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Tell Me About It: Neural Activity Elicited by Emotional Pictures and Preceding Descriptions

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Emotional pictures elicit enhanced parietal positivities beginning around 300 ms following stimulus presentation. The magnitude of these responses, however, depends on both intrinsic (stimulus-driven) and extrinsic (context-driven) factors. In the present study, event-related potentials were recorded while participants viewed unpleasant and neutral pictures that were described either more neutrally or more negatively prior to presentation; temporospatial principal components analysis identified early and late positivities: Both emotional images and descriptions had independent and additive effects on early (334 ms) and midlatency (1,066 ms) positivities, whereas the latest positivity (1,688 ms) was sensitive only to description type. Results are discussed with regard to the time course of automatic and controlled processing of emotional stimuli.

Keywords: emotion, P300, LPP, emotion regulation, reappraisal

Attention can be directed to stimuli in a top-down, conscious manner (e.g., when looking for a target) or captured automatically by certain types of stimuli. A variety of evidence suggests that emotional stimuli capture attention in a bottom-up manner, presumably because attention to threatening and appetitive stimuli has facilitated survival (Lang, Bradley, & Cuthbert, 1997). Compared to nonemotional stimuli, emotional stimuli are recognized more quickly (Ohman, Flykt, & Esteves, 2001) and are less likely to be missed during target detection tasks (Anderson & Phelps, 2001; Vuilleumier & Schwartz, 2001). In fact, attention can be directed to emotional stimuli in spite of an individual's goals to the contrary (Lang et al., 1997; Vuilleumier, 2005).

Event-related potentials (ERPs)—particularly parietal positivities beginning approximately 300 ms following stimulus presentation—have been used to study top-down and bottom-up effects of attention. The P300 is an early parieto-occipital positivity that has traditionally been associated with top-down manipulations of stimulus significance. For example, when participants are asked to count or otherwise keep track of certain stimuli, these "target" stimuli elicit a larger P300 than nontarget stimuli (e.g., Johnson, 1984, 1986). Furthermore, the magnitude of increase in the P300 is augmented when target stimuli are unexpected or infrequent (Duncan-Johnson & Donchin, 1977; Squires, Donchin, Herning, & McCarthy, 1977); when target and nontarget stimuli are equated for probability, targets still elicit a larger P300 (Duncan-Johnson & Donchin, 1977), suggesting that target status alone is sufficient for increasing P300 amplitude. In line with the notion that the P300 reflects top-down attention, it is also reduced or absent when attention is occupied by a secondary task or when target stimuli are ignored (Duncan-Johnson & Donchin, 1977; Hillyard, Hink, Schwent, & Picton, 1973). Overall, then, this early parieto-occipital positivity appears to index the allocation of capacity-limited attentional resources to motivationally salient stimuli.

The P300 is also sensitive to more bottom-up manipulations of stimulus salience, including the effects of emotion. It is increased following the presentation of emotional compared with neutral pictures (Johnston, Miller, & Burleson, 1986; Keil et al., 2002; Lifshitz, 1966; Mini, Palomba, Angrilli, & Bravi, 1996; Radilová, 1982) and adjectives (Naumann, Bartussek, Diedrich, & Laufer, 1992). The P300 appears larger, then, not only when participants are *told* that stimuli are important (as in the case of target stimuli) but also when emotional content *implies* significance. In the language of the P300, emotional stimuli might be considered *natural targets*.

Emotional pictures and words also elicit an increased late positive potential (LPP): a positive-going ERP that peaks as early as 300 ms at parietal sites and continues for the duration of stimulus presentation (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Dillon, Cooper, Grent-'t-Jong, Woldoff, & LaBar, 2006; Schupp et al., 2000; Schupp, Junghöfer, Weike, & Hamm, 2003, 2004). Indeed, the P300 and the early portion of the LPP appear quite similar in terms of their temporal and spatial characteristics, as well as sensitivity to emotional stimuli (cf. Foti, Hajcak, & Dien, 2009). The LPP, however, is evident at central and even frontal midline sites, with a more broadly superior distribution beginning around 1,000 ms after stimulus presentation (Foti & Hajcak, 2008; Foti et al., 2009; Hajcak, Dunning, & Foti, 2007; Pastor et al., 2008). In contrast to the transient P300, the LPP is evident for up to several seconds in some studies (Cuthbert et al., 2000; Foti & Hajcak, 2008; Hajcak et al., 2007; Hajcak & Olvet, 2008; Pastor et al., 2008), and has been reported in the period following picture offset (Hajcak & Olvet, 2008).

The more sustained nature and frontal scalp distribution of the LPP seem to suggest a distinction from earlier parietal positivities. In fact, recent evidence from temporospatial principal components analysis (PCA) has supported this differentiation: Foti and col-

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leagues (in press) identified spatially and temporally distinct factors corresponding to early and late positivities during passive viewing of emotional pictures. Although these positivities were similarly augmented in response to emotional pictures, they were characterized by unique temporospatial factors that varied across the scalp; in particular, later positivities were maximal at central sites, whereas earlier factors had maxima at parietal and occipital sites. These data suggest that early and late positivities likely reflect distinct, but overlapping, ERP components sensitive to emotional stimuli. On the basis of the shorter duration of early positivities and their sensitivity to nonemotional manipulations, it is possible that they may primarily index initial allocation of attention to motivationally salient stimuli; by contrast, later positivities appear to reflect more *elaborated* processing related to the significance and meaning of stimuli (cf. Olofsson, Nordin, Sequeira, & Polich, 2008; Schupp, Flaisch, Stockburger, & Junghöfer, 2006).

Several studies have shown that it is possible to modulate the emotional significance of stimuli by manipulating the context in which they are presented. For example, Smith, Dolan, and Rugg (2004) found that during a source memory task, neutral pictures previously embedded in pleasant or unpleasant pictures elicited larger late-onset parietal positivities compared with those embedded in neutral pictures. Similarly, Maratos and Rugg (2001) found that neutral words previously learned in a negative context elicited a sustained parietal positivity. Studies using fMRI have found similar results: Words or objects presented in emotional contexts were later associated with increased activation in neural regions associated with emotional processing and retrieval (e.g., Maratos, Dolan, Morris, Henson, & Rugg, 2001; Smith, Henson, Dolan, & Rugg, 2004). All of these studies, however, varied the context of neutral stimuli, and all examined neural activity during recognition following memory tasks. By manipulating both picture content and context and examining ERPs immediately following stimuli presentation, Righart and de Gelder (2008) found that fearful backgrounds elicited larger early ERPs for both happy and fearful faces.

The preceding studies collectively suggest that it is possible to modify the emotional significance of stimuli by manipulating the context in which they are presented. In fact, people are capable of altering the context of emotion by changing the way they think about emotional information, that is, by changing the meaning attributed to emotional stimuli; this process has been referred to as *cognitive reappraisal* (cf. Gross, 1998, 2002). One way people may accomplish cognitive reappraisal is by telling themselves an alternative story about emotional events (Gross, 1998, 2002). Along these lines, Kim and colleagues (2004) presented participants with pictures of surprised faces preceded by descriptions that were either positive or negative (e.g., "She just found $500" or "She just lost $500"). They found that faces presented in a negative context elicited greater ventral amygdala activity than faces presented in a positive context, suggesting that the emotional context affects neural response to subsequently presented visual stimuli.

To explore whether contextual manipulations can modulate response to *unpleasant* stimuli using ERPs, Foti and Hajcak (2008) provided participants with auditory descriptions of upcoming unpleasant and neutral images before they appeared on the screen. Unpleasant images were preceded by a description that framed the picture either more negatively or more neutrally; neutral images were always preceded by a neutral description. Results indicated that unpleasant images preceded by neutral descriptions elicited smaller parietal positivities than unpleasant images preceded by negative descriptions (Foti & Hajcak, 2008), suggesting that it is possible to modulate the electrocortical response to unpleasant pictures by describing them less negatively.

Because the Foti and Hajcak (2008) study did not manipulate the emotional context that preceded *neutral* pictures, however, a direct comparison of the time course and magnitude of neural activity elicited by intrinsic (i.e., picture type) and extrinsic (i.e., description type) factors was not possible. In addition, because only unpleasant pictures were preceded by both kinds of descriptions, it is not clear whether modulation of ERP amplitude was due to meaning change or to another mechanism such as cognitive load: it is possible that assimilating a neutral description with an unpleasant picture required more cognitive effort than incorporating congruent picture and description types. The present study used a similar design as Foti and Hajcak (2008), but by fully crossing description (neutral, negative) and picture type (neutral, unpleasant), we aimed to compare the relative effects of extrinsic and intrinsic factors on ERP components and to better characterize the mechanisms behind extrinsic effects. Furthermore, because both window and peak identification of ERPs ignore substantial overlap in waveforms (Donchin & Heffley, 1979) and render it difficult to identify components that share temporal and spatial characteristics, we employed temporospatial PCA to derive components in a "bottom-up" fashion, without collapsing over temporal or spatial data points a priori.

As an index of rapid and initial attentional allocation, we hypothesized that early parietal positivities would be modulated primarily by picture type (with unpleasant pictures eliciting larger amplitudes than neutral pictures). However, as an index of deeper evaluative processing, later positivities should be sensitive mainly to description type (with negatively described pictures eliciting larger late positivities than neutrally described pictures). Furthermore, because both intrinsic and extrinsic factors alter the *emotional significance* of the stimulus, we hypothesized that effects would operate additively to influence ERP amplitudes.

Method

Participants

Thirty-three undergraduate students (14 men, 19 women) participated in the study. One participant felt unwell and was unable to complete the task, and 2 participants were excluded from analysis because of poor quality recordings. Data from 30 participants (13 men, 17 women) were included in the final analysis. All participants received course credit.

Stimulus Materials

One hundred pictures were selected from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2005). There were 50 unpleasant pictures (e.g., war scenes, sad faces) and 50 neutral images (e.g., household objects, neutral faces). Normative ratings indicated that the unpleasant pictures were less pleasant (valence $M = 2.88$, $SD = 1.74$) than the neutral pictures ($M =$

4.78, $SD = 1.31$; higher numbers indicate more pleasant ratings), and were more emotionally arousing ($M = 5.63$, $SD = 2.18$, vs. $M = 3.51$, $SD = 1.99$, for neutral pictures; higher numbers indicate higher arousal).[1]

Before seeing each picture, participants heard a brief auditory description of the upcoming picture through headphones. Prior to half of the neutral images, participants heard a neutral description (e.g., "These people are boarding an early morning flight"); the remaining 25 neutral images were preceded by a negative description (e.g., "This plane was the target of a terrorist bomb"). Likewise, participants heard a neutral description before half of the unpleasant images (e.g., "This solider notices the child and does not shoot") and a negative description before the remaining 25 unpleasant images (e.g., "This child is about to be shot and killed by a solider"). Each image was presented once; the description for each picture (negative or neutral) was chosen pseudorandomly such that exactly 50% of the neutral and unpleasant pictures were preceded by neutral descriptions. The order of stimuli presentation was random for each participant. A list of the neutral images and corresponding descriptions is provided in the Appendix; unpleasant images and descriptions can be found in Foti and Hajcak (2008).

Auditory and visual stimuli were presented on a Pentium D computer, using Presentation software (Neurobehavioral Systems, Inc., Albany, CA). Prior to each trial, participants viewed a white fixation cross on a black background for 6,000 ms while they listened to an auditory description (2,000–5,000 ms) of the upcoming image. Each picture was displayed in color for 3,000 ms at the full size of the monitor (48.26 cm). Participants were seated approximately 60 cm from the screen and the images occupied about 40° of visual angle horizontally and vertically. Following the presentation of each image, the participant rated the picture using the Self-Assessment Manikin along the valence and arousal dimensions (Lang, 1980).

Procedure

Following a verbal introduction indicating that they would be viewing pictures of varying emotional quality, participants were seated and electroencephalograph sensors were attached. Prior to the start of the task, participants were given more detailed instructions indicating that they would hear a brief auditory description of each picture before it appeared on the screen. Participants were told that following picture presentation, they would be asked to rate each image on two visual analogue scales (Lang, 1980). The valence scale had five characters that ranged from happy to unhappy; the numbers 1 through 9 were presented below the characters, with the number 1 corresponding to the *most happy* figure and 9 corresponding to the *most unhappy* figure. Participants were instructed to use this scale to rate the extent to which they felt pleasant or unpleasant emotions in response to the picture. The arousal scale, which ranges from excited to calm, also depicted five characters displaying a strong visceral response to no visceral response; the numbers 1 through 9 were again presented below the characters. Participants were told to rate the strength of their emotional response to the picture, where 1 represented a *strong visceral* response (e.g., stimulated, jittery, wide awake) and 9 represented a *nonvisceral* response (e.g., relaxed, calm, dull, sleepy). On both of the scales, 5 represented the midpoint between the two endpoints, and participants were encouraged to use any point on the scale. For presentation purposes here, both sets of ratings have been reverse-scored so that a score of 9 represents pleasant valence and high arousal.

Participants performed one practice trial to familiarize themselves with the procedure and to ensure that they understood how to use the rating scales. Following the practice trial, all participants performed 100 trials of 50 unpleasant and 50 neutral pictures, with breaks after every 25 trials.

Electroencephalographic Recording

Continuous EEG was recorded using an elastic cap and the ActiveTwo BioSemi system (BioSemi, Amsterdam, the Netherlands). Sixty-four electrode sites were used, based on the 10/20 system, as well as 1 electrode on each of the left and right mastoids. Four facial electrodes recorded the electrooculogram generated from eyeblinks and eye movements: vertical eye movements and blinks were measured with two electrodes placed approximately 1 cm above and below the right eye; horizontal eye movements were measured with two electrodes placed approximately 1 cm beyond the outer edge of each eye. Online data were referenced according to BioSemi's design, which replaces the ground electrode used in conventional systems with two electrodes (the common mode sense active electrode and the driven right leg passive electrode); these electrodes form a feedback loop, driving the common mode potential of the participant down and reducing the effective impedance of the ground.

The EEG was digitized using ActiView software (BioSemi, Amsterdam, the Netherlands) at 512 Hz. Offline analyses were performed using Brain Vision Analyzer (Brain Products, Gilching, Germany). Data were rereferenced to the average of the two mastoids and band-pass filtered with low and high cutoffs of 0.1 and 30 Hz, respectively. The EEG was segmented for each trial beginning 500 ms prior to picture onset and continuing for 3,500 ms (the entire picture duration). For each trial, the baseline was defined as the 500 ms prior to picture onset.

Eyeblink and ocular corrections were made using the method developed by Gratton, Coles, and Donchin (1983). Noisy data due to technical problems on isolated electrodes necessitated the replacement of data from PO4 in 2 participants, F2 in 1 participant, and Oz in 1 participant. In addition, a technical malfunction with TP8 required its removal from 21 participants. Data were interpolated from the closest four electrodes in each case.

Artifact analysis identified a voltage step of more than 50.0 μV between sample points, a voltage difference of 300.0 μV within a

[1] In terms of picture complexity, 25 unpleasant (1050, 1302, 1930, 1201, 2120, 2130, 2399, 2661, 2710, 2716, 2750, 2810, 3168, 3220, 3301, 6020, 6190, 6250, 6570.1, 8230, 9042, 9490, 9600, 9635.1, 9800) and 26 neutral (2104, 2210, 2221, 2280, 2385, 2440, 2441, 2446, 2890, 5530, 6150, 7000, 7025, 7030, 7034.1, 7043, 7050, 7054, 7056, 7060, 7100, 7110, 7170, 7705, 7920, 9210) pictures had a relatively simple figure-ground composition. Forty unpleasant (1201, 2120, 2130, 2141, 2205, 2399, 2661, 2683, 2688, 2691, 2700, 2710, 2716, 2750, 2810, 3168, 3220, 3301, 6190, 6212, 6250, 6312, 6313, 6570.1, 6571, 6830, 6831, 8230, 9042, 9050, 9250, 9400, 9421, 9425, 9490, 9520, 9584, 9635.1, 9800, 9921) and 27 neutral pictures (2038, 2104, 2191, 2210, 2221, 2280, 2357, 2381, 2385, 2393, 2396, 2440, 2441, 2446, 2480, 2595, 2840, 2870, 2890, 3210, 7493, 7620, 7640, 9210, 9635.2, 9700, 9913) contained people.

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. The number of artifacts did not vary systematically by either picture or description type.[2] Statistical analyses were performed using SPSS (Version 16.0) General Linear Model software.

Results

Figure 1 presents the average ERPs at representative midline recording sites elicited by neutral and unpleasant pictures (left), as well as pictures preceded by neutral and negative descriptions (right). An early positivity can be observed at parieto-occipital sites (Johnson, 1993), peaking between 300 and 400 ms at POz, with unpleasant pictures and negative descriptions eliciting larger amplitudes than neutral pictures and descriptions, respectively. A later positivity is also evident at parieto-occipital sites (as has been found in other studies; Foti & Hajcak, 2008; Keil et al., 2002), beginning about 500 ms following picture onset at POz and peaking around 1,000 ms. An effect of picture is visible during the very beginning of this component. From about 700 ms onward, a late positivity is visible at central sites (i.e., Cz), as has been observed in other studies (Cuthbert et al., 2000; Foti & Hajcak, 2008; Hajcak et al., 2007). Both unpleasant pictures and negative descriptions elicited larger amplitudes than neutral pictures and neutral descriptions, respectively, during this midlatency positivity. At frontal sites (i.e., AFz), the effect of description type was comparatively larger than the effect of picture type on the late positivity, particularly between 1,500 and 2,000 ms, with negative descriptions eliciting larger amplitudes than neutral descriptions.

PCA

ERP components of interest were quantified using temporospatial PCA, and all subsequent presentation of data is based on this approach. PCA extracts linear combinations of data that distinguish patterns of electrocortical activity across all time points and electrode sites. Conditions were created by collapsing across each set of 25 trials to yield four conditions (i.e., averages) per participant: neutral images following neutral descriptions, neutral images following negative descriptions, unpleasant images following neutral descriptions, and unpleasant images following negative descriptions. A temporal PCA was first performed on the data (as recommended by Dien & Frischkoff, 2005), using all 1,792 time points (512 samples per second multiplied by a total trial-plus-baseline length of 3,500 ms) per trial as variables and considering as observations all 30 participants, 64 channels, and four conditions. The temporal PCA was followed by a spatial PCA that used recording sites (electrodes) as variables and all participants, conditions, and temporal factor scores as observations.

Each resulting temporospatial factor is described by spatial factor loadings that represent linear contributions of recording sites, a *virtual site* so to speak, for a given temporal factor (which itself is described by linear combinations of time points and represents a *virtual epoch*). Factor scores quantify each factor across participant and condition, and in this sense they are an effort to obtain a summary measure of each EPR component. These summary measures can be translated back into voltages by multiplying the factor scores by the appropriate spatial and temporal loadings (for the desired channel and time point) and the corresponding spatial and temporal standard deviations (Dien, Spencer, & Donchin, 2003).

The PCA was conducted using the ERP PCA Toolbox (Version 1.093; Dien, 2004) for MatLab (The MathWorks, Inc., Natick, MA) and the covariance matrix and Kaiser normalization (as per Dien, Beal, & Berg's, 2005, suggestions). The temporal PCA yielded 11 factors based on the resulting scree plot (Cattell, 1966; Cattell & Jaspers, 1967). These were submitted to Promax rotation (the preferred rotation for this step according to simulation results by Dien, Khoe, & Mangun, 2007). Following this, a spatial PCA was performed on each temporal factor and Infomax was used to rotate to independence in the spatial domain (as per Dien et al.'s, 2007, simulations). Five spatial factors were extracted for each temporal factor, yielding a total of 55 temporospatial factor combinations. Of these, 28 factors accounted for more than 1% of the variance each and were retained for further examination. To directly assess timing and spatial voltage distributions, we then translated the factors back into voltages.

Although some earlier ERP components such as the N1, P1, P200, and early posterior negativity (EPN) have also been shown to be sensitive to emotional stimuli (Brosch, Sander, Pourtois, & Scherer, 2008; Foti et al., 2009; Junghöfer, Bradley, Elbert, & Lang, 2001; Pourtois, Grandjean, Sander, & Vuilleumier, 2004; Schupp, Stockburger, et al., 2006), a variety of other influences such as picture complexity and size have been implicated in the modulation of these earlier components (Bradley, Hamby, Löw, & Lang, 2007; Codispoti, Ferrari, & Bradley, 2007; De Cesarei & Codispoti, 2006). We chose to focus on positivities in the 300-ms range and beyond because they do not appear to be sensitive to low-level perceptual differences between stimuli (Bradley et al., 2007; Codispoti et al., 2007; De Cesarei & Codispoti, 2006). On the basis of their temporal and spatial similarity with previous work on early and late positivities, we selected five factors for further statistical analysis: an early parieto-occipital positivity peaking at 334 ms; centroparietal, parieto-occipital, and frontal positivities peaking at 1,066 ms; and a frontal positivity peaking at 1,688 ms. Table 1 presents the results of a 2 (description type: neutral, negative) $\times$ 2 (picture type: neutral, unpleasant) repeated measures analysis of variance conducted on factor scores from the five temporospatial factors of interest.

Figure 2 (left) presents the spatial distribution of voltage differences (i.e., topographic maps, in μV) for significant main effects for each factor; factor waveforms for significant main effects at peak channels are presented in Figure 2 (middle). Finally, Figure 2 (right) presents factor scores for each condition. An early positivity peaked at 334 ms and, as can be seen in Figure 2a (left), had a parieto-occipital scalp distribution consistent with past research (e.g., Johnson, 1993; Keil et al., 2002). Figure 2a (middle) depicts

[2] The number of artifacts per condition was as follows: neutral pictures preceded by neutral descriptions, $M = 12.57$, $SD = 12.96$; neutral pictures preceded by negative descriptions, $M = 12.10$, $SD = 14.40$; unpleasant pictures preceded by neutral descriptions, $M = 19.27$, $SD = 29.88$; unpleasant pictures preceded by negative descriptions, $M = 16.83$, $SD = 25.47$. A 2 (description type: neutral, negative) $\times$ 2 (picture type: neutral, unpleasant) repeated measures analysis of variance confirmed that the number of artifacts did not vary as a function of picture or description type (all ps $> .125$).

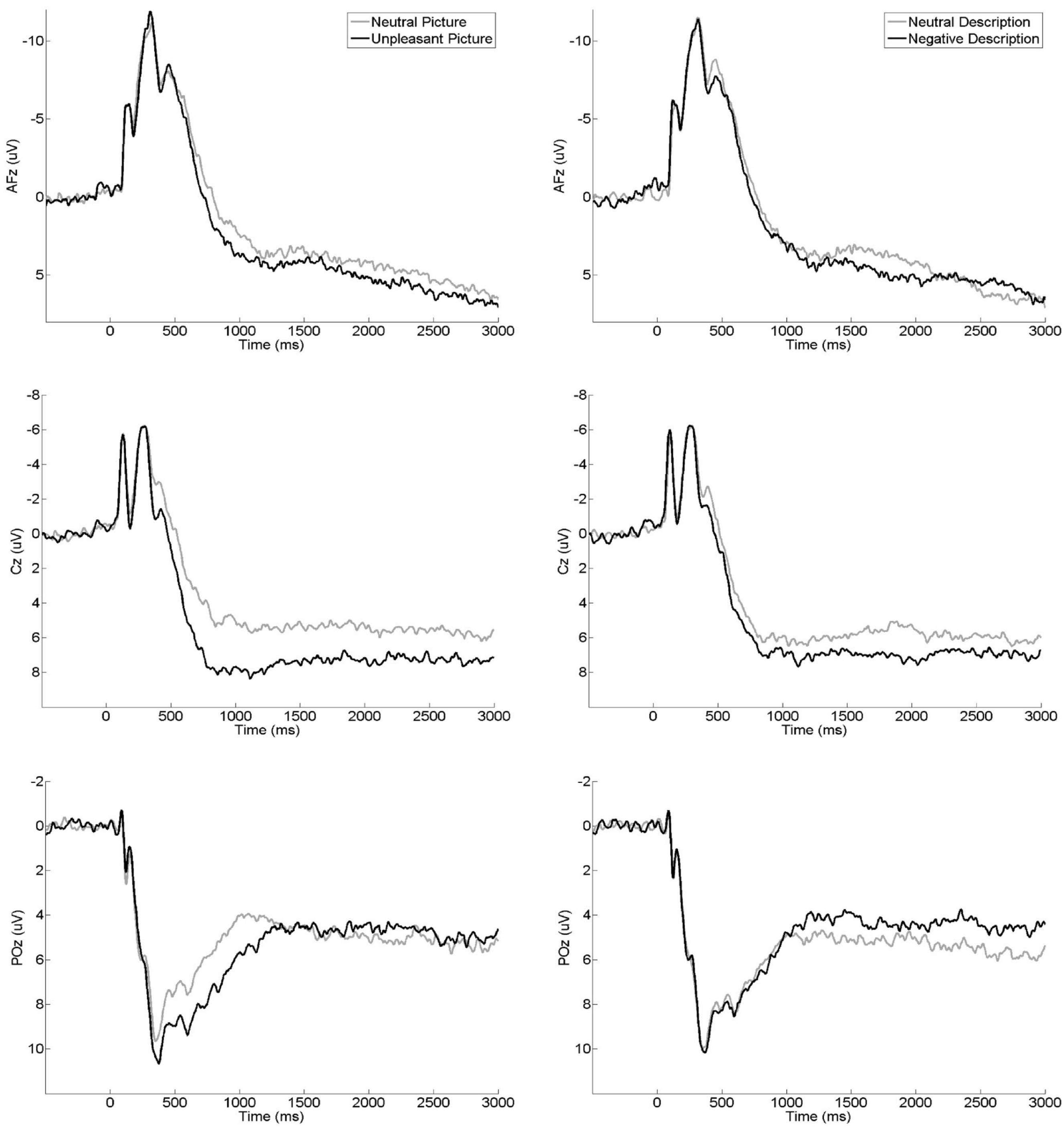

Figure 1. Grand average waveforms (in μV) for neutral and unpleasant pictures collapsed across description type (left) and neutral and negative descriptions collapsed across picture type (right) at AFz (top), Cz (middle), and POz (bottom).

the significant main effects of picture (top) and description type (bottom) on this factor, with unpleasant pictures and negative descriptions evoking larger (more positive) factor waveforms than neutral pictures and descriptions, respectively. The interaction between picture and description type did not reach significance, although as is suggested by the bar graph in Figure 2a (right), this interaction trended toward significance ($p = .051$).

Three factors shared a temporal latency of 1,066 ms, but differed in their scalp distribution. As depicted in Figure 2b (left), a centroparietally maximal positivity emerged, consistent with past

Table 1
Description and Analysis of Variance Results for Each Temporospatial Factor

Temporospatial factor	Peak loading (ms)	Spatial distribution	Main effect of picture type F (η_p^2)	Main effect of description type F (η_p^2)	Picture type × Description type F
TF2SF2	334	Parieto-occipital	23.74*** (.45)	4.65* (.14)	4.16
TF3SF3	1,066	Central	28.30*** (.49)	6.16* (.18)	1.01
TF3SF2	1,066	Parieto-occipital	16.38** (.36)	<1	<1
TF3SF1	1,066	Frontal	21.99*** (.43)	2.64	<1
TF6SF1	1,688	Frontal	<1	7.43* (.20)	<1

Note. $df = 1, 29$.
* $p < .05$. ** $p < .001$. *** $p < .0001$.

research (e.g., Foti et al., 2009; Hajcak et al., 2007) and, like the early parieto-occipital factor, this component was modulated by two main effects, depicted in Figure 2b for unpleasant and neutral pictures (Figure 2b, top) and for negative and neutral descriptions (Figure 2b, bottom). As is evident from the bar graph (Figure 2b, right), both unpleasant pictures and negative descriptions operated additively to increase scores for this centroparietal factor; the effect of picture type did not vary by preceding description type.

Another factor peaked at 1,066 ms and was largest at parieto-occipital sites. The topographic map in the left column of Figure 2c reveals a similar pattern of spatial activation as the early parieto-occipital factor (Figure 2a, left). This later parieto-occipital factor was sensitive to picture type, with unpleasant pictures evoking larger (more positive) voltages, as is evident in the factor waveform and bar graph (Figure 2c, middle and right, respectively). This factor was not affected by description type, and the interaction between picture and description type did not approach significance.

A third positivity peaked at 1,066 ms and resembled the frontal distribution of the LPP (e.g., Cuthbert et al., 2000; Foti et al., 2009; Hajcak & Olvet, 2008; Pastor et al., 2008). This positivity was sensitive to picture type, with unpleasant pictures evoking larger (more positive) voltage, as is evident from the factor waveforms (Figure 2d, middle) and bar graph (Figure 2d, right). The effect of description type and the interaction between description and picture type were not significant.

The latest peaking factor was maximal at 1,688 ms and was largest at frontal sites, as has been found regarding the later portions of the LPP in previous work (e.g., Cuthbert et al., 2000; Foti et al., 2009; Hajcak et al., 2007; Hajcak & Olvet, 2008; Pastor et al., 2008). As can be seen in Figure 2e (left), this factor had a similar spatial distribution to the earlier frontal factor (Figure 2d, left). Unlike the earlier factor, however, this latest factor was only sensitive to description type, as is depicted in the factor waveform and in the bar graph in Figure 2e (middle and right, respectively). Negative descriptions elicited a larger (more positive) amplitude than neutral descriptions regardless of picture type.

Self-Report Ratings

Table 2 presents means and standard deviations for self-report ratings of valence and arousal for each trial type. Ratings were subjected to a 2 (description type: neutral, negative) × 2 (picture type: neutral, unpleasant) repeated measures analysis of variance. Valence ratings were lower (more negative) overall for unpleasant pictures, $F(1, 29) = 53.16$, $p < .001$, $\eta_p^2 = .65$, and for pictures that followed negative descriptions, $F(1, 29) = 73.14$, $p < .001$, $\eta_p^2 = .72$. In addition, there was a significant interaction between description and picture type, $F(1, 29) = 30.22$, $p < .001$, $\eta_p^2 = .51$. A Bonferroni-corrected post hoc comparison (critical $p = .025$) indicated that the difference between negative and neutral descriptions was larger for neutral than unpleasant pictures, $t(29) = 5.50$, $p < .0001$. That is, description type had less of an effect on valence ratings for unpleasant compared with neutral pictures.

Arousal ratings were higher overall (more arousing) for unpleasant as compared with neutral images, $F(1, 29) = 39.57$, $p < .001$, $\eta_p^2 = .58$, and for pictures that followed negative as compared with neutral descriptions, $F(1, 29) = 75.23$, $p < .001$, $\eta_p^2 = .72$. In addition, there was a significant interaction between description and picture type, $F(1, 29) = 33.45$, $p < .001$, $\eta_p^2 = .54$. A Bonferroni-corrected post hoc comparison (critical $p = .025$) again indicated that description type had less of an effect on arousal ratings for unpleasant compared to neutral pictures, $t(29) = 5.78$, $p < .0001$.[3]

To examine whether the effects of picture and description type on temporospatial factor scores correlated with self-report data, we calculated difference scores between unpleasant and neutral pictures (collapsed across description type) for each factor; this was also done for both the valence and arousal self-report ratings. Difference scores for the effect of picture type on arousal ratings had a range of 5.52 ($SD = 1.11$); for valence ratings, the range was 2.80 ($SD = 0.68$). We conducted two sets of bivariate correlations, corrected for five tests each, using a Bonferroni-corrected significance level (critical $p = .01$) between arousal and valence difference scores and difference scores for each of the temporospatial factors. No correlations were significant (all *p*s > .18). Next, difference scores were calculated between negative and neutral descriptions (collapsed across picture type) for each factor and each self-report rating. Difference scores for the effect of description type on arousal ratings had a range of 5.04 ($SD = 1.30$); for

[3] For the valence ratings, 29 of 30 participants rated neutral pictures preceded by negative descriptions more negatively than those preceded by neutral descriptions, and 28 did so for unpleasant pictures (with 1 participant giving both kinds of pictures equivalent ratings). For the arousal ratings, 29 participants rated neutral pictures preceded by negative descriptions more strongly than those preceded by neutral descriptions, and 27 participants did so for unpleasant pictures (with 1 participant giving both kinds of pictures equivalent ratings).

valence ratings, the range was 3.20 ($SD = 0.98$). Again, using a Bonferroni-corrected significance level for five tests, correlations between difference scores for factors and self-report data were not significant (all $ps > .075$).

Discussion

To investigate the relative contributions of intrinsic (i.e., picture content) and extrinsic (i.e., contextual) effects on neural response to affective stimuli, the present study examined ERPs elicited by neutral and unpleasant pictures that were preceded by either neutral or negative descriptions. Consistent with previous studies, an examination of ERP waveforms revealed a sustained positive deflection beginning around 300 ms that appeared generally larger following unpleasant pictures (Cuthbert et al., 2000; Dillon et al., 2006; Foti et al., 2009; Hajcak et al., 2007; Schupp et al., 2000) and negative descriptions (Foti & Hajcak, 2008). To better differentiate the influence of intrinsic and extrinsic factors on early and late positivities, we analyzed ERP data using temporospatial PCA.

The spatial and temporal distributions of factors identified in the present study are consistent with past research (Cuthbert et al., 2000; Foti & Hajcak, 2008; Foti et al., 2009; Hajcak et al., 2007; Hajcak & Olvet, 2008; Johnson, 1993; Keil et al., 2002; Pastor et al., 2008; Sutton, Braren, Zubin, & John, 1965): an early positivity was reflected by a parieto-occipital component that peaked 334 ms following stimulus presentation; later positivities were evident at centroparietal, parieto-occipital, and frontal recording sites (maximal at 1,066 ms and 1,688 ms). These data are in line with previous suggestions that the scalp-recorded positivity that is larger for emotional than neutral stimuli may comprise several underlying and overlapping components distributed along the midline (Foti et al., 2009).

Both the early positivity that peaked at 334 ms and the centroparietal positivity that peaked at 1,066 ms were larger both for unpleasant compared with neutral pictures and for negative compared with neutral descriptions. However, both frontal and parieto-occipital positivities peaking at 1,066 ms were larger for unpleasant than neutral pictures, but were not sensitive to whether the preceding description was neutral or negative. Moreover, the later and more frontal factor that peaked at 1,688 ms was larger following only negative compared with neutral descriptions and was not sensitive to the type of picture presented. Collectively, these results suggest a complex cascade of influences on stimulus-elicited positivities: both intrinsic (picture type) and—contrary to our hypotheses—extrinsic (description type) factors influenced early and midlatency positive-going components; as predicted, extrinsic effects were solely responsible for modulation of the latest positivity.

The present results are in line with previous work demonstrating larger parietal positivities to stimuli presented in emotional contexts (Foti & Hajcak, 2008; Maratos & Rugg, 2001; Smith, Dolan, & Rugg, 2004). Unlike previous work, however, that embedded stimuli in emotional pictures or sentences (Maratos et al., 2001; Maratos & Rugg, 2001; Righart & de Gelder, 2008; Smith, Dolan, & Rugg, 2004; Smith, Henson, et al., 2004), the present study and that of Foti and Hajcak (2008) used auditory descriptions presented *before* picture onset. Although auditory descriptions may better approximate cognitive reappraisal, it is important to recognize that intrinsic (visual) and extrinsic (auditory) manipulations in this paradigm were presented in different modalities. Future ERP studies might eliminate such modality differences by presenting written descriptions of upcoming pictures, or by manipulating the meaning of one picture using a different picture (cf. Kim et al., 2004). Unlike previous work (Foti & Hajcak, 2008; Kim et al., 2004; Righart & de Gelder, 2008), the present study manipulated the contextual significance of both neutral and emotional pictures, and examined neural response immediately following picture presentation rather than in a subsequent memory task (Maratos et al., 2001; Maratos & Rugg, 2001; Smith, Dolan, & Rugg, 2004; Smith, Henson, et al., 2004).

Although efforts were made to minimize low-level perceptual differences between neutral and unpleasant pictures, neutral pictures were less likely to contain people than unpleasant pictures. Neutral pictures containing people do appear to elicit larger parietal positivities than neutral pictures without people (Schupp, Cuthbert, et al., 2004). In the present study, pictures containing people were just as likely to be described negatively as neutrally. Accordingly, this potential confound regarding more frequent people in unpleasant than neutral pictures applies to the effect of picture type, but not description type. Better control over content differences between unpleasant and neutral pictures would have strengthened the design of the current experiment; in addition, controlling for the number of times particular stimuli were paired with negative or neutral contexts across the study would have provided an additional means of minimizing Type I error. Nevertheless, the fact that both unpleasant pictures and negative descriptions similarly increased the amplitude of parietal positivities seems to suggest that electrocortical responses are primarily modulated by stimulus meaning.

Although the present study found evidence for an effect of description type as early as 334 ms following picture presentation, this effect was substantially smaller ($\eta_p^2 = .14$) than the effect of picture type ($\eta_p^2 = .45$); the effect of description type, however, increased later in the ERP epoch (reaching a maximum $\eta_p^2 = .20$ at 1,688 ms). This is consistent with the Foti and Hajcak (2008) study, in which unpleasant pictures that were described neutrally elicited increased positivities (compared with neutral pictures) until about 1,000 ms; *after* 1,000 ms, however, extrinsic effects dominated and positive amplitudes to unpleasant pictures and neutral pictures did not differ.

In addition to the effects on ERP data, both picture and description type modulated self-report ratings of valence and arousal. Participants rated unpleasant pictures and negatively described pictures as less pleasant and more emotionally arousing than neutral pictures and neutrally described pictures, respectively. Thus, intrinsic and extrinsic effects modulated the perceived emotionality of pictures in a manner similar to ERP amplitude. We did not find a correlation between the degree of change in self-report ratings and ERP factor scores—a finding that is both consistent with (Foti & Hajcak, 2008) and contradicts (Hajcak & Nieuwenhuis, 2006) past research. There are several reasons why this may be the case, from intermediary variables contributing to variance in self-report (e.g., emotional awareness, memory, accuracy in translating emotions into numerical report, and motivation to report emotions) to potential ceiling or floor effects associated with scale-based responding. Indeed, there was a rather narrow range of difference scores for both the

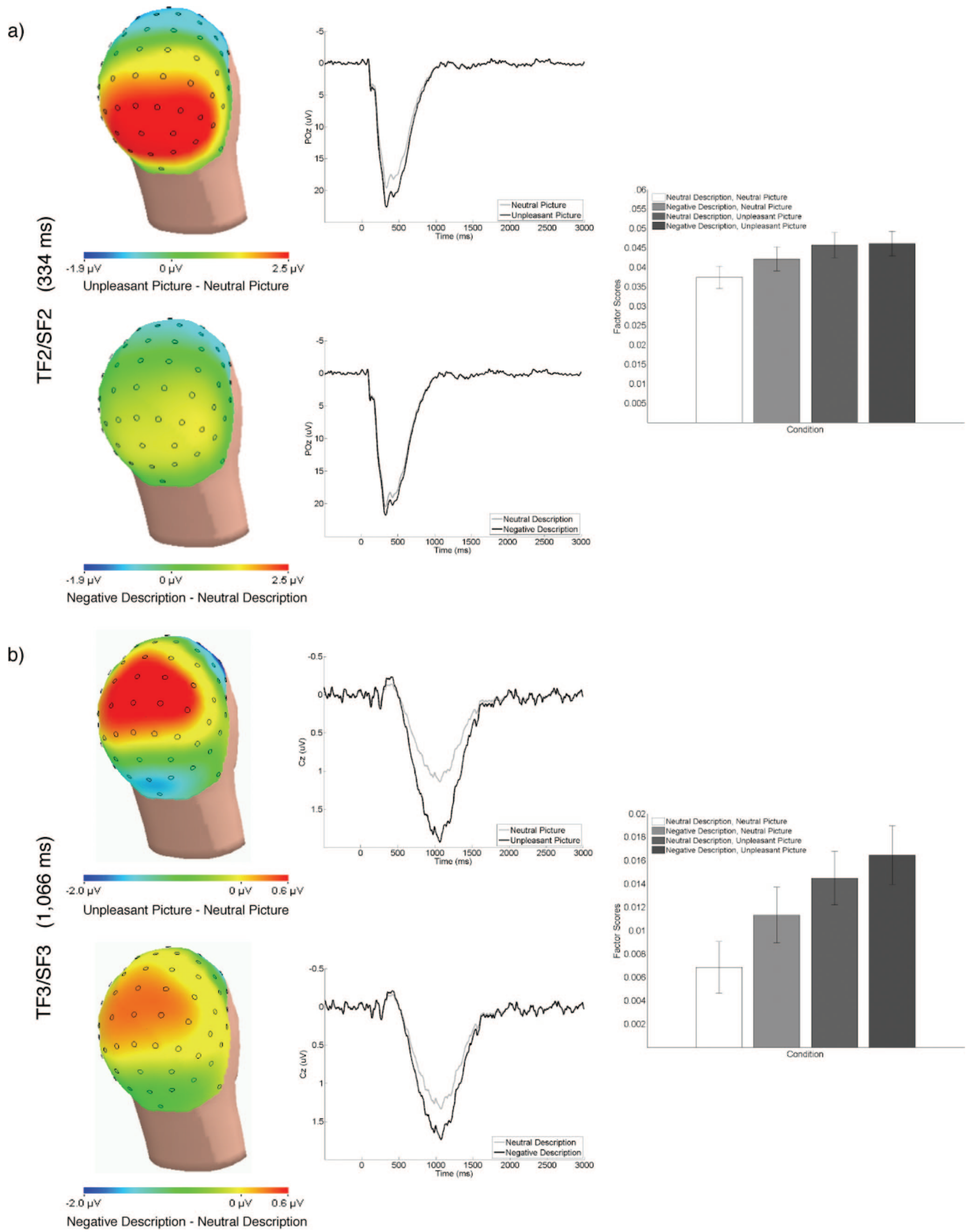

Figure 2 (opposite).

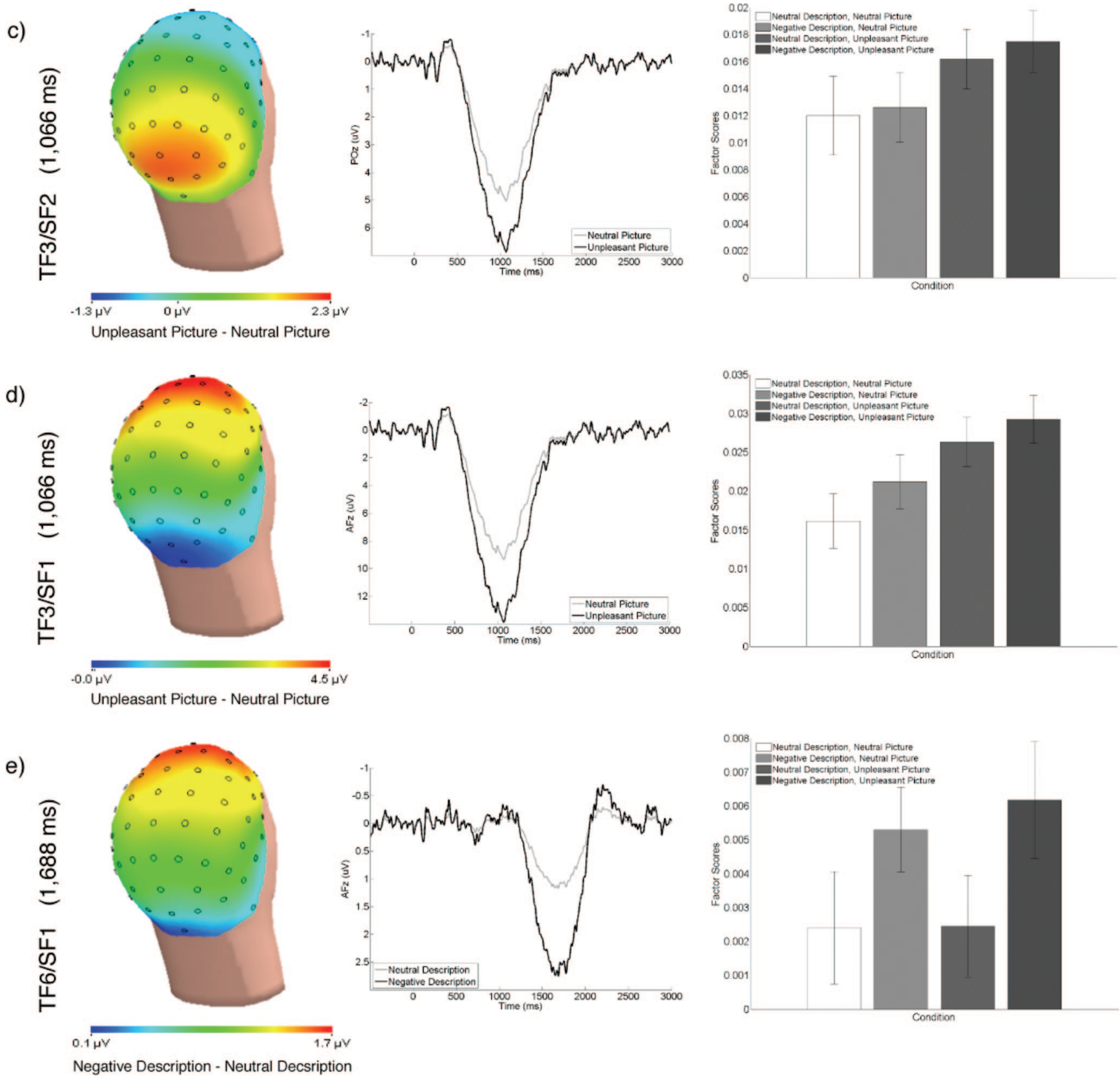

Figure 2. Principal components analysis results for each of the following temporospatial factors: (a) an early parieto-occipital positivity, (b) a midlatency central positivity, (c) a midlatency parieto-occipital positivity, (d) a midlatency frontal positivity, and (e) a late frontal positivity. Color-coded spatial distributions of amplitude (in μV) for main effects —the difference between the mean amplitude for unpleasant and neutral pictures or negative and neutral descriptions—appear on the left. In the middle, factor waveforms (in μV) at the site of component maximum are presented for unpleasant and neutral pictures or negative and neutral descriptions. Bar graphs depicting factor scores and the standard error of the mean (*SEM*) for each of neutrally described neutral pictures, negatively described neutral pictures, neutrally described unpleasant pictures, and negatively described unpleasant pictures appear on the right.

effects of picture and description type on self-report ratings. Future research might continue to explore the relationship between subjective and neural response to emotional stimuli, particularly as they relate to individual differences in emotional reactivity and regulation. In addition, examining whether viewing time and reaction times to rate pictures are modulated by intrinsic and extrinsic effects might provide an interesting avenue for future work.

Table 2
Mean Self-Report Ratings and Standard Deviations According to Description and Picture Type

		Valence		Arousal	
Description	Picture	*M*	*SD*	*M*	*SD*
Neutral	Neutral	5.05	0.94	1.67	0.84
Negative	Neutral	3.15	1.10	4.41	1.86
Neutral	Unpleasant	3.77	0.86	3.63	1.49
Negative	Unpleasant	2.61	0.91	5.00	1.73

In the present study, contextual and intrinsic effects operated additively on early and midlatency positivities. This is in line with previous research showing that the effect of target status and emotion (Ferrari, Codispoti, Cardinale, & Bradley, 2008) and spatial attention and emotion (Keil, Moratti, Sabatinelli, Bradley, & Lang, 2005) operate additively to determine electrocortical amplitude (but see Schupp et al., 2007, for evidence of interactive effects). According to additive factors logic, additive effects imply independent underlying processes (Sternberg, 1969, 2001). However, Ferrari and colleagues (2008) propose that both top-down and bottom-up factors might recruit similar attentional processes reflected in parietal positivities. Historically, these circuits may have responded to intrinsically motivating stimuli (e.g., threatening predators); however, over time they may have evolved to index more top-down modulations of stimuli significance (Ferrari et al., 2008). This view is supported by previous research—cited by Ferrari and colleagues (2008)—showing that both extrinsic and intrinsic factors may elicit activity in the anterior cingulate gyrus (Yamasaki, LaBar, & McCarthy, 2002), a neural region that has been suggested as the site of origin of the P300 (Kok, 2001).

The current findings can be considered, more generally, to support the utility of parietal positivities in indexing emotional up- and down-regulation. Although instructions to down-regulate emotional experience have been shown to have a corresponding effect on the LPP (e.g., Hajcak & Nieuwenhuis, 2006; Moser, Hajcak, Bukay, & Simons, 2006), attempts to increase the LPP via instructed up-regulation of emotional experience have so far been unsuccessful (Krompinger, Moser, & Simons, 2008; Moser et al., 2006). The present study provides initial evidence for the effects of up-regulation insofar as negatively described neutral pictures were associated with larger parietal positivities than neutrally described neutral pictures. These results are consistent with the possibility that a "ceiling effect" (Moser et al., 2006) may have been responsible for previous failures to increase ERP response to pleasant and unpleasant pictures (although participant reluctance to willfully up-regulate negative emotions in previous studies cannot be entirely ruled out; Krompinger et al., 2008).

The current findings also suggest that extrinsic effects modified response to stimuli via meaning change, not cognitive load. Processing neutral pictures following a negative description would presumably require more mental effort than neutral pictures following neutral descriptions. If description type modulated amplitudes via cognitive load, neutral pictures preceded by negative descriptions should have elicited smaller positivities. Instead, amplitudes were *more positive* when pictures were described negatively and *less positive* when they were described neutrally, irrespective of the type of picture presented.

Results also suggest that it may be easier to contextually modulate the significance of neutral as compared with unpleasant pictures, a finding that is in line with past research (e.g., Pastor et al., 2008). Extrinsic modulation of the early parieto-occipital positivity was informed by a trend toward significance for the interaction between description and picture type (p = .051). An examination of means revealed that the difference in amplitude between negatively and neutrally described pictures was larger for neutral than unpleasant pictures. Self-report data in the present study mirrored this trend for the early positivity: when participants were asked to rate the strength and valence of their response to the pictures they had seen, an interaction between picture and description type confirmed that the difference between negative and neutral descriptions was reliably larger for neutral than for unpleasant pictures.

Overall, the present results indicate that both intrinsic and extrinsic factors contribute to the emotional significance of stimuli, although these effects differ temporally and in magnitude. Between about 300 and 1,000 ms, intrinsic and extrinsic effects on positive-going ERPs operated additively: one explanation is that these positivities index input into neural systems associated with both contextual and stimulus-driven indications of stimulus significance (Ferrari et al., 2008). From this perspective, top-down cognitions may modulate the same systems of attention that initially facilitated adaptive responses to evolutionarily salient stimuli. Perhaps because of their more complex and higher order nature, top-down manipulations of emotional significance appear to have a slower time course and smaller effect on emotional response, a finding that has implications for cognitive reappraisal as a regulatory strategy. It will be important for future work to continue to examine the parameters of top-down manipulations of emotional response, such as the duration of extrinsic effects and their influence on response to subsequent encounters with the same stimuli.

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Appendix

International Affective Picture System (IAPS) Numbers and Corresponding Descriptions for Neutral Images

IAPS no.	Negative description	Neutral description
1390	These bees have killed people with one sting.	These bees are leaving the hive for the day.
2038	This woman was later mugged on her porch.	This woman is working at her computer.
2104	This woman just found out she has breast cancer.	This woman is waiting for her friend.
2191	This farmer has accidentally poisoned many people.	This farmer is examining his crop.
2210	This man killed his wife in a fit of anger last year.	This man works as a carpenter in Vermont.
2221	This judge has sentenced an innocent man to death.	This is a judge in a civil court.
2280	This boy was diagnosed with leukemia.	This boy is 9 years old.
2357	This man has suffered a stroke.	This man is taking an afternoon rest.
2381	This woman's baby is drowning in the tub.	This woman is answering a phone survey.
2385	This girl was forced into prostitution at age 6.	This girl is a college student.
2393	This safety check failed and 300 people died.	This man and woman are working on an assembly line.
2396	The man is plotting to blow up the subway.	This man and his wife are doing errands.
2440	This 16-year-old was abused by her stepfather.	This woman is waiting for an early morning bus.
2441	This girl was abused by her older brother.	This girl has brown hair and blue eyes.
2446	This man is burying a body by the river.	This man is researching insects by the river.
2480	This man suffers with Alzheimer's disease.	This man is looking out the window.
2595	These women are about to have a violent fight.	These women are coworkers and neighbors.
2840	This boy's parents always forget to pick him up.	This boy is learning how to play chess.
2870	This boy has sex with men for money.	This boy is eating an apple.
2890	These twins were responsible for 12 murders.	These are identical twins.
3210	This patient died due to doctor error.	This is a routine surgery.
5120	Police will find the body of a 14-year-old girl here.	These twigs and logs are in a forest.
5530	These mushrooms poisoned a 12-year-old boy.	These are edible mushrooms.
6150	A 2-year-old child was electrocuted here.	This is a common electrical socket found in many homes.
7000	A man used this rolling pin to beat his wife.	This is a common wooden rolling pin.
7025	A man hung himself using this stool.	This is a common kitchen stool.
7030	A mother uses this iron to burn her 9-year-old son.	This iron is used to press shirts and dresses.
7034.1	This hammer was used to crush the skull of a 65-year-old.	This hammer is used by a carpenter in his workshop.
7037	This was the scene of a brutal murder.	These trains transport commercial goods.
7043	This drill was used in a grizzly murder.	This drill is used by a repair man.
7050	This hairdryer fell into a bathtub and electrocuted a woman.	This hairdryer is sitting on a laundry basket in a bathroom.
7054	This broken glass was used to commit suicide.	This glass has fallen on the floor.
7056	This tool was used by hijackers to make a bomb.	This tool is often used by electricians for wiring.
7060	A dead baby was found in this trashcan.	This garbage can is in the kitchen.
7100	A family burned alive because there was no water in this fire hydrant.	This is a typical yellow fire hydrant on a suburban street.
7110	A woman was beaten to death with this mallet.	This mallet is used in construction.
7170	A journalist was tortured under this light bulb.	This light bulb is in an old office.
7180	A woman was abducted here last week.	This is an old-fashioned theater.
7491	Two women were raped at this abandoned office.	This building is used for park maintenance.
7493	This pedophile was arrested in France.	This man is a tourist visiting France.
7560	This highway collapsed in a deadly earthquake.	This traffic is moving smoothly even though it is nearly rush hour.
7620	This plane was the target of a terrorist bomb.	These people are boarding an early morning flight.
7640	This man later fell to his death.	This construction is for an office tower.
7705	Severed body parts were found in this cabinet.	This is a filing cabinet in an office that holds folders.
7710.1	A prostitute was murdered in this bed.	These beds are in a hotel.
7920	The driver of this car was raped in a field.	This is a car that is stuck in the mud.
9210	This woman's family have kicked her out of the house.	This woman is standing outside in the rain.
9635.2	This man is burning a civilian alive.	This man is burning brush to clear land.
9700	These scientists are searching for the source of a mass poisoning.	These scientists are being trained to sort waste at a recycling facility.
9913	A woman's body was found inside this truck.	These men were called to help.

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