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Affective picture perception: Emotion, context, and the late positive potential

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Abstract

Event-related potentials (ERP) were measured when pleasant, neutral or unpleasant pictures were presented in the context of similarly valenced stimuli, and compared to ERPs elicited when the same pictures were viewed in an intermixed context. An early ERP component (150–300 ms) measured over occipital and fronto-central sensors was specific to viewing pleasant pictures and was not affected by presentation context. Replicating previous studies, emotional pictures prompted a larger late positive potential (LPP, 400–700 ms) and a larger positive slow wave (1–6 s) over centro-parietal sensors that also did not differ by presentation context. On the other hand, ERPs elicited when viewing neutral pictures varied as a function of context, eliciting somewhat larger LPPs when presented in blocks, and prompting smaller slow waves over occipital sensors. Taken together, the data indicate that emotional pictures prompt increased attention and orienting that is unaffected by its context of presentation, whereas neutral pictures are more vulnerable to context manipulations.

Keywords

Emotion; Event-Related Potentials; Pictures; Attention; Late Positive Potential

1. Introduction

Bioelectric measures of neural activity at the scalp using event-related potentials (ERPs) result in reliable differences when viewing affective or neutral pictures. In a number of different studies, emotionally arousing (pleasant and unpleasant) pictures elicit a larger late positive potential (LPP), compared to neutral pictures, which develops around 300–400 ms following picture onset, lasts for several hundred milliseconds and is maximal over centro-parietal sites (Cacioppo, Crites, Berntson, & Coles, 1993; Cacioppo, Crites, Gardner, & Berntson, 1994; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Keil, Bradley, Hauk, Rockstroh, Elbert, & Lang, 2002; Palomba, Angrilli, & Mini, 1997; Schupp, Cuthbert, Bradley, Cacioppo, Ito, & Lang, 2000; Schupp, Junghöfer, Weike, & Hamm, 2003; 2004).

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Using a slow time constant, Cuthbert et al. (2000) also noted an extended centro-parietal positive slow wave that was significantly larger for affective than neutral pictures, and was sustained over a 6-s picture viewing period. These findings have been interpreted in terms of motivated attention, in which emotional pictures naturally engage attentional resources as a result of activation in fundamental motivational systems mediating appropriate survival behaviors (Lang, Bradley, & Cuthbert, 1997).

Modulation of the late positive potential when viewing emotional, compared to neutral, pictures has proved to be a stable, replicable finding. Moreover, affective differentiation in the late positive potential remains intact despite multiple repetitions (up to 60) of the identical pleasant, neutral, and unpleasant pictures (Codispoti, Ferrari, & Bradley, 2006; 2007), suggesting that the enhanced LPP during emotional picture processing may be obligatory, reflecting processing essential in initial semantic categorization. In the current study, we assessed ERPs to pleasant, neutral and unpleasant pictures that were presented in blocks of similarly valenced stimuli, and compared these ERPs to those elicited when viewing affective pictures intermixed with neutral stimuli. When pictures are presented in blocks of similarly valenced material, hedonic valence remains the same from trial to trial, presumably eliminating some of the evaluative processing. To the extent that the LPP reflects the result of an initial evaluative categorization (i.e., "good" or "bad"), its modulation by emotional arousal could be attenuated in a blocked context, in which this categorization is aided by previous stimulus information. On the other hand, if the LPP reflects an obligatory attention allocation to emotionally engaging stimuli, presentation context should not affect the magnitude of the LPP.

Previous studies have suggested that affective discrimination of this late ERP component is relatively unaffected by a variety of stimulus and context manipulations. For example, Cuthbert, Schupp, McManis, Hillman, Bradley, & Lang (1995) found similar ERP modulation when either passively viewing pictures, or making explicit evaluative ratings. Relatedly, Cardinale, Ferrari, De Cesarei, Biondi, & Codispoti (2005) found that affective modulation of the LPP was present in the context of making non-affective categorizations. Codispoti and coworkers also reported that modulation of the late positive potential by affect was unaffected when a simultaneous non-affective task was presented at the fovea (Codispoti, Ferrari, DeCesarei, & Cardinale, 2006). Moreover, similar modulation by emotion is found regardless of stimulus size (DeCesarei & Codispoti, 2006), duration (Codispoti et al., 2007) or complexity (Bradley, Hamby, Löw, & Lang, 2007). Taken together, these findings suggest that affective modulation of the LPP is a robust phenomenon that is not strongly influenced by perceptual factors (e.g., stimulus size, complexity), familiarity, or task requirements. On the other hand, in all of these studies, information regarding picture affect was not available prior to presentation.

Several studies that have focused on earlier ERP components (150–300 ms) have found that emotional pictures also prompt less positivity over occipital sites, compared to neutral pictures (e.g., Codispoti et al., 2007; Schupp et al., 2003). This earlier component, however, is also strongly affected by perceptual complexity (Bradley et al., 2007) and is most pronounced when viewing pleasant, particularly erotic, pictures (De Cesarei & Codispoti, 2006; Schupp et al., 2004), which may be mediated by featural overlap. If so, we expected to find increased occipital positivity in this early time window for pleasant pictures in the current study as well.

Heart rate and skin conductance activity were measured as additional indices of processing that might inform any differences found as a function of the context of presentation. When pictures are mixed in hedonic valence, unpleasant pictures prompt significantly greater cardiac deceleration than either neutral or pleasant pictures, which we have interpreted as

indexing heightened sensory intake (e.g., Bradley, Codispoti, Cuthbert, & Lang, 2001), drawing on previous data and theory linking cardiac deceleration to orienting activity (Graham, 1992). Previous studies have indicated that this cardiac component quickly disappears with picture repetition (Bradley, Lang, & Cuthbert, 1993), suggesting it may be related to initial evaluative processing required for determining hedonic valence. If so, we expected that differences in cardiac deceleration would be attenuated when pictures are presented in hedonically similar blocks.

Skin conductance magnitude typically varies with emotional arousal, with unpleasant or pleasant pictures eliciting larger responses than neutral stimuli in an intermixed presentation context (e.g., Lang, Greenwald, Bradley & Hamm, 1993; Bradley et al., 2001). To the extent that skin conductance changes are due to novelty, surprise or unexpectedness (e.g., suddenly seeing a picture of a mutilated body), which are also known to modulate electrodermal responsivity (e.g., Maltzman & Boyd, 1984), blocked presentation could attenuate the differences between emotional and neutral stimuli. On the other hand, if skin conductance reflects the intensity with which motivational systems are activated by the picture cue, as we have hypothesized (e.g., Lang et al., 1993), the same pattern of modulation was expected regardless of presentation context.

2. Results

2.1. Event Related Potentials

Figure 1 illustrates ERP waveforms at representative fronto-central, centro-parietal, and occipital sensors when pictures were presented in a blocked or mixed presentation mode.

Early time window (150–300 ms)—In the early time window, Picture Content modulated ERPs over occipital, $F(2,72) = 11.21$, $p < .001$, and fronto-central sensors, $F(2,72) = 8.94$, $p < .001$, with pleasant pictures showing less positivity over occipital sites and less negativity over fronto-central sites compared to either neutral ($F(1,36) > 8.96$, $ps < .005$), or unpleasant pictures ($F(1,36) > 16.67$, $ps < .001$). Table 1 lists the means used in the analyses. Although the interaction of Picture Content and Presentation Context was not significant for any sensor group, the effects over fronto-central sensors were somewhat more reliable for Blocked, $F(2,36) = 6.49$, $p < .005$, compared to Mixed, presentation, $F(2,36) = 3.36$, $p = .06$.

Late Positive Potential window (400–700 ms)—In the 400–700 ms time window, a main effect of picture content over centro-parietal sensors, $F(2,72) = 10.10$, $p < .001$, replicated previous studies finding a heightened LPP when viewing emotional, compared to neutral, pictures (quadratic $F(1,72) = 19.86$, $p < .001$; pleasant vs. neutral $F(1,72) = 17.27$, $p < .001$; unpleasant vs. neutral $F(1,72) = 12.69$, $p < .005$). Although the interaction of Presentation Context and Picture Content was not significant for centro-parietal sensors, post-hoc testing indicated that neutral pictures prompted slightly larger LPPs when presented in blocked, compared to mixed, presentation, $F(1,36) = 5.43$, $p < .05$.

Over occipital sensors, presentation context affected the pattern of ERPs, as evidenced by a significant interaction of Presentation Context and Picture Content, $F(2,72) = 5.89$, $p < .005$. In this region, pleasant and unpleasant pictures did not differ as a function of presentation context, whereas neutral pictures elicited greater positivity when presented in blocked, compared to mixed, presentation, $F(1,36) = 6.55$, $p < .05$.

Slow wave window (1–6 s)—Over centro-parietal sensors, a significant main effect of Picture Content, $F(2,72) = 4.79$, $p < .05$, indicated that pleasant and unpleasant pictures prompted a larger positive slow wave than neutral pictures (quadratic, $F(1,36) = 9.31$, $p < .$

005; pleasant vs. neutral $F(1,36) = 5.70$, $p < .05$; unpleasant vs. neutral $F(1,36) = 8.40$, $p < .001$). Presentation context did not modulate the centro-parietal slow wave, interaction $F < 1$.

A similar effect of picture content extended to fronto-central sensors, $F(2,72) = 17.53$, $p < .001$, in which emotional pictures again prompted more positivity than neutral pictures (quadratic $F(1,36) = 34.82$, $p < .001$; pleasant vs. neutral $F(1,36) = 28.64$, $p < .001$; unpleasant vs. neutral, $F(1,36) = 23.71$, $p < .001$). An interaction between Picture Content and Presentation Context for the fronto-central sensors, $F(2,72) = 3.79$, $p < .05$, primarily indicated that this effect was somewhat more reliable for Blocked ($F(2,36) = 17.28$, $p < .005$) than for Mixed presentation ($F(2,36) = 2.80$, $p = .08$).

For occipital sensors, a significant interaction of Picture Content and Presentation Context ($F(2,72) = 3.34$, $p < .05$) indicated that when pictures were presented in blocks, neutral pictures prompted less negativity than emotional pictures (quadratic $F(1,36) = 16.06$, $p < .001$; pleasant vs. neutral $F(1,36) = 13.17$, $p < .005$; unpleasant vs. neutral $F(1,36) = 10.98$, $p < .005$). For mixed presentation, however, there were no significant differences as a function of picture content for ERPs measured over occipital sensors in the slow wave window.

2.2. Autonomic responses

Table 2 lists autonomic responses for pleasant, neutral, and unpleasant pictures presented in a blocked or mixed presentation context. For skin conductance, a main effect of picture content, $F(2,78) = 15.62$, $p < .001$, replicated previous studies which found that pleasant and unpleasant pictures prompt larger skin conductance changes than neutral pictures, $F(1,78) = 10.57$, $p < .005$ and $F(1,78) = 30.94$, $p < .001$, respectively; quadratic $F(1,78) = 25.89$, $p < .001$. Unpleasant pictures also prompted slightly larger responses than pleasant pictures overall in this study, $F(1,78) = 5.34$, $p < .05$. The interaction of Presentation Context and Picture Content was only marginal, $F(2,78) = 2.48$, $p = .10$, but post-hoc tests indicated that unpleasant pictures prompted reliably larger responses than pleasant pictures only in the blocked presentation mode ¹, $F(1,40) = 7.46$, $p < .05$.

For heart rate, a main effect of Picture Content, $F(2,76) = 3.61$, $p < .05$, replicated previous findings that unpleasant pictures prompt more cardiac deceleration than neutral pictures, $F(1,76) = 7.16$, $p < .01$. Separate tests indicated that picture content only affected heart rate change for pictures presented in the mixed ($F(2,36) = 3.76$, $p < .05$), but not blocked presentation mode ($F < 1$), with larger deceleration for unpleasant, compared to neutral, pictures, $F(1,36) = 7.49$, $p < .01$. Moreover, heart rate deceleration when viewing unpleasant pictures was significantly greater in mixed, compared to blocked presentation, $F(1,38) = 4.64$, $p < .05$, whereas heart rate change for pleasant and neutral pictures did not significantly vary as a function of presentation mode (see Table 2).

3. Discussion

The present study replicates and extends prior ERP research during affective picture processing, manipulating the context of picture presentation. In general, the current results suggest that whether emotional pictures were presented in blocks of similarly valenced content, or in an intermixed presentation mode, ERPs measured during sustained picture viewing were strikingly similar. In both cases, pleasant and unpleasant pictures prompted a larger late positive potential (400–700 ms) than neutral pictures over centro-parietal sensors

¹For blocked presentation, means of skin conductance level during the 12 s picture-viewing period and the following 12 s interpicture intervals were computed for each trial, and a repeated-measures ANOVA was conducted to assess effects of picture content on the tonic level of skin conductance during picture viewing. Results showed the same pattern described for phasic changes, indicating stronger and sustained reactivity for unpleasant pictures compared to neutral or pleasant, pictures, $F_s(1, 40) < 10$, $p_s < .005$.

that developed into a sustained positive slow wave. A number of studies have found similar results when using mixed presentation of affective and neutral pictures, regardless of experimental variations involving stimulus or task (e.g., Bradley et al., 2007; Cacioppo et al., 1994; Cuthbert et al., 2000; Diedrich et al., 1997; Keil et al., 2002; Schupp et al., 2004). The stable modulation of ERP components such as the late positive potential (LPP) and the centro-parietal positive slow wave by emotion is consistent with the hypothesis that these ERPs index selective processing of motivationally relevant cues.

In an early (150–300 ms) time window, ERPs primarily distinguished pleasant from neutral or unpleasant pictures, with pleasant pictures prompting less positivity over occipital sensors (and less negativity over fronto-central sensors) compared to either neutral or unpleasant materials. This effect replicates previously reported data indicating specific modulation of pleasant pictures in this early time window (e.g., Cuthbert et al., 2000; Keil et al., 2002), and which has subsequently been found to be most pronounced for erotica (Codispoti, Ferrari, Junghöfer, & Schupp, 2006; Schupp, Stockburger, Codispoti, Junghöfer, Weike, & Hamm, 2006), a specific content that was well-represented in the current set of pleasant pictures. One hypothesis is that this early component reflects perceptual processing (Bradley et al., 2007), a low-level stimulus process that is required for initial identification and recognition (Codispoti et al., 2007), but which is not affected by prior information regarding hedonic content.

In both the 400–700 ms and the slow wave (1–6 s) windows, there were no significant differences in the magnitude of the centro-parietal LPP or the sustained positive slow wave when viewing pleasant or unpleasant, compared to neutral, pictures, regardless of presentation mode, indicating that the context of picture presentation does not greatly influence the brain processes indexed by these ERPs. Moreover, skin conductance activity was heightened when viewing emotional, compared to neutral, pictures, regardless of presentation context, which provides corroborating evidence that processing a novel, emotionally arousing picture elicits similar motivational activation regardless of prior knowledge concerning its hedonic content.

The lack of generalization in the blocked condition is consistent with recent hypotheses that suggest modulation of the late positive potential reflects an obligatory process in picture encoding, based on findings that it remains intact despite multiple repetitions of the same picture (Codispoti et al., 2006, 2007). In the current study, the heightened LPP when viewing emotional, compared to neutral, pictures, was not eliminated even though blocked presentation includes information regarding its evaluative categorization. On the other hand, cardiac deceleration, an index of initial orienting, was greatly attenuated in blocked presentation, particularly when viewing unpleasant pictures, suggesting that is associated with information intake specifically relevant to evaluative processing. Taken together, the data are consistent with a hypothesis that modulation of the late positive potential indexes a cue's associative links to fundamental motivational systems of appetite and defense (Bradley, 2002). In this scenario, modulation of the late positive potential for affective pictures occurs even during blocked presentation because it reflects the reflexive activation of the motivational circuits in the brain that mediate emotional engagement. Prior information regarding hedonic valence is not expected to affect the strength of cue's motivational associations.

ERPs for neutral pictures were more affected by the context of presentation than were emotional pictures. When presented in blocks, neutral pictures did not prompt the prolonged negative slow wave over occipital sensors that was found when neutral pictures were presented in a mixed context. One hypothesis is that this slow component indexes sustained processing, which is naturally engaged by all emotional pictures (whether blocked or mixed)

but also by neutral pictures in a mixed presentation mode, perhaps due to a continued search for motivationally relevant information.

Taken together, then, the data suggest that a very similar ERP profile is obtained when viewing emotional pictures regardless of whether they are presented in a context that includes a variety of pleasant, neutral, or unpleasant pictures, or in a blocked context that presents only similarly valenced pictures. The similarities in the ERP are particularly striking given the between-subject design and the relatively small number of trials and blocks used here. The major differences in the ERPs that arose as a function of presentation context were centered on processes involved in neutral picture viewing, suggesting that task and context differences may be more evident for stimuli that are low in affective relevance and do not normally engage selective processing. The fact that affective pictures elicit similar cortical processing regardless of whether previous trials herald hedonic valence or content is consistent with the hypothesis that these motivationally relevant pictures naturally draw selective processing during encoding (Bradley, 2002).

4. Experimental Procedure

4.1. Participants

Forty-one participants (21 men, 20 women; 18–22 years old) from a University of Florida General Psychology course participated as part of a class requirement. Half of the participants viewed pictures presented in blocks of similarly valenced stimuli (11 men, 10 women); the other half viewed pictures in a mixed condition (10 men, 10 women), in which the hedonic valence of the picture varied from trial to trial. Some participants were excluded on the basis of artifacts in the physiological data. Final Ns were as follows: ERPs analysis, $n = 38$; heart rate, $n = 40$; skin conductance changes, $n = 41$.

4.2. Stimuli and Design

Forty-eight pictures were selected from the International Affective Picture System (IAPS: Lang, Bradley, & Cuthbert, 1999) consisting of 16 pleasant (erotic couples, happy families), 16 neutral (faces, household objects), and 16 unpleasant pictures (threat, and mutilated bodies)². An additional 8 pictures of angry faces from the Japanese and Caucasian Facial Expressions of Emotion set (Matsumoto & Ekman, 1989) were presented, but are not included here. Pictures were displayed on a 49 cm monitor, with a maximum size of 27×37 cm, presented approximately 1.25 m from the participant's eyes with a visual angle of 16° horizontally and 12° vertically.

For participants in the *Blocked group*, the pictures were presented in blocks of 8 pictures of the same picture content, with participants viewing 2 blocks of pleasant pictures (i.e., erotic, families), 2 blocks of neutral pictures (i.e., faces, objects) and 2 blocks of unpleasant pictures (i.e., threat, mutilation). The serial position of each block was counterbalanced across participants using 6 different orders, such that, each picture category was seen equally often in the first or second half of the session, as well as in the first, second, or third position within the half of the experiment.

For participants in the *Mixed group*, pictures were arranged in 8 sets of 7 pictures, such that each set contained at least 2 exemplars from each picture category (pleasant, neutral, or

²The IAPS picture numbers used in this study are Erotica: 4680, 4652, 4658, 4670, 4651, 4660, 4664, 4650; Families: 2080, 2311, 2050, 2360, 2341, 2160, 2070, 2165; Household objects: 7235, 7080, 7040, 7009, 7175, 7010, 7002, 7030; Mutilation: 3053, 3110, 3000, 3010, 3102, 3060, 3080, 3130; Attack: 1120, 3530, 6350, 1050, 1930, 6260, 1300 6510. Pictures used from the JACFEE set are Angry Faces: RH 1C24, NM 2C14, KG 1C21, BM 1C22, LR 1C24, AL 1C21, ES1 2C17, AF 1C30; Neutral Faces: CF 2C01, NH1 1C01, ES2 1C04, SW1 1C02, WW 1C02, GO 1C01, JC 1C02, AK2 1C02.

unpleasant). The position of specific pleasant, neutral and unpleasant pictures was counterbalanced across participants, such that a specific picture was viewed in the first or second half of the experiment, across participants.

For both groups, each trial consisted of a 12-s picture presentation period followed by a 12-s inter-picture interval³.

4.3. Physiological Recording and Data Reduction

EEG data were collected from the scalp using a 129-channel system (Electrical Geodesics, Inc., Eugene, OR). Scalp impedance for each sensor was kept below 50 k Ω . The EEG was recorded continuously with a sampling rate of 250 Hz, the vertex sensor as reference electrode, and on-line bandpass filtered from 0.01 to 100 Hz. Offline, continuous EEG data were low-pass filtered at 30 Hz using a digital filtering before stimulus synchronized epochs were extracted from 100 ms before until 10,000 ms after picture onset. Single trial epochs were corrected for vertical and horizontal eye movements using a correlative eye movement algorithm (Miller, Gratton, & Yee, 1988). The raw EEG epochs were passed through a computerized artifact-detection algorithm (Junghöfer, Elbert, Tucker, & Rockstroh, 2000). For the blocked group, means (and SD) of good trials across categories were 10.53 (2.46), 10.0 (2.29) and 10.0 (2.19), for pleasant, neutral and unpleasant, pictures, respectively; for the intermixed group, means (and SD) of good trials per picture valence categories were 10.67 (2.05), 10.61 (2.77) and 10.5 (2.50), respectively. Finally, the data were transformed to an average reference and baseline corrected (100 ms before picture onset).

Stimulus control and physiological data acquisition were accomplished using an IBM-compatible computer running VPM software (Cook, 1997). Skin conductance activity was recorded using SensorMedics Ag/AgCl standard electrodes, filled with 0.05-m NaCl Unibase paste, and placed adjacently on the hypothenar eminence of the left palmar surface. The signal was acquired with a Coulbourn V71-22 skin conductance coupler calibrated prior to each session to detect activity in the range from 0 to 40 mS. Skin conductance changes were calculated by subtracting activity in the initial second after picture presentation⁴ from that occurring at each half-second after picture onset. A log transform was computed for statistical analyses. The electrocardiogram was recorded from the left and right forearm using SensorMedics Ag/AgCl standard electrodes, filled with electrolyte paste. The signal was filtered using a Coulbourn S75-01 bioamplifier, and a Schmitt trigger interrupted the computer each time it detected a cardiac R-wave. Interbeat intervals were recorded to the nearest millisecond and reduced off-line into heart rate in beats per minute, in half-second bins. The average change in heart rate was computed from activity in the second before picture viewing.

4.4. Procedure

After arrival at the laboratory, participants signed an informed consent form and then the electrodes were attached. The participants were instructed that a series of pictures would be displayed and that they should look at the picture while it was on the screen. In addition, they were told to keep their eyes on the fixation dot when the picture was off the screen.

³We selected the duration of the picture viewing period and the intertrial interval to be suitable for use in future fMRI explorations using the same design.

⁴Due to a programming error, physiological data for the 1 s prior to the presentation of the first picture in each block were not collected for a subset of participants in the blocked group. Thus, for analyses of skin conductance changes, change scores were computed using the first second after picture onset as baseline. As skin conductance changes are quite slow (i.e., begin 2–4 s post picture onset), there is no significant difference in skin conductance in the 1 s before or after picture onset. For the HR analyses, the first trial of each block of pictures was excluded, leaving 14 trials per picture content (pleasant, neutral, unpleasant) for a subset of participants in the blocked group.

Following the picture trials, participants filled out a post-experimental questionnaire, and were debriefed.

4.5. Data analysis

Average EEG waveforms for pleasant, neutral, and unpleasant pictures were calculated for each sensor and participant. For statistical analyses, the scalp voltages at 129 electrodes were averaged for 3 midline regions (fronto-central, centro-parietal, occipital), using the following EGI sensors of the net: 5, 6, 7, 12, 13, 21, 29, 30, 31, 35, 36, 37, 105, 106, 107, 111, 112, 113, 117, 118, 119 (fronto-central region); 32, 38, 43, 48, 52, 53, 54, 55, 60, 61, 62, 68, 79, 80, 81, 86, 87, 88, 93, 94, 99, 129 (centro-parietal region); and 64, 65, 66, 67, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 82, 83, 84, 85, 89, 90, 91, 95, 96 (occipital region). Mean voltages in these regions were assessed in 3 time windows corresponding to an early waveform component (150–300 ms), the late positive potential (LPP, 400–700 ms), and a slow wave window (1–6 s). Mixed model ANOVAs with a between subject variable of *Presentation context* (mixed, blocked) and a repeated measure of *Picture content* (pleasant, neutral, unpleasant) was conducted separately for each time window and each region⁵. Similar mixed model ANOVAs were conducted for skin conductance and heart rate change. For repeated measures analyses, multivariate statistics are reported.

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⁵An additional 3 (*Picture content*) × 2 (*Laterality*: right vs. left) × 4 (*Site*: frontal, central, parietal, occipital) repeated-measures ANOVA was also conducted on four additional lateral regions for each time window and for each experimental group. There were no main effects of Laterality, nor any interactions involving this factor in any region or time window. Moreover, over these regions, ERP mean voltage varied as a function of picture content similarly to the effects reported above for the midline region.

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Figure 1. ERP waveforms averaged over representative sensors placed over fronto-central, centro-parietal, and occipital sites, when pleasant, neutral, and unpleasant pictures were presented in a *mixed* (left figure) or *blocked* (right figure) presentation context.

Mean voltage (standard error) for pleasant, neutral, and unpleasant pictures presented in a mixed or blocked presentation mode in three time windows for four sensor groupings.

Table 1

Time window	Mixed Presentation			Blocked Presentation		
	Pleasant	Neutral	Unpleasant	Pleasant	Neutral	Unpleasant
150 – 300 ms						
Fronto-Central	−0.35 (0.47)	−0.66 (0.46)	−1.29 (0.38)	0.41 (0.65)	−1.65 (0.48)	−1.88 (0.71)
Centro-Parietal	0.66 (0.80)	0.80 (0.50)	1.37 (0.52)	1.79 (0.52)	1.04 (0.54)	1.85 (0.57)
Occipital	0.83 (0.72)	2.19 (0.56)	3.42 (0.60)	1.82 (0.96)	4.12 (0.84)	4.60 (1.21)
400 – 700 ms						
Fronto-Central	−0.67 (0.55)	−1.55 (0.44)	−1.43 (0.55)	−0.03 (0.58)	−2.87 (0.65)	−1.65 (0.88)
Centro-Parietal	5.71 (0.82)	2.55 (0.67)	5.53 (0.76)	6.04 (0.71)	4.78 (0.68)	5.59 (0.72)
Occipital	3.03 (0.73)	3.06 (0.78)	5.00 (0.91)	2.87 (0.97)	6.30 (1.00)	4.39 (1.30)
1000 – 6000 ms						
Fronto-Central	2.15 (0.40)	1.12 (0.45)	2.17 (0.38)	3.24 (0.51)	0.26 (0.42)	2.86 (0.51)
Centro-Parietal	1.92 (0.92)	−0.61 (0.69)	1.49 (0.58)	0.52 (0.53)	−0.13 (0.60)	1.63 (0.57)
Occipital	−3.54 (0.91)	−2.41 (0.67)	−2.62 (0.75)	−4.92 (1.12)	−0.61 (0.68)	−4.55 (1.18)

Table 2

Mean (standard error) skin conductance and heart rate changes during viewing of pleasant, neutral, and unpleasant pictures presented in a mixed or blocked presentation mode.

Autonomic measure	Mixed Presentation			Blocked Presentation		
	Pleasant	Neutral	Unpleasant	Pleasant	Neutral	Unpleasant
Skin conductance	0.04 (0.01)	0.002 (0.003)	0.04 (0.01)	0.04 (0.01)	0.01 (0.004)	0.08 (0.02)
Heart rate	-0.76 (0.36)	-0.30 (0.33)	-1.35 (0.32)	-0.18 (0.43)	0.26 (0.40)	-0.25 (0.39)