Journal of Neurolinguistics 44 (2017) 203–222

Contents lists available at ScienceDirect

Journal of Neurolinguistics

journal homepage: www.elsevier.com/locate/jneuroling

# Processing gender agreement and word emotionality: New electrophysiological and behavioural evidence

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ARTICLE INFO

*Article history:*
Received 9 March 2017
Received in revised form 15 June 2017
Accepted 30 June 2017
Available online 14 July 2017

*Keywords:*
Gender agreement
Emotional words
Event-related potentials
LAN
P600

ABSTRACT

The present article reports an ERP study with two experiments designed to assess the influence of emotional adjectives on sentence processing by means of a gender agreement (grammaticality) judgment task. Participants were shown transitive sentences in Spanish presented word-by-word, with a complex object-NP consisting of a noun + an adjective + some additional material. ERPs were recorded at the critical adjectives, which could be either emotionally unpleasant, neutral, or pleasant, and could either agree (match) or fail to agree (mismatch) in gender with the modified noun. Results replicate the typical ERP signatures of morphosyntactic errors. Specifically, larger amplitudes for LAN and P600 components were found in sentences with a gender mismatch in both experiments. However, ERP components did not show any differences between emotional and neutral adjectives in these sentences. Only in Experiment 2 was a significant interaction found between grammaticality and emotionality. Thus, in the 500–700 ms window larger amplitudes emerged for neutral words than for emotional words in match sentences. Likewise, a significant interaction between grammaticality and emotionality in the participants' performance revealed that the presence of emotional adjectives did facilitate the detection of gender errors. Overall, these results show that during sentence reading syntactic error detection seems to occur in an encapsulated manner, although performance may indeed be facilitated by the presence of emotional words.

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## 1. Introduction

In recent years the study of the emotional dimension of words has come to constitute a solid field of research in psycholinguistics and neurolinguistics. Most work done thus far has focused on words in isolation (e.g., Citron, 2012; Herbert, Junghofer, & Kissler, 2008; Kuperman, Estes, Brysbaert, & Warriner et al., 2014; Hofmann, Kuchinke, Tamm, Vo, & Jacobs, 2009; Kissler, Herbert, Winkler, & Junghofer, 2009; Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2011; Scott, O'Donnell, Leuthold, & Sereno, 2009; Sheikh & Titone, 2013). In this context, and although a definitive account is not yet in sight, a number of findings support the view that emotional words occupy a special place in the processing of language. In

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http://dx.doi.org/10.1016/j.jneuroling.2017.06.002
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particular, event-related potentials (ERPs hereafter) studies have revealed two different components relatively consistently (Citron, 2012; Kissler, Assadollahi, & Herbert, 2006). The first of these is an early effect, a modulation of the amplitude elicited by emotional words relative to neutral ones which becomes visible in a posterior negativity peak at around 200–300 ms (the so-called Early Posterior Negativity, EPN hereafter; Citron, 2012; Scott et al., 2009). Other early effects have also been reported, such as the modulation of a positive component that peaks at around 80–120 ms (P1; Bernat, Bunce, & Shevrin, 2001; Scott et al., 2009; Wong, Bernat, Snodgrass, & Shevrin, 2004), a negative component at around 100 ms (N1, Bernat et al., 2001; Hinojosa et al., 2015; Hofmann et al., 2009), and a positive component with larger amplitudes at around 200 ms (P2, Bernat et al., 2001; Herbert, Kissler, Junghofer, Peyk, & Rockstroh, 2006). Although tasks, materials and interpretations differ (see Citron, 2012 for a review), a conservative conclusion regarding these early effects or family of effects might be that, when processed in isolation, words with prominent emotional connotations launch a cascade of automatic processes that prevail temporarily over linguistic processes (such as pure lexical access; note however that previous studies have also found interactive effects between the emotional content of the words and their frequency of use (a lexical variable) at both early and late latency time-windows (Méndez-Bértolo et al., 2011; Scott et al., 2009)). The second consistent effect is a positive component with latencies at around 500–800 ms, and a parieto-central topographic distribution quite similar to the P600. This component is known as the Late Positive Complex (LPC) or Late Posterior Positivity (LPP; Citron, 2012; Fischler & Bradley, 2006; Kissler et al., 2009), and it is customarily interpreted as the result of higher-level, strategic control (Citron, 2012), as well as sustained evaluative processing (Delaney-Busch, Wilkie, & Kuperberg, 2016). Taken together, these two sets of components indicate that the processing of emotion-laden words differs from that of neutral ones.

However, evidence also exists that when emotional words are embedded in their natural habitat (the sentence structure), their processing signature is not the same compared to neutral words. This seems to be supported by the observation that the early effects widely reported when such words are processed in isolation often disappear in sentence processing. For instance, in a semantic decision task involving high arousal unpleasant words embedded in sentences, Bayer, Sommer, and Schacht (2010) were able to register significant effects in the LPC component, but no EPN or any other kind of early signature. Likewise, using both pleasant and unpleasant words, Holt, Lynn, and Kuperberg (2009) failed to report early effects in either a sentence comprehension task or a passive reading task. The fact that in these two studies N400-like effects did indeed emerge has been interpreted as an indication that the emotional valence of a word is part of its lexico-semantic representation (cf. Palazova, Mantwill, Sommer, & Schacht, 2011), and that it should therefore be able to modulate lexical access or semantic integration processes (see also, Lüdtke & Jacobs, 2015). More interestingly, the absence of EPN when words are embedded in sentences may indicate an interaction between sentence processing and the emotional content of words (Martín-Loeches et al., 2012). A brief description of the main ERP sentence studies can be seen in Table 1.

Martín-Loeches et al. (2012) carried out two experiments to explore whether such an interaction does indeed take place. The first considered whether pleasant, unpleasant or neutral adjectives, either syntactically correct or incorrect (by violating number agreement with their head nouns), modulated the ERP components which are typically elicited by syntactic anomalies (i.e., LAN and P600). In the second experiment, they used similar types of adjectives in a semantic violation task. They reported an increase in the amplitude of the LAN component related to unpleasant words that were syntactically incorrect, as well as a decrease in the amplitude for pleasant words in the same component. In the semantic violation task, the N400 was not affected as a function of the emotional valence of the violating word. However, a centro-parietal positivity, interpreted as "a possible N400 decrease", was found for positive words in the semantic violation experiment irrespective of their sentential correctness. This could be an indication of the otherwise widely-attested processing advantage for positively valenced words (the *Positive Word Superiority Effect*; e.g., Hofmann et al., 2009; Kanske & Kotz, 2007; Palazova et al., 2011; Scott et al., 2009) as well as of the fact that pleasant words seem to facilitate meaning integration (Lüdtke & Jacobs, 2015). Interestingly, Martín-Loeches et al. did not find significant effects of emotionality in either the modulation of the early components (i.e., EPN, P1, N1, P2) or the late ones (P600). In another recent study, Hinojosa et al. (2014) explored the impact of negative content on the processing of syntactic agreement relations. To this end they used three-word phrases (e.g., *the dear lady*) comparing unpleasant and neutral words while participants performed a gender agreement judgment task. They found that LAN disappeared in the presence of emotional adjectives, which they interpreted as meaning that gender agreement relations involving unpleasant words (as compared to neutral words) are given processing priority, in line with the *Affective Primacy Hypothesis* (Storbeck & Clore, 2007). No other standard ERP emotion-driven effects were reported, of either an early or a late kind, as in Loeches et al.'s study.

These two studies are partially discordant, in that Martín-Loeches et al. (2012) found that unpleasant content increased the costs of processing, whereas Hinojosa et al. (2014) observed that the processing of gender agreement mismatches in unpleasant words was facilitated in the 300–500 ms time window. Nevertheless, both studies found interactions between word emotionality and morphosyntactic operations (LAN). These patterns of results seem to contradict the *Syntactic Encapsulation Hypothesis*, according to which syntactic processes, such as agreement co-indexations, should both precede any other types of processes and be unaffected by them (Friederici & Weissenborn, 2007; Friederici, 2002, 2004). Conversely, the two studies are compatible with the idea that once the parser detects the presence of information that may be of potential biological relevance for the reader, processing of such information is prioritized. In this context, it is worth noting that even the N400 effect has been seen to be significantly affected by word emotionality. Thus, Delaney-Busch and Kuperberg (2013) looked at whether the habitual reduction of the N400 amplitude evoked by words which are semantically congruous (vs. incongruous) with their previous discourse context (e.g., Kutas & Federmeier, 2011) was affected by the presence of emotional content. They reported a reduction in the congruity effect for emotional words compared to neutral ones, in line with the *Affective*

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