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Postauricular reflex responses to pictures varying in valence and arousal

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Abstract

Reflexes are modulated by emotions. Much research has revealed that the startle reflexive eyeblink response is modulated by emotion, particularly in response to pictures of emotional scenes. Investigations of other reflexes are limited. Recently, research suggested that the postauricular reflex in response to a startling noise was modulated by emotion. In particular, pleasant stimuli enhanced the postauricular reflex. However, these first investigations were limited: One experiment demonstrated only a marginal difference between the pleasant stimuli and neutral stimuli and the other lacked the typical neutral scene comparison. The present experiment was designed to assess whether significant emotion versus neutral differences would occur. Results demonstrated that pleasant stimuli, regardless of arousal level, evoked larger postauricular reflex activation than neutral and unpleasant emotional stimuli.

Descriptors: Emotion, Normal volunteers, EMG, Postauricular reflex, Startle blink

Reflexes are modulated by the emotional state of the organism. Much research has revealed that the startle reflexive eyeblink response is modulated by emotion (e.g., Amodio, Harmon-Jones, & Devine, 2003; Hawk & Kowmas, 2003; Vrana, Spence, & Lang, 1988). During the midst of processing of stimuli (2–5 s after stimulus onset), unpleasant emotional images increase the startle eyeblink response, whereas pleasant emotional stimuli decrease this reflexive response, compared to neutral emotional stimuli. These results have been interpreted in terms of a response-matching hypothesis that suggests that the defensive startle reflex is enhanced during unpleasant emotional visual and auditory cues because the motivational state induced by the stimuli is defensive (Lang, Bradley, & Cuthbert, 1990). In contrast, the startle eyeblink reflex is reduced during pleasant emotional visual and auditory cues because the defensive motivational state induced by the startle noise is inconsistent with the appetitive state evoked by the pleasant cues. In support of a motivational interpretation of these results, experiments have revealed that it is primarily high arousal pleasant images that cause attenuation of startle eyeblink responses and high arousal unpleasant images that cause potentiation of startle eyeblink responses (Cuthbert, Bradley, & Lang, 1996).

In an innovative experiment, Benning, Patrick, and Lang (2004) extended research on emotion–reflex interactions by examining the postauricular reflex, a vestigial muscle response in humans that acts to pull the ear backward. During the presentation of the pictures, startling noises were occasionally presented, and postauricular reflex was recorded. Results revealed a significant effect of picture valence on the postauricular reflex. Follow-up tests showed that the postauricular reflex was larger during pleasant pictures than during unpleasant pictures. However, the postauricular reflex was only marginally larger during pleasant as compared to neutral pictures. When the arousing nature of the valenced pictures was taken into account, the postauricular reflex was larger during high arousal pleasant pictures than high arousal unpleasant pictures. The postauricular reflex did not differ between high arousal pleasant pictures and the low arousal pleasant and unpleasant pictures.

In another experiment, Hess, Sabourin, and Kleck (2007) found that during the viewing of female faces, the postauricular reflex was increased during happy expressions and decreased during angry expressions, as compared to neutral expressions. During the viewing of male faces, the postauricular reflex was attenuated during anger expressions compared to both neutral expressions and happy expressions, which did not differ. Hess et al. also found that the postauricular reflex was potentiated during the viewing of pleasant scenes compared to intertrial intervals and unpleasant scenes, which did not differ. The latter results involving affective scenes partially replicated the results of Benning et al. (2004) but lacked the neutral picture control condition used in most previous startle eyeblink experiments.

Taken together, these results suggest that postauricular reflex is larger during pleasant pictures compared to unpleasant pictures. However, in Benning et al. (2004), the postauricular reflex was only marginally larger during pleasant as compared to neutral pictures. In Hess et al. (2007), a neutral affective picture condition was not included, so comparisons with this critical condition could not be made. Other experiments using similar methods have found no effects of affective picture type on post-

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auricular reflex (see Benning et al., 2004). For the relationship between postauricular reflex and emotion to be clearly interpretable, the postauricular reflex should differ significantly between neutral pictures and at least one type of affective picture. The present experiment was designed to examine whether such would occur with a different experimental paradigm.

In previous postauricular reflex and emotion experiments, pleasant, unpleasant, and neutral affective pictures were intermixed. In such designs, an unpleasant picture stimulus can occur at any time, and the affective tone of the pictures differs drastically from one presentation to the next. This degree of uncertainty may increase tonic negative affect throughout the entire picture viewing session, as (at least some) individuals are vigilant for unpleasant pictures. The tonic elevation of negative affect may attenuate positive affective responses (Neumann, Seibt, & Strack, 2001). Similarly, affective responses may be less intense in this mixed picture viewing session because of difficulties involved in switching from one valenced affect to an opposite valenced affect. To eliminate these design features that may work against observing emotional valence affecting the postauricular reflex and to give the postauricular reflex a stronger likelihood of differing between pleasant and neutral pictures, we had participants view the pictures in a block-type design, where affective pictures of one type were only pitted against neutral pictures. We also included high and low arousal pleasant and unpleasant pictures to assess whether the arousal level of the pictures would affect postauricular reflex activation to startle probes.

Method

Participants

Forty-eight undergraduates (10 women and 38 men) participated in exchange for course credit. To ensure participants were pleasantly aroused and not upset by the erotic pictures, the sample was prescreened to include only those who were willing to view pictures of partially nude couples.

Stimuli and Design

Participants viewed 128 color photographs, selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). Half were affective and half were neutral. Neutral pictures were matched with valenced pictures for color, brightness, object size, and human presence.[1]

Pictures were displayed for 6 s and preceded by a fixation cross for 3 s. Intertrial interval varied between 8 and 12 s. At either 3.5 or 4.5 s after picture onset, a 50-ms 102-dB (near-instantaneous rise time) startle probe of white noise was delivered through over-ear stereo headphones. During 25% of the trials, startle probes were delivered during the intertrial interval to increase the unpredictability of startle noise stimulus. Probes were presented either during the picture or during the ITI, not both. Six neutral pictures with startle probes were presented before picture viewing to habituate participants.

Pictures were presented in a semi-blocked fashion. Each block consisted of 32 pictures: 16 pictures from one affective picture category type (high arousal pleasant, low arousal pleasant, high arousal unpleasant, or low arousal unpleasant) and 16 matching neutral pictures. Thus, four blocks of pictures occurred. Neutral pictures and affective pictures (e.g., high arousal pleasant pictures) were randomly presented within a particular block. Block order was randomized between participants.

Physiological Measures

Placement and measurement of the postauricular reflex followed Benning et al. (2004). Electrode sites were prepared with an abrasive gel and an alcohol pad. Two tin electrodes were used to measure postauricular muscle activity. One electrode was placed in line with the postauricular muscle tendon on the pinnea of the ear. The other was placed on the scalp over the postauricular muscle. A ground electrode was placed on the forehead. Electrode impedance was below 5 kΩ. Data were amplified and filtered online using a bandpass filter of 0.05–1000Hz (sampling rate = 5000 Hz).

Data were hand artifact rejected; 5.3% of trials were excluded. Then, data were epoched for 50 ms before probe onset until 125 ms after probe onset, filtered off-line with a bandpass of 8–1000 Hz. Peak amplitude activity was measured as the maximum EMG activity within a window of 5–35 ms. The window for peak measurement was based on visual inspection. Individual trials were standardized across individuals, then averaged by picture block.[2]

Procedure

After providing informed consent, participants were instructed that they would be viewing a variety of pictures. They were told to watch each picture the entire time it was displayed and to ignore intermittent noises presented over the headphones. Following picture viewing, participants rated pictures on valence and arousal in the same randomly sorted semi-blocked design. As shown in Table 1, our arousal ratings were lower than normative arousal ratings. This result is most likely due to our sample rather than the semi-blocked design, because we have observed similar results in other mixed presentation designs in similar samples.

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[1]IAPS picture numbers: high arousal pleasant = 4695, 4608, 4656, 4659, 4651, 4658, 4681, 4670, 7460, 7480, 7402, 7350; low arousal pleasant = 5551, 5611, 5201, 5200, 5010, 5001, 1900, 1419, 5781, 1812, 1603, 5891, 1610, 1441, 2360, 7545; high arousal unpleasant = 6260, 3250, 9300, 9400, 8480, 9430, 1300, 2811, 6560, 9902, 1052, 6510, 3022, 3400, 3550, 6360; low arousal unpleasant = 2795, 2715, 2490, 9830, 9220, 2722, 9280, 9330, 2455, 9190, 2205, 9471, 9390, 9000, 9331, 9912; neutral = 1945, 1616, 7820, 7009, 7041, 7059, 7182, 2038, 7500, 7038, 9360, 5900, 7236, 7249, 7495, 7000, 7031, 7025, 2575, 7020, 2394, 7004, 2870, 2518, 6150, 2570, 7006, 2485, 2487, 2200, 7056, 7053, 7493, 7233, 2506, 5740, 2190, 5731, 2513, 7187, 2516, 2215, 2620, 2850, 7140, 7090, 5535, 2393, 7150, 7039, 7035, 5534, 2397, 5390, 7161, 2880, 7192, 7179. Four high arousal pleasant pictures of food were not from IAPS. Valence and arousal ratings for theses pictures were obtained through pilot testing ($n = 134$; valence $M = 7.02$, $SD = 0.36$; arousal $M = 6.09$, $SD = 0.42$); they have been used in other research (Gable & Harmon-Jones, 2008a, 2008b). In addition, six neutral pictures matched with the high arousal unpleasant pictures were not from IAPS. We added these pictures of people depicting neutral facial expressions so that the neutral pictures set would match the high arousal unpleasant picture set for people presence. Because Benning et al. (2004) found no differences in postauricular reflex as a function of picture content, we focused on valence and arousal. Picture content was not controlled.

[2]Due to equipment problems, data were not recorded from 1 participant during the low arousal unpleasant pictures and high arousal pleasant pictures and from another participant during the low arousal pleasant pictures.

Table 1. *Participant and Normative Valence and Arousal Ratings for Picture Blocks*

	Participant ratings		Normative ratings	
	Valence	Arousal	Valence	Arousal
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)
High arousal pleasant	6.98 (1.62)	5.19 (1.65)*	6.82 (0.35)	6.04 (0.75)*
Low arousal pleasant	6.67 (1.44)	2.70 (1.72)*	7.17 (0.40)	3.50 (0.31)*
High arousal unpleasant	3.18 (1.72)	4.19 (2.13)*	2.77 (0.63)	6.34 (0.49)*
Low arousal unpleasant	3.65 (1.15)*	2.69 (1.59)*	3.05 (0.59)*	4.26 (0.36)*
Neutral	5.48 (1.28)	2.49 (1.50)*	5.22 (0.42)	3.12 (0.65)*

*Differences between participant and normative ratings, $p < .05$.

Results

Because pictures were presented in a blocked fashion, comparisons were made between neutral pictures and their matched affective pictures from within each block. Postauricular reflex activation was greater during high arousal pleasant pictures ($M = 0.21$, $SD = 0.49$) than matched neutral pictures ($M = 0.05$, $SD = 0.49$), $t(47) = 2.79$, $p = .007$. It was also greater during low arousal pleasant pictures ($M = 0.07$, $SD = 0.43$) than matched neutral pictures ($M = -0.05$ $SD = 0.43$), $t(47) = 1.99$, $p = .05$. Neither unpleasant picture set differed significantly from matched neutral pictures, $ts < .14$, $ps > .73$ (see Figure 1).[3]

Next, difference scores were created between affective and neutral pictures within each block. Postauricular reflex activation to neutral pictures was subtracted from activation to affective pictures, such that greater scores indicate more activation to affective than neutral pictures. A 2 (pleasant vs. unpleasant) × 2 (low vs. high arousal) ANOVA revealed a significant main effect of picture valence, $F(1,45) = 7.52$, $p = .009$, $\eta_p{}^2 = .14$. This main effect indicated that postauricular reflex activation was significantly greater during pleasant pictures ($M = 0.15$, $SE = 0.05$) than unpleasant pictures ($M = -0.02$, $SE = 0.04$). The main effect of arousal and the Valence × Arousal interaction were not significant, $ps > .39$. A 2 (valence) × 2 (arousal) ANOVA for matched neutral pictures produced no significant effects, $ps > .39$. To further test for possible effects of arousal within pleasant pictures only, we conducted a 2 (arousal) × 2 (pleasant vs. neutral) ANOVA. A significant main effect for pleasant versus neutral pictures emerged, $F(1,45) = 10.48$, $p = .002$, $\eta_p^2 = .19$. No other effects were significant, $ps > .27$.

To examine whether order of block presentation affected postauricular reflex, we tested whether first block presented (pleasant vs. unpleasant) affected it; it did not, $p = .33$. Furthermore, neither sex of participant nor ear produced significant effects, $ps > .35$.

[3]Because 3 participants differed greatly from other participants in overall postauricular reflex activation, we standardized amplitude scores within subjects. All critical effects were replicated with the raw data. Postauricular reflex activation was greater for the high arousal pleasant pictures ($M = 14.88$, $SD = 34.14$) than matched neutral pictures ($M = 12.17$, $SD = 30.31$), $t(47) = 3.05$, $p = .004$. It was greater for low arousal pleasant pictures ($M = 12.24$, $SD = 31.73$) than matched neutral pictures ($M = 10.32$, $SD = 31.58$), $t(48) = 2.96$, $p = .005$. Neither unpleasant picture set differed significantly from matched neutral pictures, $ts < .80$, $ps > .43$. The 2 (pleasant vs. unpleasant) × 2 (low vs. high arousal) analysis of variance (ANOVA) replicated the main effect of picture valence, $F(1,46) = 8.20$, $p = .006$, partial eta squared $(\eta_p^2) = .15$, indicating that postauricular reflex activation was greater during pleasant ($M = 13.41$, $SD = 32.34$) than unpleasant pictures ($M = 8.00$, $SD = 34.30$). No other significant effects occurred, $ps > .25$.

Startle eyeblinks were also collected. Data replicated past results, 2 (valence) × 2 (arousal) ANOVA, $F(1,45) = 20.07$, $p < .0001$, $\eta_p{}^2 = .31$. High arousal unpleasant pictures evoked greater eyeblinks ($M = 0.15$, $SD = 0.51$) than matched neutral pictures ($M = -0.13$, $SD = 0.44$), $t(48) = 4.66$, $p < .0001$. Also, high arousal pleasant pictures evoked smaller eyeblinks ($M = -0.22$, $SD = 0.46$) than matched neutral pictures ($M = -0.06$, $SD = 0.54$), $t(47) = 3.10$, $p = .003$. No other picture types differed from matched neutral pictures, $ts < .51$, $ps > .61$.

Discussion

The present experiment demonstrated that pleasant scenes caused significant potentiation of the postauricular reflex relative to neutral scenes and unpleasant scenes. Finally, the arousal level of the scenes did not affect the postauricular reflex activation. This is the first demonstration of a significant difference between pleasant and neutral scenes on postauricular reflex potentiation. These results are in accord with previous expectations that the postauricular reflex is potentiated by pleasant stimuli (Benning et al., 2004; Hess et al., 2007).

In the current experiment, the postauricular reflex was not modulated by unpleasant scenes. These results are consistent with the previous results of Benning et al. (2004) and Hess et al. (2007), which used IAPS to manipulate unpleasantness. However, Hess et al. found postauricular reflex inhibition to angry facial expressions emitted by men and women. Considering the results of these two experiments with the present results, it

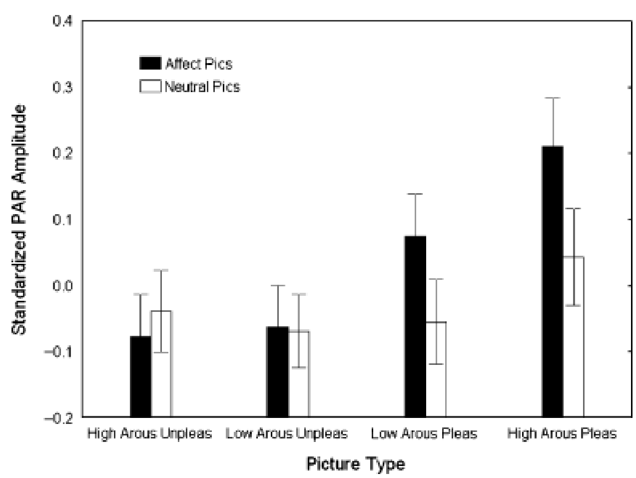

Figure 1. Standardized postauricular reflex amplitude as a function of picture type.

appears that the postauricular reflex is more responsive to pleasant stimuli than unpleasant stimuli. Further research is required to understand the special effect angry facial expressions have on postauricular reflex responses.

The present experiment used a semi-blocked design in which valenced scenes of one type were presented against neutral scenes. No intermixing of pleasant and unpleasant scenes occurred within one block of presentations. This separation of affective types appears to have potentiated the effects of positive affect on the postauricular and eyeblink reflex. That is, we observed a significant difference between pleasant and neutral scenes on postauricular and eyeblink responses. Past experiments using mixed designs have not produced this significant difference for postauricular reflex. Moreover, this difference is occasionally not significant for eyeblink responses (Larson, Nitschke, & Davidson, 2007). Unpleasant scenes in an event-related design may dampen the physiological responses associated with positive affect. However, self-reports, particularly when obtained during a second viewing, may not be sufficiently sensitive to detect differences between mixed and blocked designs. By including matched neutral pictures within blocks and randomly ordering block presentations, concerns regarding habituation can be eliminated. Consequently, future reflex studies should consider using semi-blocked designs.

Unlike the startle eyeblink reflex, the postauricular reflex was not affected by the arousal level of the scenes. This result suggests that the postauricular reflex may directly tap pleasantness independent of arousal, and thus may not be a reflex modulated by motivation but one only modulated by affective valence. To our knowledge, the postauricular reflex is the only reflex that shows greater activation to pleasant than neutral stimuli. Consequently, it can be used fruitfully in investigations of positive affect. Moreover, interrogation of the neural underpinnings of positive affect's modulatory influence on the postauricular reflex may enlighten the understanding of basic emotion-reflex linkages.

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