International Journal of Psychophysiology 86 (2012) 143–151

Contents lists available at SciVerse ScienceDirect

International Journal of Psychophysiology

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

High arousal words influence subsequent processing of neutral information: Evidence from event-related potentials

José A. Hinojosa *, Constantino Méndez-Bértolo, Miguel A. Pozo

Instituto Pluridisciplinar, Universidad Complutense de Madrid, Madrid, Spain

ARTICLE INFO

Article history:
Received 24 February 2012
Received in revised form 21 April 2012
Accepted 4 June 2012
Available online 10 June 2012

Keywords:
Arousal
Emotion
N100
LPC
ERPs

ABSTRACT

Recent data suggest that word valence modulates subsequent cognitive processing. However, the contribution of word arousal is less understood. In this study, behavioral and electrophysiological measures to neutral nouns and pseudowords that were preceded by either a high-arousal or a low-arousal word were recorded during a lexical decision task. Effects were found at an electrophysiological level. Target words and pseudowords elicited enhanced N100 amplitudes when they were preceded by high- compared to low-arousing words. This effect may reflect perceptual potentiation during the allocation of attentional resources when the new stimulus is processed. Enhanced amplitudes in a late positivity when target words and pseudowords followed high-arousal primes were also observed, which could be related to sustained attention during supplementary analyses at a post-lexical level.

1. Introduction

The processing of emotional information has important survival consequences for human beings. Emotions have been shown to affect different stages of information processing, ranging from attentional engagement to action execution. In support of this view, several behavioral studies reported differences between the processing of affective and neutral stimuli in tasks with different processing requirements, such as affective categorization (e.g., Dijksterhuis and Aarts, 2003), lexical decision (e.g., Thomas and LaBar, 2005) or digit-parity (e.g., Aquino and Arnell, 2007). These findings have been confirmed in a number of event-related potential (ERP) studies, which have reported modulations of several early and late latency components to various types of emotional stimuli (e.g. Carretié et al., 2007; Delplanque et al., 2006; Hinojosa et al., 2010; Schupp et al., 2004). It is generally assumed that differences between neutral and affective stimuli reflect the automatic capture and engagement of attentional resources in the processing of emotional information.

To fully understand the ways in which emotion modulates cognitive processing, it is important to note that emotional and neutral stimuli likely differ from one another in more than one dimension, valence and arousal being the most important of them (Kensinger, 2004; Lang et al., 1997; Reisenzein, 1994; Russel, 1980). Valence refers to how positive or negative an event is, whereas arousal reflects the degree of activation associated with a stimulus. Some authors claim that arousal is not completely independent of valence. Rather, arousal indicates the degree of activation of either an appetitive system that responds to positive valence, or a defensive system that is sensitive to negative valence (Lang et al., 1997). In accordance with this view, some studies have found interactions between valence and arousal during stimulus processing (Larsen et al., 2008; Robinson et al., 2004). Other theorists argue that valence and arousal have independent effects and should be considered as orthogonal dimensions of the affective experience (Russel, 1980). Evidence from research in different cognitive domains supports this distinction. For instance, dissociations with regard to the effects of valence and arousal have been reported within the perceptual (Anderson et al., 2003), the mnemonic (Kensinger and Schacter, 2006), the linguistic (Lewis et al., 2007), or the face processing (Gerber et al., 2008) domains. A different source of evidence comes from the affective priming literature. Affective priming refers to the faster processing of a target word that is preceded by a prime word of a similar valence (Fazio, 2001; Herring et al., 2011; Klauer and Musch, 2003). This advantage has been thought to operate at different processing stages. Some authors claim emotional influences on response tendencies (Fazio, 2001), whereas others emphasize the role of affective content in accessing target meaning following spreading activation from primes (Klauer et al., 2005). Interestingly, the results of at least two ERP studies suggest that valence and arousal might sometimes show different effects on target processing. In the first of these studies (Zhang et al., 2006), the authors found larger N400 amplitudes for targets of valence-incongruent word pairs compared to congruent pairs. The arousal dimension was manipulated in the second study (Hinojosa et al., 2009a), in which pairs of positive words with either high or low arousal values were presented to participants in an arousal categorization task. The results showed that high-arousal target words that were

* Corresponding author at: Instituto Pluridisciplinar, Universidad Complutense de Madrid, 28040 Madrid, Spain.
E-mail address: hinojosa@pluri.ucm.es (J.A. Hinojosa).

0167-8760/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijpsycho.2012.06.001

preceded by prime words with congruent high-arousal values elicited reduced amplitude of a late positive component. Arousal effects were interpreted in terms of a reduction in the amount of attentional resources that are needed to process high-arousal targets when they followed congruent primes.

In sum, emotional content modulates behavioral and brain responses not only to current, but also to subsequent emotional information. However, the capacity of emotional words to attract and engage attentional resources has led some authors to question the cost of the processing of subsequent neutral stimuli. Indeed, negative words have been shown to impair subsequent cognitive processing in Posner cueing paradigms (Fox et al., 2001, Exp. 5), Stroop tasks (McKenna and Sharma, 2004), lexical decision tasks (Calvo and Castillo, 2005), or when they have been presented as distracters in rapid serial visual presentation paradigms (Barnard et al., 2005). Conversely, a different set of studies have found facilitated processing for neutral words when they were preceded by emotional stimuli. In a recent work, Ode et al. (2012), found that positive word primes led participants to judge subsequently presented neutral letters as larger in size. Also, Stormark et al. (1995) found reduced P1 amplitudes and shorter RTs when the target was validly cued by a negative word in a spatial cueing task. Overall, word prime valence influences on the subsequent processing of neutral stimuli have been explained in terms of the capacity of affective stimuli to automatically capture attentional resources when they have to compete with non-emotional stimuli; as a consequence, the processing of a concurrent stimulus would be modified (Calvo and Castillo, 2005; Robisnson, 1998). This modulation seems to operate at several levels including perceptual, attentional or response-related processing stages (Calvo and Castillo, 2005; Ode et al., 2012; Stormark et al., 1995).

Given the importance of the arousal dimension for some theoretical views (Russel, 1980; Lang et al., 1993), the question arises as to whether similar effects could be found for word arousal manipulations. The answer to this question remains imprecise, although there is some evidence that suggests that word arousal might play an important role in the processing of a subsequent neutral stimulus (e.g., Arnell et al., 2007). In this regard, Ihssen et al. (2007) presented task-irrelevant pictures followed by target neutral words and pseudowords in a lexical decision task. High-arousal pictures reduced the amplitude of an N100 to both target types. This finding was interpreted to reflect impaired lexical access, that is, the activation of entries in a hypothetical mental lexicon. Word processing difficulties on a post-lexical stage involving the formation of semantic associations were also found for word targets preceded by high-arousal pictures, as reflected in smaller amplitudes of a late positivity in the N400 time range. It should be noted that Ihssen et al. (2007) used a cross-modal design in which pictures instead of words were presented as prime stimuli. It has been argued that the processing of pictures and words differ in several important aspects. For instance, some theoretical models (Glaser, 1992; Glaser and Glaser, 1989) assume that pictures have a privileged access to the semantic system because language perception comprises additional processing before accessing the semantic system. It could be the case that picture but not word arousal can capture the attention due to the fact that information is more directly available from a picture for early information processing, whereas a word is a more indirect representation of the emotion (Arnell et al., 2007). In fact, the results of several studies have shown a differential processing of affective information in words and pictures (De Houwer and Hermans, 1994; Hinojosa et al., 2009b; Kensinger and Schacter, 2006). Therefore, it is an open question whether the findings of Ihssen et al. (2007) generalize to the use of words as primes.

At a theoretical level, the so-called 're-entrant processing hypothesis' might provide a plausible explanation about how word arousal could enhance subsequent neutral information processing (Herbert et al., 2009). The finding of bidirectional relationships between the amygdala and the extrastriate cortex during the processing of emotional pictures (Sabatinelli et al., 2005), led some authors to postulate that the amygdala amplifies perception during the processing of emotional information by means of reciprocal feedback connections to extrastriate regions. Moreover, it has been shown that this perceptual facilitation also potentiates attentional processing (Phelps et al., 2006). Interestingly, several studies have shown that arousal enhances the amount of emotional stimuli processing in the extrastriate cortex (Bradley et al., 2003; Herbert et al., 2009) and the degree to which the amygdala responds to affective content (Kensinger and Schacter, 2006; Phan et al., 2003). On the basis of these findings, the possibility exists that the perceptual enhancement extends to the processing of a new stimulus.

Therefore, the aim of the present study is to test the hypothesis that high-arousal words influence the processing of subsequent neutral words. In particular, the influence of word arousal on the subsequent processing of lexico-semantic information in neutral words will be explored during a lexical decision task. To get a better understanding of this phenomenon, behavioral (reaction times) and event-related potential (ERP) measures, a temporal agile signal, will be recorded. Word processing implies different stages including letter analysis, lexical access or semantic integration processes (Hauk et al., 2006; Hinojosa et al., 2001; Scott et al., 2009). In this regard, ERP research shows that different lexical properties of the words are linked to distinct components. Lexicality effects have been found as early as 100 ms after word onset. They have been thought to index the processing of the visual word form and the access to lexical information as reflected in modulations of the N100 (e.g., Hauk et al., 2006; Sereno et al., 1998). Furthermore, lexical processing related to the extraction of orthographic and phonological information has shown to influence the amplitude of the P200 (e.g., Barber et al., 2004; Sereno et al., 1998). Subsequent lexical-semantic integration efforts related to the formation of semantic associations have been associated with enhanced N400 responses (e.g., Hauk et al., 2006; Kutas and Federmeier, 2000, 2011). Finally, the LPC seems to reflect several aspects of semantic retrieval, integration and revision that occur at a post-lexical level (e.g., Kandhadai and Federmeier, 2008; Salmon and Pratt, 2002).

Since this is a first attempt to systematically explore the influence of word arousal in the processing of subsequent neutral words, hypotheses are tentative. However, according to the 're-entrant processing hypothesis', it could be expected that high-arousal compared to low-arousal word primes enhance perceptual and attentional processes, which would influence the processing of the subsequently presented stimuli. In particular, if the findings of Ihssen et al. (2007) using pictures as stimuli generalize to words, we would expect that the capacity of high-arousal words to engage attentional resources would affect subsequent early lexico-semantic processing of both neutral words and pseudowords. This would be reflected in a modulation of N100 amplitudes. The attentional grabbing power of high-arousal words should also influence post-lexical processing involved in the formation of semantic associations, decision making and response planning of neutral nouns. This would be reflected by amplitude modulations of the N400 and/or the LPC. Additionally, we will examine the occurrence of possible effects elicited by low- and high-arousal nouns during the processing of orthographic/phonological information as reflected by the P200, since this component has been previously observed in lexical decision tasks (e.g., Barber et al., 2004; Hauk et al., 2006).

2. Methods and materials

2.1. Participants

Twenty right-handed native Spanish speakers participated in the study (18 females; 17–28 years, mean 19 years; lateralization quotient 78–100%, mean 95% measured by the Edinburgh Handedness Scale, Oldfield, 1971). All participants reported normal or corrected-to-normal vision. They gave their informed consent to participate in the study.