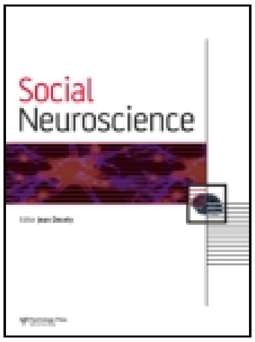

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I see people: The presence of human faces impacts the processing of complex emotional stimuli

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I see people: The presence of human faces impacts the processing of complex emotional stimuli

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Both emotional images and human faces are particularly salient compared to other categories of visual stimuli. The late positive potential (LPP) is larger for emotional than neutral images, and some evidence suggests that the LPP is further enhanced for images containing people. Studies of emotion frequently compare pleasant and unpleasant IAPS pictures to neutral, without an explicit understanding of how the presence of faces in these images may affect attentional allocation and psychophysiological response. The present experiment examined the effect of faces on the LPP elicited by neutral and threatening IAPS images. The LPP was enhanced by faces in neutral images, but no difference was observed between threatening images with and without faces. These results demonstrate that the inclusion of faces in IAPS images significantly impacts the LPP; however, this effect is unique to neutral images.

Keywords: Faces; Emotion; Late positive potential; Vertex positive potential; ERP; IAPS.

The ability to rapidly recognize and respond to emotional information can be critical for survival, as well as for more nuanced social functioning (Bradley, Codispoti, Cuthbert, & Lang, 2001; LoBue & DeLoache, 2010). Indeed, there is ample evidence that emotional stimuli are subject to prioritized processing. For example, compared to neutral stimuli, emotional stimuli are viewed longer (Lang, Greenwald, Bradley, & Hamm, 1993), detected faster (Öhman, Flykt, & Esteves, 2001), and capture and hold attention more efficiently (Lang, Bradley, & Cuthbert, 1997). Some research has suggested that the processing of emotional stimuli may even occur unconsciously (Whalen et al., 1998). This efficient processing of emotional information is thought to rely, in part, on the amygdala (Phan, Wager, Taylor, & Liberzon, 2002; Sergerie, Chochol, & Armony, 2008). The amygdala, along with a network of prefrontal, parietal, and occipital regions, is consistently shown to be more active for emotional than neutral stimuli (Phan et al., 2002).

The ability to recognize and process faces is also a critical skill, and a wealth of evidence suggests that the processing of facial stimuli is also prioritized (Haxby, Hoffman, & Gobbini, 2002; Kanwisher & Yovel, 2006; Öhman, 2009; Schupp et al., 2004; Tsao & Livingstone, 2008). Like emotional content, faces capture attention rapidly—adults can detect and discriminate between faces and other objects as quickly as 100 ms after presentation (Batty & Taylor, 2003; Wheatley, Weinberg, Looser, Moran, & Hajcak, 2011). This enhanced processing of faces may also occur both unconsciously and automatically (Öhman, 2002). Further, this ability is present early in life: Newborns show a preference for faces by directing their attention to face-like objects over other objects (Valenza, Simion, Cassia, & Umiltà, 1996). Neuroimaging studies have identified a distributed core network of brain regions that tend to respond preferentially to faces, including the inferior occipital gyrus, the lateral fusiform gyrus, and the superior temporal gyrus (Fusar-Poli et al., 2009; Haxby, Hoffman, & Gobbini, 2000).

Despite evidence for specialized networks for emotion and face processing, there is significant overlap in the neural response to both emotional and facial stimuli (Britton, Taylor, Sudheimer, & Liberzon,

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2006). For example, a meta-analysis of face processing by Fusar-Poli and colleagues (2009) found that, compared to baseline, even neutral faces produced increases in areas traditionally associated with emotional processing, such as the amygdala, as well as in prefrontal regions such as the middle frontal gyrus, the posterior cingulate cortex, and the insula. Thus, regions of the brain that are responsive to both emotion and faces, such as the amygdala, may respond more generally to salient stimuli—stimuli that are important for basic biological drives and psychological needs (Liberzon, Phan, Decker, & Taylor, 2003; Whalen et al., 1998).

Although fMRI research is able to identify brain networks critical for processing emotional content and faces, event-related potentials (ERPs) are particularly useful for research examining the time course over which emotional features might interact with other perceptual features of emotional stimuli. The late positive potential (LPP), in particular, is a component that is useful for examining the dynamic allocation of attention to visual stimuli (Ferrari, Bradley, Codispoti, & Lang, 2010; Weinberg, Hilgard, Bartholow, & Hajcak, in press). The LPP is thought to reflect sustained attention to salient visual stimuli; it is most prominent at centro-parietal sites, is maximal beginning roughly 300 ms after stimulus presentation, and continues throughout, and even beyond, stimulus presentation (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Foti, Olvet, Klein, & Hajcak, 2010; Hajcak, Dunning, & Foti, 2009; Hajcak & Olvet, 2008; Schupp et al., 2000). The LPP is larger in response to visual stimuli that are made salient due to task demands, such as target stimuli (Azizian, Freitas, Parvaz, & Squires, 2006; Ferrari, Codispoti, Cardinale, & Bradley, 2008; Weinberg et al., in press), as well as to stimuli that are salient because of their content, such as emotional pictures (Foti, Hajcak, & Dien, 2009; Hajcak & Olvet, 2008; Schupp et al., 2004). Similar to activity in limbic and frontal regions, the LPP is also sensitive to emotional faces (Foti et al., 2010; Holmes, Nielsen, & Green, 2008), and to the presence of people in otherwise neutral pictures (Ito & Cacioppo, 2000; Weinberg & Hajcak, 2010).

Combined, these results demonstrate that both emotional stimuli and faces can independently modulate the same set of brain regions and ERP components. However, how faces and emotional content interact to determine brain activity is less understood. Studies of emotion often use stimuli from the International Affective Picture Set (IAPS), a large, normatively rated set of pictures (Lang, Bradley, & Cuthbert, 2005). The IAPS can be separated into broad categories of pleasant, unpleasant, and neutral images, as well as more specific sub-categories such as threat in the unpleasant category (e.g., images depicting harm or the potential for harm such as knives or kidnapping scenes), and exciting in the pleasant category (e.g., images of roller coasters or race cars). Within each category, the IAPS contains a large variety of images, both with and without people and faces. The impact of the presence of faces within each category of IAPS images is unclear, though there is evidence that the presence of people, more generally, impacts attentional allocation and psychophysiological response. Ito and Cacioppo (2000) demonstrated that IAPS images containing people attracted more attention and elicited larger LPPs than images that did not contain people. More recently, Weinberg and Hajcak (2010) reported that neutral scenes containing people generate a larger LPP than neutral scenes without people, or neutral objects. In addition, neutral scenes containing people generated a larger LPP than the ostensibly emotional category of pleasant, exciting IAPS images, despite being rated as less arousing and less positive (Weinberg & Hajcak, 2010). This may be partially explained by the presence of faces, because, although exciting images contain people, the faces in such scenes are frequently obscured by sports equipment, are too small to see clearly, or are averted.

Given that human faces are particularly salient compared to other categories of visual stimuli (Batty & Taylor, 2003; Kanwisher & Yovel, 2006; Öhman, 2009), images containing people or faces, even when they are part of a neutral category, seem to capture attention more readily than images that do not contain faces (Ito & Cacioppo, 2000; Weinberg & Hajcak, 2010). Studies of emotion frequently compare pleasant and unpleasant images to neutral images, without an explicit understanding of the impact of faces within those images on attentional allocation and neurophysiological response. Selecting neutral images containing faces as a baseline may reduce the observed impact of emotional stimuli. Conversely, selecting emotional images that contain faces could further increase differences between emotional and neutral categories.

In light of these possibilities, the current study aimed to systematically examine the effect of faces (i.e., present versus absent) on ERPs elicited by both neutral and threatening IAPS images—focusing on the LPP. We planned to examine the additive and interactive effects of emotion and faces, as well as to compare the magnitude of these effects. To our knowledge, previous studies have not examined the impact of faces in both neutral and threatening images during passive viewing. We predicted that the LPP would be sensitive to both the presence of faces and threat content, with threatening images that contain faces eliciting the largest LPP. Further, we expected that the magnitude of the LPP would be increased for threatening images with and without faces, as well as neutral images with faces, relative to neutral images without faces.

METHOD

Participants

A total of 60 undergraduates (28 women) from Stony Brook University participated in the study for course credit. Five participants had poor-quality EEG recordings; thus, 55 participants (26 women) were included in the final EEG analyses. The mean age of the sample was 19.83 ($SD = 2.64$) years. A total of 41.8% of the participants were Caucasian, 16.4% were Asian, 9.1% were African-American, 5.5% were Hispanic, and 27.2% were "Other." This study was approved by the Stony Brook University Institutional Review Board.

Stimuli

Thirty-nine images were selected from the IAPS (Lang et al., 2005). There were 20 neutral images (10 with faces and 10 without) and 19 threat images (10 with faces and 9 without), each presented twice (with the exception of one threat image without faces which was presented four times), for a total of 80 trials. The specific images that were used appear in the Appendix. Images in all categories were selected to be representative of the types of images used in studies comparing threatening to neutral images. Neutral images without faces depicted scenes or buildings, while neutral images with faces featured prominent faces with a neutral expression and a neutral background. Threatening images without faces included hands or figures (no visible face) holding weapons, while threatening images with faces primarily depicted prominent faces in an attack scene. Normative ratings (Lang et al., 2005) indicated that threat images were less pleasant ($M = 2.66$, $SD = 1.63$) than neutral images ($M = 5.23$, $SD = 1.35$), and more arousing ($M = 6.31$, $SD = 2.22$) than neutral images ($M = 3.43$, $SD = 2.00$); higher numbers indicate more pleasant and more arousing ratings. Because previous studies have indicated that LPP magnitude is influenced by subjective arousal ratings (Cuthbert et al., 2000), images with and without faces were matched on normative ratings of arousal, such that there were no significant differences in arousal due to the presence of faces for neutral, $t(18) = 0.42$, $p = .68$, or threat, $t(18) = 0.22$, $p = .83$, images. There were also no differences in valence between neutral images with faces and neutral images without faces, $t(18) = 0.07$, $p = .94$; however, threat images with faces were rated as more negative than threat images without faces, $t(18) = 2.36$, $p = .03$.

Stimuli were presented on a Pentium D computer, using Presentation software (Neurobehavioral Systems, Inc.; Albany, CA, USA). Each image was displayed in color at the full size of the monitor, 48.26 cm. Participants were seated approximately 70 cm from the screen.

Procedure

After verbal instructions indicating that they would be passively viewing images of varying emotional quality, participants were seated, and electroencephalograph sensors were attached. The IAPS images were presented randomly along with other stimuli depicting emotional and neutral faces from the Karolinska (Lundqvist, Flykt, & Öhman, 1998) and NimStim (Tottenham et al., 2009) face sets; only the results for the IAPS images will be reported in the present study.[1] Each trial consisted of the presentation of an image for 1500 ms followed by a variable intertrial interval, consisting of a fixation of between 1500 and 2000 ms. Neutral images with faces, neutral images without faces, threat images with faces, and threat images without faces were presented in a random order. Participants were shown one neutral practice trial prior to the onset of the experiment.

Electroencephalographic recording and data processing

The ActiveTwo BioSemi system (BioSemi, Amsterdam, Netherlands) was used to collect continuous EEG recording with an elastic cap. Based on the 10/20 system, 64 electrode sites were used, along with two electrodes on the right and left mastoids, which were used as reference electrodes. The electrooculogram (EOG) generated from eye movements and eye blinks was recorded by four facial electrodes: Horizontal eye movements were measured via two electrodes located approximately 1 cm outside the outer edge of the right and left eyes. Vertical eye movements and blinks were measured via two electrodes placed approximately 1 cm above and below the right eye.

[1] We ran this study a second time with five individuals, using only the IAPS stimuli (no concurrently presented face stimuli). This study produced comparable results to those presented in the current study.

The EEG signal was pre-amplified at the electrode to improve the signal-to-noise ratio and amplified with a gain of 1 × by a BioSemi ActiveTwo system. The data were digitized at 24-bit resolution with a LSB value of 31.25 nV and a sampling rate of 512 Hz, using a low-pass fifth-order sinc filter with −3 dB cutoff point at 104 Hz. Each active electrode was measured online with respect to a common mode sense (CMS) active electrode, located between PO3 and POz, producing a monopolar (non-differential) channel. CMS forms a feedback loop with a paired driven right leg (DRL) electrode, located between POz and PO4, reducing the potential of the participants and increasing the common mode rejection rate (CMRR). Off-line, all data was referenced to the average of the left and right mastoids, and band-pass filtered with low and high cutoffs of 0.01 and 30 Hz, respectively; eye-blink and ocular corrections were conducted by the algorithm and methods described by Gratton, Coles, and Donchin (1983). A semi-automatic procedure was used to detect and reject artifacts. The criteria applied were a voltage step of more than 50.0 μV between sample points, a voltage difference of 300.0 μV within a trial, and a maximum voltage difference of less than 0.50 μV within 100-ms intervals. These intervals were rejected from individual channels in each trial. Additional visual inspection of the data was conducted to detect and reject remaining artifacts. An average of 2.6 trials per subject were rejected.

The EEG was segmented for each trial, beginning 200 ms prior to picture onset and continuing for 1700 ms (i.e., the entire duration of the picture presentation). For each trial, the baseline was defined as the 200 ms prior to picture onset. ERPs were constructed by separately averaging neutral images with faces, neutral images without faces, threat images with faces, and threat images without faces.

Statistical analyses

The LPP was scored as the overall average of five centro-parietal sites where it has been reported as being maximal: Pz, POz, CPz, CP1, and CP2 (Foti & Hajcak, 2008; Foti et al., 2009; Keil et al., 2002; Schupp et al., 2000). Visual inspection of the present data confirmed that the LPP was maximal at these sites and within these time windows. Previous research has indicated that important differences in the time course of emotional responding may be reflected in different portions of the LPP (Foti & Hajcak, 2008; Foti et al., 2009); therefore, the LPP was scored in three windows following stimulus onset: an early window of 400–800 ms, a middle window of 800–1200 ms, and a later window of 1200–1500 ms.

The effect of threat and face was analyzed for the LPP with a 2 (emotion: neutral versus threat) × 2 (face: presence versus absence) repeated-measures analysis of variance (ANOVA). Statistical analyses were performed with PASW statistics (Version 18.0) general linear model software. Greenhouse–Geisser correction was applied if the assumption of sphericity was violated for the repeated-measures comparisons; *p* values were adjusted by the Bonferroni correction for multiple post-hoc comparisons.

RESULTS

LPP (early window: 400–800 ms)

Grand averaged stimulus-locked ERPs from sites Pz, POz, CPz, CP1, and CP2 for neutral images with and without faces and threat images with and without faces are presented in Figure 1. Figure 2 presents topographical maps depicting voltage differences (in μV) for the effect of face in neutral and threat images (neutral with faces minus neutral without faces, threat with faces minus threat without faces) and for the effect of threat in images with and without faces (threat with faces minus neutral with faces and threat without faces minus neutral without faces) in the time windows of the early, middle, and late portions of the LPP. As suggested by Figures 1 and 2, the overall magnitude of the early window of the LPP was larger in response to images containing faces, $F(1, 54) = 20.61$, $p < .001$, $\eta_p^2 = .28$, as well as to threatening stimuli, $F(1, 54) = 78.81$, $p < .001$, $\eta_p^2 = .59$. There was a significant interaction between face and threat, $F(1, 54) = 16.50$, $p < .001$, $\eta_p^2 = .23$.

Post-hoc comparisons revealed that the magnitude of the early LPP was significantly larger for neutral images with faces than neutral images without faces, $t(54) = 5.49$, $p < .001$, critical *p* value = .01 for four contrasts. However, there were no significant differences in LPP magnitude between threat images with faces and threat images without faces, $t(54) = 0.07$, $p = .95$. Post-hoc comparisons also demonstrated that the LPP elicited by threat images with faces was larger than that elicited by neutral images with faces, $t(54) = 2.59$, $p = .01$, and threat images without faces elicited a larger LPP than neutral images without faces, $t(54) = 5.83$, $p < .001$. Thus, the early portion of the LPP was larger for threatening than neutral images, and the presence of faces increased the amplitude of the early LPP, but only for neutral pictures.

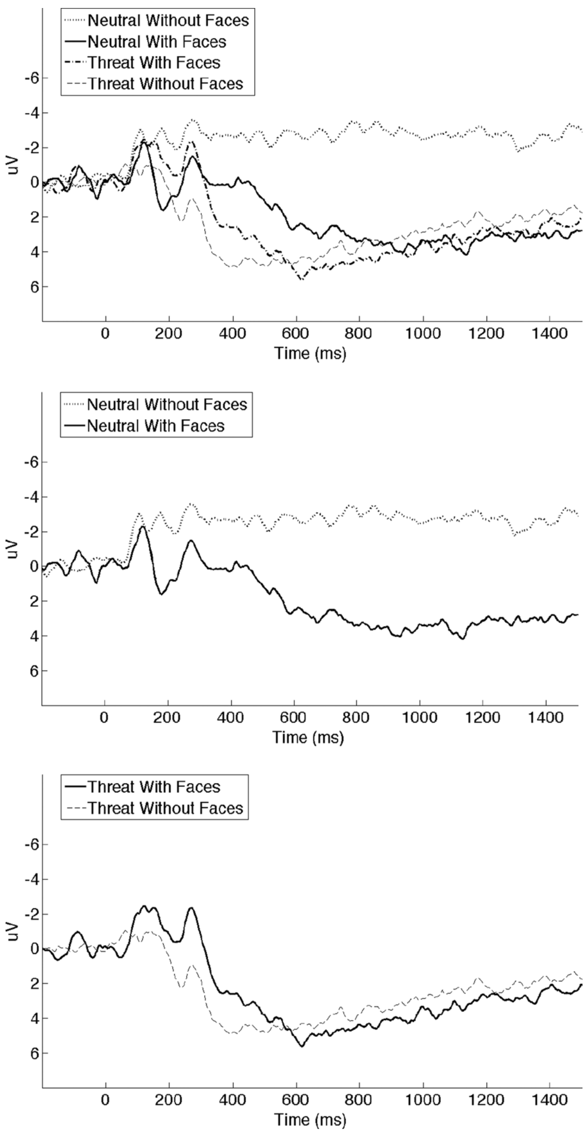

Figure 1. Stimulus locked ERPs averaged at Pz, POz, CPz, CP1, and CP2 for all image categories (neutral without faces, neutral with faces, threat with faces, and threat without faces; top), neutral images alone (neutral without faces and neutral with faces; center), and threat images alone (threat with faces and threat without faces; bottom).

LPP (middle window: 800–1200 ms)

In the middle window, the LPP was again larger in response to images containing faces, $F(1, 54) = 47.30$, $p < .001$, $\eta_p^2 = .47$, as well as to threatening stimuli, $F(1, 54) = 23.17$, $p < .001$, $\eta_p^2 = .30$. There was again a significant interaction between face and threat, $F(1, 54) = 16.61$, $p < .001$, $\eta_p^2 = .24$.

As in the earlier window, post-hoc comparisons indicated that the magnitude of the middle window of the LPP was significantly larger for neutral images with faces than neutral images without faces, $t(54) = 6.52$, $p < .001$, while there was again no difference in the magnitude of the LPP elicited by threat images with faces and threat images without faces, $t(54) = 1.13$, $p = .23$, critical p value = .01 for four contrasts. As in the earlier window, the LPP elicited by threat images without faces was larger than that elicited by neutral images without faces, $t(54) = 5.83$, $p < .001$. However, in this middle time window, threat images with faces no longer elicited a larger LPP than neutral images with faces, $t(54) = .28$, $p = .78$. Thus, similar to the early portion, the middle portion of the LPP was larger for threatening than neutral images, and the presence of faces increased the amplitude of the late LPP, but only for neutral pictures. However, in contrast to the early window, threat images with faces no longer differed from neutral images with faces.

LPP (late window: 1200–1500 ms)

In the late window, faces again appeared to enhance the magnitude of the LPP, $F(1, 54) = 23.66$, $p < .001$, $\eta_p^2 = .31$, as did threatening stimuli, $F(1, 54) = 11.06$, $p < .002$, $\eta_p^2 = .17$. There was again a significant interaction between face and threat, $F(1, 54) = 11.45$, $p < .001$, $\eta_p^2 = .18$.

As in the previous windows, post-hoc comparisons indicated that the magnitude of the late window of the LPP was significantly larger for neutral images with faces than neutral images without faces, $t(54) = 5.16$, $p < .001$, while there was no difference in the magnitude of the LPP elicited by threat images with faces and threat images without faces, $p < .78$, critical p value = .01 for four contrasts. The LPP elicited by threat images without faces was again larger than that elicited by neutral images without faces, $t(54) = 4.18$, $p < .001$. As in the middle window, threat images with faces did not elicit a larger LPP than neutral images with faces, $t(54) = .78$, $p < .44$. Thus, like the early and middle portions, the late portion of the LPP was larger for threatening than neutral images, and the presence of faces increased the amplitude of the late LPP, but only for neutral pictures. In contrast to the early window, threat images with faces did not differ from neutral images with faces in the middle or late window.

DISCUSSION

The current study examined the effect of faces in neutral and threatening IAPS images on the LPP. We hypothesized that both emotion and face content

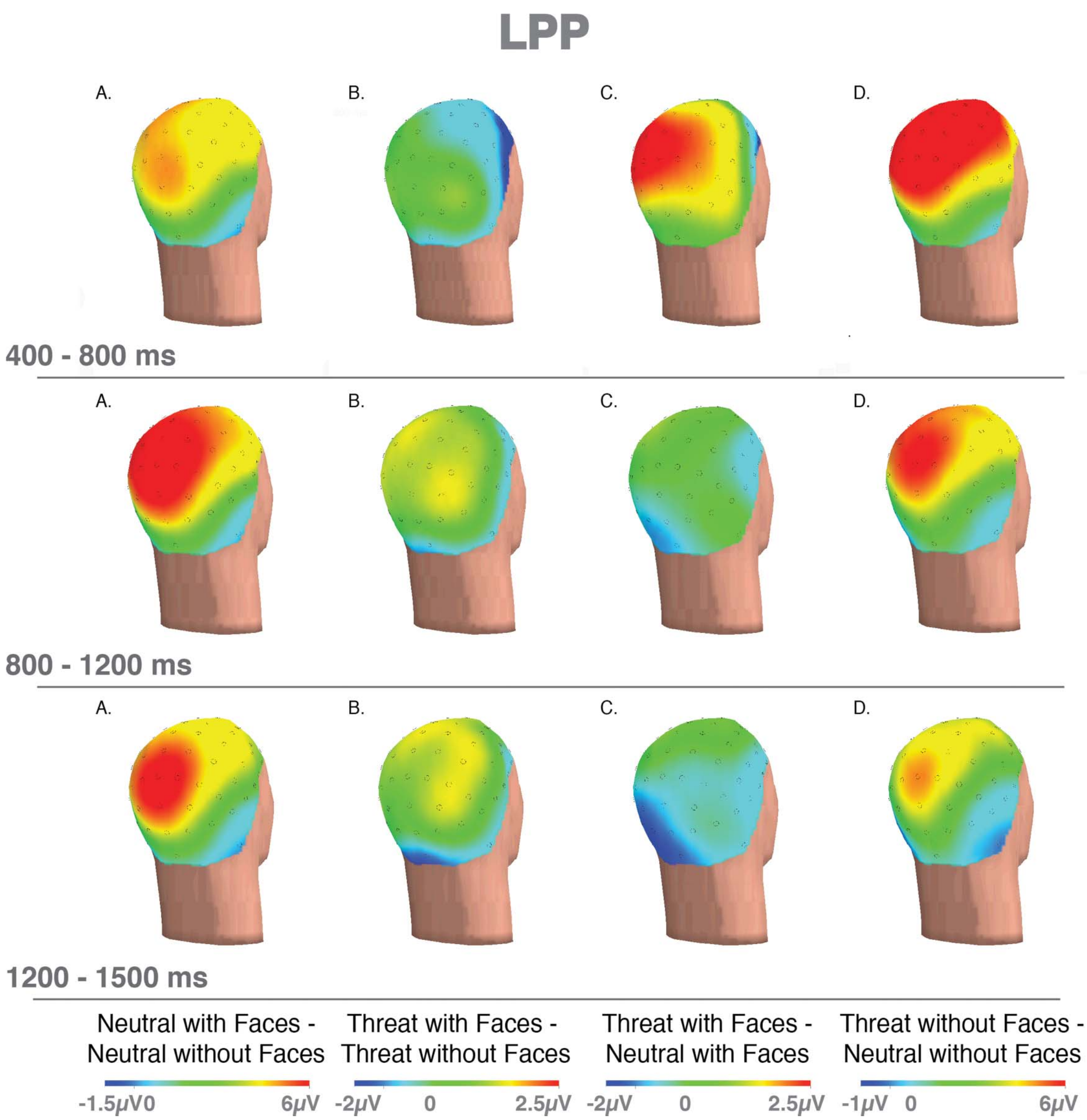

Figure 2. Topographical maps depicting voltage differences in the time range of the early window of the LPP (400–800 ms following stimulus onset; top), during the middle window of the LPP (800–1200 ms following stimulus onset; center), and during the late window of the LPP (1200–1500 ms following stimulus onset; bottom): neutral with faces minus neutral without faces (A), threat with faces minus threat without faces (B), threat with faces minus neutral with faces (C), and threat without faces minus neutral without faces (D).

would enhance the LPP, and that threatening images with faces would produce the largest LPP. As predicted, throughout the duration of the LPP, threatening images with and without faces, and neutral images with faces, elicited larger LPPs than neutral images without faces. However, it was only within the context of neutral images that faces increased the magnitude of the LPP; within threatening images, the magnitude of the LPP was not enhanced by faces.

In the early window of the LPP, between 400 and 800 ms, threat images with and without faces produced larger LPPs than either type of neutral image. In contrast, beyond 800 ms, threatening images and neutral images with faces elicited comparable responses—the magnitude of the LPP to neutral images with faces no longer differed from that of threat images with or without faces. Indeed, after 800 ms, only neutral images without faces significantly differed from the other image categories. This suggests that both threat content and faces in ostensibly neutral images impact sustained allocation of attention and that this impact varies over the time course of the LPP.

The LPP, in particular the later portion of the LPP, is thought to reflect sustained attention to motivationally salient stimuli, including images that are salient due to task demands, such as targets (Ferrari et al., 2008), and images that are inherently salient because they are related to survival or reproduction, such as threat or erotic images (Briggs & Martin, 2009; Weinberg & Hajcak, 2010). Because faces are able to convey critical information related to both physical survival and social success (Haxby et al., 2002; LoBue & DeLoache, 2010), even neutral images containing faces may function as inherently salient stimuli. In this manner, neutral images with faces may capture attention in a way that is similar to emotional images, and distinct from neutral scenes. This enhancement of the LPP to neutral images containing faces was observed despite the fact that neutral images with and without faces were matched on normative ratings of valence and arousal. This finding is consistent with previous studies illustrating an increased LPP to neutral images containing people (Ito & Cacioppo, 2000; Weinberg & Hajcak, 2010). Therefore, the LPP, principally the latter portion of the LPP during which there was no differentiation between threat images and neutral images with faces, appears to respond to the salience of both emotion and face content, despite differences in arousal and valence. These findings complement those from fMRI research, which also suggest a generalized response to salience in regions of the brain such as the amygdala (Britton et al., 2006; Liberzon et al., 2003).

Contrary to our expectations, the LPP was not enhanced by faces in the threat category, demonstrating an important interaction between emotional content and the presence of faces in complex stimuli. Whereas both threat and face content produce a robust LPP, they do not operate in an additive fashion; it is only in the context of neutral images that faces enhance the LPP. However, it is possible that these results are unique to threat stimuli that are highly arousing, and that threat and faces can function additively in the context of less arousing stimuli. Future studies using threat stimuli that reflect a range of intensities may help elucidate the ways in which threat and faces interact to influence the allocation of attention to emotional images. Future studies may wish to collect subjective affect ratings, to ensure that variance in the selected sample is not mediating the observed effects. Finally, future studies could improve the manipulation of the presence of faces by systematically controlling for other potentially salient non-face objects. These studies may also wish to categorize pictures on another non-face dimension in order to better understand the effect of salience on LPP magnitude across picture types.

In sum, these findings illustrate that the presence of faces in complex neutral stimuli can enhance the magnitude of the LPP. The presence of faces in the threat category, however, seems to have less of an impact. Faces within the neutral category appear to impact attentional allocation in a manner similar to highly arousing threat content, resulting in LPPs of comparable magnitude. This suggests that the inclusion of faces in a neutral baseline will reduce the observed difference between emotional and neutral conditions. Neutral images containing faces will likely produce a considerable LPP, which will confound the baseline by increasing the averaged response to neutral images. Controlling for the presence of faces, therefore, particularly within images serving as neutral baselines, may be a critical consideration when using complex emotional stimuli to study emotion.

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APPENDIX

IAPS images used in the present study

- neutral with faces: 2214, 2200, 2280, 2305, 2372, 2383, 2393, 2495, 2510, 2513.
- neutral without faces: 5390, 5471, 5510, 5731, 7491, 7504, 7546, 7547, 7500, 7560.
- threat with faces: 2811, 3530, 6242, 6250, 6312, 6313, 6315, 6560, 6571, 9425.
- threat without faces: 2681, 6190, 6210, 6211, 6230, 6260, 6263, 6300, 6570.