Biological Psychology 90 (2012) 211–217

Contents lists available at SciVerse ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Embodying approach motivation: Body posture influences startle eyeblink and event-related potential responses to appetitive stimuli

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ARTICLE INFO

Article history:
Received 18 January 2012
Accepted 3 April 2012
Available online 11 April 2012

Keywords:
LPP
Startle-eyeblink
Posture
Event Related Potentials
P100
Approach Motivation
Emotion
Embodiment

ABSTRACT

Past research suggested that the motivational significance of images influences reflexive and electrocortical responses to those images (Briggs and Martin, 2009; Gard et al., 2007; Schupp et al., 2004), with erotica often exerting the largest effects for appetitive pictures (Grillon and Baas, 2003; Weinberg and Hajcak, 2010). This research paradigm, however, compares responses to different types of images (e.g., erotica vs. exciting sports scenes). This past motivational interpretation, therefore, would be further supported by experiments wherein appetitive picture content is held constant and motivational states are manipulated with a different method. In the present experiment, we tested the hypothesis that changes in physical postures associated with approach motivation influences reflexive and electrocortical responses to appetitive stimuli. Past research has suggested that bodily manipulations (e.g., facial expressions) play a role in emotion- and motivation-related physiology (Ekman and Davidson, 1993; Levenson et al., 1990). Extending these results, leaning forward (associated with a heightened urge to approach stimuli) relative to reclining (associated with less of an urge to approach stimuli) caused participants to have smaller startle eyeblink responses during appetitive, but not neutral, picture viewing. Leaning relative to reclining also caused participants to have larger LPPs to appetitive but not neutral pictures, and influenced ERPs as early as 100 ms into stimulus viewing. This evidence suggests that body postures associated with approach motivation causally influence basic reflexive and electrocortical reactions to appetitive emotive stimuli.

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1. Introduction

Two of the most widely used psychophysiological measures of responses to affective stimuli are the startle eyeblink response and the late positive potential (LPP) of the event-related potential (ERP). Both appear responsive to the motivational significance of affective stimuli. That is, arousing affective stimuli exert the largest effects on the startle eyeblink response and LPP. And arousal has been posited to be a proxy for motivational significance (Bradley and Lang, 2007). For instance, highly arousing appetitive pictures have been found to influence startle responses (Gard et al., 2007; Grillon and Baas, 2003) and the LPP (Briggs and Martin, 2009; Schupp et al., 2004; Weinberg and Hajcak, 2010) more than less arousing appetitive pictures. Although these results do indeed suggest that motivational significance influences the startle eyeblink and LPP responses, more causal evidence for this postulate could come from a manipulation of motivational intensity that held the appetitive stimulus content constant. The present research was designed to provide this evidence.

1.1. *Motivational modulation of the startle eyeblink response*

The startle reflex causes the orbicularis oculi muscle around the eye to contract to sudden aversive events, protecting the eye from potential harm. In the lab, the startle response is typically induced by loud (100 db) bursts of white noise with instantaneous rise time (Blumenthal et al., 2005). When startle probes are presented early into picture viewing (e.g., 300 ms following picture onset; Grillon and Baas, 2003), startle eyeblinks have been found to be modulated primarily by attentional processes (Bradley et al., 1993, 2006). Consistent with this notion, behavioral research suggested that both unpleasant and pleasant pictures receive equal attention at an early processing stage (Calvo and Lang, 2004). For startle stimuli presented later into picture viewing, however, the startle eyeblink response has been found to be reliably modulated by the emotive significance of stimuli (Bradley et al., 2001; Lang et al., 1990; Vrana et al., 1988). This emotive modulation of the startle reflex occurs even when the same picture is presented 30 times in a row

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http://dx.doi.org/10.1016/j.biopsycho.2012.04.001

(Ferrari et al., 2011). The magnitude of startle eyeblinks is potentiated by arousing negative pictures and attenuated by arousing positive pictures. This effect is explained by the response-matching hypothesis, which postulates that the startle eyeblink is a basic defensive reaction that is responsive to the presence of affective cues. Aversive cues, such as arousing negative pictures, exacerbate the congruent avoidant motivation elicited by the startling sound and lead to larger startle blinks. Appetitive cues, such as arousing positive pictures, contrast the avoidant motivation of the startling sound and these inconsistent motivational states lead to smaller startle blinks. Animal research has found that nuclei within the amygdala play a critical role in the affective modulation of the startle response (Davis, 2006).

Consistent with the response-matching hypothesis, the startle response has been linked with motivation. High trait behavioral approach system (BAS) sensitivity, measured with Carver and White's (1994) scale, is correlated with smaller startle responses during arousing positive pictures (Hawk and Kowmas, 2003). Furthermore, trait emotions associated with approach motivation (e.g., anger, enjoyment, surprise) are correlated with smaller startle responses during arousing positive pictures (Amodio and Harmon-Jones, 2011). In addition, positive pictures associated with approach motivation (e.g., erotic images) attenuate startle responses more than positive pictures less associated with basic motivational impulses (e.g., sports scenes; Gard et al., 2007).

Although these studies provide support for the idea that the startle response is influenced by the motivational significance of stimuli, more work is needed. For example, pictures of erotica and exciting sports scenes differ in variables other than approach motivational intensity; for instance, they differ in content (e.g., sport scenes are more likely outdoors than erotic scenes). In the present experiment, we manipulated motivational states by changing physical posture (i.e., leaning forward vs. reclining backward) while keeping the image content of appetitive stimuli constant across posture. Based on past research as well as associations between posture and approach motivation, we predicted that leaning forward would cause greater approach motivation than reclining backward.

Our ideas about the body posture manipulation are consistent with past research demonstrating that bodily manipulations influence emotion- and motivation-related physiology. For example, different facial expressions have been linked to different patterns of autonomic nervous system activity (Levenson et al., 1990). In addition, genuine smiles with Duchenne's marker (activation of zygomatic major and orbicularis muscle regions) as compared to less genuine smiles have been found to cause greater relative left frontal cortical activity, a neural correlate of approach motivation (Ekman and Davidson, 1993; for other emotional facial expression evidence, see Coan et al., 2001). Similarly, in response to appetitive stimuli, reclining backward has been found to cause lesser relative left frontal cortical activity as compared to sitting upright (Harmon-Jones and Peterson, 2009) and leaning forward (Harmon-Jones et al., 2011). In addition, slumped or helpless postures have been found to cause less task persistence as compared to upright and expansive postures (Riskind and Gotay, 1982). This past work, however, did not address if changes in physical posture influence more basic, reflexive physiological responses. In the present experiment, we tested whether changes in physical posture would influence the magnitude of the emotion-modulated startle eyeblink reflex.

1.2. Motivational modulation of the LPP

In addition, we investigated whether physical posture influences the LPP, an ERP starting 300 ms after stimulus onset and lasting for several 100 ms over central–parietal regions. The LPP has been found to be reliably influenced by the emotive significance of stimuli (Hajcak et al., 2012). For example, LPPs are larger to erotic pictures compared to positive pictures less associated with basic motivational impulses, such as exciting sports scenes (Briggs and Martin, 2009; Weinberg and Hajcak, 2010). In addition, mothers have larger LPPs to pictures of their own children's faces relative to pictures of familiar children, unfamiliar children, familiar adults, and unfamiliar adults (Grasso et al., 2009). Individuals who are currently in love with another person, furthermore, evince larger LPPs to pictures of that person relative to pictures of a friend or a beautiful but unknown person of the opposite sex (Langeslag et al., 2007). LPPs are also larger to scenes of mutilation and threat compared to scenes of contamination and loss (Schupp et al., 2004). Functional magnetic resonance imagining (fMRI) and electroencephalography (EEG) studies have revealed multiple neural generators of the LPP, such as the occipitotemporal and parietal cortex (Keil et al., 2002; Sabatinelli et al., 2007).

Similar to work with the emotion-modulated startle response, however, the idea that the LPP is responsive to motivational significance would be further supported if manipulated changes in motivational states were found to influence the LPP to identical pictures. To our knowledge, no work has examined if manipulating motivational states via body posture influences startle and LPP responses to emotive stimuli that are otherwise held constant. In addition, no work has examined if whole body manipulations influence fast responses such as the startle eyeblink and LPP. However, the possibility exists that bodily manipulations might influence even faster ERP responses.

1.3. Motivational modulation of early ERP components

Several earlier visual components of the ERP have also been found to be modulated by emotive as compared to neutral stimuli, though they produce less consistent effects (see review by Olofsson et al., 2008). In contrast to the LPP, whether these earlier ERP components differ between emotive and neutral stimuli depends on reference scheme and type of analyses used (Hajcak et al., 2012, for review). Early ERP components that occasionally differ between emotive and neutral pictures are the N1, which is a negative-going wave that peaks between 100 and 200 ms following stimulus onset (Foti et al., 2009; Keil et al., 2001); the P1, which is a positive-going wave that peaks between 100 and 200 ms following stimulus onset (Bernat et al., 2001; Pourtois et al., 2005; Santesso et al., 2008); and the early posterior negativity (EPN), a relative negative-going wave that peaks between 200 and 300 ms following stimulus onset (Dunning et al., 2011; Olofsson et al., 2008; Schupp et al., 2003).

1.4. The present experiment

To investigate if postures varying in approach motivation influence these physiological responses, we had participants recline backward or lean forward in a fully counterbalanced within-subjects design. Leaning often occurs in approach behavior and reclining often occurs when individuals are satiated; thus, these two postures reflect extremes in approach motivation (in a chair). While in these postures, participants viewed sexual scenes involving pairs of men and women (erotic images) and scenes of pairs of individuals talking or walking (neutral images). Based on prior research, we predicted that startle eyeblinks would be smaller during erotic images than neutral images, and moreover, that startle eyeblinks during erotic images would be smaller when viewed in the high approach leaning as compared to the low approach reclining posture. Posture, however, was not predicted to influence startle responses during neutral images.

In addition, we predicted that LPPs would be larger to erotic images than neutral images, and moreover, that the LPPs to erotic images would be larger when viewed in the high approach leaning posture as compared to the low approach reclining posture. These postures, however, were not predicted to influence LPPs to neutral images. Finally, we explored whether early ERP amplitudes differed as a function of picture type and body posture.

2. Methods

2.1. Participants

Thirty-one (16 women) university students aged 18–24 years were recruited from introductory psychology classes and participated for course credit. Participants were randomly assigned to condition; experimenters were blind to condition. Twenty-two subjects were Caucasian and nine were Hispanic. Students were prescreened to insure they were not offended by erotic images between men and women. This study received institutional ethics review and participants supplied informed consent.

2.2. Stimuli and procedure

Two sets of 70 pictures (140 total pictures) were used in this experiment, counterbalanced alongside the two posture conditions. Each set contained 35 neutral pictures (pairs of individuals talking or walking in public) and 35 erotic pictures (pairs of men and women in sexual situations). Thus, pictures were matched with regard to having two persons in each picture. A given participant saw one set of 70 pictures, followed by the other set of 70 pictures. Participants, therefore, did not see duplicate images. Erotic and neutral pictures were randomly ordered in each set. Pictures were selected from non-copy righted sources on the internet. Three neutral pictures, used as practice trials before each condition, were selected from the International Affective Picture System (IAPS; Lang et al., 1999) along with18 erotic pictures and 8 neutral pictures depicting persons from the IAPS.

The experiment was conducted in one session. Participants were situated in a chair that could recline. Participants wore computer goggles so that text instructions and pictures could be presented equidistant from their eyes (Fig. 1). The lights inside the room were turned off during picture viewing, to focus participants on the presented images. For reclining, participants were instructed to fully recline the chair while keeping their hands' on the armrests, their legs' suspended on the footrest, and their head against the headrest. For leaning, participants were instructed to put the chair in the upright position, look forward and bend forward so that their back was bent and their elbows' were directly on their knees. Participants were also instructed to place their hands out in front of them.

Participants maintained one of these postures for one minute before picture trials began. This time interval was included so that participants could acclimate to the posture. Each picture set began with three neutral pictures, followed by a set of neutral and erotic pictures. Each trial consisted of a 2 s fixation cross, followed by 6 s of picture viewing. Inter trial intervals ranged from 10 to 16 s.

Startle-probes were presented for 50 ms at 100 db. In each set of 70 pictures, 40 pictures contained startle probes (20 during neutral, 20 during erotic pictures) presented either 3.5 or 4 s during picture viewing. These trials were used in the startle eyeblink analyses. To make the probes appear randomly presented to participants, 18 probes (9 after neutral, 9 after erotic pictures) were presented at random intervals during the ITI. Twelve trials (6 neutral, 6 erotic) did not contain a startle probe.

Following completion of the first posture condition, participants were given a 2 min break. Immediately after this break, participants assumed the second posture and began the second condition of the experiment.

Upon completing both posture conditions, participants were instructed to sit upright. Next, they viewed each of the erotic and neutral pictures presented in the experiment and rated them on affective valence and arousal. Participants rated erotic pictures ($M = 3.52$, $SD = .45$) as significantly more positive than neutral pictures ($M = 2.92$, $SD = .49$, $p < .001$) and rated erotic pictures ($M = 2.48$, $SD = .81$) as significantly more arousing than neutral pictures ($M = 1.35$, $SD = .33$, $p < .0001$). The scales for these ratings ranged from 1 (negative valence or low arousal) to 5 (positive valence or high arousal).[1]

Fig. 1. Leaning and reclining body positions.

2.3. EEG assessment and processing

EEG was recorded with 59 tin electrodes in a stretch-lycra electrode cap (Electro-Cap International, Eaton, OH). All sites were referenced online to the left earlobe, and re-referenced to averaged ears offline. All electrode impedances were less than 5 kΩ. Signals were amplified (60-Hz notch filter), bandpass filtered (.05–500 Hz), and digitized at 2500 Hz. Artifacts were removed by hand. Then, a regression-based eye blink correction using sensor Fp1 was applied (Semlitsch et al., 1986). Following the blink correction algorithm, the EEG files were reinspected to ensure that the correction was appropriate.

Data were epoched for 100 ms before, until 1000 ms after picture onset, and were filtered with a low pass of 35 Hz. Aggregated waveforms for each picture type were created and baseline corrected using prestimulus activity. LPPs were measured as average EEG activity within a window of 300–1000 ms during stimulus viewing at site Pz, where the LPP is maximal (Hajcak et al., 2012). This EEG activity served as the dependent variable in the −2 (leaning-neutral) vs. −2 (reclining-neutral) vs. 3 (leaning-erotic) vs. 1 (reclining-erotic) planned contrast.

The N1 is maximal at around 130 ms after stimulus onset at site Cz (Foti et al., 2009; Keil et al., 2001); therefore, the N1 peak was located in an epoch of 80–175 ms during stimulus viewing at site Cz. We also measured the P1 consistent with prior research that has found it to be maximal over occipital sites (Olofsson et al., 2008). Thus, we created an average of sites POZ, OZ, O1, and O2 at a range of 100–200 ms after stimulus onset. Finally, we measured the EPN consistent with prior research that has found it also to be maximal over the visual cortex (Dunning et al., 2011; Olofsson et al., 2008; Schupp et al., 2003). We created a composite of the average of sites POZ, OZ, O1, and O2 at a range of 200–300 ms following stimulus onset (Dunning et al., 2011). Because no a priori predictions were made for N1, P1, and EPN, traditional interactions were used to test the effect of posture and picture type.

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[1] One reviewer asked if valence ratings differed between genders, and if a gender by valence by posture interaction was present. We could examine this by examining which posture participants assumed before rating pictures in an upright posture and treating that as well as gender as between-subjects variables in a factorial ANOVA (posture × gender on ratings of erotic pictures). Thus, posture in this analysis is not the posture in which participants rated pictures, but the posture they assumed just prior to rating the pictures (because pictures were always rated in the upright posture at the end of the session). When this test is conducted, the interaction is not significant, $F(1, 24) = .20$, $p = .65$, nor is the main effect of sex, $F(1, 24) = 1.24$, $p = .27$. Interestingly, however, participants who leaned forward and then rated erotica in an upright posture ($M = 3.70$, $SD = .11$) rated these images as more positive as compared to participants who reclining backward and then rated erotica in an upright posture ($M = 3.35$, $SD = .10$); that is, there was a significant main effect of posture $F(1, 24) = 4.77$, $p = .03$, partial eta-squared = .16. This fits with our interpretation of the results.

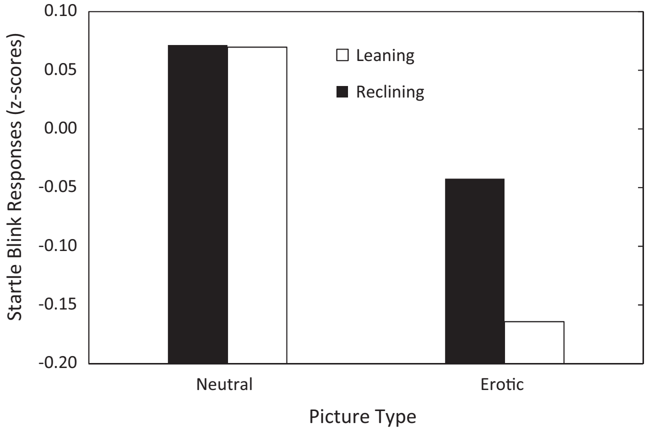

Fig. 2. Means for startle blink responses as a function of body posture and picture type.

2.4. Startle eyeblink assessment and processing

To measure startle eyeblink responses, the area under the left eyelid was cleaned using exfoliating gel and dry gauze. Two tin 4 mm (Electrocap, Eaton, OH) electrodes filled with conductive gel were applied to the skin just over the orbicularis oculi muscle in accordance with startle eye-blink measuring standards (Blumenthal et al., 2005). Impedances for these bipolar sensors were below 10 kΩ. Neuroscan Synamps 2 system was used for data collection. The data were rectified offline using Scan 4.5 analysis software, run through a low pass analog-simulator at 30 Hz, and baseline corrected to 50 ms before the startle eliciting stimulus. Each blink was inspected off line. Blinks were rejected if an EMG artifact or spontaneous blink occurred from 50 ms before until 20 ms after the probe onset. Additionally, in order to eliminate spontaneous blinks, blink trials were rejected if two or more blinks occurred during the response window. Peak amplitudes were found between 20 and 120 ms and were then standardized for each participant. Means for the four conditions of the experiment were calculated using these standardized values. These values served as the dependent variable in a 2 (leaning-neutral) vs. 2 (reclining-neutral) vs. −3 (leaning-erotic) vs. −1 (reclining-erotic) planned contrast.[2]

3. Results

3.1. Startle eyeblink

As predicted, posture influenced startle responses to appetitive but not neutral stimuli (Fig. 2). Leaning caused participants to have smaller startle responses to erotic images ($M = -.16$, $SD = .07$) relative to reclining ($M = -.04$, $SD = .06$, $p = .008$ for the simple effect). Leaning did not influence startle responses to neutral pictures ($M = .06$, $SD = .08$) relative to reclining ($M = .07$, $SD = .08$, $p = .96$ for the simple effect). Thus, leaning relative to reclining caused an attenuation of startle responses to erotic images [$t(30) = 3.56$, $p = .0006$, for the planned contrast]. Picture type and posture did not vary as a function of gender for startle responses, $F(1, 29) = .02$, $p = .87$.

3.2. LPP

The pattern of results obtained for the LPP also fit with predictions (Fig. 3). Leaning increased LPPs to erotic images ($M = 10.08$, $SD = .91$) relative to reclining ($M = 8.45$, $SD = .87$, $p = .006$, for the simple effect). Leaning did not influence LPPs to neutral images ($M = 1.72$, $SD = .89$) relative to reclining ($M = 1.66$, $SD = .71$, $p = .91$, for the simple effect). Thus, leaning relative to reclining increased this neural measure of emotive processing to erotic images [$t(30) = 14.16$, $p < .0001$, for the planned contrast].[3] Picture type and posture did not vary as a function of gender for LPP responses, $F(1, 29) = .10$, $p = .74$.[4]

3.3. N1

The interactive effect of posture and picture type on N1 peaks was non-significant, $F(1, 30) = .41$, $p = .52$. The main effect of picture type was also non-significant, $F(1, 30) = .31$, $p = .58$. The main effect of posture was also non-significant, $F(1, 30) = 2.16$, $p = .15$.

3.4. P1

The interactive effect of posture and picture type on P1s was significant, $F(1, 30) = 9.32$, $p = .004$, partial eta-squared = .23 (see Fig. 4). Follow-up tests revealed that participants had larger P1s to erotica in the leaning posture ($M = 4.73$, $SD = .54$) as compared to erotica in the reclining posture ($M = 3.01$, $SD = .51$; $p < .01$), neutral pictures in leaning posture ($M = 3.57$, $SD = .60$; $p < .01$), and neutral pictures in the reclining posture ($M = 2.98$, $SD = .48$; $p < .01$). Follow-up tests also indicated that participants had larger P1s to neutral pictures in the leaning posture as compared to neutral ($p = .03$) and erotic ($p = .04$) pictures in the reclining posture. P1 amplitudes were similar to erotic and neutral pictures in the reclining posture ($p = .89$). The main effect of picture type was also significant, $F(1, 30) = 5.09$, $p = .03$, partial eta-squared = .14, such that larger P1s were observed for erotica ($M = 3.87$, $SD = .47$) as compared to neutral ($M = 3.27$, $SD = .50$) pictures. The main effect of posture was also significant, $F(1, 30) = 8.16$, $p = .007$, partial eta-squared = .21, such that larger P1s were observed when participants leaned ($M = 4.15$, $SD = .54$) as compared to reclined ($M = 2.99$, $SD = .47$). Picture type and posture did not vary as a function of gender for P1 responses, $F(1, 29) = .62$, $p = .43$.

3.5. EPN

The interactive effect of posture and picture type for the EPN was non-significant, $F(1, 30) = .66$, $p = .42$. The main effect of picture type was also non-significant, $F(1, 30) = 2.60$, $p = .11$. Interestingly, the

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[2] The traditional 2 × 2 interaction of an ANOVA is most likely to yield a $p < .05$ when the means form an X pattern. The traditional 2 × 2 interaction is tested with contrast codes of +1, −1, −1, +1, thus the traditional ANOVA interaction is testing a pattern of means just like a planned comparison but the traditional ANOVA pattern is a pattern of means we would never predict. That is, we would not expect for the LPP to be larger to neutral pictures than appetitive pictures in the reclining condition, whereas the LPP to be larger to appetitive than neutral pictures in the leaning condition. However, that pattern of results is being tested by the traditional ANOVA interaction. These would be unexpected and unsupported findings based on prior work; reclining should not produce an opposite pattern of effects from leaning for LPP and startle responses. In this research, therefore, we tested our predictions with planned comparisons using a one-tailed criterion of significance because our predictions were directional, derived from theory, and specified in advance (Rosenthal et al., 2000).

[3] The omnibus within-subjects ANOVA testing startle, $F(30) = 3.16$, $p = .08$, partial eta-squared = .09, and LPP responses, $F(1, 30) = 3.25$, $p = .08$, partial eta-squared = .09, as a function of body posture and picture type approached conventional levels of significance in both instances. In addition, a main effect of picture type emerged for both responses. Participants showed more startle inhibition to erotic ($M = -.10$, $SD = .01$) than neutral pictures ($M = .07$, $SD = .02$), $F(1, 30) = 19.40$, $p = .0001$, partial eta-squared = .39. Participants showed larger LPPs to erotic ($M = 9.27$, $SD = .81$) than neutral ($M = 1.69$, $SD = .76$) pictures, $F(1, 30) = 207$, $p < .01$, partial eta-squared = .87. Simple effects tests indicated that within the leaning condition, participants had smaller startle responses to erotica than neutral pictures ($p < .01$). Within the reclining condition, participants had smaller startles to erotica than neutral pictures ($p = .02$). Simple effects tests also indicated that within the leaning condition, participants had larger LPPs to erotica than neutral pictures ($p < .01$). Within the reclining condition, participants had larger LPPs to erotica than neutral pictures ($p < .01$).

[4] We think it important to note that the pictures we used were not solely IAPS. They were carefully selected pictures of erotic couples that we thought would appeal equally to men and women. And indeed, our results supported our thought. In many past IAPS studies, male subjects are shown nude women and female subjects are shown nude men.

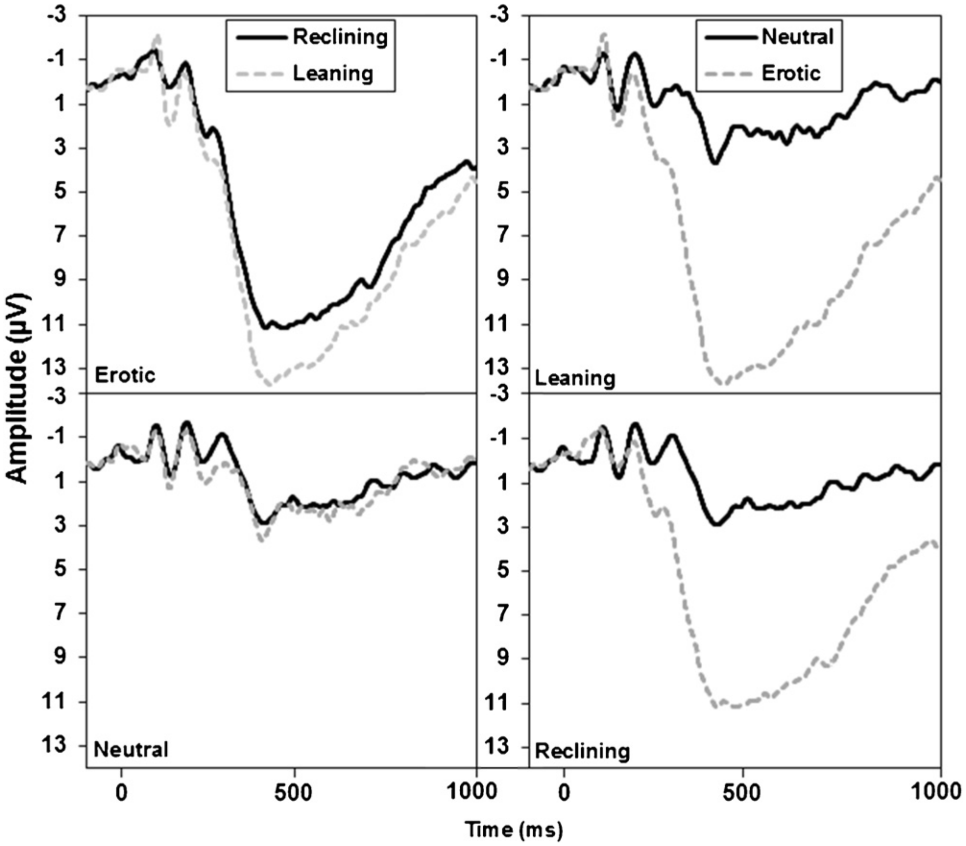

Fig. 3. Averaged ERPs at site Pz. The left side displays ERPs during leaning and reclining for erotic (top) or neutral (bottom) pictures. The right side displays ERPs to erotic and neutral pictures while leaning (top) or reclining (bottom). LPPs are in the 300–1000 ms range.

main effect of posture was significant, $F(1,30)=10.44$, $p=.002$, partial eta-squared = .25. Leaning caused participants to have a larger negative deflection to all stimuli ($M=3.88$, $SD=.54$) as compared to reclining ($M=5.48$, $SD=.58$). Picture type and posture did not vary as a function of gender for EPN responses, $F(1,29)=.08$, $p=.77$.

4. Discussion

As predicted, leaning compared to reclining influenced several measures of physiological activity that are sensitive to emotive processes, the startle eyeblink reflex and the LPP of the ERP primarily. Leaning relative to reclining may influence these physiological responses elicited by appetitive images because the viewers' posture is consistent with the approach motivational inclination evoked by the images participants are viewing.

These results extend research investigating the connection between trait approach motivation and startle responses during arousing positive pictures (Amodio and Harmon-Jones, 2011; Gard et al., 2007; Hawk and Kowmas, 2003). Whereas past research has found that individual differences in approach motivation are correlated with startle responses during arousing positive pictures, our results indicate that manipulating approach motivation causally influences startle and LPP responses during appetitive pictures. Our results also extend research linking startle eyeblink and LPP responses with the motivational significance of stimuli (e.g., Gard et al., 2007). Whereas past research suggests that motivationally significant stimuli compared to less significant stimuli attenuate startle eyeblink responses (Gard et al., 2007) and increase the amplitude of the LPP (Briggs and Martin, 2009), our results indicate that manipulating approach motivation influences startle eyeblink and LPP responses during appetitive images even when image content is held constant. In particular, heightened approach motivation embodied via leaning forward compared to lowered approach motivation embodied via reclining backward causes smaller startle eyeblink and larger LPP responses during appetitive images.

These results also suggest that bodily manipulations influence how individuals physiologically process emotive stimuli as early as 100 ms. The P1 is among the earliest ERPs to index attention to emotion; it is responsive to emotional stimulus types including faces (Pourtois et al., 2005; Santesso et al., 2008), images (Smith et al., 2003), and words (Bernat et al., 2001). The P1 is thought to relate to the rapid visual processing of stimuli; it is influenced by low level stimulus features (Pourtois et al., 2005), and its amplitude increases linearly as a function of stimulus perceptibility (Schupp et al., 2008). In the present experiment, leaning caused an emotion modulation of the P1, whereas reclining did not. Our results, therefore, suggest that heightened approach motivation might influence how individuals process the motivational significance of images even within a very early time frame.

5. Limitations and future directions

One might question if leaning prompts appetitive responses compared to a more neutral condition, such as an upright or 'normal' posture. We have conducted research that suggests this possibility (Price and Harmon-Jones, 2011). In this between-subjects experiment, participants reclined, leaned, or sat upright without viewing any stimuli for one minute of EEG recording. Results focused on frontal asymmetry, that is, relative left frontal cortical activity assessed via EEG alpha power which has been associated with approach motivation (Harmon-Jones et al., 2010).

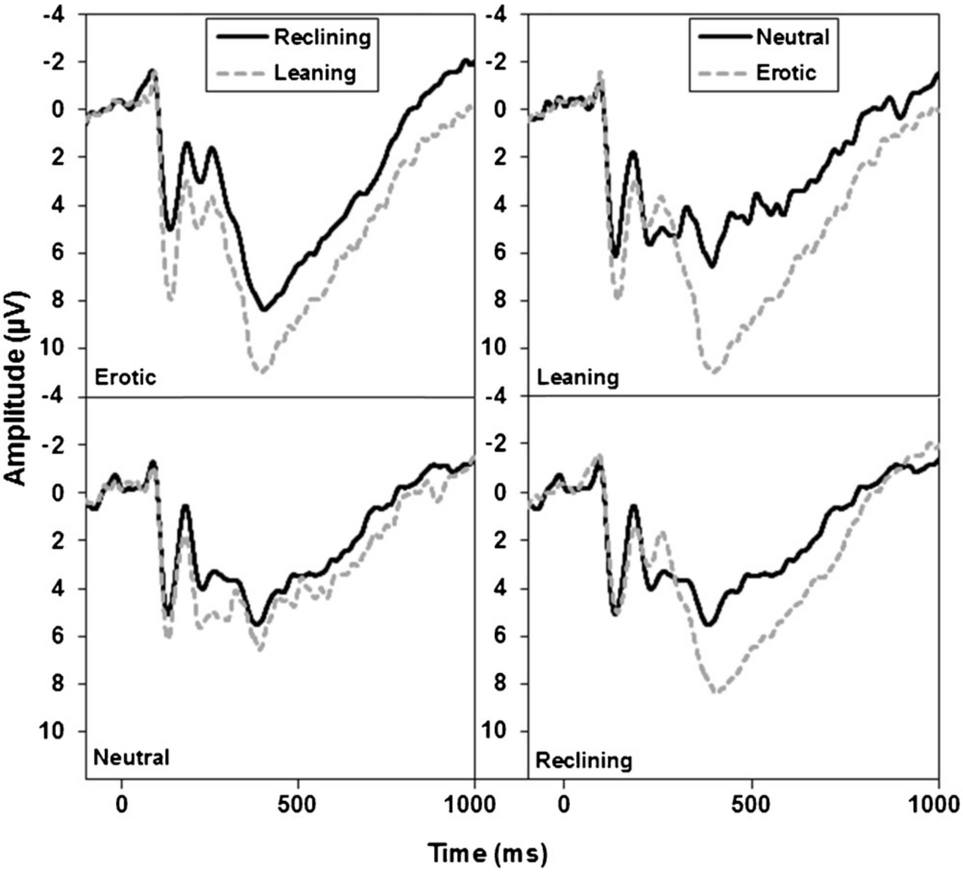

Fig. 4. Averaged ERPs at site Oz. The left side displays ERPs during leaning and reclining for erotic (top) or neutral (bottom) pictures. The right side displays ERPs to erotic and neutral pictures while leaning (top) or reclining (bottom). P1s are in the 100–200 ms range.

Results suggested a linear trend wherein leaning caused more relative left frontal cortical activity than the upright posture, which caused more relative left frontal cortical activity than the reclining posture. The significant difference in relative left frontal activity, however, emerged between leaning and reclining conditions, with the upright condition non-significantly between the other two conditions. Another experiment found relative left frontal cortical activation to be lower in a reclining than upright posture in response to an anger evocation (Harmon-Jones and Peterson, 2009). Finally, a behavioral experiment found the predicted linear trend across the three body postures for cognitive judgments influenced by approach motivation (Price and Harmon-Jones, 2010). It remains to be seen if this pattern of results would also occur with startle and LPP responses. Due to time constraints and concerns about participant fatigue, we did not include an upright posture condition, but instead manipulated what may be the extremes of approach motivated body postures that can occur while sitting in a chair.

One might also question if, alongside picture content, other elements of pictures (e.g., contrast, brightness) that differ between appetitive and neutral pictures influence startle and LPP responses. This is also a future empirical question with regard to the startle reflex and the specific ERP components examined in the present research. Some ERP research, however, has suggested that emotional/motivational discrimination of visual stimuli occurs independently of formal picture properties such as color and brightness (Junghofer et al., 2001).

Another question is whether the startle and LPP responses are correlated with one another. This was not the case in the present experiment (and we could find no previous research reporting these results). Recent research has found that, despite being influenced by the motivational significance of stimuli, the LPP and startle response are influenced differently by attention (Ferrari et al., 2011). In this experiment by Ferrari et al., stimulus novelty influenced LPPs to emotive but not neutral stimuli, whereas stimulus novelty had similar effects on startle blinks to both emotive and neutral stimuli. Thus, these two measures may differ in the way in which they measure initial motivated attention and, as a result, they may not be correlated with one another despite the fact that they are both influenced by the motivational significance of stimuli. Moreover, affective modulation of the startle eyeblink response is driven primarily by cells in the amygdala region (Lang, 1995), whereas affective modulation of the LPP is thought to be driven primarily by lateral occipital, inferotemporal, and parietal visual areas (Sabatinelli et al., 2007). Some work has suggested that the LPP might reflect re-entrant projections from the amygdala to other areas of the visual cortex (Lang and Bradley, 2010). The direct contribution of the amygdala to the magnitude of the LPP, however, remains unclear. Thus, although activations in these different regions may be correlated, these different areas of activation may also suggest different psychophysiological variables are being assessed.

6. Conclusions

The present findings extend previous reflex, ERP, as well as embodiment research. While past research has found that facial expressions influence autonomic nervous system activity (Levenson et al., 1990) and asymmetric frontal cortical activations (Coan et al., 2001; Ekman and Davidson, 1993), and whole body postures influence asymmetric frontal cortical activations (Harmon-Jones et al., 2011; Price and Harmon-Jones, 2011), our results indicate that whole body postures influence reflexive and electrocortical reactions to emotive stimuli. Prominent embodiment theories have also stimulated lines of research investigating how conceptual knowledge about emotion leads to simulating, or partial activation of modality specific sensations or physical actions related to emotional expression (Halberstadt et al., 2009). For example, studies have shown that reading words related to certain facial expressions of emotion (e.g., smiling, frowning) leads to facial muscle movements specific to these words (Foroni and Semin, 2009). Denervating facial muscles with BOTOX, in addition, has been found to slow the reading of emotional passages (Havas et al., 2010). Furthermore, studies have shown that generating emotional information influences posture; generating disappointment-related words led participants to decrease their height more than generating pride-related words (Oosterwijk et al., 2009). The full extent of this potential bi-directional relationship, between emotive processes and the physical body (Price et al., 2012), remains to be fully explored and thus continues to be an avenue for exciting research.

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