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# Early Influence of Affective Context on Emotion Perception: EPN or Early-N400?

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Recent studies have shown that affective context influences the processing of emotional images at early stages. Yet, the mechanisms underlying the emotional modulation of early sensory processing have not been totally elucidated. Emotional information plays a relevant role modulating several cognitive processes such as perception (Vuilleumier et al., 2004), attention (Vuilleumier, 2005; Yiend, 2010), memory (Kensinger, 2009), semantic integration (Egidi and Nusbaum, 2012), and social cognition (Forgas, 2001; Gross, 2002; Batty and Taylor, 2003). Emotions are supported by dynamic interactions among neuronal networks, linking emotional processing centers (e.g., amygdala, hippocampus), with noticeable connections to early sensory areas (Pessoa, 2008). These influences have been characterized through the modulation of two different Event Related Potentials (ERPs): (a) the Early Posterior Negativity (EPN) (Hietanen and Astikainen, 2013), related with the amount of attentional resources to facilitate the early selective perceptual processing of emotional stimuli (Junghöfer et al., 2001; Schupp et al., 2003); and (b) the early-N400 (Diéguez-Risco et al., 2015; Dozolme et al., 2015), classically related with the contextual influence on the effort to integrate incoming information in semantic processing (Kutas and Federmeier, 2011). Here, we discuss that the variations in latency, topography, and amplitude reported in these previous studies as an early-N400 component, fit better with those modulations observed in the EPN component, suggesting that affective context influences the allocation of attentional resources for emotional stimuli processing at early stages of perception.

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## EPN AND THEIR ROLE IN SELECTIVE ATTENTION DURING PERCEPTUAL PROCESSING OF EMOTIONAL STIMULI

EPN is a negative-going deflection over temporo-occipital sites, peaking between 250 and 350 ms after visual stimulus presentation. It has been considered as a marker of the earliest processing of selective emotional perception in relation to the amount of attentional resources (Junghöfer et al., 2001; Schupp et al., 2004a,b). The amplitude of the EPN correlates with emotional arousal (Junghöfer et al., 2001; Schupp et al., 2004a,b) and with emotional content of pictures (Low et al., 2005). The emotional information associated to stimulus content influences its salience (Öhman et al., 2000). Critically, the amount of allocated attentional resources correlates with the stimulus emotional salience (Ohman et al., 2001; Vuilleumier, 2005). This relationship indicates an attentional flexibility to modulate perceptual processing as a function of stimulus emotional content (Tipples and Sharma, 2000). Therefore, EPN amplitude reflects the amount of attentional resources allocated to salient stimuli, and the interaction between emotional information and attentional direction (Schupp et al., 2004a,b, 2006a).

Several studies have addressed the relationship between attentional resources and emotional salience of stimuli, observing EPN modulations (Schupp et al., 2003, 2006a; Kissler et al., 2009). Using rapid serial visual presentation paradigms (RSVP), it has been shown smaller EPN amplitudes in those stimuli that were preceded by emotional pictures (Flaisch et al., 2008a,b), suggesting that stimulus emotional relevance guides attentional resources assigned to perceptual processing (Lang et al., 1997; Codispoti et al., 2006; Schupp et al., 2007b). These findings have been interpreted as an emotional modulation of attentional salience and engagement in the first picture, interfering with subsequent emotional pictures processing (McHugo et al., 2013). This has been considered an "emotional blink," quantified through EPN amplitude (Schupp et al., 2003). However, this effect is unspecific regarding emotional valence of the first picture, and the emotional content of the subsequent one (Most et al., 2007). Thus, aside from the emotional modulation of attentional processing, EPN amplitude in RSVP paradigms reflects the attentional engagement and competition between pictures (Shapiro et al., 1997; Potter et al., 2002). Its modulation can be interpreted as an early marker of attentional facilitation for the eliciting stimulus, with the subsequent depletion of attentional resources for competing one.

## AFFECTIVE CONTEXT MODIFIES THE ALLOCATION OF ATTENTIONAL RESOURCES FOR EMOTIONAL STIMULI PROCESSING AT EARLY STAGES OF PERCEPTION

Recently, different studies have explored the influence of emotional context during emotional faces processing, showing that emotional context modulates early ERP amplitudes elicited by faces with emotional expressions (Hietanen and Astikainen, 2013; Diéguez-Risco et al., 2015; Dozolme et al., 2015). From these studies, Dozolme et al. (2015) and Diéguez-Risco et al. (2015) have interpreted these amplitude changes as early-N400 modulations. However, Hietanen and Astikainen (2013) interpret a similar negativity as an EPN modulation. Dozolme et al. (2015) recorded ERPs during the presentation of five emotional faces (sad, angry, fear, happy, neutral), that could be emotionally congruent or incongruent with a previous exposed situational sentence. After the presentation of emotional faces, they observed an occipital negative-going deflection between 200 and 340 ms, with larger amplitudes for the congruent condition. They interpreted this result as an early-N400. Nevertheless, they recognize that both, posterior localization and reversed congruence effects are inconsistent with a classical N400 component, finally suggesting that more research is needed to understand their results (Dozolme et al., 2015). In a similar study, Diéguez-Risco et al. (2015) presented two emotional faces (angry vs happy), which could be congruent or incongruent with a previously depicted situational sentence. They observed a posterior negative deflection between 250-350 ms, also interpreted as N400. This early negativity exhibited enhanced amplitude for congruent condition, without statistically significant congruence effects. Altogether, Dozolme et al. (2015) and Diéguez-Risco et al. (2015) interpreted these putative N400 modulations as a reflection of emotional contextual influence in the process of information integration. The fact that the negative component observed in these studies was labeled as an N400 might be related with the long literature reporting this component in experimental designs that contrast congruency between context and critical stimuli (Kutas and Federmeier, 2011).

Yet, the interpretation of these early negativities as N400 does not provide a clear explanation on how the affective context influences the processing of emotional information. The reason of this is twofold. First, considering their hedonistic condition (pleasant vs. unpleasant), the number of stimuli differs between the experiments. The effects of emotional content in congruent conditions obtained by Dozolme et al. (2015) and Diéguez-Risco et al. (2015) can be explained by the lack of counterbalanced distribution of stimuli regarding their affective valence (positive/pleasant vs. negative/unpleasant). Dozolme et al. (2015) included three emotions with negative valence (sad, fear, angry), but only one emotion with positive valence (happy). Conversely, positive and negative affective valences (happy and angry faces) were equally distributed in Diéguez-Risco et al. (2015). Additionally, Diéguez-Risco et al. (2015) suggested that the number of introduced emotions in the task can account for amplitude differences in early components. According to them, changes in the component amplitude imply different cognitive efforts. Specifically, the use of five emotions in Dozolme et al. (2015) increases the cognitive effort to solve the task, as compared with only two emotions (Diéguez-Risco et al., 2015).

The second reason is that this emotionally modulated negative component may correspond to an EPN. Specifically, there are major discrepancies between the observed 200–340 ms negativity, with a classical N400 in latency, topography and amplitude modulation. Classically, N400 is a negative-going deflection with enhanced amplitudes during the presentation of incongruent stimuli. This ERP component has been functionally related to the degree of effort during meaning comprehension and expectancy (Kutas and Federmeier, 2011). Also, N400 is modulated by faces, pictures, or gestures (Nigam et al., 1992; Debruille et al., 1996; Cornejo et al., 2009), among others stimuli. Different studies have shown that N400 amplitude is affected by different contextual factors like discourse (Otten and Van Berkum, 2007), music (Koelsch et al., 2004), world knowledge (Hagoort et al., 2004), prosodic cues (Steinhauer et al., 1999), or pitch accent (Wang et al., 2011). Altogether, these findings suggest that N400 signs the influence of context on expectancy and meaning comprehension.

The maximum peak of the negative component found in the studies of Diéguez-Risco et al. (2015) and Dozolme et al. (2015) was observed around 270 ms. Classically, N400 peaks around 400 ms, with a range between 300 and 500 ms (Kutas and Federmeier, 2011), whereas the EPN peak is usually observed between 250 and 350 ms (Schupp et al., 2004b). Additionally, this early negative deflection is located at posterior sites, whereas N400 is mostly located at fronto-parietal sites, rather anterior compared with the location of the observed

negativity. Furthermore, the observed congruence effect in these studies was reverted compared with what is usually expected on an N400 congruence effect, obscuring the functional interpretation. Considering the accepted interpretation of the classically reported N400 component, the results of Diéguez-Risco et al. (2015) and Dozolme et al. (2015) would imply that congruent affective contexts involve a greater effort to integrate emotional stimuli. On the contrary, if these early negativities are considered as EPN, their amplitude modulation would indicate that the affective congruent context also influences the processing of emotional stimulus at very early stages, through an attentional facilitation mediated by its emotional content.

A third study provides further support to the hypothesis that affective context influences early stages of selective attentional perception (EPN). In an emotional classification task, Hietanen and Astikainen (2013) explored the influence of contextual scenes on emotional face perception. They recorded brain activity for happy and sad faces preceded by congruent and incongruent scenes. Participants were instructed to attend to faces and classified them as happy or sad. The authors reported a modulated EPN component between 250 and 350 ms at posterior regions, with larger amplitude for happy faces, in alignment with Diéguez-Risco et al. (2015) reports, among others (Schupp et al., 2006b; Flaisch et al., 2008a; Franken et al., 2008). They also observed a congruence effect for happy faces. EPN amplitude was larger when faces were preceded by congruent contexts. Importantly, the topography and latency of the elicited negative component were similar to those observed in the Dozolme et al. (2015) and Diéguez-Risco et al. (2015) studies. Considering that EPN reflects the amount of attentional resources in early selective processing of emotions, enhanced EPN amplitudes for congruent conditions might reflect more allocation of attentional resources during emotional stimulus processing. The enhanced effect observed for pleasant emotional information has been previously reported, suggesting a natural bias that facilitate the processing of such emotional stimuli (Herbert et al., 2008). Accordingly, new stimulation paradigms, including parameterization of hedonic information during context, together with the quantification of EPN amplitude changes could help understand the role of emotional information during early attentional processing.

In conclusion, here we yielded a unitary interpretation of the observations of affective contextual influence on emotional stimuli processing and its ERPs correlates. Our interpretation assumes that changes in EPN amplitude reflect both, stimulus emotional significance and the amount of attentional resources on early processing (Schupp et al., 2007a; Dunning et al., 2011; Weinberg et al., 2013). Consequently, we suggest that the observed EPN amplitude differences for the same type of stimulus, but under different emotional contexts, imply that the emotional significance might be derived not only from the stimulus in itself, but also from the affective context. The fact that effect of affective context can be observed at such early latencies, may suggest that the brain can use these modulatory signals to improve the efficiency of neural representations, and optimize stimulus inference, in line with novel theories of efficient and predictive coding (Vinck and Bosman, 2016).

## AUTHOR CONTRIBUTIONS

NA Conception, analysis and interpretation of the literature, she has participated in drafting of the manuscript and critical revision of the manuscript for important intellectual content, final approval of the version to be submitted. VL Conception drafting of the manuscript and critical revision of the manuscript for important intellectual content; final approval of the version to be submitted. CB has participated in drafting of the manuscript and critical revision of the manuscript for important intellectual content; final approval of the version to be submitted.

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