Research Report

The influence of emotional words on sentence processing: Electrophysiological and behavioral evidence

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ABSTRACT

Whereas most previous studies on emotion in language have focussed on single words, we investigated the influence of the emotional valence of a word on the syntactic and semantic processes unfolding during sentence comprehension, by means of event-related brain potentials (ERP). Experiment 1 assessed how positive, negative, and neutral adjectives that could be either syntactically correct or incorrect (violation of number agreement) modulate syntax-sensitive ERP components. The amplitude of the left anterior negativity (LAN) to morphosyntactic violations increased in negative and decreased in positive words in comparison to neutral words. In Experiment 2, the same sentences were presented but positive, negative, and neutral adjectives could be either semantically correct or anomalous given the sentence context. The N400 to semantic anomalies was not significantly affected by the valence of the violating word. However, positive words in a sentence seemed to influence semantic correctness decisions, also triggering an apparent N400 reduction irrespective of the correctness value of the word. Later linguistic processes, as reflected in the P600 component, were unaffected in either experiment. Overall, our results indicate that emotional valence in a word impacts the syntactic and semantic processing of sentences, with differential effects as a function of valence and domain.

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1. Introduction

Human verbal communication can be a highly emotional experience, including both the expression of emotional states to others and the elicitation of feelings like pleasure, distress, outrage, and many others, depending on several factors. Arguably one of the most important of these factors is the emotional meaning of the words composing the linguistic message. Although the study of emotion has made much progress in many domains, it is in its infancy when language is concerned, particularly with respect to sentence processing. Indeed, reports on the impact of emotional words on the structural processing of sentences seem to be absent in the scientific literature. It is the aim of the present study to contribute to filling this gap by investigating whether and how the emotional valence of words within sentences affects syntactic and semantic processes of sentence comprehension.

1.1. Studying emotional words and sentence comprehension with event-related brain potentials

Both the processing of emotional words and sentence comprehension have often been investigated with event-related potentials (ERPs). However, with a few exceptions (discussed below), emotional language processing has always been studied using words in isolation (for a review, see Citron, 2012). Emotional words often elicit at least two temporally and topographically dissociable ERP components. The first effect is seen in a negative-going difference wave at temporo-occipital electrodes, termed the early posterior negativity (EPN), starting at about 200 ms after stimulus onset for both positive and negative relative to neutral words (Herbert, Junghofer, & Kissler, 2008; Kissler, Herbert, Peyk, & Junghofer, 2007; Schacht & Sommer, 2009a, 2009b). Given its resemblance to ERP components elicited by voluntary attention to non-emotional stimuli, the EPN has been suggested to reflect reflex-like attention allocation caused by the high intrinsic relevance of emotional stimuli (Schupp, Junghöfer, Weike, & Hamm, 2003). The second ERP effect is an enhancement of the late positive complex (LPC), typically starting at about 300 ms and lasting for several hundred milliseconds (e.g., Fischler & Bradley, 2006; Kissler, Herbert, Winkler, & Junghofer,

2009; Schacht & Sommer, 2009b). Although it has been interpreted as reflecting sustained elaborate processing of high-arousal stimuli regardless of their valence (e.g., Dillon, Cooper, Grent-'t-Jong, Woldorff, & LaBar, 2006; Fischler & Bradley, 2006), this is not unequivocal (e.g., Herbert et al., 2008; Kissler et al., 2009).

Studies of sentence processing, on the other hand, have usually yielded different ERP components that seem to honor the distinction between syntactic and semantic processing. In the syntactic domain, the main ERP effects are anterior negativities and posterior positivities. Anterior negativities are typically labeled as LAN (left anterior negativity), between roughly 250 and 550 ms, or ELAN (early LAN), appearing as early as 100–200 ms. Word category violations are the variations most frequently associated with ELAN (e.g., Friederici & Mecklinger, 1996), whereas other grammatical anomalies, including morphosyntactic violations (e.g., Coulson, King, & Kutas, 1998), usually evoke a LAN. Both anterior negativities may reflect highly automatic first-pass parsing processes, the detection of a morphosyntactic mismatch, and/or the inability to assign the incoming word to the current phrase structure (Friederici, 2002). A late positive-going component with a parietal maximum, labeled P600, has typically been considered as a syntax-related ERP fluctuation because it is elicited by syntactic violations (e.g., Osterhout & Holcomb, 1992). However, a P600 also appears in structurally ambiguous or garden path sentences (Frisch, Schlesewsky, Saddy, & Alpermann, 2002). Therefore, it has been suggested that the P600 indicates increased syntactic processing costs due to revisions and reanalyses of structural mismatches, possibly also reflecting subsequent repair processes (Münte, Heinze, Matzke, Wieringa, & Johannes, 1998). Finally, the occasional observation of P600 deflections to semantic violations has also motivated recent alternative accounts, such as the reflection of the activity of a combinatorial system that integrates both semantic and syntactic information (Kuperberg, 2007), or a domain-general monitoring mechanism (Kolk & Chwilla, 2007).

In the semantic domain, the so-called N400 effect is the main finding (Kutas & Hillyard, 1984). The N400 effect is a negative-going component resembling the LAN in latency, usually most pronounced over central and posterior electrode sites (Kutas & Besson, 1999). Typically, this component increases in amplitude with the difficulty of integrating words into their semantic context—be it a sentence or a preceding prime word (Chwilla, Brown, & Hagoort, 1995). Alternatively, the N400 has also been characterized as an index of the access to long-term multimodal lexico-semantic memory, reflecting the efforts of activating long-term memory representations of features associated with a lexical item (Kutas & Federmeier, 2011).

1.2. Emotional words in context

Interestingly, when emotional words have been studied within the context of sentences (Bayer, Sommer, & Schacht, 2010; Holt, Lynn, & Kuperberg, 2009), they have not been found to elicit the EPN, while LPC enhancements have been observed. That the EPN, typically obtained for emotional words in isolation, vanishes when the words are embedded in sentences could be indication that sentence processing and the emotional content of words might interact. Remarkably, this would occur during the time window at which the EPN normally emerges. Furthermore, in the second experiment of Holt et al. (2009), using passive reading, the EPN remained absent whereas a small N400 to negative and positive words was observed instead, interpreted as reflecting a larger engagement of initial semantic analysis for emotional than for non-emotional words embedded in sentences. Similarly, Bayer et al. (2010) found an N400-like ERP effect to emotionally

negative words within sentences. A number of studies have found effects of emotional states or mood—induced by pictures, films, or faces—on the subsequent processing of sentences, both at semantic (Federmeier, Kirson, Moreno, & Kutas, 2001) as well as syntactic levels (Vissers et al., 2010). Although these studies support the interplay between emotions and higher-order cognitive processes such as sentence comprehension, they do not address the impact of emotional words on the processing of sentences in which they are embedded. Finally, a number of studies have explored the effects on the N400 when the emotion induced by non-linguistic material contradicts the emotional valence of a single word presented subsequently, finding significant modulations of this component (e.g., Kiefer, Schuch, Schenck, & Fiedler, 2007).

The latter findings further reinforce the assumption that the emotional content of a word is actually part of its lexico-semantic information (cf. Palazova, Mantwill, Sommer, & Schacht, 2011). Accordingly, it should be able to modulate the lexical access or semantic integration processes of the word, as could be reflected in the N400. In the same line, several neuroimaging studies reveal that the semantic content of words may tap into limbic structures (for a review, see Binder, Desai, Graves, & Conant, 2009). Accordingly, it appears plausible that the emotional content of a word might affect the N400 modulations typically elicited by semantic sentential violations. To explore this possibility is one of the aims of the present study.

On the other hand, if the emotional content of a word is part of its lexico-semantic information, whether it might also affect syntactic processing depends upon our assumptions on the interplay between semantic and syntactic information during sentence comprehension. In this regard, strongly modular models assume that informationally encapsulated and at least partly sequential processes construct distinct syntactic and semantic representations (e.g., Ferreira & Clifton, 1986). In contrast, fully interactive models suggest that syntactic and semantic constraints interact directly and simultaneously with each other at the message-level representation of the input (e.g., McClelland, John, & Taraban, 1989). Intermediate proposals also exist, differing in the degree of independence and prevalence ascribed to semantic and syntactic information (e.g., Kim & Osterhout, 2005).

A large body of evidence from ERPs supports a syntactocentric view, in which syntactic information prevails over and affects semantic processing, with no influence in the opposite direction (e.g., Friederici, 2004). In these studies, double violations—containing both syntactic and semantic anomalies simultaneously—usually yield a LAN and a P600, the N400 being either absent or importantly modulated—for example, boosted—by the syntactic violation (Hagoort, 2003). However, several studies have also reported an inversion of the direction of these effects, demonstrating that at least under certain circumstances semantic information may prevail and modulate syntactic processing (e.g., Martín-Loeches, Nigbur, Casado, Hohlfeld, & Sommer, 2006). The appearance of emotional words within a sentence could actually be one of these situations in which semantics prevails, given their presumed capacity to prompt early attentional resources, as reflected in the EPN. The present study also explores this possibility.

1.3. The present study

None of the previous studies reviewed above has investigated the effects of the emotional content of a word on the structural processing of a sentence in which it is embedded, neither in the syntactic nor the semantic domain. The present study was designed to fill this gap. To this aim, participants had to read sentences containing emotional words that were either correct or represented either a syntactic or a semantic violation. Our main