



Modulation of the startle reflex across time by unpleasant pictures distinguishes dysphoric from non-dysphoric women

Lauren E. Taubitz, Jordan S. Robinson, Christine L. Larson *

University of Wisconsin - Milwaukee, United States

ARTICLE INFO

Article history:

Received 18 June 2012

Received in revised form 27 October 2012

Accepted 2 November 2012

Available online 9 November 2012

Keywords:

Startle reflex

Dysphoria

Emotion

Affective startle modulation

Time course

ABSTRACT

While several investigators have examined differences in affective startle modulation between individuals with and without Major Depressive Disorder, fewer researchers have evaluated the time course of this response, particularly in dysphoric individuals. The purpose of this study was to evaluate emotion modulation of the startle reflex during and after the presentation of affective pictures in dysphoric and non-dysphoric women. Dysphoric subjects showed attenuated startle for unpleasant compared to neutral pictures 1.5 s post-stimulus onset relative to non-dysphoric subjects and potentiated startle for unpleasant compared to neutral pictures 3 s post-stimulus offset. These findings extend the literature on the time course of affective startle modulation in dysphoria, and mirror results of studies in which other psychophysiological responses were examined in this population with regard to negative emotion.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Davidson (1998) and Davidson et al. (2000) define affective style as variability between individuals in the quality and intensity of emotional reactions to similar events. An important component of affective style is affective chronometry, or the time course of emotions. Affective chronometry can be decomposed into several different elements, including threshold for reactivity, peak amplitude of response, rise time to peak, and recovery time (Davidson, 1998; Davidson et al., 2000). Of particular interest for understanding psychopathology-relevant individual differences in affective chronometry is the recovery time associated with experiences of negative affect (Davidson, 1998; Davidson et al., 2000). Researchers using electroencephalogram (EEG), event-related potentials (ERPs), pupil dilation, and eye-tracking have found evidence for prolonged responses to negatively valenced stimuli in subjects with a range of depressive symptomatology including Major Depressive Disorder (MDD), dysthymia, and dysphoria, defined as exhibiting elevated symptoms of depression without a formal MDD diagnosis (Caseras et al., 2007; Deldin et al., 2001; Ellis et al., 2011; Siegle et al., 2001, 2003; Kellough et al., 2008). Thus, it is important to examine later stages of emotion processing when comparing individuals with depressive symptomatology, including dysphoria, to controls using psychophysiological measures.

The startle reflex is a psychophysiological measure that has been used extensively to evaluate responsivity to affective material in

both unselected samples and groups with psychopathology. The time course of the startle reflex has been well-characterized in unselected samples (Bradley et al., 1993, 2006; Dichter et al., 2002; Larson et al., 2007) and individuals with psychopathology (Dichter and Tomarken, 2008; Dichter et al., 2004). In the unselected samples, researchers have found that there is a quadratic relationship between emotional valence and startle amplitude when probes occur prior to picture onset whereby individuals show potentiated startle when anticipating high-arousal unpleasant and pleasant pictures relative to neutral pictures (Dichter et al., 2002; Nitschke et al., 2002). When probes are presented immediately after picture onset (less than 500 ms), blinks are generally reduced in amplitude with greater reduction for more arousing stimuli regardless of emotional valence (Bradley et al., 1993, 2006; Dichter et al., 2002), suggesting an effect of attention. Later during picture presentation (approximately 3–6 s post-stimulus onset), unselected samples and individuals without psychopathology tend to show a linear increase in startle magnitude for highly arousing emotional stimuli as the valence becomes more unpleasant (Bradley et al., 1990, 1993, 2001, 2006; Cook et al., 1991; Dichter et al., 2002, 2004; Vrana et al., 1988; for a review, see Lang et al., 1990). By 2000 ms after picture offset, such individuals tend to show no affective modulation of the startle reflex (Bradley et al., 1993, 2006; Dichter et al., 2002).

More recently, researchers have evaluated the time course of affective modulation of the startle reflex in MDD and dysphoria (Dichter and Tomarken, 2008; Dichter et al., 2004; Larson et al., 2007). The time course of affective startle modulation in dysphoria has not been well-investigated; however, there is more extensive research in this area in clinically defined MDD. In the anticipatory phase of picture presentation (2000 ms pre-picture onset), Dichter and

* Corresponding author at: University of Wisconsin - Milwaukee, Department of Psychology, 2441 E. Hartford Ave., Milwaukee, WI 53211, United States. Tel.: +1 414 229 4996; fax: +1 414 229 5219.

E-mail address: larsoncl@uwm.edu (C.L. Larson).

Tomarken (2008) found that, unlike controls, participants with MDD showed no difference in startle amplitude between emotional valence conditions. During the latter half of picture presentation (3–6 s post-stimulus onset), many researchers have found that individuals with MDD fail to exhibit potentiated startle in response to negative pictures compared to neutral pictures (Dichter and Tomarken, 2008; Dichter et al., 2004; Forbes et al., 2005; for reviews, see Kaviani et al., 2004 and Vaidyanathan et al., 2009). However, this pattern has not been observed in dysphoric (Cook et al., 1991; Thibodeau, 2011) or anhedonic (Larson et al., 2007) individuals unselected for MDD or in individuals with MDD experiencing mild to moderate symptoms of depression (Allen et al., 1999), suggesting that mildly dysphoric or anhedonic individuals exhibit normal startle modulation during this time frame. This suggests that severity of depression may affect affective startle modulation. This is consistent with some literature showing that normal defensive reactivity may be compromised by more severe or long-lasting distress disorders (Forbes et al., 2005; Lang and McTeague, 2009; McTeague and Lang, 2012; McTeague et al., 2009, 2011). Finally, shortly after picture offset (1.5 s), Larson et al. (2007) found that subjects with greater symptoms of anhedonia exhibited blink potentiated startle relative to controls for unpleasant compared to neutral pictures. This finding is consistent with the idea that individuals with symptoms of depression exhibit sustained processing of unpleasant information compared to controls.

Understanding the time course of affective startle modulation in dysphoria is important in light of evidence for differences in startle modulation as a function of the severity and chronicity of illness in the anxiety disorders (Lang and McTeague, 2009; McTeague and Lang, 2012; McTeague et al., 2009, 2011). Although the time course of affective startle modulation has been addressed in individuals with clinical MDD, it is unknown how dysphoric individuals may differ from non-dysphoric individuals in startle modulation or whether dysphoric individuals exhibit a different pattern of startle modulation than individuals with MDD. Given that dysphoria is putatively a less severe and/or chronic state, it is possible that they may not exhibit the same startle modulation characteristics as individuals with MDD.

Because there has been very little research on the time course of affective startle modulation in dysphoria, the purpose of the present study was to extend this literature by examining affective startle modulation at four time points in affective picture processing: two during picture presentation (1.5 and 4.5 s post-stimulus onset), and 2 after picture offset during the inter-trial interval (ITI; 1.5 and 3 s post-stimulus offset). No prior studies have addressed affective startle modulation after picture offset in subjects with MDD (Dichter and Tomarken, 2008; Dichter et al., 2004) or in subjects selected for dysphoria (Larson et al., 2007). Based on previous research on affective startle modulation in dysphoric or anhedonic subjects unselected for MDD (Cook et al., 1991; Larson et al., 2007; Thibodeau, 2011), it is expected that dysphoric subjects will not show attenuation of the startle reflex for unpleasant compared to neutral pictures during picture onset. However, based on findings from previous psychophysiological research on the time course of emotional responses (Larson et al., 2007; Deldin et al., 2001; Siegle et al., 2001, 2003; Kellough et al., 2008) and cognitive models of depression implicating impaired disengagement from negative affective material (Caseras et al., 2007; Donaldson et al., 2007; Koster et al., 2011), it is expected that dysphoric subjects will continue to show startle potentiation for unpleasant compared to neutral pictures at later time points after picture onset relative to non-dysphoric subjects.

2. Methods

2.1. Participant characteristics

An unselected sample of 249 participants (mean age = 18.96, S.D. = 1.04) recruited from undergraduate psychology courses at

Michigan State University completed an affective startle paradigm and responded to the Beck Depression Inventory (BDI; Beck and Steer, 1987). Data from this sample are also reported in Larson et al. (2010). After participation, participants were divided into two groups based on their BDI scores taken before the startle session. Using the BDI cut-off scores to define dysphoria in college students recommended by Kendall et al. (1987), participants with BDI scores of 9 or less were classified as non-dysphoric ($n = 187$) while participants with BDI scores of 16 or more were classified as dysphoric ($n = 20$). Because there was only 1 dysphoric man, only women were included in this study to avoid confounds due to gender, leaving 19 women in the dysphoric group.¹ Because of the disparity in group size, 19 non-dysphoric women were matched to the 19 dysphoric women on age and race.² These 19 non-dysphoric subjects were chosen by ordering the subjects according to subject numbers in ascending order and locating the first non-dysphoric subject who matched the demographic characteristics of the first dysphoric subject in order of subject number. As expected, the dysphoric and non-dysphoric groups significantly differed in terms of BDI score ($t = -13.40$, $df = 36$, $p < 0.001$) but no other demographic factors (all $p > 0.26$). Participant characteristics are presented in Table 1.

2.2. Materials

Forty-two unpleasant, 42 pleasant, and 42 neutral pictures were selected from the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1999) based on published norms for valence and arousal (Lang et al., 1999).³ Unpleasant and pleasant pictures were selected to be toward the extremes of the bipolar valence rating scale and high on arousal. Neutral pictures were selected to be in the middle of the valence scale and low on arousal. Valence and arousal ratings by women for the pictures used in this study are presented in Table 2. Pictures were viewed on a 21-inch LCD monitor placed approximately 1 m in front of the participant.

2.3. Procedure

Participants provided informed written consent. For the task, pictures were presented in a quasi-random order (not more than two of each valence presented consecutively) for 6 s with a 12–18 s blank screen inter-trial interval. The acoustic startle probe was a 50 ms 100 dB burst of white noise presented binaurally via pneumatic intra-ear headphones. Stimuli were presented using STIM software (James Long Company, Caroga Lake, NY). After electrode placement, participants completed a practice set of 9 pictures, including 8 startle probes, in order to habituate them to the task and probe. The task

¹ There was 1 dysphoric man who was initially matched to a non-dysphoric man. Results did not differ when these two men were included in the analyses. To avoid complications of the effect of gender on the results, these men were not included in these analyses.

² Dysphoric and non-dysphoric subjects were also matched on parent education level and estimated family annual income when available; however, these variables were only recorded for 5 dysphoric participants, so these data are not reported in detail. Ethnicity is only indicated for 14 out of 19 participants in each group because five dysphoric participants did not indicate ethnic group membership. These five dysphoric participants were matched to 5 non-dysphoric subjects who also did not indicate ethnic group membership.

³ IAPS pictures used in this study were: Unpleasant: 3000, 3010, 3015, 3030, 3051, 3053, 3060, 3071, 3080, 3100, 3102, 3120, 3130, 3140, 3150, 3168, 3170, 3266, 3350, 3400, 3500, 3530, 6212, 6230, 6260, 3212, 6313, 6350, 6360, 6510, 6560, 6570, 9040, 9252, 9410, 9500, 9560, 9570, 9800, 9810, 9910, 9921; Neutral: 1670, 2620, 5510, 5520, 5531, 5532, 5533, 5534, 5731, 6150, 7000, 7002, 7006, 7009, 7010, 7025, 7030, 7034, 7035, 7040, 7050, 7060, 7080, 7090, 7100, 7130, 7140, 7150, 7170, 7190, 7207, 7217, 7224, 7233, 7234, 7235, 7490, 7500, 7700, 7710, 7920, 9210; Pleasant: 1710, 2216, 2391, 4599, 4660, 4670, 4680, 5260, 5270, 5450, 5460, 5470, 5480, 5621, 5623, 5629, 5700, 5910, 7230, 7270, 7502, 8030, 8034, 8080, 8170, 8180, 8185, 8190, 8200, 8210, 8300, 8340, 8370, 8380, 8400, 8420, 8470, 8500, 8501, 8502, 8510, 8531.

Table 1
Participant characteristics for each group.

Demographic	Non-dysphoric	Dysphoric
Age (S.D.)	19.00 (0.75)	18.95 (0.78)
Race/ethnicity		
Asian/Pacific Islander (%)	1 (5.26%)	1 (5.26%)
African American/Black (%)	1 (5.26%)	1 (5.26%)
Hispanic/Latino(a) (%)	1 (5.26%)	1 (5.26%)
Caucasian/White (%)	11 (57.89%)	11 (57.89%)
Not provided (%)	5 (26.32%)	5 (26.32%)
BDI (S.D.)	2.63 (2.24)	20.16 (5.24)
Minimum	0	16
Maximum	7	39

consisted of 6 blocks of 21 trials (7 pictures of each valence per block) for a total of 126 trials. Probes were presented during 36 pictures of each valence at one of the following four probe times: 1.5, or 4.5 s post-stimulus onset, or 1, or 3 s post-stimulus offset (9 trials of each valence at each probe time). Eighteen trials total (6 per valence) contained no startle probe. Probes occurred quasi-randomly with the constraint that no more than two of each probe time occurred consecutively. Probe time order and picture valence order varied across each block. Three different orders of pictures were used, counterbalanced across subjects. Finally, participants completed questionnaires including the BDI, were debriefed, and were given course credit for participation.

2.4. Startle recording and data reduction

EMG was recorded from the orbicularis oculi using two Sensormedics mini-electrodes placed approximately 36 mm apart on the inferior left orbicularis oculi muscle (van Boxtel et al., 1998) (impedance < 20 k Ω). EMG signals were amplified 10,000 times and filtered with a bandpass of 1–200 Hz using SAI Bioelectric amplifiers (SA Instrumentation Co., Caroga Lake, NY). A 30 Hz high-pass filter was applied prior to rectification of the raw EMG signal and low-pass filtering of the rectified signal (time constant = 20 ms). A PC running SnapMaster software (HEM Data Corporation, Springfield, MI) and a 12-bit analog-to-digital board (Analogic Corporation, Wakefield, MA) was used to digitize and store signals at 500 Hz.

Blink magnitude was computed as the difference between magnitude at peak and at blink onset between 20 and 120 ms following probe onset. Trials with excessive noise in the 50 ms baseline period prior to the probe were discarded. To correct for large individual variability in blink magnitude, eye-blink reflex magnitudes were z-transformed within subjects. Blinks greater than 3 standard deviations from each participant's mean were excluded (a mean of 0.24% of blinks per subject). Approximately 12.1% of eye blink reflexes were excluded due to an unstable baseline, or because reflex onset was prior to 20 ms following probe onset. All participants had at least three good startle responses (those responses not excluded from analyses based on aforementioned criteria) of the nine possible for each condition (Picture Condition $\times$ Probe Time; mean number of probes per condition included in analyses = 7.88, SD = 0.57).

Table 2
Mean valence and arousal ratings presented here are based on ratings reported by Lang et al. (1999). Means with different subscripts in each row are significantly different from each other ($p < 0.05$).

	Picture category					
	Unpleasant		Neutral		Pleasant	
	M	SD	M	SD	M	SD
Valence	1.64 _a	0.34	5.05 _b	0.43	7.56 _c	0.43
Arousal	6.89 _a	0.56	3.01 _b	0.43	6.04 _a	0.57

2.5. Statistical analysis

All statistical analyses were performed using SPSS version 16.0 (SPSS Inc., Chicago, IL). A 2 (Group: dysphoric, non-dysphoric) $\times$ 4 (Time; 1.5, 4.5 s post-stimulus onset; 1.3 s post-stimulus offset) $\times$ 3 (Valence: unpleasant, neutral, pleasant) mixed-model ANOVA was run with z-transformed startle magnitude as the dependent variable, Group as a between-subjects factor, and Time and Valence as within-subjects factors.

3. Results

The omnibus ANOVA was used to evaluate whether dysphoric and non-dysphoric participants differed in the time course of processing emotional images. All main effects and interactions were qualified by a significant three-way interaction between Time, Valence, and Group ($F(6, 216) = 2.76, p = 0.013, \eta_p^2 = 0.071$). Given the research question, this statistical test is of utmost interest. Less relevant effects included significant main effects of Time ($F(3, 108) = 5.23, p = 0.002, \eta_p^2 = 0.127$) and Valence ($F(2, 72) = 25.39, p < 0.001, \eta_p^2 = 0.414$), and a significant Time $\times$ Valence interaction ($F(6, 216) = 4.78, p < 0.001, \eta_p^2 = 0.117$). The Group main effect, Group $\times$ Valence interaction, and Group $\times$ Time interaction were non-significant (all $p > 0.18$). Mean z-transformed blink magnitude for each time, valence, and group are presented in Fig. 1 and affective startle modulation is depicted in Fig. 2.

To examine group differences in emotion modulation patterns at specific time points, the significant Time $\times$ Valence $\times$ Group interaction was broken down using one 3 (Valence: unpleasant, neutral, pleasant) $\times$ 2 (Group: non-dysphoric, dysphoric) mixed model ANOVA for each time point (1.5 and 4.5 s post-stimulus onset; 1, and 3 s post-stimulus offset). There was a significant Valence $\times$ Group interaction at 1.5 s post-stimulus onset ($F(2, 72) = 6.81, p = 0.002, \eta_p^2 = 0.159$) and a non-significant trend for a Valence $\times$ Group interaction at 3 s post-stimulus offset ($F(2, 72) = 2.81, p = 0.067, \eta_p^2 = 0.072$). There was not a significant Valence $\times$ Group interaction at 4.5 s post-stimulus onset or 1 s post-stimulus offset (both $p > 0.47$). Because there were significant group differences in emotion modulation at 1.5 s post-stimulus onset and an a priori hypothesis that there would be group differences in emotion modulation post-stimulus offset, the Valence $\times$ Group interactions at 1.5 s post-stimulus onset and 3 s post-stimulus offset were followed up with simple contrasts using the neutral picture condition as the reference group. Dysphoric and non-dysphoric groups differed at both 1.5 s post-stimulus onset and 3 s post-stimulus offset for unpleasant compared to neutral pictures ($F(1, 36) = 6.81, p = 0.002, \eta_p^2 = 0.159$; and $F(1, 36) = 4.82, p = 0.035, \eta_p^2 = 0.118$, respectively), but not pleasant compared to neutral pictures at either time point (both $p > 0.10$).

4. Discussion

These data suggest that dysphoric and non-dysphoric individuals differ in their processing of unpleasant pictures across time as indicated by emotion modulation of the startle reflex. Dysphoric participants exhibited blunted startle for unpleasant relative to neutral pictures early during picture presentation (1.5 s post-stimulus onset) but heightened startle for unpleasant relative to neutral pictures late after picture offset (3 s post-stimulus offset) compared to non-dysphoric participants.

4.1. Unpleasant picture startle modulation

The finding that dysphoric subjects exhibit blunted startle for unpleasant compared to neutral images at 1.5 s post-stimulus onset is similar to previous research findings in the MDD literature, although in subjects with MDD blunted startle is usually observed slightly later

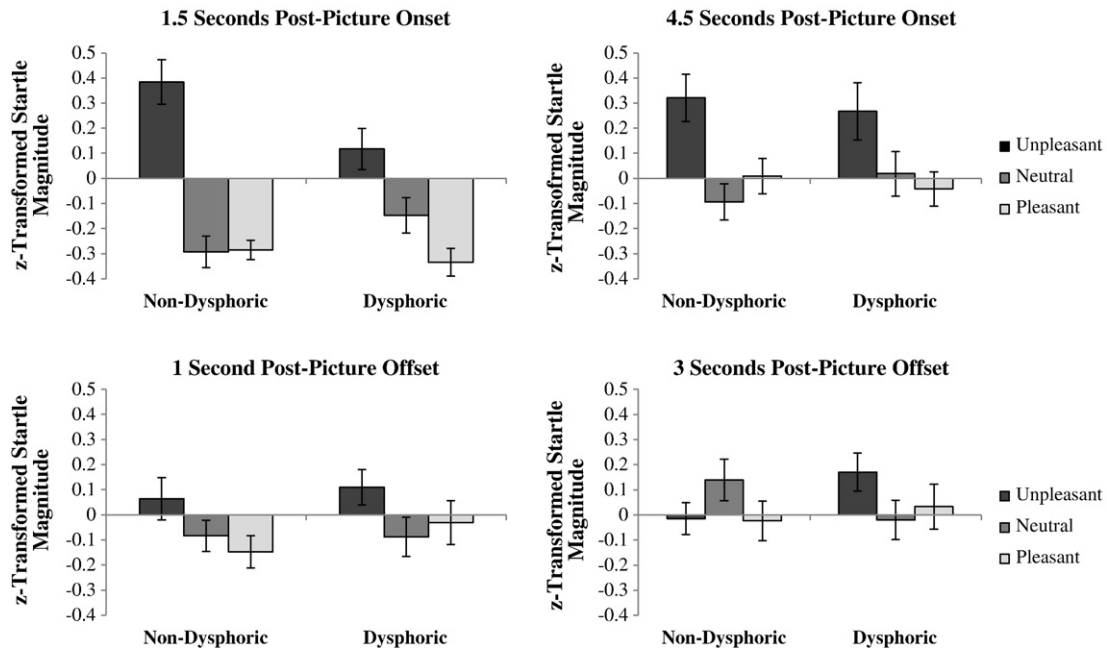


Fig. 1. Startle modulation at each time point during and after picture presentation for each group. The probe at 7 s post-picture onset occurred 1 second post-picture offset during the ITI, and the probe at 9 s post-picture onset occurred 3 s post-picture offset during the ITI.

during picture presentation (i.e., 3.5–4.5 s post-stimulus onset; Dichter and Tomarken, 2008; Dichter et al., 2004; Kaviani et al., 2004; Vaidyanathan et al., 2009).

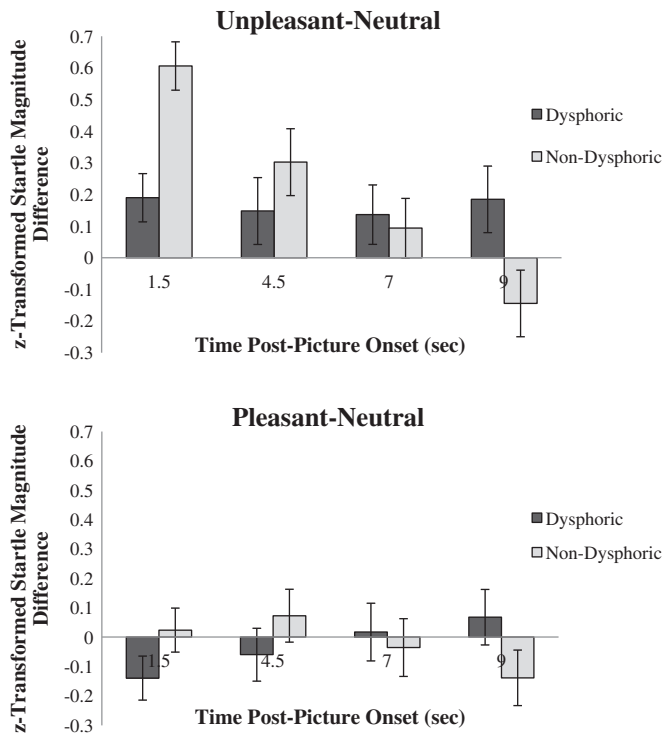


Fig. 2. Unpleasant minus neutral and pleasant minus neutral startle modulation for all time points by group. A positive difference score indicates that the startle magnitude was greater for the positive or negative pictures than the neutral pictures while a negative difference score indicates that there was a reduced startle magnitude for the pleasant or unpleasant pictures than the neutral pictures.

The lack of a group difference in startle modulation during picture presentation at 4.5 s post-stimulus onset replicates findings by Thibodeau (2011), Kaviani et al. (2004), and Allen et al. (1999) showing normal startle modulation at that time in individuals with mild symptoms of depression. This is discrepant from research indicating blunted startle modulation at that time in subjects with MDD or more severe symptoms of depression (Allen et al., 1999; Dichter and Tomarken, 2008; Dichter et al., 2004; Kaviani et al., 2004; Vaidyanathan et al., 2009) but supports findings by Kaviani et al. (2004) and Allen et al. (1999) who found evidence for blunted startle modulation in their severely depressed group but not their mildly depressed group. The discrepancy in startle modulation findings between samples of participants with MDD versus dysphoria may be accounted for by differences between MDD and dysphoria in the severity and/or chronicity of negative affect. Evidence for differences in startle modulation as a function of severity and chronicity is evident in the anxiety disorders both within and between broad diagnostic categories (Lang and McTeague, 2009; McTeague and Lang, 2012; McTeague et al., 2009, 2011). It may also be accounted for by severity of anhedonia. Kaviani et al. (2004) found that depressed individuals who rated high on anhedonic symptoms to exhibit blunted startle potentiation while depressed individuals who rated low did not. However, others have found anhedonia to be unrelated to differences in affective startle modulation in college students who were not selected for MDD (Gooding et al., 2002).

As the subjects in this study were selected based on elevated symptoms of depression rather than a formal diagnosis of MDD, this would explain our findings at 4.5 s post-stimulus onset, but would not account for blunted startle modulation observed at 1.5 s post-stimulus onset. These results suggest that depression severity may affect not only the magnitude of startle modulation but also the time course. It is possible that dysphoric participants show a similar pattern of startle modulation but that it is shifted forward in time such that dysphoric individuals don't initially show large startle modulation for unpleasant pictures but continue to show startle modulation later than their non-dysphoric peers.

The finding that dysphoric participants exhibit potentiated startle for unpleasant compared to neutral pictures 3 s after picture offset is novel for the startle reflex literature. Previous researchers examining the startle reflex in dysphoria have not examined modulation after picture offset (Thibodeau, 2011), so this finding extends previous research on the time course of startle modulation in this population. Larson et al. (2007) found that anhedonic depression was associated with greater startle potentiation 1.5 s post-stimulus offset but not 3 s post-stimulus offset; While the results of this study are somewhat discrepant from their findings, the groups employed represent different aspects of depression, and this may explain this discrepancy.

Nonetheless, this finding fits with the idea that dysphoria is characterized by prolonged responses to unpleasant stimuli and replicates findings from research using other psychophysiological measures in dysphoric populations (Deldin et al., 2001; Siegle et al., 2001, 2003; Caseras et al., 2007; Leyman et al., 2011). This also mirrors previous work showing that an MAOA genotype associated with mood-related psychopathology is associated with sustained startle potentiation 3 s after picture offset relative to subjects without this risk genotype (Larson et al., 2010). Finally, sustained affective startle modulation for unpleasant pictures is consistent with information processing models of depression showing that dysphoria is characterized by mood-congruent attentional biases at later stages of information processing related to impaired disengagement of attention from negative information (Caseras et al., 2007; Donaldson et al., 2007; Koster, et al., 2011; Leyman et al., 2011).

Prolonged startle modulation for unpleasant pictures in the dysphoric group may also reflect a stronger tendency for dysphoric subjects to ruminate relative to non-dysphoric subjects. Rumination has been robustly associated with dysphoria (Roberts et al., 1998). Rumination increases attentional bias toward negative information by impairing attentional disengagement from such material (Donaldson et al., 2007; Koster et al., 2011) and is associated with sustained pupil dilation following emotional stimuli (Siegle et al., 2003). Similarly, inducing worry increases fear potentiated startle and reduces extinction learning. Because rumination is associated with prolonged responses to negative information after stimulus offset and is associated with dysphoria, it is possible that prolonged startle modulation for unpleasant pictures may reflect rumination.

4.2. Pleasant picture startle modulation

The group differences in startle modulation for pleasant compared to neutral pictures are more difficult to interpret. Many other researchers have reported startle attenuation for high arousal pleasant compared to neutral pictures in unselected samples or individuals without psychopathology during picture presentation (Allen et al., 1999; Bradley et al., 1990, 2001), but there is no evidence of this in these data during or after picture presentation. However, modulation for pleasant pictures has been shown to be affected by picture content whereby startle inhibition is most pronounced for erotica and reduced, absent, or even potentiated for other pleasant content (e.g., sports, food, babies, and adventure; Bernat et al., 2006; Bradley et al., 2001), even when arousal is equated between picture categories (Bernat et al., 2006). Thus, even though our pleasant and unpleasant pictures did not differ in arousal on average and we utilized a variety of pleasant picture content, it is possible that the content of our pleasant pictures was slightly different than that used in other studies and this affected startle inhibition.

The follow-up ANOVAs at the two time points for which there was a significant Group $\times$ Valence interaction (1.5 s post-stimulus onset and 3 s post-stimulus offset) show that dysphoric and non-dysphoric subjects do not differ in startle magnitude for pleasant compared to neutral pictures. Allen et al. (1999) found that individuals with severe depression exhibit potentiated startle for pleasant compared to neutral pictures, and Thibodeau (2011) found that increased startle for erotica

was predictive of greater depressive symptoms in dysphoric students 3–5 s into picture presentation.

Thus, the lack of group differences supports the idea that dysphoric subjects do not differ from non-dysphoric subjects in their pattern of affective startle modulation for pleasant images across time, as well as the idea that differences in pleasant picture startle modulation may only be seen at more severe levels of depression (Allen et al., 1999; Thibodeau, 2011). However, it is possible that our non-dysphoric group differs from the non-dysphoric, control, or unselected samples in other studies as startle magnitude for pleasant images is not attenuated.

4.3. Limitations

In addition to the aforementioned discrepancies, this study has some methodological limitations to consider. First, neither group of participants was selected for the presence or absence of clinically defined psychopathology, so it is unclear if these results would generalize to more homogenous samples. Second, the sample size of each group was somewhat small ($n = 19$ per group), and both groups were comprised solely of women (19 women). Follow-up studies will require a large sample size in each group and greater inclusion of men. Finally, affective ratings were based on those reported in Lang et al. (1999), so it is unknown how these subjects perceived these images with regard to valence and arousal or whether these groups differed in their perception of the images' valence and arousal. For example, it is plausible that the dysphoric subjects may have perceived the unpleasant pictures as more unpleasant or arousing than the non-dysphoric subjects, and this could account for group differences; however, other researchers have found that valence and arousal ratings of IAPS pictures did not differ between depressed and non-depressed individuals (Dichter and Tomarken, 2008; Forbes et al., 2005) and they did not differ based on symptoms of depression (Sloan and Sandt, 2010), so it is unlikely that this would explain the group differences at 1.5 and 9 s.

5. Conclusion

Overall, these data represents an important look into the time course of the affective startle modulation in dysphoria. These data differ from previous research examining affective startle modulation during picture presentation by showing that dysphoric individuals exhibit attenuated startle for unpleasant relative to neutral pictures early during picture presentation (1.5 s post-stimulus onset), but they support previous research in dysphoric populations indicating no difference in startle modulation from non-dysphoric subjects later during picture presentation (4.5 s post-stimulus onset; Allen et al., 1999; Kaviani et al., 2004; Thibodeau, 2011). Although no prior studies report on startle modulation in dysphoric subjects as early as 1.5 s post-picture onset, the attenuated startle modulation here resembles the attenuated startle modulation seen in subjects with MDD later during picture presentation (Dichter et al., 2004; Dichter and Tomarken, 2008). However, this data also suggests an important novel finding that dysphoric subjects exhibit potentiated startle after picture offset for unpleasant compared to neutral images. Prolonged startle potentiation supports other psychophysiology literature showing that depressed or dysphoric individuals show sustained processing of negatively valenced material compared to individuals without psychopathology. Future work in this area should focus on how the time course aspect of the startle reflex is related to severity, course, and treatment outcomes in affective pathology.

References

- Allen, N.B., Trinder, J., Brennan, C., 1999. Affective startle modulation in clinical depression: preliminary findings. *Biological Psychiatry* 46, 542–550. [http://dx.doi.org/10.1016/S0006-3223\(99\)00025-6](http://dx.doi.org/10.1016/S0006-3223(99)00025-6).

- Beck, A.T., Steer, R.A., 1987. Beck depression inventory manual. Harcourt Brace Janovich, San Antonio.
- Bernat, E., Patrick, C.J., Benning, S.D., Tellegen, A., 2006. Effects of picture content and intensity on affective physiological response. *Psychophysiology* 43, 93–103. <http://dx.doi.org/10.1111/j.1469-8986.2006.00380.x>.
- Bradley, M.M., Cuthbert, B.N., Lang, P.J., 1990. Startle reflex modification: emotion or attention? *Psychophysiology* 27, 513–522. <http://dx.doi.org/10.1111/j.1469-8986.1990.tb01966.x>.
- Bradley, M.M., Cuthbert, B.N., Lang, P.J., 1993. Pictures as prepulse: attention and emotion in startle modification. *Psychophysiology* 30, 541–546. <http://dx.doi.org/10.1111/j.1469-8986.1993.tb02079.x>.
- Bradley, M.M., Codispoti, M., Cuthbert, B.N., Lang, P.J., 2001. Emotion and motivation I: defensive and appetitive reactions in picture processing. *Emotion* 1, 276–298. <http://dx.doi.org/10.1037/1528-3542.1.3.276>.
- Bradley, M.M., Codispoti, M., Lang, P.J., 2006. A multi-process account of startle modulation during affective perception. *Psychophysiology* 43, 486–497. <http://dx.doi.org/10.1111/j.1469-8986.2006.00412.x>.
- Caseras, X., Garner, M., Bradley, B.P., Mogg, K., 2007. Biases in visual orienting to negative and positive scenes in dysphoria: an eye-movement study. *Journal of Abnormal Psychology* 116, 491–497. <http://dx.doi.org/10.1037/0021-843X.116.3.491>.
- Cook, E.W., Hawk, L.W., Davis, T.L., Stevenson, V.E., 1991. Affective individual differences and startle reflex modulation. *Journal of Abnormal Psychology* 100, 5–13. <http://dx.doi.org/10.1037/0021-843X.100.1.5>.
- Davidson, R.J., 1998. Affective style and affective disorders: perspectives from affective neuroscience. *Cognition and Emotion* 12, 307–320. <http://dx.doi.org/10.1080/026999398379628>.
- Davidson, R.J., Jackson, D.C., Kalin, N.H., 2000. Emotion, plasticity, context, and regulation: perspectives from affective neuroscience. *Psychological Bulletin* 126, 890–909. <http://dx.doi.org/10.1037/0033-2909.126.6.890>.
- Deldin, P.J., Deveney, C.M., Kim, A.S., Casas, B.R., Best, J.L., 2001. A slow wave investigation of working memory bias in mood disorders. *Journal of Abnormal Psychology* 110, 267–281. <http://dx.doi.org/10.1037/0021-843X.110.2.267>.
- Dichter, G.S., Tomarken, A.J., 2008. The chronometry of affective startle modulation in unipolar depression. *Journal of Abnormal Psychology* 117, 1–15. <http://dx.doi.org/10.1037/0021-843X.117.1.1>.
- Dichter, G.S., Tomarken, A.J., Baucom, B.R., 2002. Startle modulation before, during, and after exposure to emotional stimuli. *International Journal of Psychophysiology* 43, 191–196. [http://dx.doi.org/10.1016/S0167-8760\(01\)00170-2](http://dx.doi.org/10.1016/S0167-8760(01)00170-2).
- Dichter, G.S., Tomarken, A.J., Shelton, R.C., Sutton, S.K., 2004. Early- and late-onset startle modulation in unipolar depression. *Psychophysiology* 41, 433–440. <http://dx.doi.org/10.1111/j.1469-8986.00162.x>.
- Donaldson, C., Lam, D., Mathews, A., 2007. Rumination and attention in major depression. *Behaviour Research and Therapy* 45, 2664–2678. <http://dx.doi.org/10.1016/j.brat.2007.07.002>.
- Ellis, A.J., Beevers, C.G., Wells, T.T., 2011. Attention allocation and incidental recognition of emotional information in dysphoria. *Cognitive Therapy and Research* 35, 425–433. <http://dx.doi.org/10.1007/s10608-010-9305-3>.
- Forbes, E.E., Miller, A., Cohn, J.F., Fox, N.A., Kovacs, M., 2005. Affect-modulated startle in adults with childhood-onset depression: relations to bipolar course and number of lifetime depressive episodes. *Psychiatry Research* 134, 11–25. <http://dx.doi.org/10.1016/j.psychres.2005.01.001>.
- Gooding, D.C., Davidson, R.J., Putnam, K.M., Tallent, K.A., 2002. Normative emotion-modulated startle response in individuals at risk for schizophrenia-spectrum disorders. *Schizophrenia Research* 57, 109–120. [http://dx.doi.org/10.1016/S0920-9964\(01\)00295-X](http://dx.doi.org/10.1016/S0920-9964(01)00295-X).
- Kaviani, H., Gray, J.A., Checkley, S.A., Raven, P.W., Wilson, G.D., Kumari, V., 2004. Affective modulation of the startle response in depression: influence of the severity of depression, anhedonia, and anxiety. *Journal of Affective Disorders* 83, 21–31. <http://dx.doi.org/10.1016/j.jad.2004.04.007>.
- Kellough, J.L., Beevers, C.G., Ellis, A.J., Wells, T.T., 2008. Time course of selective attention in clinically depressed young adults: an eye tracking study. *Behaviour Research and Therapy* 46, 1238–1243. <http://dx.doi.org/10.1016/j.brat.2008.07.004>.
- Kendall, P.C., Hollon, S.D., Beck, A.T., Hammen, C.L., Ingram, R.E., 1987. Issues and recommendations regarding the use of the Beck Depression Inventory. *Cognitive Therapy and Research* 11, 289–299. <http://dx.doi.org/10.1007/BF01186280>.
- Koster, E.H.W., de Lissnyder, E., Derakshan, N., de Raedt, R., 2011. Understanding depressive rumination from a cognitive science perspective: the impaired disengagement hypothesis. *Clinical Psychology Review* 31, 138–145. <http://dx.doi.org/10.1016/j.cpr.2010.08.005>.
- Lang, P.J., McTeague, L.M., 2009. The anxiety disorder spectrum: fear imagery, physiological reactivity, and differential diagnosis. *Anxiety, Stress, and Coping* 22, 5–25. <http://dx.doi.org/10.1080/10615800802478247>.
- Lang, P.J., Bradley, M.M., Cuthbert, B.N., 1990. Emotion, attention, and the startle reflex. *Psychological Review* 97, 377–395. <http://dx.doi.org/10.1037/0033-295X.97.3.377>.
- Lang, P.J., Bradley, M.M., Cuthbert, B.N., 1999. International affective picture system: technical manual and affective ratings. Center for Research in Psychophysiology, University of Florida, Gainesville, FL.
- Larson, C.L., Nitschke, J.B., Davidson, R.J., 2007. Common and distinct patterns of affective response in dimensions of anxiety and depression. *Emotion* 7, 182–191. <http://dx.doi.org/10.1037/1528-3542.7.1.182>.
- Larson, C.L., Taubitz, L.E., Robinson, J.S., 2010. MAOA T941G polymorphism and the time course of emotional recovery following unpleasant pictures. *Psychophysiology* 47, 857–862. <http://dx.doi.org/10.1111/j.1469-8986.2010.01005.x>.
- Leyman, L., de Raedt, R., Vaeyens, R., Philippaerts, R.M., 2011. Attention for emotional facial expressions in dysphoria: an eye-movement registration study. *Cognition and Emotion* 25, 111–120. <http://dx.doi.org/10.1080/02699931003593827>.
- McTeague, L.M., Lang, P.J., 2012. The anxiety spectrum and the reflex physiology of defense: from circumscribed fear to broad distress. *Depression and Anxiety* 29, 264–281. <http://dx.doi.org/10.1002/da.21891>.
- McTeague, L.M., Lang, P.J., Laplante, M.C., Cuthbert, B.N., Strauss, C.C., Bradley, M.M., 2009. Fearful imagery in social phobia: generalization, comorbidity, and physiological reactivity. *Biological Psychiatry* 65, 374–382. <http://dx.doi.org/10.1016/j.biopsych.2008.09.023>.
- McTeague, L.M., Lang, P.J., Laplante, M.C., Bradley, M.M., 2011. Aversive imagery in panic disorder: agoraphobia, comorbidity, and defensive physiology. *Biological Psychiatry* 70, 415–424. <http://dx.doi.org/10.1016/j.biopsych.2011.03.005>.
- Nitschke, J.B., Larson, C.L., Smoller, M.J., Navin, S.D., Pederson, A.J.C., Ruffalo, D., Davidson, R.J., 2002. Startle potentiation in aversive anticipation: evidence for state but not trait effects. *Psychophysiology* 39, 254–258. <http://dx.doi.org/10.1017/S004857720139217X>.
- Roberts, J.E., Gilboa, E., Gotlib, I.H., 1998. Ruminative response style and vulnerability to episodes of dysphoria: gender, neuroticism, and episode duration. *Cognitive Therapy and Research* 22, 401–423. <http://dx.doi.org/10.1023/A:1018713313894>.
- Siegle, G.J., Granholm, E., Ingram, R.E., Matt, G.E., 2001. Pupillary response and reaction time measures of sustained processing of negative information in depression. *Biological Psychiatry* 49, 624–636. [http://dx.doi.org/10.1016/S0006-3223\(00\)01024-6](http://dx.doi.org/10.1016/S0006-3223(00)01024-6).
- Siegle, G.J., Steinhauer, S.R., Carter, C.S., Ramel, W., Thase, M.E., 2003. Do the seconds turn into hours? Relationships between sustained pupil dilation in response to emotional information and self-reported rumination. *Cognitive Therapy and Research* 27, 365–382. <http://dx.doi.org/10.1023/A:1023974602357>.
- Sloan, D.M., Sandt, A.R., 2010. Depressed mood and emotional responding. *Biological Psychology* 84, 368–374. <http://dx.doi.org/10.1016/j.biopsycho.2010.04.004>.
- Thibodeau, R., 2011. Individual differences in depressive symptoms are associated with impaired incentive, but not aversive motivation. *Personality and Individual Differences* 50, 376–380. <http://dx.doi.org/10.1016/j.paid.2010.10.025>.
- Vaidyanathan, U., Patrick, C.J., Cuthbert, B.N., 2009. Linking dimensional models of internalizing psychopathology to neurobiological systems: affect-modulated startle as an indicator of fear and distress disorders and affiliated traits. *Psychological Bulletin* 135, 909–942. <http://dx.doi.org/10.1037/a0017222>.
- van Boxtel, A., Boelhouwer, A.J.W., Bos, A.R., 1998. Optimal EMG signal bandwidth and interelectrode distance for the recording of acoustic, electrocutaneous and photic blink reflexes. *Psychophysiology* 35, 690–697. <http://dx.doi.org/10.1017/S0048577298970317>.
- Vrana, S.R., Spence, E.L., Lang, P.J., 1988. The startle probe response: a new measure of emotion? *Journal of Abnormal Psychology* 97, 487–491. <http://dx.doi.org/10.1037/0021-843X.97.4.487>.