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Trait Emotions and Affective Modulation of the Startle Eyeblink: On the Unique Relationship of Trait Anger

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We examined relationships among individual differences in trait emotions and the emotion-modulated startle-eyeblink response. In particular, we examined the extent to which trait anger, which is negative in valence, would be associated with a pattern of approach motivation in startle eyeblink responses to appetitive stimuli. Self-reported trait emotions were compared with emotion-modulated startle eyeblink responses to auditory probes during appetitive, aversive, and neutral pictures. Results revealed that trait anger, enjoyment, and surprise were each associated with greater blink inhibition to appetitive pictures, indicating an approach motivational response. No other trait emotions were associated with startle eyeblink responses to appetitive or aversive pictures. These results support the idea that trait anger, although experienced as a negative emotion, is associated with an approach-related motivational response to appetitive stimuli at basic, reflexive levels of processing.

Keywords: anger, approach, emotion, motivation, startle eyeblink

Emotions influence a broad range of psychological processes, from complex decision making down to basic reflexes. For example, several studies have shown that one's emotional state, evoked by visual or auditory cues, affects the strength of the startle reflex—the defensive whole-body response to a startling (and potentially harmful) stimulus (Lang, Bradley, & Cuthbert, 1990). In this literature, aversive emotional states have been shown to potentiate the startle reflex, whereas appetitive emotional states have been found to inhibit the startle reflex. Associations between trait emotions and startle eyeblink response patterns are interesting because they provide insight into the basic-level affective and motivational processes associated with emotional dispositions. The present research examined associations between trait emotions and startle eyeblink responses to positive, negative, and neutral pictures. In particular, we examined the hypothesis that trait anger, although objectively negative in valence, would be associated with an approach-motivated pattern of startle-eyeblink response, as characterized by startle inhibition to appetitive stimuli.

The Startle-Eyeblink Measure of Affect and Motivation

The startle response has been utilized in numerous investigations of emotion and motivation, in both human and nonhuman animals (e.g., Amodio, Harmon-Jones, & Devine, 2003; Blumenthal & Franklin, 2009; Davis, 2006; Hawk & Kowmas, 2003; Vrana, Spence, & Lang, 1988). The startle response refers to a defensive reflex, evoked by abrupt, intense stimulation, which functions to protect the body from potential harm. A large body of research has reliably shown that when an animal is in an aversive affective state at the time it is exposed to an abrupt, loud noise (referred to as a *startle probe*), the magnitude of the resulting startle response is greater (Davis, 2006). This effect reflects the modulation of the startle reflex circuit by the amygdala, via the nucleus pontis recticularis caudalis (Davis, 2006). Alternatively, when an animal is in an appetitive state at the time of the startle probe, the resulting startle magnitude is often reduced.

In humans, the startle response in humans is typically assessed by measuring the magnitude of a participant's eyeblink, the most persistent component of the startle response. Most research on the emotion-modulated startle eyeblink response in humans has used a picture-viewing paradigm, in which highly arousing pleasant and unpleasant pictures, and low-arousal neutral pictures, are shown in sequence for several seconds each. Startle probes are presented, usually through headphones, during the midst of picture viewing. The typical finding is that participants' startle eyeblink response is increased while viewing arousing unpleasant pictures, and decreased while viewing arousing pleasant pictures, relative to neutral pictures. These results have been interpreted in terms of a response-matching hypothesis, which posits that the defensive startle reflex is enhanced during aversive emotional visual and auditory cues because the motivational state induced by the stimuli is defensive (Lang et al., 1990). Given the defensive function of the startle reflex, demonstrations of emotion-modulated startle in aversive states have been especially robust. That is, in support of a motivational interpretation of these results, research has generally found that high-arousal unpleasant cues cause potentiation of startle eyeblink responses, whereas high-arousal pleasant cues cause an attenuation of startle eyeblink responses (Cuthbert, Bradley, & Lang, 1996). By the same logic, the startle eyeblink reflex

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is inhibited during appetitive emotional visual and auditory cues because the defensive motivational state induced by the startle noise is inconsistent with the approach-motivational state evoked by the appetitive cues.

Trait Emotion and the Emotion-Modulated Startle-Eyeblink Response

Several personality traits associated with affect and motivation have been found to relate to startle eyeblink responses to affective stimuli. Most studies have focused on trait predictors of startle potentiation, which refers to the enhancement of the startle eyeblink response during exposure to aversive stimulus cues in comparison with nonemotional cues. That is, individuals with specific phobias show more startle potentiation while viewing scenes related to their own phobias (Vrana, Constantine, & Westman, 1992). In other research, individuals high in trait fearfulness exhibited greater startle potentiation during aversive pictures compared with other individuals (Cook, Davis, Hawk, Spence, & Gautier, 1992; Corr, Kumari, Wilson, Checkley, & Gray, 1997; Vaidyanathan, Patrick, & Bernat, 2009). Individuals who appear to lack fear (e.g., those scoring high on the affective-interpersonal feature of psychopathy) fail to show startle potentiation (Benning, Patrick, & Iacono, 2005; Patrick, Bradley, & Lang, 1993).

Whereas startle potentiation is observed in response to aversive stimuli, *startle inhibition* often occurs in response to appetitive stimuli. However, fewer studies have examined personality traits that predict greater blink inhibition to appetitive stimuli. Two studies have found that greater trait approach motivation, as measured by the behavioral activation subscale of Carver and White's (1994) Behavioral Inhibition System and Behavioral Activation System (BIS/BAS) questionnaire, relates to more startle eyeblink inhibition to arousing pleasant stimuli (Hawk & Kowmas, 2003; Peterson, Gable, & Harmon-Jones, 2008). That is, high trait-approach motivation is associated with greater blink inhibition to appetitive stimuli.

This research on BAS and startle eyeblink responses suggest the counterintuitive prediction that trait anger may relate to greater startle inhibition to appetitive stimuli. This prediction follows from a growing body of evidence that suggests that anger, although negative in affective valence, relates directly with approach motivation (for review, see Carver & Harmon-Jones, 2009). Evidence supporting the anger and approach motivation relationship comes from several different sources. For example, studies have found (1) that BAS is related to greater trait (Harmon-Jones, 2003a) and state (Carver, 2004) anger as well as aggressive inclinations (Harmon-Jones & Peterson, 2008); (2) that BAS and anger are both related to greater relative activity in left frontal cortex (Harmon-Jones, 2003b), a region involved in approach motivational processes; (3) and that anger during extinction is associated with higher levels of joy, interest, and relearning when the learning aspect of tasks are reinstated (Lewis, Alessandri, & Sullivan, 1990). Perhaps even more counterintuitively, anger correlates directly with positive activation (PA) as measured by the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), and this correlation is not because of anger being evaluated as a positive affect but is instead because both anger and PA are associated with approach motivation (Harmon-Jones, Harmon-Jones, Abramson, & Peterson, 2009).

Present Study

The anger-as-approach idea suggests that trait anger should be related to startle eyeblink inhibition during exposure to appetitive stimuli. A test of this idea would be particularly novel because no past research has linked trait anger to approach motivational processes at the reflex level. In this study, we measured trait anger and other trait emotions using the Differential Emotions Scale (DES-IV; Izard, Libero, Putnam, & Haynes, 1993). The DES-IV is based on an extensive body on research testing Differential Emotions Theory, and it measures 12 trait emotions: *interest*, *enjoyment*, *surprise*, *sadness*, *anger*, *disgust*, *contempt*, *fear*, *guilt*, *shame*, *shyness*, and *hostility inward*. Our prediction was that anger, as well as the positive approach-related emotions enjoyment and interest, would relate to blink inhibition to probes while viewing arousing pleasant stimuli, but that other negative emotional traits would not show this pattern. For startle eyeblinks to arousing unpleasant stimuli, we predicted that greater trait negative emotions would relate to more startle potentiation. We advanced no predictions for the relationship between positive emotional traits and startle eyeblink responses to unpleasant stimuli, or for the relationship between nonanger-related negative emotional traits and startle eyeblink responses to pleasant stimuli.

Method

Participants and Procedure

Twenty-three female volunteers enrolled in introductory psychology participated individually for extra course credit. After providing consent and being prepared for physiological recording, participants viewed a series of images according to a standard picture-viewing paradigm used in much past research (Lang et al., 1990). To familiarize participants with the procedure and the sound of the startle probe, the task began with four neutral images, with a startle probe occurring during three of the images and during one of the intertrial intervals. The critical trials included 36 IAPS pictures that were viewed in two blocks, separated by a short break. All participants viewed the same set of pictures. Pictures were presented for 6 s, following a 3-s fixation point, and intertrial intervals ranged from 14–22 s. Participants were instructed to attend to each image but to make no response. Images included 12 positive, 12 neutral, 12 negative pictures, selected based on normative ratings of valence and arousal.[1] Within valence type, four trials included probes presented at 350 ms, four trials included probes presented at 3500 ms, and four trials did not include any probes. (clear trials; Amodio et al., 2003). Four additional probe were presented during ITIs but were not scored. Trial order was quasi-random, such that no single trial type repeated more than

[1] The following IAPS pictures were selected based on ratings of valence and arousal published by Lang, Bradley, and Cuthbert (1997): Positive slides included 1440, 1463, 1650, 5621, 1811, 2040, 7270, 7230, 7330, 8030, 8080, 8501; neutral slides included 5500, 5740, 7000, 7002, 7010, 7090, 7130, 7170, 7500, 7560, 7950; negative slides included 1120, 1220, 1270, 1300, 1930, 3060, 3110, 3350, 6230, 9300, 9410, 9570. Mean ratings of valence and arousal were 7.60 and 5.77 (positive), 5.05 and 2.97 (neutral), and 2.63 and 6.38 for negative pictures, respectively, scored on a scale ranging from 1 (lowest) to 9 (highest).

once consecutively. The startle probe was a 50 ms burst of white noise at 96 dB, presented binaurally through headphones. Probe volume was calibrated before each session. Stimulus presentation was performed using DMDX software (Forster & Forster, 2003).

At the end of the session, participants completed the DES-IV (Izard et al., 1993), a 36-item scale comprising 12 subscales for each trait emotion (see Table 1). Participants were asked to rate the extent to which they experienced various emotions and emotion-related responses on a scale ranging from 1 (*rarely or never*) to 5 (*very often*). Scores were averaged within each subscale to produce individual trait emotion scores. Reliability of these subscales was generally high, and scores were within the typical range (see Table 1).

EMG Recording and Analysis

EMG was recording from 4 mm Ag/AgCl electrodes placed over the left inferior orbicularis oculi below the inner and outer canthi (van Boxtel, Boelhouwer, & Bos, 1998), with a forehead ground. Impedances were below 10 kOhms. Raw EMG signal was amplified (20,000 times), passed through a 30–500 Hz filter, and digitized at 2,000 Hz (Contact Precision Instruments, Cambridge, MA). Startle eyeblink amplitude was determined by calculating the root mean square of EMG signal between 30 and 90 ms after probe onset (Grillon & Davis, 1995). Artifact-free blink responses were standardized to *T* scores ($M = 50$, $SD = 10$), as in Globisch, Hamm, Esteves, and Öhman (1999), and then averaged within trial types to yield blink amplitude scores for each picture type at each probe latency.

Results

To establish the basic emotion-modulated startle effect, eyeblink amplitudes were submitted to a 3 (valence) × 2 (probe time) within-subjects analysis of variance (ANOVA). This analysis produced a significant interaction, $F(2, 44) = 4.47$, $p < .02$. Simple analyses revealed the expected emotion-modulated startle effect of valence for long-latency probes, $F(2, 44) = 8.95$, $p < .001$, replicating previous findings (Lang et al., 1990). Blink amplitudes were significantly smaller for positive pictures ($M = 47.15$, $SD = 3.66$) versus neutral pictures ($M = 50.18$, $SD = 3.61$), $t(22) = 2.29$, $p = .03$, indicating approach-related blink inhibition toward appetitive stimuli. Blink amplitudes were marginally larger for negative pictures ($M = 52.57$, $SD = 3.49$) versus neutral pictures, $t(22) = 1.93$, $p = .067$, indicating withdrawal-related amplification to aversive stimuli. Blink amplitudes also differed for negative versus positive images, $t(22) = 4.20$, $p < .001$. The effect of valence was not significant for short-latency probes, $F < 1$.

Next, we tested our hypotheses regarding the relation between trait anger and startle responses. Specifically, we hypothesized that individuals reporting high trait anger, like those reporting high trait enjoyment, would show greater blink inhibition to positive stimuli. That is, on long-latency probe trials, high trait anger and enjoyment should be associated with smaller blink amplitudes on positive trials, but not on neutral or negative trials. Indeed, this pattern of correlations was observed (see Table 2). Trait surprise was also associated with greater blink inhibition to positive stimuli. This pattern of correlations remained significant in partial correlations, in which amplitudes to neutral stimuli were covaried (see Table 2). A scatterplot illustrating the relation between trait anger and appetitive blink amplitude (with neutral blink amplitude covaried) is presented in Figure 1.

As a more stringent test of our hypothesis, a regression analysis was conducted in which all trait emotions were entered simultaneously, along with blink amplitudes for neutral pictures as a covariate, to predict positive blink amplitudes. Only three effects were significant, for trait anger, $\beta = -.65$, $t = -2.59$, $p = .03$, trait enjoyment, $\beta = -.44$, $t = -2.55$, $p = .03$, and trait surprise, $\beta = -.60$, $t = -2.94$, $p = .02$. In each case, higher levels of the trait emotion was associated with greater blink inhibition. All other predictors were nonsignificant, $ps > .10$. In an additional regression analysis that included only negative trait emotions, along with blink amplitudes on neutral trials, the only significant emotion predictor was anger, $\beta = -.86$, $t = -2.36$, $p = .04$. Overall, the pattern of observed effects supported our hypothesis that although anger is negative in valence, it functions similarly to enjoyment in that it is associated with enhanced approach-related responsiveness to appetitive stimuli.

Table 1
Descriptive Statistics for Subscales of the Differential Emotions Scale

Trait emotion	Mean	*SD*	α
Anger	2.47	0.70	.85
Enjoyment	3.74	0.56	.85
Interest	3.59	0.52	.65
Guilt	2.60	0.56	.72
Shyness	2.30	0.77	.86
Disgust	1.84	0.54	.73
Inward hostility	1.98	0.50	.64
Fear	1.93	0.44	.61
Shame	2.56	0.84	.83
Sadness	2.63	0.54	.59
Surprise	2.68	0.61	.78
Contempt	2.06	0.49	.12

Note. Mean, *SD*, and Cronbach's α were computed for the present sample. Ratings were made on a 1 (*rarely or never*) to 5 (*very often*) scale.

Discussion

The present research examined associations between trait emotions and individual differences in the emotion-modulated startle eyeblink response. The first goal of this research was to assess the correspondence between dispositional emotional tendencies and relatively low-level reflexive modulations to appetitive and aversive pictures. The results indicated that the trait emotions *anger*, *enjoyment*, and *surprise* were significantly associated with blink inhibition during the presentation of appetitive stimuli, suggesting stronger engagement of approach-related tendencies.

We did not observe significant correlations between trait emotions and startle eyeblink amplitudes to either neutral or aversive images. This result is inconsistent with some past results that have found associations between fear-related traits and startle potentiation to aversive images (Cook et al., 1992; Corr et al., 1997; Vaidyanathan et al., 2009), but consistent with other studies that have not found such an association (Hawk & Kowmas, 2003; Peterson et al., 2008). However, trait fear may be more likely to relate to startle potentiation among individuals with extreme levels

Table 2
Zero-Order and Partial Correlations Between Trait Emotions and Long-Latency Startle Eyeblink Amplitudes on Positive, Neutral, and Negative Trials

	Picture valence				
Trait emotion	Positive	Neutral	Negative	Positive (partial)	Negative (partial)
Anger	−.44*	.02	.34	−.51*	.38
Enjoyment	−.50*	.34	.13	−.40†	.32
Interest	−.17	.15	.07	−.11	.15
Guilt	−.13	−.02	.10	−.17	.10
Shyness	.06	−.26	.34	−.09	.26
Disgust	−.20	−.12	.11	−.31	.07
Inward hostility	.03	−.27	.09	−.14	−.02
Fear	−.18	.07	.09	−.17	.13
Shame	.19	−.39	.15	−.03	−.01
Sadness	−.08	.07	.00	−.05	.03
Surprise	−.55**	.36	.20	−.45*	.40
Contempt	−.35	.29	−.01	−.24	.12

Note. Partial correlations refer to correlations in which blink amplitudes from neutral trials were covaried.
† $p = .06$. * $p < .05$. ** $p < .01$.

of trait fear (Cook, Hawk, Davis, & Stevenson, 1991), or when other individual differences, such as impulsivity, are considered in concert with trait fear (Corr, 2002). For example, Corr (2002) found that high trait anxiety was associated with greater startle potentiation, relative to low-anxiety participants, only among individuals who reported low impulsivity. In other research, the effect of trait fear on startle potentiation concerned specific phobia, with stimuli tailored to the phobia (e.g., Vrana et al., 1992). The apparent inconsistencies in this literature may be because of these factors. Hence, these findings raise a set of new questions regarding the correspondence between trait measures of emotion and the expression of these emotions in physiological responses.

The second goal of this research was to test the hypothesis that trait anger would be associated with stronger approach-related

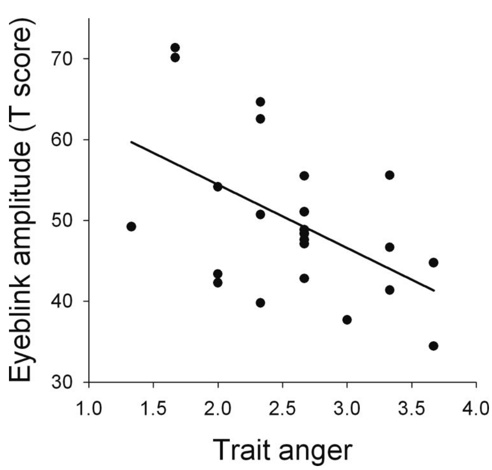

Figure 1. Scatterplot illustrating the relation between trait anger and startle blink amplitudes to positive pictures (with eyeblink amplitude to neutral pictures covaried). Trait anger scores ranged from 1 (lowest) to 5 (highest). Smaller eyeblink amplitude scores indicate greater blink inhibition.

responses to appetitive images, despite its negative subjective valence. Indeed, individuals with higher levels of trait anger evidenced stronger blink inhibition while viewing appetitive stimuli, suggesting stronger approach motivation responses toward these stimuli. The effect of trait anger of startle eyeblink responses was similar to that of trait enjoyment—an emotion that is also associated with motivational approach, but different in its subjective valence. This finding extends previous research on the functional significance of anger as an approach-related emotion to include the modulation of reflexes. It is notable that there was a nonsignificant trend for trait anger to be related to blink potentiation during aversive pictures. Although such trends should be interpreted with caution, it may suggest that trait anger is associated with stronger reactions to negative, as well as positive, stimuli—a hypothesis to be investigated in future research. Overall, these results add to the growing body of research examining the interplay between subjective experience and motivational functions associated with emotion, and they are consistent with previous work linking anger to approach motivational responses.

In addition to our central findings concerning trait anger, we observed that enjoyment and surprise were also associated with blink inhibition during positive picture viewing. The effect for enjoyment is consistent with the hypothesis that positive, approach-related emotions should be associated with greater startle inhibition during positive states. But what explains the effect for surprise? Surprise is usually viewed as representing a reaction to the unexpected. However, it is notable that questionnaire measures of trait surprise, such as the DES-IV used here, use items to assess surprise that include words that are generally considered positive in our culture (e.g., *surprised*, *amazed*). When measured in this way, trait surprise represents a positively valenced emotion. Indeed, it may be very difficult to capture trait surprise tendencies in a questionnaire, and this issue may in part explain why the status of surprise as a basic emotion has been debated. Similarly, we did not observe a correlation between trait interest and blink inhibition during positive picture viewing, even though interest theoretically represents an approach-motivated state. However, "interest" is not usually characterized as an emotion in many theoretical models, and it is possible that the endorsement of interest on a questionnaire may reflect a more cognitive inclination toward interest rather than more basic-level approach motivation that would be evidenced in the emotion-modulated startle eyeblink response.

The link between trait anger and approach motivational responses observed here corroborates past research and extends it to include basic reflexive mechanisms of emotion and motivation. Whereas past research has found trait anger to be associated with approach motivation measured using self-reports, patterns of learning, facial expressions, and patterns of cortical activity, it had not tested the relationship of trait anger to motivational responses at lower levels of the neural axis. By incorporating measures of the startle reflex to appetitive stimuli into this literature, the present research suggests that trait anger is related to approach motivation at multiple levels of processing, which function in concert to facilitate adaptive behavior.

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