Brain & Language 134 (2014) 34–43

Contents lists available at ScienceDirect

Brain & Language

journal homepage: www.elsevier.com/locate/b&l

On pleasure and thrill: The interplay between arousal and valence during visual word recognition

Guillermo Recio [a,*], Markus Conrad [b,c], Laura B. Hansen [d], Arthur M. Jacobs [b,e]

[a] Universität Hamburg, Department of Psychology, Von-Melle-Park 5, Room 4004, D-20146 Hamburg, Germany
[b] Freie Universität Berlin, Experimental and Neurocognitive Psychology, Habelschwerdter Allee 45, D-14195 Berlin, Germany
[c] Universidad de La Laguna, Cognitive Neuroscience & Psycholinguistics Lab, Campus de Guajara, E-38205 La Laguna, S.C. de Tenerife, Spain
[d] Universidad de Granada, Department of Experimental Psychology, Campus de Cartuja s/n, E-18071 Granada, Spain
[e] Dahlem Institute for Neuroimaging of Emotion (DINE), Habelschwerdter Allee 45, D-14195 Berlin, Germany

ARTICLE INFO

Article history:
Accepted 22 March 2014
Available online 9 May 2014

Keywords:
Valence
Arousal
Emotion
Lexical decision
Event-related potentials

ABSTRACT

We investigated the interplay between arousal and valence in the early processing of affective words. Event-related potentials (ERPs) were recorded while participants read words organized in an orthogonal design with the factors valence (positive, negative, neutral) and arousal (low, medium, high) in a lexical decision task. We observed faster reaction times for words of positive valence and for those of high arousal. Data from ERPs showed increased early posterior negativity (EPN) suggesting improved visual processing of these conditions. Valence effects appeared for medium and low arousal and were absent for high arousal. Arousal effects were obtained for neutral and negative words but were absent for positive words. These results suggest independent contributions of arousal and valence at early attentional stages of processing. Arousal effects preceded valence effects in the ERP data suggesting that arousal serves as an early alert system preparing a subsequent evaluation in terms of valence.

1. Introduction

From the gratification experienced while reading a poem to the aggression expressed with an insult, words are fundamental means to elicit and express emotions. Many theories have taken the challenge to understand and classify emotion stimuli and emotional responses. According to dimensional models of affect (e.g., Osgood, Suci, & Tannenbaum, 1957; Russell, 1980; Wundt, 1896), an emotional experience can be described in terms of its position within an affective space defined by certain dimensions. The two most largely accepted dimensions to account for emotional experiences are valence and arousal. The appetitive/aversive model of Lang, Bradley, and Cuthbert (1997) considers valence a bipolar dimension that defines stimuli in terms of pleasure and displeasure and activates two motivational brain systems, either appetitive or aversive, eliciting basic reactions of approach and withdrawal (Lang et al., 1997). Arousal is considered an unipolar dimension that defines the intensity in the activation of the respective motivational system quantitatively. Normative ratings of visually presented words have shown that differences in valence seem to be more salient than differences in arousal, hence, depicting the relation between the two in a U-shaped distribution (Bradley & Lang, 1994, 1999; Lang, Bradley, & Cuthbert, 1999). This finding has been consistently replicated in other languages, and so has the finding that correlations between the two variables are high when looking at the domains of positive and negative valence separately (e.g., Schmidtke, Schröder, Jacobs, & Conrad, 2014). Although the use of both dimensions has provided a useful theoretical background, there are reasons to assume that the relations between valence and arousal are more complex. For example, ratings of German words (e.g., Schmidtke et al., 2014; Võ, Jacobs, & Conrad, 2006; Võ et al., 2009) show that the correlation between valence and arousal differs considerably between the positive and negative domain: an increase in negative valence is normally accompanied by an increase in arousal, that is, the more negative a stimulus, the more arousing it tends to be. For positive words, however, the correlation between valence and arousal appears much attenuated, reflecting that both exciting and calm events can be perceived as highly pleasant. Similar asymmetries have been found for ratings of affective pictures (Keil et al., 2002).

These asymmetries in the relation between valence and arousal observed in large scale rating databases are in line with the view that both positive valence and low arousal generate responses of approach, whereas stimuli of either negative valence or high arousal elicit withdrawal (Robinson, 1998). The author demonstrated

* Corresponding author. Fax: +49 40 42838-5492.
E-mail address: guillermo.recio@gmail.com (G. Recio).

http://dx.doi.org/10.1016/j.bandl.2014.03.009
0093-934X/

that congruent combinations (i.e., positive low-arousal or negative high-arousal) are responded faster to than incongruent ones (i.e., positive high-arousal or negative low-arousal), likely because they are easier to process and demand fewer resources (Robinson, Storbeck, Meier, & Kirkeby, 2004). Similarly, Cacioppo (2004) used the term *positivity offset* to describe that the approach system is typically activated in situations of low arousal, providing the basis for exploration and curiosity. At a high level of arousal, instead, a *negative bias* is assumed, as the withdrawal system responds strongly at high levels of arousal (see also Ito & Cacioppo, 2000). Studies using affective pictures and faces have supported this negative bias and positivity offset with behavioral and cortical responses (see Norris, Gollan, Berntson, & Cacioppo, 2010, for a review). However, it is unclear whether the same asymmetries apply to the processing of emotional words (Kissler, Assadollahi, & Herbert, 2006).

From a theoretical perspective, such asymmetries involving more specific or fine grained valence and arousal effects are more in line with models of emotion that consider valence and arousal as orthogonal, bipolar and independent from each other (e.g., Russell, 1980). According to Russell's (1980) circumplex model, affective space forms a circle of emotional states organized around two bipolar axes, one for valence (positive, negative), and one for arousal (activation, calm). Behavioral studies using multidimensional scaling and factorial analyses provided empirical support for the independence assumption (e.g., Russell & Barrett, 1999). Neuroimaging and electroencephalogram (EEG) studies have also indicated separate neural routes for valence and arousal, although with some inconsistencies in the results (Anders, Lotze, Erb, Grodd, & Birbaumer, 2004; Colibazzi et al., 2010; Gianotti et al., 2008; Kensinger & Corkin, 2004; Kensinger & Schacter, 2006; Lewis, Critchley, Rotshtein, & Dolan, 2007).

Data from ERP studies support the idea of several stages in visual word processing (for reviews see Kissler et al., 2006; Ponz et al., 2013). Previous evidence has shown that emotion-laden words can modulate cortical responses at all stages (see Citron, 2012, for a review). Recent studies have helped to identify which variables (i.e., word class, word frequency) impact the time course of the processing of emotional meaning (Palazova, Mantwill, Sommer, & Schacht, 2011). Consistently, differences in ERP amplitudes for emotional relative to neutral words appear at around 200–350 ms in the form of a negative deflection, which is maximal at posterior electrode sites, called early posterior negativity (EPN; Bayer, Sommer, & Schacht, 2010; Conrad, Recio, & Jacobs, 2011; Herbert, Kissler, Junghöfer, Peyk, & Rockstroh, 2006; Kissler, Herbert, Peyk, & Junghöfer, 2007; Kissler, Herbert, Winkler, & Junghöfer, 2009; Schacht & Sommer, 2009a, 2009b; Scott, O'Donnell, Leuthold, & Sereno, 2009). This enhanced EPN for emotion-laden words reflects improved visual processing in the visual cortices and allocation of attention to the emotional content of the stimuli due to their higher motivational significance (e.g., Kissler et al., 2006).

At later stages of processing following 400 ms after stimulus onset, emotional words elicit larger positivities than neutral ones at central electrodes, in the so-called late positive complex (LPC), which is thought to reflect enhanced *motivated attention* (see Lang et al., 1997) and evaluation of emotional words (e.g., Conrad et al., 2011; Herbert et al., 2006; Schacht & Sommer, 2009a, 2009b). Larger LPC amplitudes to affective words have been attributed not only to the manipulation of valence, but also to differences in arousal (see Dillon, Cooper, Grent-'t-Jong, Woldorff, & LaBar, 2006; Fischler & Bradley, 2006). Fischler and Bradley (2006) reported a latency delay of 150 ms for the LPC when participants were engaged in a classification task based on valence, as compared to when they were asked to classify the arousal of the same words, and concluded that the LPC primarily reflects the intensity of arousal, rather than differences in valence. Similar findings have been observed with affective pictures (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000).

Based on the assumption that high arousal co-occurs with extreme valence (Lang et al., 1997), in the majority of studies investigating emotion effects, stimuli were selected to maximize the contrast between emotional and neutral conditions using conjoint manipulations of the two variables. Namely, high-arousal words of either positive or negative valence were compared with low arousal, neutral words. Findings obtained under such manipulations document, in general, the largest emotional effects, but do not allow more fine-grained attributions concerning their source. Moreover, other theories (e.g., Russell, 1980) and empirical data indicate independence of the two dimensions valence and arousal (e.g., Anders et al., 2004; Gianotti et al., 2008). Hence, it is unclear whether the emotional modulation of the EPN and LPC reported previously is due to the processing of either valence or arousal alone, or rather to a combination of both. In an attempt to solve this problem, several ERP studies – mostly using affective pictures – have analyzed valence effects while keeping constant the level of arousal, not only between positive and negative, but also between emotional and neutral conditions (e.g., Conroy & Polich, 2007; Delplanque, Lavoie, Hot, Silvert, & Sequeira, 2004; Huang & Luo, 2006; Yuan et al., 2007). Overall, they indicate that negative images are preferentially processed at high and medium levels of arousal, demonstrated in the larger amplitudes of ERP components for these conditions at early and later stages of processing, and congruent with the idea of a negative bias (Cacioppo, 2004).

Despite the growing interest in the investigation of the emotion–cognition coupling in language processing, to our knowledge, such fine-grained valence effects have rarely been investigated with visually presented words. Probably, the lack of comprehensive studies trying to disentangle specific effects of valence and arousal is due to a non-trivial methodological challenge in selecting the stimulus material. The relatively high correlation between valence and arousal – considering both the positive and the negative domain of valence separately – makes it difficult to independently manipulate the two factors, especially when only a limited number of words with corresponding emotion ratings are available.

Available studies attempting to disentangle the respective effects of valence on the one hand and of arousal on the other provide a heterogeneous picture of results concerning response latencies or ERP effects. For example, a behavioral study that compared words of different valence at similar – though not completely matched – arousal levels, reported a facilitation for positive and negative words of high arousal relative to neutral words of medium arousal, and no asymmetry between valence poles (Kousta, Vinson, & Vigliocco, 2009).

A recent ERP study investigating emotion effects on high and low arousal words with different valence (positive, negative, neutral) proposed three steps in the time course of emotional effects on ERPs. First, an early (100 ms) impact of (positive) valence in the P1 component, followed by an effect of (high) arousal within the EPN time window; and finally, simultaneous and additive effects of valence and arousal in later stages in the LPC (Bayer, Sommer, & Schacht, 2012). In line with Russell's model (1980), the effects of valence and arousal were independent from each other as they did not interact in any time window. Emotional modulations of the P1 have also been observed due to arousal while keeping valence constant, i.e., involving only negative words (Hofmann, Kuchinke, Tamm, Võ, & Jacobs, 2009). Additional data, also controlling for both dimensions – at least for negative and positive words – showed interactive effects of valence and arousal in the EPN time window, in form of an enhanced EPN for positive high-arousal and negative low-arousal words (Citron, Weekes, &