

# Semantic integration in single sentences and stories: Evidence from the N400

## The issue

Research on sentence comprehension has shown that language users very rapidly construct a semantic interpretation of the sentence, and do so incrementally, as the input unfolds. Kutas and Hillyard (1980, 1983), for instance, observed that a semantically anomalous word, as in *He spread the warm bread with socks and jam*, elicited an N400 effect, a characteristic negative shift in event-related brain potentials (ERPs) that began at about 200-250 ms and peaked at about 400 ms after onset of the critical word.

Most follow-up research has studied this N400 effect by varying aspects of the semantics of isolated sentences only. We conducted two ERP experiments to see whether we could elicit the same N400 effect with words that, although semantically coherent in a single sentence, made no sense in the context of the wider discourse. Our purpose was to examine how and when the language processing system relates an incoming word to semantic representations of the unfolding local sentence and the global discourse:

- If people first relate word meaning to the local sentence context before relating it to the wider discourse (e.g., Fodor et al., 1996; Perfetti, 1990), discourse-dependent semantic anomalies may well elicit a delayed N400 effect or even a qualitatively different ERP effect.
- On the other hand, if discourse-dependent anomalies do elicit a standard N400 effect, this would support theories that deny a fundamental processing distinction between the computation of local and global semantics (e.g., Clark, 1996; Gibbs, 1984).

## Sentence experiment

We first obtained a standard sentence-dependent N400 effect with 16 subjects, by using pairs of single sentences that only differed in whether a critical word was semantically acceptable or anomalous in the local sentence context, e.g. (translated from Dutch):

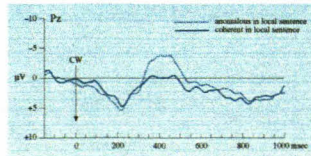
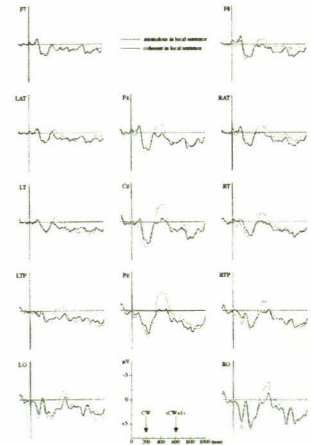
- (1a) *Patiently the waiter served the troublesome customer.*
- (1b) *Patiently the waiter served the troublesome train.*

Panel 1 shows that sentence-anomalous words elicited a reliable standard N400 effect, with an onset between 250-300 ms, a peak at about 400 ms, and a centroparietal maximum.

## Panel 1: Sentence-dependent semantic anomalies

*Patiently the waiter served the troublesome customer / train.*

Grand average ERPs elicited by critical words (CWs) that were semantically anomalous or coherent within the context of a single sentence.



## Discourse experiment

In the next experiment, we recorded ERPs from 24 subjects as they were reading sentences like:

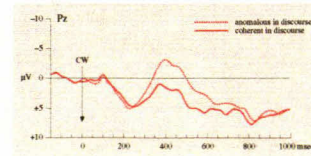
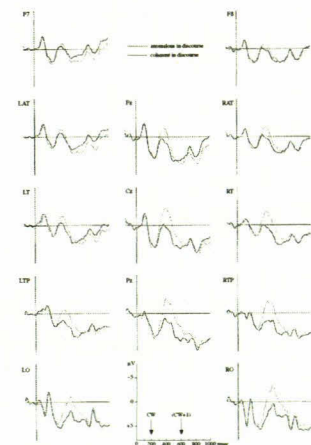
- (2a) *Jane told the brother that he was exceptionally quick.*
- (2b) *Jane told the brother that he was exceptionally slow.*

These sentences had been designed to be equally acceptable in isolation (e.g., the two critical words were matched on cloze probability in the

## Panel 2: Discourse-dependent semantic anomalies

*As agreed upon, Jane was to wake her sister and her brother at five o'clock in the morning. But the sister had already washed herself, and the brother had even got dressed. Jane told the brother that he was exceptionally quick / slow.*

Grand average ERPs elicited by critical words (CWs) that were semantically anomalous or coherent given the wider discourse.

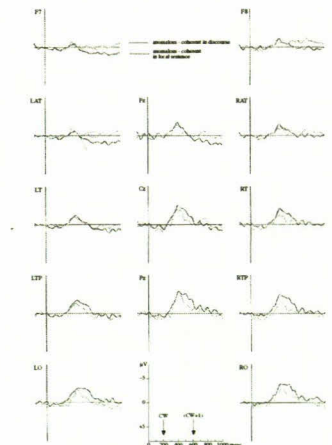


local carrier sentence). But in the experiment, we presented them in a wider discourse context in which one of the two critical words was semantically anomalous, and the other one remained fully coherent (see panel 2, upper part).

Panel 2 shows that discourse-anomalous words elicited a large and reliable N400 effect that began at about 200-250 ms after word onset and peaked at some 400 ms, with a centroparietal maximum and a small right-to-left asymmetry. Also, a separate control investigation revealed

## Panel 3: Discourse- versus sentence-dependent N400 effects

Anomalous - coherent difference waveforms, with the anomaly hinging on prior discourse or local sentence context.



## Discourse versus single sentences

The difference waveforms in Panel 3 show the separate *per* N400 effects for stories and for single sentences, computed by subtracting, for each

stimulus type, the average ERP elicited by the coherent control words from that elicited by the anomalous words.

Semantic integration problems at the level of the discourse and semantic integration problems at the level of a single sentence clearly elicit identical N400 effects, sharing overall morphology, time-course, and scalp distribution. Also, there is no evidence that discourse-level processing is delayed.

## Summary and conclusions

1. If a word is acceptable in a single sentence but semantically anomalous given a wider discourse (e.g., *Jane told the brother that he was exceptionally slow* presented in a discourse context where he had in fact been very quick), it elicits an N400 effect in event-related brain potentials that begins within 200-250 ms after word onset. This implies that words are related to the semantics of the earlier discourse within approximately 250 ms.
2. The discourse-dependent N400 effect is indistinguishable from the standard N400 effect elicited by words that are anomalous given the 'local' semantics of a single sentence (e.g., *Patiently the waiter served the troublesome train*). This accords well with models of language processing in which there is no fundamental distinction between the integration of a word in its local (sentence-level) and its global (discourse-level) semantic context.
3. We suggest that both N400 effects reflect a problem with integrating the meaning of the current word into a representation of the relevant *common ground* (Clark, 1996), which includes a model of the unfolding discourse. With a single sentence, the relevant common ground will only include whatever discourse and world knowledge has just been activated by the sentence fragment presented so far (in this physical context, task setting, culture, etc.). For a sentence presented in discourse context, the relevant common ground will be somewhat richer, now also including information elicited by the specific earlier discourse.

## References:

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