integration difficulty resulting from comprehending unexpected words. Taken together, these results suggest that the P600, like reading times, may reflect a graded meaning-centric notion of Surprisal in language comprehension.

Figure 1: Stimuli

- A: **A+E+** Gestern **schärfte** der Holzfäller, *bevor er das Holz stapelte*, die Axt.  
[Yesterday **sharpened** the lumberjack, *before he the wood stacked*, the axe]
- B: **A-E+** Gestern **schärfte** der Holzfäller, *bevor er den Film schaute*, die Axt.  
[Yesterday **sharpened** the lumberjack, *before he the movie watched*, the axe]
- C: **A+E-** Gestern **aß** der Holzfäller, *bevor er das Holz stapelte*, die Axt.  
[Yesterday **ate** the lumberjack, *before he the wood stacked*, the axe]
- D: **A-E-** Gestern **aß** der Holzfäller, *bevor er den Film schaute*, die Axt.  
[Yesterday **ate** the lumberjack, *before he the movie watched*, the axe]

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