Spatial Attention Focus, Awareness in Emotion Processing

Subjects: Psychology

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Emotional faces constitute important social information in the daily life. Expressions like fear can act as cues for potential threats in the environment and are therefore thought to be prioritised for attention. The relationship between attention and emotion processing have focused essentially on consciously-viewed, supraliminal stimuli, while the attention-emotion interplay remains unexplored in situations where visual awareness is restricted.

Keywords: attention ; awareness ; emotion processing ; EEG

1. The Role of Spatial Attention Focus in Emotion Processing

The interplay between attention and emotion processing has been extensively investigated using emotional faces. Especially for negative expressions, previous studies have shown that they compete more for attentional resources, compared to neutral faces [1][2][3]. One aspect of the attentional bias to emotional faces is their access to conscious awareness independent of spatial attention focus. Indeed, it has been suggested that emotional faces can be processed pre-attentively, i.e., without spatial attention focus [4]. However, other researchers argue that emotion processing requires attentional focus [5][6].

The question of whether emotional faces can be processed outside the focus of attention has been investigated using electroencephalography or EEG, a useful tool for revealing the electrical activity during a wide range of cognitive processes in the human brain. Using EEG, it has been shown that emotional compared to neutral faces can increase the amplitudes of event-related potentials (ERPs) from mid-latency onwards (i.e., N170, N2, P3 [2]. Specifically, the P3, an ERPs component with an onset of around 300 ms post-stimulus at parietal regions, can be most consistently increased for emotional relative to neutral faces when attention is directed to the facial expressions of the stimuli [2]. It is possible that later stages of visual processing for emotional faces, as characterised by the P3, need attention.

In comparison, emotional expressions, in particular fear and anger, produce an enhancement effect on earlier ERPs (i.e., N170, N2) largely independently of whether they are attended or not, across different attention tasks [2]. For example, Huang and colleagues found that, unattended fearful faces presented laterally could enhance an early component (i.e., P2), compared to unattended neutral faces, but this effect was modulated by participants' attentional load [7]. Similarly, using affective non-face pictures, early and mid-latency components (i.e., N1, P2, N2) were enhanced for unattended negative-valence pictures, compared to unattended neutral pictures, only in a low attentional load condition [8][9]. These results showed that unattended emotional stimuli can enhance neural activity under certain circumstances. However, it is unclear how the emotion-related modulations on the ERPs compare directly to situations where the faces are attended.

Moreover, other studies found that emotional faces did not enhance early ERPs when they were not spatially attended. In one previous study, participants were presented with a vertical/horizontal pair of house images and a horizontal/vertical pair of face images and had to attend to either the horizontal or vertical pair of stimuli [6]. It was found that, when the faces were spatially attended, the fearful expression of the faces enhanced an early frontal positivity starting at around 100 ms post-stimulus, compared to neutral faces. When the faces were unattended, however, no emotion-related effect could be found on the ERPs [6]. Correspondingly, it was concluded that spatial attention gates emotion processing even at an early stage of processing.

Similarly, in another ERP study, participants were presented with pairs of lateral face images and were asked to either discriminate an emotional face from a neutral one, or compare the lengths of two lines presented close to the screen centre [5]. The fearful expression was found to enhance the early frontal positivity and the N2 at posterior electrodes, when participants had to indicate the emotional expressions of the faces. However, the emotion-related effects on the ERPs

disappeared when spatial attention was directed away from the faces and engaged in the rather demanding line task [5]. It was concluded that, again, the processing of emotional expressions requires spatial attention.

Therefore, it is still disputed to date whether emotion processing can indeed occur outside spatial attention focus. To address this question, it would be necessary to perform direct comparisons between responses to attended and unattended faces while assessing the neural markers for emotional face processing across different attentional conditions. Specifically, does the strength of neural activity differ for emotional and neutral expressions for an unattended face? How does the effect compare to the emotion-related modulations on an attended face?

2. The Role of Awareness in Emotion Processing

Previous research has shown that early ERP components like the face-sensitive N170 can be enhanced by emotional expressions in both supraliminal and subliminal viewing conditions [10][11][12]. The enhanced N170 for emotional faces presented subliminally has been taken as evidence that emotional expressions can be processed without visual awareness. However, in these studies, faces were often presented at the centre of the screen and the implementation of inattention to the faces was rare. Specifically, it has not yet been examined whether any nonconscious emotion processing can occur outside the focus of spatial attention. Relevant to this particular question, one previous ERP study examined the relationship between visual awareness and emotion processing for faces that were irrelevant to the experimental task [11]. In their study, participants were presented with a central face stimulus, backward masked, either subliminally (16 ms) or supraliminally (166 ms) and were asked to compare the lengths of two vertical lines presented on either side of the face [11]. It was found that the fearful expression of the task-irrelevant faces enhanced the N170, compared to a neutral expression, regardless of stimulus visibility [11]. It was concluded that subliminal processing of facial expressions is possible and that it can occur outside participants' attentional focus [11].

However, because the face stimuli were presented at the screen centre where participants' overt attention was focused, it is questionable whether the faces indeed remained unattended. Instead, their implementation of inattention was mitigated by task-relevancy of the faces. Therefore, some supports for nonconscious processing of emotional expressions of task-irrelevant faces were provided, it is difficult to conclude unequivocally that the stimuli were processed outside the focus of spatial attention. It thus remains an open question whether nonconscious processing of emotion is independent of spatial attention.

In addition, the subliminal emotion-related effect on the N170 has been found to occur prior to the emergence of the visual awareness negativity or the VAN [10][12], an indicator of early perceptual awareness. Studies on awareness would benefit from an examination of the awareness-related components, such as the VAN, as they provide information about whether and how the neural correlates of visual awareness can be modulated by experimental manipulations.

The VAN is a relative negativity in ERP signals appearing at 200–300 ms post-stimulus for supraliminal compared to subliminal stimuli over occipito-temporal electrodes, and it has been suggested to index an early, perceptual stage of awareness [13]. Another potential neural correlate of awareness is the P3, a positive-going wave appearing at around 300–600 ms post stimulus at parietal regions, which is also greater for consciously perceived stimuli compared to unconscious stimuli [14]. The P3 has been suggested to index a later, reflective stage of awareness [13][15]. Additionally, as a relatively later component in visual processing, the P3 has been linked to a variety of awareness-unrelated cognitive processes [16][17], whereas the VAN is suggested to be the earliest component related to visual awareness in the human brain [18]. Thus far, there has been very limited evidence on whether these awareness-related components, namely the VAN and the P3, can be modulated by the emotional valence of face stimuli.

Similarly, the investigation on the relationship between awareness-related components, the VAN in particular, and spatial attention is lacking. Several studies showed that the N2-posterior-contralateral (the N2pc), the neural marker for spatial attention shifting, could be enhanced with higher levels of awareness [19][20] or was present only when participants were aware of the stimuli [21][22]. However, the examination of how the neural markers for awareness (i.e., the VAN and the P3) can in turn be modulated by attention is limited yet indispensable to a comprehensive understanding of the attention-awareness relationship. In a previous VAN study, Koivisto and colleagues used a bilateral presentation of letters in conjunction with backward masking to investigate the interactions between the VAN and spatial attention [23]. It was found that successful detection of a target letter and the VAN were dependent on the focus of spatial attention. Specifically, the VAN was only observed in the spatial visual field participants selectively attended but not in the unattended visual field [23]. It has not yet been studied, however, whether this pattern can be observed for more complex and biologically meaningful stimuli such as human faces.

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