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

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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.

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 symptomology 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 symptomology, 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

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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.