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BRIEF REPORT

Postauricular and eyeblink startle responses to facial expressions

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Abstract

Emotional facial expressions have affective significance. Smiles, for example, are perceived as positive and responded to with increased happiness, whereas angry expressions are perceived as negative and threatening. Yet, these perceptions are modulated in part by facial morphological cues related to the sex of the expresser. The present research assessed both eyeblink startle and the postauricular reflex during happy and angry expressions by men and women. For this 14 male and 16 female undergraduates saw happy, neutral, and angry facial expressions as well as positive and negative pictures. The postauricular reflex was potentiated during happy expressions and inhibited during anger expressions; however, as expected, this pattern was more clearly found for female expressers. Conversely, the expected pattern of eyeblink startle potentiation during angry faces and inhibition during happy faces was found only for male expressers.

Descriptors: Emotion, Facial expression, Eyeblink startle, Postauricular reflex

Ample research has demonstrated that the startle eyeblink reflex to a sudden acoustic probe is modulated by the individual's emotional state (e.g., Lang, 1995; Lang, Bradley, & Cuthbert, 1990; Vrana, Spence, & Lang, 1988). According to Lang (Lang, 1995; Lang et al., 1990), when an individual is exposed to an unpleasant stimulus, the relevant subcortical, aversive system circuitry is activated, leading to the augmentation of defensive reflexes such as the eyeblink reflex. As appetitive and aversive/defensive states are opponent states, the opposite effect can be observed when the individual is exposed to pleasant stimuli. More recently, Benning, Patrick, and Lang (2004) obtained a pattern opposite to that for the eyeblink reflex for the postauricular reflex, the muscle response that serves to pull the ear back and up (Berzin & Fortinguerra, 1993). Specifically, individuals showed an augmented postauricular reaction to an acoustic startle probe when exposed to pleasant stimuli and a reduced one when exposed to unpleasant stimuli.

Although the general pattern for eyeblink startle modulation has been shown to hold for a large number of positive and negative stimuli (Lang, 1995; Lang et al., 1990), results regarding human faces are equivocal. Whereas Balaban (1995) found that human infants showed potentiated eyeblink startle when exposed to angry faces and reduced eyeblink startle when exposed to happy faces, Spangler, Emlinger, Meinhardt, and Hamm (2001) did not find startle modulation in response to pictures of emotional expressions by infants. Likewise, Alpers and Adolph (2006) did not find evidence for startle modulation to adult human emotional facial expressions. Thus, human emotional faces do not seem to reliably modulate startle reactions.

One possible reason for the inconsistent findings regarding emotional facial expressions is that a certain arousal level is required for stimuli to modulate the eyeblink startle reflex. Although there is little doubt that emotional facial expressions induce emotions as evidenced by so-called contagion effects, that is, self-reports of congruent affect after exposure to emotional expressions (e.g., Blairy, Herrera, & Hess, 1999; Hess & Blairy, 2001; Neumann & Strack, 2000; Totterdell, 2000), these emotions may not be sufficiently strong in the present context. An additional goal of the present study is therefore to assess whether adult facial displays can modulate eyeblink startle.

However, emotional expressions not only induce emotions in observers, but more importantly, they also have signal value pertinent to the nuturing and defensive motives as perceived in others. Thus, anger expressions signal dominance on the part of the expresser, whereas happy expressions signal affiliation (Hess, Blairy, & Kleck, 2000; Knutson, 1996). In turn, perceptions of the dominance and affiliation tendencies of others are relevant to the approach/avoidance dimension. Specifically, in hierarchical primate societies such as ours, highly dominant alpha individuals pose a certain threat insofar as they can claim territory or possessions (e.g., food) from lower status group members (Menzel, 1973, 1974). Hence the presence of a perceived dominant other should lead to increased vigilance and preparedness for withdrawal (Coussi-Korbel, 1994). In contrast, affiliation is related

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to nurturing behaviors and should lead to approach when the other is perceived to be high on this behavioral disposition.

Interestingly, these two dispositions are also signaled by stable physiognomic traits in humans. For example, a square jaw, high forehead, or heavy eyebrows connote dominance (e.g., Keating, Mazur, & Segall, 1981; Senior, Phillips, Barnes, & David, 1999) whereas a rounded face with large eyes—a baby-face—connotes approachability or affiliation (e.g., Berry & McArthur, 1985, 1986). Importantly, certain of the perceptual cues that mark anger expressions, such as lowered eyebrows and tight lips, mimic features also associated with dominance. On the other hand, high eyebrows and smiling in happiness expressions reinforce affiliative features.

Hess, Adams, and Kleck (2007) have proposed a functional equivalence hypothesis that postulates that facial expressive behavior and morphological cues to dominance and affiliation are similar in their effects on emotional attributions. This notion also implies that there are interactions between facial expressions and facial morphology in the decoding of expressions of emotion. Importantly in the present context, the cues linked to perceived dominance (e.g., square jaw, heavy eyebrows, high forehead) are more typical for men, and men are generally perceived as more dominant than are women. In contrast, baby-facedness, a facial aspect more closely linked to perceived affiliation, is more common in women. This leads to the hypothesis that anger in men should be seen as more threatening due to anger's association with dominance. Likewise, happiness in women should be perceived as more appetitive due to its association with affiliativeness.

The present study had three main goals. First, we assessed eyeblink startle and postauricular responses during exposure to emotional facial expressions. Second, we tested the hypothesis that happiness when displayed by a woman is more appetitive, whereas anger when shown by a man is more threatening. Consequently, we expected potentiated postauricular reflex for female happiness versus male happiness and potentiated eyeblink startle to male anger versus female anger. Third, nonsocial emotional scenes were also included in the design to validate the emotional modulation of the postauricular reflex (e.g., Benning et al., 2004).

Method

Participants

Thirty undergraduate volunteers (16 women) with a mean age of 21 years participated individually.

Procedure

Participants were informed about the general procedure and invited to read and complete an informed consent form. As part of the form they were asked to not participate if they suffered from hearing impairments, tinnitus, or were allergic to band-aids. Participants who completed the form were seated in a comfortable chair in front of a computer monitor. Electrodes were attached to the right side of the face.

Materials

Participants saw 12 emotional facial expressions and 12 neutral facial expressions as well as 8 unpleasant and 8 pleasant images from the International Affective Picture System (IAPS, Lang, Bradley, & Cuthbert, 1999).

The emotional facial expressions were three anger and three happiness expressions shown by men and women taken from the Montreal Set of Facial Displays of Emotion (MSFDE; Beaupré & Hess, 2005), the Dartmouth Set of Young Adult faces (Adams & Kleck, 2001), and the NimStim Stimulus Set (Tottenham, Borscheid, Ellertsen, Marcus, & Nelson, 2002). The neutral expressions were taken from the same sources as well as from stimuli collected by Elfenbein, Beaupré, Leveque, and Hess (in press).[1] The unpleasant images from the IAPS depicted accidents, dead animals, and disgusting scenes.[2] The pleasant IAPS images depicted baby animals and nature scenes.[3]

Stimulus Presentation

Images were presented for 10 s. Between 3 s and 5 s after the onset of each image, a brief binaural white noise probe (50 ms, 95 dB) was presented. In addition, three probes were presented during ITIs to reduce the predictability of the noise stimulus. To ensure attention to the images, participants were required to rate each image for valence, arousal, and their tendency to withdraw from it. Following the ratings a blank screen appeared for 15 s.

EMG Measures

Eye-blink startle was assessed by a pair of Med Associates 0.25 cm Ag/AgCl electrodes placed under the right eye. For the *postauricular reflex* measurement electrodes were placed near the tendon of insertion of the postauricular muscle behind the right ear. The skin was cleansed with PDI disposable electrode prep pads (70% alcohol and pumice). Impedance was below 20 kΩ. A Contact Precision Instruments system with a 60-Hz notch filter was used to amplify the raw EMG signals at 1000 Hz.

The EMG data were filtered online with a bandpass of 50–1000 Hz and were off-line rectified, integrated with a time constant of 10 ms, and hand scored for artifacts. The magnitude of the startle reflex was scored from the across trials within conditions aggregate waveform as a baseline-to-peak measure (Hackley, Woldorff, & Hillyard, 1987; Sollers & Hackley, 1997). The baseline was defined as the average rectified postauricular and eyeblink EMG activity during the 50 ms before the onset of the noise probe. The peak was calculated as the maximum EMG activity within an onset window of 8–50 ms after noise probe onset. As the data were skewed, analyses were performed using log-transformed data. Data were analyzed using repeated measures ANOVA. LSD Post hoc tests were conducted with a $p < .05$ criterion level.

Results

Startle Modulation to Pleasant versus Unpleasant IAPS Images

Eye-blink startle. To assess effects of picture valence, an ANOVA was conduced comparing the pleasant and unpleasant

[1]The facial stimuli are available upon request from the first author. The overall arousal ratings were, for happy, 2.47 (.83), for neutral, 3.17 (.57), and for angry, 2.24 (.78); the overall valence ratings were, for happy, 1.46 (.79), for neutral, 3.08 (.46), and for angry, 4.22 (.68).

[2]The IAPS identification numbers were 1440, 1463, 1710, 1731, 1750, 2070, 5831, and 7480. As 2070 contains a face, it was excluded from analysis. The overall ratings were, for arousal, 3.45 (.83) and, for valence, 1.15 (.71).

[3]The IAPS identification numbers were 9040, 9140, 9181, 9320, 9560, 9570, 9571, and 9921. The overall ratings were, for arousal, 1.78 (.93) and, for valence, 4.97 (.57).

IAPS pictures with the ITI (no picture) condition; a contrast comparing eyeblink startle both to ITIs and positive images was conducted to assess the predicted potentiation during negative images. As expected, eyeblink startle during unpleasant images ($M = 1.36$, $SD = 0.47$) was potentiated compared both to ITIs ($M = 1.27$, $SD = 0.50$) and pleasant images ($M = 1.30$, $SD = 0.44$), which did not differ, $F(2,28) = 3.27$, $p = .053$, $\eta^2 = .19$.

Postauricular reflex. An ANOVA was conduced comparing the pleasant and unpleasant IAPS pictures with the ITI condition. Opposite to the pattern observed for eyeblink startle, the postauricular reflex was potentiated during pleasant images ($M = 0.52$, $SD = 0.52$) compared both to ITIs ($M = 0.35$, $SD = 0.43$) and unpleasant images ($M = 0.29$, $SD = 0.45$), which did not differ, $F(2,28) = 4.69$, $p = .017$, $\eta^2 = .25$. This result replicates the findings by Benning et al. (2004) for pleasant and unpleasant pictures.

Startle Modulation to Angry and Happy Faces

Eye-blink startle. To assess effects of emotion expressions a 3 (emotion expression: happy, neutral, angry) $\times$ 2 (sex of the expresser) ANOVA was conducted. No main effect for valence, $F(2,28) = 0.57$, $p = .574$, $\eta^2 = .04$, or sex, $F(1,28) = 0.10$, $p = .753$, $\eta^2 = .00$, emerged. The Valence $\times$ Sex interaction was significant, $F(2,28) = 3.71$, $p = .037$, $\eta^2 = .21$. Post hoc tests revealed no significant differences in startle reactions to female faces, $F(2,28) = 2.04$, $p = .149$, $\eta^2 = .13$. For male faces, however, startle was potentiated during angry ($M = 1.40$, $SD = .40$) compared to both neutral ($M = 1.34$, $SD = 0.44$) and happy faces ($M = 1.31$, $SD = 0.49$), which did not differ, $F(2,28) = 3.90$, $p = .032$, $\eta^2 = .22$.

Postauricular reflex. The 3 (emotion expression: happy, neutral, angry) $\times$ 2 (sex of the expresser) ANOVA revealed a main effect of sex, $F(1,29) = 7.95$, $p = .009$, $\eta^2 = .22$, such that the postauricular reflex was potentiated during female ($M = 0.41$, $SD = 0.38$) compared to male faces ($M = 0.36$, $SD = 0.37$). A main effect of emotion, $F(2,28) = 24.43$, $p < .001$, $\eta^2 = .64$, was qualified by a Valence $\times$ Sex interaction, $F(2,28) = 5.31$, $p = .011$, $\eta^2 = .28$. Figure 1 shows the means as a function of emotion and sex. As expected, for female faces, post hoc tests revealed that, compared to the neutral expression condition, the postauricular reflex was augmented during happy expressions and attenuated during anger expressions. For male faces, the postauricular reflex was attenuated during anger expressions compared to both neutral expressions and happy expressions, which did not differ.

Comparing Startle Reactions to Male and Female Faces

T tests were conducted to compare eyeblink startle reactions during male and female anger expressions and the postauricular reflex during male and female happiness expressions. As predicted by the functional equivalence hypothesis, during male anger expressions ($M = 1.40$, $SD = 0.40$) compared to female anger expressions ($M = 1.31$, $SD = 0.51$) eyeblink startle was potentiated, $t(29) = 2.27$, $p = .031$. Further, in line with predictions, no significant difference was found for neutral expressions. Eyeblink startle was, however, potentiated during female ($M = 1.42$, $SD = 0.34$) versus male ($M = 1.31$, $SD = 0.49$) happiness expressions, $t(29) = 2.27$, $p = .31$. This difference cannot be attributed to a difference in arousal between these stimuli, as arousal ratings were identical ($M = 2.47$, $SD = 0.83$ versus $M = 2.46$, $SD = 98$, $t[29] = .07$, $p = .949$).

As predicted, the postauricular reflex was potentiated during female happiness expressions ($M = 0.62$, $SD = 0.43$) compared to male happiness expressions ($M = 0.38$, $SD = 0.42$), $t(29) = 3.70$, $p = .001$. Further, and again in line with predictions, no differences emerged for neutral and anger expressions.

Discussion

The present study had three principal goals. First, to replicate findings by Benning et al. (2004), who demonstrated emotional modulation of the postauricular reflex. As predicted, we found that, compared to ITIs, the postauricular reflex was potentiated during pleasant scenes and attenuated during unpleasant scenes.

Second, we assessed eyeblink startle and the postauricular reflex during viewing of emotional facial expressions. Third, we tested the hypothesis based on the functional equivalence notion (Hess et al., 2007) that happiness when shown by a woman is more appetitive, whereas anger when shown by a man is more threatening. Specifically, we predicted that eyeblink startle would be potentiated during male anger expressions compared to female anger expressions, whereas the postauricular reflex would

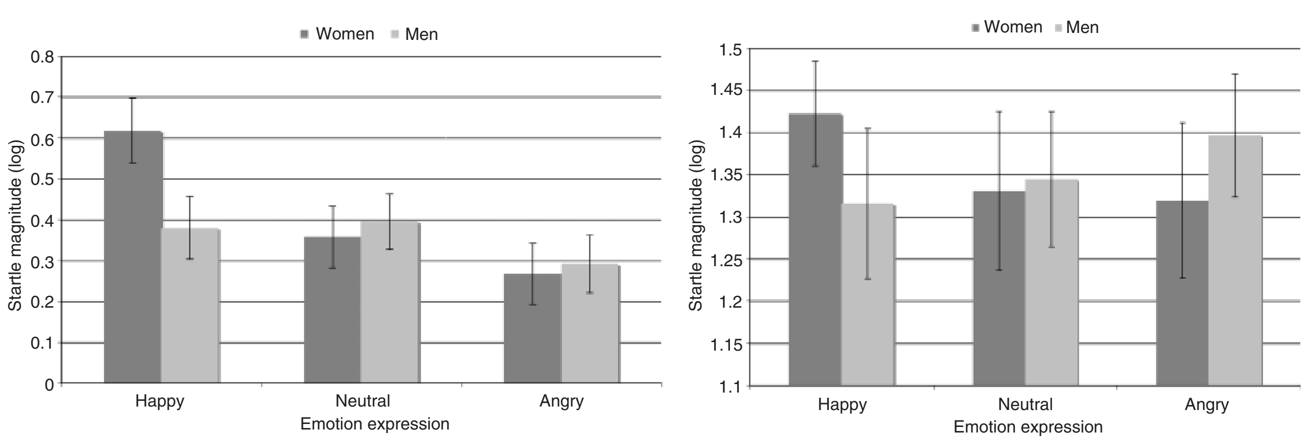

Figure 1. Left panel: Mean log-transformed postauricular reflex magnitude as a function of emotional facial expression and expresser sex. Right panel: Mean log-transformed eyeblink startle reflex magnitude as a function of emotional facial expression and expresser sex.

be potentiated to female happiness expressions versus male happiness expressions.

Overall, we found significant startle modulation for emotional facial expressions. However, as predicted by the functional equivalence notion, these effects were dependent on the sex of the expresser. Specifically, eyeblink startle was potentiated during male anger faces compared to neutral and happy faces, as well as compared to female anger faces. In contrast, the postauricular reflex was potentiated during female happiness faces and attenuated during male anger faces, compared to neutral faces as well as to male happiness faces.

Thus, anger, even though this expression signals threat (e.g., Aronoff, Barclay, & Stevenson, 1988), potentiated eyeblink startle only when shown by a man, that is, shown on a face suggesting social dominance. Averill (1997) has postulated that the power to act on anger is an important requirement for this expression to be perceived as "legitimate." Given women's more affiliative appearance, it is possible that female anger does not activate the aversive/defensive system to the same degree as does male anger, and hence exposure to female anger will not result in an eyeblink startle potentiation effect. This explanation is also in line with the finding that postauricular potentiation was overall larger during female faces than during male faces—suggesting that female faces are more appetitive stimuli. Following this line of argument, the female anger expression is actually a combination of an appetitive face with a threatening expression. Male anger, on the other hand, represents a less ambiguous example of a threat stimulus.

The above considerations may also explain the failure of Spangler et al. (2001) to find evidence for startle modulation during exposure to the facial expressions of distressed infants. Although infant distress elicits negative emotions, it should also elicit approach tendencies, as juvenile distress carries a strong demand for succor. This view is also in line with the finding by Balaban (1995) that eyeblink startle was potentiated in infants viewing emotional faces. Arguably, very young infants may not yet comprehend the social signal value of facial appearance cues and hence react to the emotional information only.

This leads to a secondary consideration in the context of startle responses during emotional facial expressions. Though eyeblink startle modulation is usually considered a function of valence, this formulation is actually a shortcut referring to an underlying association of negative valence and withdrawal or submission, and positive valence and approach. It is important to keep this distinction in mind when assessing startle modulation in response to human faces because human emotional expressions carry both valence and social information. Emotion information and social information may only incompletely map onto each other such that, as in the case of infant distress, and presumably female anger, negative valence and approach tendency can cooccur in a way less likely for nonsocial stimuli.

As noted earlier, we found potentiation of the postauricular reflex to emotional facial expressions by both men and women. However, the pattern was somewhat different depending on the sex of the expresser. The postauricular reflex was potentiated during female happiness expressions in line with the notion that these expressions are positive, appetitive stimuli. Startle was inhibited during female anger expressions compared to neutral expressions. In contrast, whereas male anger faces attenuated the postauricular reflex, male happy faces did not elicit potentiation. This pattern of findings suggests that the postauricular reflex may be less sensitive to threat information and more directly responsive to the positive–negative valence dimension.

In sum, the present research replicated the sensitivity of the postauricular reflex modulation to the valence of stimuli. Further, both postauricular reflex and eyeblink startle modulation to the valence of emotional facial expressions was found. As expected, this effect was moderated by expresser sex. We argue that this moderation is due to the added social signal value of human emotional expressions, which does not in all cases map onto the emotional information. Specifically, human facial expressive stimuli may be at the same time appetitive and negative, such as shown for fear by Marsh, Adams, and Kleck (2005), thus weakening their ability to modulate eyeblink startle reactions. This may be the case to a lesser degree with regard to the postauricular reflex, which seems to be modulated more by valence than by an aversive/defensive reaction. Overall, the present research underlines the importance of considering the social information contained in emotional stimuli.

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