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Affective picture modulation: Valence, arousal, attention allocation and motivational significance

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ABSTRACT

The present study analyses the modulatory effects of affective pictures in the early posterior negativity (EPN), the late positive potential (LPP) and the human startle response on both the peripheral (eye blink EMG) and central neurophysiological levels (Probe P3), during passive affective pictures viewing. The affective pictures categories were balanced in terms of valence (pleasant; unpleasant) and arousal (high; low). The data shows that EPN may be sensitive to specific stimulus characteristics (affective relevant pictures versus neutral pictures) associated with early stages of attentional processing. In later stages, the heightened attentional resource allocation as well as the motivated significance of the affective stimuli was found to elicit enhanced amplitudes of slow wave processes thought to be related to enhanced encoding, namely LPP,. Although pleasant low arousing pictures were effective in engaging the resources involved in the slow wave processes, the highly arousing affective stimuli (pleasant and unpleasant) were found to produce the largest enhancement of the LPP, suggesting that high arousing stimuli may are associated with increased motivational significance. Additionally the response to high arousing stimuli may be suggestive of increased motivational attention, given the heightened attentional allocation, as expressed in the P3 probe, especially for the pleasant pictures. The hedonic valence may then serve as a mediator of the attentional inhibition to the affective priming, potentiating or inhibiting a shift towards defensive activation, as measured by the startle reflex.

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1. Introduction

Emotions have been conceptualized as adaptive action dispositions (Izard, 1993; Lang, 1979) functionally preparing the organism for either avoidance (defensive system) or approach (appetitive system) related behaviours. These action dispositions may compete for ongoing mental resources, affecting stimulus appraisal and coping responses (Davidson, 2001; Frijda, 1986; Lang et al., 1997). Individual survival is dependent on the dynamic balance between these appetitive and defensive behaviours (Lang et al., 1997).

With the use of high temporal resolution methods, it has been shown to be possible to detect subtle changes in the cognitive and motor processing induced by affectively laden stimuli: the activity of the central nervous system (ERPs) and the peripheral nervous system response (e.g., electromyography — EMG).

The modulation of ERPs by affectively laden pictures has been widely addressed by research on affective and cognitive processing (Lang and Bradley, 2010). However, only recently have researchers started systematically exploring the interactions between the two types of valence (pleasant versus unpleasant) and arousal (high versus low) to assess their relative contributions in several ERP latencies (Briggs and Martin, 2009; Conroy and Polich, 2007; Rozenkrants et al., 2008).

Multiple ERP components are sensitive to affective pictures. For example, the early posterior negativity (EPN), the P300 and the late positive potential (LPP), have shown increased amplitude for both pleasant and unpleasant, when compared with neutral pictures (e.g. Cacioppo et al., 1994; Cuthbert et al., 2000; Keil et al., 2002; Schupp et al., 2004a); . These results have been interpreted as reflecting increased allocation of attentional resources (i.e. motivated attention) to motivationally relevant stimuli (e.g. Cuthbert et al., 2000; Foti et al., 2009; Hajcak et al., 2007; Hajcak and Olvet, 2008; Schupp et al., 2000, 2003a, 2004a). Other studies found an enhanced processing of the affective stimulus (i.e. motivated significance) with high arousal affective pictures, when compared with neutral or relaxing ones, reflected by the larger amplitudes on the late positive components (Hinojosa et al., 2009; Schupp et al., 2000).

In fact, the study of different ERP components allows the identification of different stages of the affective processing. Thus, while the EPN is associated with early selective attention to the stimulus, the LPP seems to reflect the initial attentional processing (along with

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the P300), as well as the sustained processing associated with encoding mechanisms (Foti et al., 2009).

In addition to ERP, the use of the startle response has been widely used to study the modulatory effects of valence and arousal in attention (Lang, 1995). The startle response is an evolutionary primitive fear reflexive reaction to the presentation of a sudden and intense sensorial probe, most typically an acoustic burst (Sokolov and Worters, 1963). It primarily consists of a stereotyped action pattern of somatic and facial muscles (Ekman et al., 1985), with the activation of both the autonomic and central nervous systems (Soto et al., 2005). Depending on the intensity, it can generate either a whole-body defensive response (Sokolov and Worters, 1963), an electromyographic (EMG) response associated with eye blinking and an evoked related potential (Probe P3).

Priming subjects with a stimulus of a contradictory affective valence significantly interferes with the magnitude of the startle response. Thus, the presentation of unpleasant stimuli (e.g., pictures, music, films) increases the magnitude of the startle reflex, while the presentation of pleasant stimuli significantly attenuates it (Lang et al., 1990).

Additionally, the startle probe also elicits a pronounced positive ERP wave referred as the startle P3 Probe peaking around 300 ms (Bradley et al., 2006; Cuthbert et al., 2000). While the eye-blink reflex is a good peripheral nervous system index of automatic subcortical affective processing, the P3 Probe represents a central nervous system marker of cortical cognitive-emotional regulation.

The P3 Probe is considered to be an index of the amount of resources allocated during the processing of affective pictures (i.e., workload measure)(Bradley et al., 2006). As greater attention is allocated to affectively laden pictures, fewer resources will be available to the sound probe. Therefore, lower probe amplitudes would indicate that more attentional resources are allocated to affectively laden pictures (Bradley et al., 2006; Schupp et al., 1997). This interpretation was also supported by studies where the reaction times to secondary probes were slower when viewing affective, compared to neutral pictures (Bradley et al., 1999; De Cesarei and Codispoti, 2008). One of the first studies exploring the mediators of the P3 Probe (Schupp et al., 1997) showed that, contrary to the eye blink response, the P3 is primarily modulated by the level of arousal, with attenuated auditory P3 waves for high arousal, affective stimuli, either pleasant or unpleasant.

Research on picture perception, following the multi-process startle modulation (Bradley et al., 2006) shows that instead of a single defensive response (i.e. the eye-blink reflex), the activation of the defense system is better explained by a cascade of several physiological responses (Bradley and Lang, 2007). The defense cascade (e.g. Bradley et al., 2001b; Bradley and Lang, 2000; Lang et al., 1997; Ohman and Wiens, 2003) states that stimuli activating the defensive system will orient our attention leading to increased sensory intake and resource allocation. As the stimulus becomes increasingly threatening, the active defense system starts to mobilize the available resources in order to prime defensive activation, thus potentiating the reflex. Appetitive inhibition of the reflex occurs with increasingly attention allocation to the appetitive stimulus (e.g. high arousing pleasant one), that could act as a single process of attentional inhibition or in conjunction with inhibition of the defensive system (Bradley et al., 2006). Both pleasant and unpleasant pictures with low to moderate arousal, as well as pleasant high arousing pictures may be responsible for startle inhibition, whereas unpleasant high arousal pictures may elicit startle potentiation (Cuthbert et al., 1996).

In sum, the multi-process model of startle modulation states that emotional autonomic responses to affective reactive stimuli are characterized by an initial orienting response followed by subsequent defense/appetitive activation.

Although startle probe and EMG have been already studied before (e.g. Amrhein et al., 2004; Ferrari et al., 2011), the present study focus on affective pictures categories balanced in terms of valence and arousal in response to a startle probe; as well as with EPN and LPP in response to the same pictures, in a passive viewing task. Therefore, the present study has two main objectives: (1) to test the effects of different categories of valence (pleasant; unpleasant) and arousal (high; low) on two event-related potentials (Early Posterior Negativity (EPN) and Late Positive Potential (LPP)) in response to passive picture viewing; and (2) to analyse the relative contributions of those valence (pleasant; unpleasant) and arousal (high; low) categories in modulating the human startle response on both the peripheral (eye blink EMG) and central neurophysiological levels (Probe P3).

2. Methods

2.1. Participants

Fifteen female university student volunteers (mean age: 20.27; SD: 1.87) participated in the study. All of the participants were healthy, with normal or corrected-to-normal visual and hearing acuity, self-reported right-handedness and without a present or past history of neurological or psychiatric disorder; they had not taken any medication or psychotropic drugs during the 4 weeks prior to the study. Participants were advised to avoid alcohol, cigarettes and caffeinated drinks on the day of the experiment, and none reported fatigue due to insufficient sleep. All of the participants gave their informed consent prior to their inclusion in the study and were awarded academic credits in an introductory psychology course. None of the participants were familiar with the protocols used in the study, including the IAPS (Lang et al., 2005) pictures.

The study was approved by the local ethics committee and was in accordance with the Declaration of Helsinki.

2.2. Stimulus material

A total of one hundred and twenty five pictures were used, which were taken from the IAPS database: 25 pleasant high arousing (PH), 25 pleasant low arousing (PL), 25 unpleasant high arousing (UH), 25 unpleasant low arousing (UL), and 25 neutral (NL).[1]

The startle stimulus was a 105 dB, 50 ms burst of white noise with instantaneous rise/fall times. Startle tones started 2500 ms after the onset of the picture, allowing the possibility to extract the first 1000 ms of each picture presentation and to examine the electric brain potentials in a passive picture viewing task, prior to the delivery of the startle tone.

2.3. Procedure and experimental design

The participants remained seated in a comfortable chair at an approximate distance of 1.5 meters to a 48.3 cm screen (19 inches) in an electrically isolated laboratory with attenuated light and sound. They were instructed not to move during the recording. Each picture was presented at approximately a 14.7° visual angle.

All of the participants were instructed that pictures of different affective content would be presented on a computer screen and to view the picture slide for the entire time it remained on the screen. They were also told that they might hear some noises, which they were instructed to ignore.

[1] The IAPS (Lang et al., 2005) pictures used in the experiment were the following: Pleasant Low (Valence: 7.37 (0.72); Arousal: 4.16 (0.55)): 2000, 2005, 2010, 2025, 2030, 2040, 2050, 2057, 2070, 2080, 2091, 2153, 2154, 2165, 2170, 2299, 2304, 2306, 2310, 2311, 2332, 2340, 2341, 2360, 2370; Unpleasant Low (Valence: 3.92 (1.17); Arousal: 4.00 (0.62)): 2095, 2100, 2110, 2190, 2221, 2230, 2271, 2272, 2276, 2278, 2280, 2312, 2383, 2399,2455, 2490, 2491, 2520, 2590, 2682, 2750, 2753, 9220, 9265, 9331; Pleasant High (Valence: 6.68 (0.36); Arousal: 6.44 (0.29)): 4607, 4643, 4647, 4651, 4652, 4656, 4658, 4659, 4660, 4664, 4666, 4670, 4672, 4676, 4677, 4680, 4681, 4683, 4687, 4689, 4690, 4694, 4695, 4800, 4810; Unpleasant High (Valence: 1.69 (0.25); Arousal: 6.64 (0.57)): 3000, 3010, 3015, 3016, 3030, 3053, 3060, 3061, 3062, 3063, 3064, 3068, 3069, 3071, 3080, 3100, 3102, 3110, 3120, 3130, 3140, 3150, 3168, 3170, 3266; Neutral(Valence: 4.95 (0.31); Arousal: 2.97 (0.52)): 7002, 7020, 7025, 7030, 7031, 7034, 7038, 7040, 7042, 7043, 7044, 7050, 7052, 7053, 7055, 7056, 7058, 7059, 7060, 7090, 7100, 7110,7130,7140,7150

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