

The relationship between the N400 as a semantic prediction error and implicit memory

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A lot of studies on the N400 component of the event-related brain potential (ERP) have tried to understand its functional significance. A relationship between N400 amplitudes and implicit memory seems suggested by a series of studies demonstrating N400 repetition effects modulated by cloze probability: unexpected nouns, which elicit a more negative N400^[1], have a stronger reduction in N400 amplitude if repeated after a delay, compared to expected nouns^[2]. A possible explanation for this effect is that N400 amplitudes reflect a semantic prediction error that drives model adaptation^[3]. Building on these assumptions, higher N400 amplitudes should induce greater adaptation and be predictive of enhanced implicit memory. Interestingly, in a study aiming to investigate ERP correlates of memory encoding, the authors observed a relation between an N400 like negativity for single words presented during the study phase and subsequent implicit memory performance as reflected in a stem completion task during test^[4]. In the current study, we want to actively manipulate the cloze probability of sentences to systematically investigate and corroborate the relationship between N400 as a semantic prediction error, adaptation and implicit memory.

We will record a 64-channel EEG of 42 participants. For the first part of the study, participants will read German sentences word by word on a computer screen. These sentences end either with an expected (high cloze probability) or unexpected (low cloze probability) critical noun. Participants are unaware of an upcoming implicit memory task while reading the sentences. Implicit memory for target nouns will be measured in a stem completion task^[5] in the second part of the experiment. The presented word stems correspond to previously expected, unexpected and not seen (not primed) nouns. To eliminate potential explicit memory effects, participants will be completing a n-back working memory task in-between the two main experimental blocks. We will focus on the following research questions:

- (1) *The effect of expectancy on N400 amplitudes:* We predict unexpected critical nouns (low cloze probabilities) to elicit a more negative N400 than expected nouns (high cloze probabilities), replicating typical N400 findings.
- (2) *The effect of expectancy on implicit memory:* As unexpected nouns should lead to higher adaptation, we expect increased implicit memory for these nouns. Participants should be more likely to complete stems with the primed noun if the respective nouns were previously presented in the unexpected compared to previously expected condition as modeled in a logistic GLMM with random by-item and by-subject effects that includes the baseline probabilities of stem completion.
- (3) *Relationship between N400 amplitude and implicit memory:* More negative N400 amplitudes for unexpected nouns (1) are assumed to reflect a semantic prediction error and lead to an implicit memory benefit (2) by inducing adaptation. We therefore want to investigate whether N400 amplitudes are predictive of implicit memory performance (i.e. a stem completion with primed target noun) on a single trial basis in a logistic GLMM with random by-item and by-subject effects that includes the baseline probabilities of stem completion.

The study will contribute to a better understanding of the relationship between N400 amplitudes and adaptation as reflected in implicit memory. This will help the overall interpretation of the N400 component's functional significance and possibly support the view that N400 amplitudes reflect a learning signal driving adaptation within the lexico-semantic system.

Examples of sentences used with *expected/unexpected* nouns:

- 1 exp) Der Zauberer holte ein Kaninchen aus seinem *Hut*
(The magician took a rabbit out of his *hat*)
- 1 unexp) Der Tierwärter holte ein Kaninchen aus seinem *Hut*
(The zoo keeper took a rabbit out of his *hat*)

- 2 exp) In Bayern angekommen, aß der Tourist eine frisch gebackene *Brezel*
(After arriving in Bavaria the tourist ate a freshly baked *pretzel*)
- 2 unexp) In Italien angekommen, aß der Tourist eine frisch gebackene *Brezel*
(After arriving in Italy the tourist ate a freshly baked *pretzel*)

Sentences were created in pairs with a minimal difference that creates different expectations. Sentences were divided into 3 lists that were controlled for sentence length, as well as length, frequency and orthographic neighborhood of the target noun. Lists were additionally controlled for baseline stem completion probabilities of the respective target nouns (as measured in a separate online task).

References

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