

Emotional responding in depression: Distinctions in the time course of emotion

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The current studies were designed to investigate if the emotion context insensitivity hypothesis (ECI; Rottenberg & Gotlib, 2004) is applicable across the time course of emotion. Recent affective science research has pointed to the importance of considering anticipation and maintenance of emotion. In the current studies, we assessed emotion responses among college students with depression symptoms in anticipation of, during, and after an emotional picture using the emotion modulated startle paradigm. People with and without depression symptoms did not differ in blink magnitude in anticipation of emotional pictures suggesting that some anticipatory processes may not be impaired by depression symptoms. In contrast, individuals with depression symptoms did not exhibit blink magnitudes that varied by valence, either during viewing or after the pictures were removed from view. These findings suggest that ECI is relevant not only for those diagnosed with major depressive disorder, but also for people with depression symptoms that may not cross the diagnostic threshold. These data also point to the importance of considering the time course of emotion to better understand emotional deficits in individuals with differing levels of depression symptoms. Identifying where emotion goes awry across the time course of emotion can help inform treatment development.

Keywords: Depression; Startle modulation; Emotion; Dysphoria; Anticipation; Maintenance.

Although conventional wisdom suggests that major depressive disorder (MDD) is associated with heightened negative emotion, research supporting this notion is mixed. On the one hand, evidence suggests that people with depression report generally experiencing high negative and low positive affect relative to people with few symptoms of depression (e.g., Clark, Watson, & Mineka, 1994; Watson, Clark, & Carey, 1988), a

pattern consistent with the MDD symptoms of sad mood and anhedonia. On the other hand, and perhaps somewhat paradoxically, when faced with emotionally evocative stimuli, people with depression exhibit a different pattern of emotional responding.

More specifically, studies that have investigated expressive, experiential, and physiological responses to emotional stimuli have found that

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depression is associated with similar or *reduced* responses to negative stimuli compared to people without depression (Allen, Trinder, & Brennan, 1999; Berenbaum & Oltmanns, 1992; Dunn, Dalgleish, Lawrence, Cusack, & Ogilvie, 2004; Gehricke & Shapiro, 2000; Sloan, Strauss, Quirk, & Sajatovic, 1997; Sloan, Strauss, & Wisner, 2001). In addition, studies have found that depression is associated with reduced responses to positive stimuli (Allen et al., 1999; Berenbaum & Oltmanns, 1992; Dunn et al., 2004; Katsikitis & Pilowsky, 1991; Rottenberg, 2005; Rottenberg, Kasch, Gross, & Gotlib, 2002; Shestyuk, Deldin, Brand, & Deveney, 2005; Sloan et al., 1997, 2001). In short, these studies suggest, somewhat counterintuitively, that depression is associated with an overall dampening of both positive and negative emotion responses.

In part to help explain the discrepancy between dampened responses to evocative stimuli amidst reports of heightened negative affect, Rottenberg and Gotlib (2004) proposed the emotion context insensitivity hypothesis (ECI), which states that depressed mood influences a person's ability to vary emotional response according to context. That is, depressed mood inhibits variation in emotional responses to both positive and negative stimuli. Bylsma, Morris, and Rottenberg's (2008) meta-analysis of 19 studies of emotion responsivity among people with MDD generally supported ECI, though there were differences depending upon valence (i.e., positive or negative) and emotion response component (i.e., expression, experience, physiology). More specifically, they reported medium or large effect sizes for dampened positive expression and experience but not physiology. By contrast, they reported medium effect sizes for dampened negative experience and physiology, but not expression. They also suggested that the severity of depression symptoms may influence the observation of ECI. Indeed, people with few depression symptoms do not seem to show the dampened emotional response pattern consistent with ECI (e.g., Vanman, Dawson, & Brennan, 1998). On the other hand, evidence suggests that the clinical significance of depression symptoms does not depend on meeting

diagnostic criteria for a depressive episode (Lewinsohn, Solomon, Seeley, & Zeiss, 2000; Solomon, Haaga, & Arnow, 2001). Thus, in order to fully understand when ECI may be observed, it is important to study depression symptoms ranging from moderate to severe (Beck, Steer, & Carbin, 1988).

The time course of emotion

Another important factor to consider when investigating emotional responding in depression is the time course of emotion. Most prior research on emotional responsivity in depression has focused on responses in the presence of emotional stimuli (i.e., "in-the-moment" responses). Yet, affective science research has identified different aspects of emotional responses as they develop across time (Davidson, 1998). That is, studies using expressive, experiential, and physiological measures have found that emotional responses unfold prior to stimulus presentation, (i.e., in anticipation; e.g., Nitschke et al., 2002; Poli, Sarlo, Bortoletto, Buodo, & Palomba, 2007; Sabatinelli, Bradley, & Lang, 2001), during stimulus presentation, and through to the post-stimulus period (i.e., maintenance or recovery; e.g., Bradley, Cuthbert, & Lang, 1996; Garrett & Maddock, 2001). While studies with healthy participants and select clinical populations have examined the time course of emotion (e.g., schizophrenia; see Kring & Moran, 2008, for a review), studies have only just begun to examine the linkage between depression symptoms, anticipation, and maintenance processes. These processes in particular may be important for understanding the boundaries of ECI that could in turn inform intervention. For example, if depression is also associated with dampened emotion during anticipation, treatment might be improved by focusing on the anticipation of an emotional response in addition to in-the-moment responses. In contrast, if depression is associated with dampened emotion response after emotional stimuli are removed, treatment might be focused on the in-the-moment experience and savouring of emotion.

A useful method for studying the time course of emotion is the startle eyeblink modulation (SEM) paradigm. In this paradigm an abrupt, startling stimulus (e.g., burst of white noise air) is paired with an evocative stimulus and the magnitude of a person's eyeblink is assessed. During stimulus presentation, blink magnitude is largest when the stimulus is negative and smallest when the stimulus is positive, thus indicating that blink magnitude varies by the valence of the stimulus and the participant's emotional experience (Lang, Bradley, & Cuthbert, 1990). For the most part, findings from studies using the SEM paradigm in depression are consistent with the ECI hypothesis. That is, prior studies have found diminished emotion-modulated blink responses during stimulus presentation (Allen et al., 1999; Dichter & Tomarken, 2008; Dichter, Tomarken, Shelton, & Sutton, 2004; Kaviani et al., 2004; Larson, Nitschke, & Davidson, 2007; Mneimne, McDermut, & Powers, 2008). However, severity of depression symptoms appears to be an important moderator. For example, Forbes, Miller, Cohn, Fox, and Kovacs (2005) found that those reporting more MDD episodes failed to show emotion-modulated blink response (i.e., an ECI pattern) while those with fewer MDD episodes exhibited emotion-modulated blink responses. Other studies have found that depression is associated with an overall reduction in blink magnitude, regardless of whether it varies by valence (Allen et al., 1999; Sloan & Sandt, 2010).

Anticipation of emotion and depression. The SEM paradigm has also been used to assess anticipation. Among people without depression symptoms, blink magnitude is larger in response to anticipatory cues signalling forthcoming positive or negative stimuli than in response to anticipatory cues signalling neutral stimuli (Dichter, Tomarken, & Baucom, 2002; Lipp, Cox, & Siddle, 2001; Sabatinelli et al., 2001). Potentiated blink magnitude in anticipation of both positive and negative stimuli has been hypothesised to represent a preparatory response for an impending emotional response, regardless of valence (e.g.,

Dichter et al., 2002) as well as an attentional response to forthcoming emotionally arousing stimuli (Bradley, Lang, & Cuthbert, 1993; Lipp et al., 2001).

To our knowledge, only two SEM studies have studied anticipation in depression. Dichter and Tomarken (2008) found that people diagnosed with MDD showed blink *attenuation* to positive and negative anticipatory cues presented 2 s prior to pictures relative to neutral cues. By contrast, people without MDD showed blink *potentiation* to positive and negative anticipatory cues (relative to neutral). Larson and colleagues (2007), by contrast, found no differences in blink magnitude to cues presented 1 s prior to emotional compared to neutral pictures between people with and without anhedonic depression symptoms. Differences in sample characteristics may account for the discrepant findings between the two studies. That is, participants in Larson et al.'s study exhibited moderate anhedonic depression symptoms, and thus other symptoms may be more influential in the anticipation of emotion (e.g., difficulties with attention/concentration). Dichter and Tomarken (2008) studied people with a diagnosis of MDD, suggesting that blink attenuation in anticipation may be associated with depression severity or diagnostic status.

A few studies have examined anticipation of emotion in depression using different methods, including self-report and fMRI, yet no consistent findings have emerged, perhaps due to widespread methodological differences. Self-report studies that ask participants to anticipate future positive and negative events found that those with depression symptoms reported anticipating fewer positive (but not negative) events compared to those without depression symptoms (e.g., Abramson, Metalsky, & Alloy, 1989; Bjarehed, Sarkohi, & Andersson, 2009; MacLeod & Salaminiou, 2001). By contrast, fMRI studies assessing anticipation of positive stimuli (monetary reward, positive pictures) found no differences in brain activation or reaction time between people with and without depression symptoms in areas associated with anticipation (e.g., nucleus accumbens, amygdala; Abler, Erk, Herwig, & Walter, 2007; Knutson,

Bhanji, Cooney, Atlas, & Gotlib, 2008; Pizzagalli et al., 2009). However, two fMRI studies assessing anticipation of negative stimuli (negative pictures, pain) found that people with depression symptoms showed greater amygdala activation compared to people without depression despite no differences in reported experience or reaction times (Abler et al., 2007; Strigo, Simmons, Matthews, Craig, & Paulus, 2008).

Maintenance of emotion and depression. A handful of studies have examined the maintenance of emotional responses after emotional stimuli are removed from view in the context of depression symptoms (Deldin, Deveney, Kim, Casas, & Best, 2001; Rottenberg et al., 2002; Siegel, Granholm, Ingram, & Matt, 2001; Siegel, Steinhauer, Carter, Ramel, & Thase, 2003). Siegel and colleagues (2001) found that people with depression showed persistent processing of negative words, as indexed by pupil dilation, even after the negative words were no longer present. In a follow-up study, Siegel, Steinhauer, Thase, Stenger, and Carter (2002) found continued amygdala activation to negative (but not positive) words in those with depression that lasted up to 30 seconds, while those without depression showed a decay in amygdala activity within 10 seconds following stimulus presentation.

To our knowledge, two studies have used the SEM paradigm to assess maintenance or recovery of emotion response in depression. Forbes et al. (2005) found that people with and without depression exhibited comparable potentiated blink responses during and following the offset (average of 5 s post picture) of negative pictures compared to blink responses during and following the offset of positive pictures. However, individuals with more lifetime episodes of MDD exhibited dampened emotion-modulated responses during and after pictures, a pattern consistent with ECI. Larson et al. (2007) found that participants with and without anhedonic depression symptoms exhibited blink potentiation to negative pictures compared to positive pictures. However, those without anhedonic depression symptoms exhibited blink attenuation to positive pictures

relative to neutral whereas those with anhedonic depression symptoms did not. Thus, findings from Larson and colleagues suggest ECI may be observed for positive, but not negative, pictures once emotional stimuli are removed from view. Taken together, findings from SEM studies suggest that those with depression symptoms may exhibit ECI during the maintenance period, particularly for positive stimuli. However, studies using other methods suggest that those with depression symptoms may continue to maintain responses to negative stimuli.

The present studies

In summary, although several studies have found that people with depression exhibit dampened responses to both positive and negative stimuli, consistent with the ECI hypothesis, some studies do not find this pattern. One possibility for the discrepant findings is the range of depression symptoms studied. Thus, studies investigating emotion in those with varying levels of depression symptoms are necessary to better understand whether symptom severity plays a role in ECI. In addition, while the affective science literature has pointed to the importance of investigating the time course of emotion, only a handful of studies have taken this approach in the study of depression. Emotion responses unfold over time, and thus there are several points during the time course of emotion where emotion responses may go awry. Given that studies suggest that intact emotional responding is associated with recovery from depression (Geschwind et al., 2011; Morris, Bylsma, & Rottenberg, 2009; Peeters, Berkhof, Rottenberg, & Nicolson, 2010; Rottenberg et al., 2002), it is important to understand the point at which response dampening may occur or continue.

The present studies took a systematic approach to investigating the time course of emotion in those with and without depression symptoms. In Study 1, we examined emotional responses during the anticipation and presentation of emotionally evocative stimuli. Thus, Study 1 sought to clarify and replicate prior studies reporting a pattern of

ECI while viewing emotionally evocative stimuli, along with extending prior research to investigate whether those with depression symptoms exhibit ECI during the anticipation of emotional stimuli. In Study 2 we sought to replicate our findings from Study 1 during picture viewing, while also extending the examination of ECI to the maintenance of emotion. In short, the present studies sought to test the hypothesis that ECI extends to anticipation, in-the-moment experience and maintenance of emotion responses.

STUDY 1

In Study 1 we tested several specific hypotheses. First, consistent with ECI, we hypothesised that people with depression symptoms would exhibit dampened emotion responses during the presentation of evocative stimuli, including dampened reports of experienced emotion and dampened blink magnitude relative to people without depression symptoms. Second, we hypothesised that those without depression symptoms would show potentiated blink responses during the anticipation of emotional compared to neutral pictures. In contrast, we hypothesised that people with depression symptoms would not exhibit potentiated blink responses during anticipation of emotional relative to neutral pictures, a pattern consistent with ECI.

Methods

Participants. A total of 80 participants were enrolled in the study. Depression symptoms were assessed using the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). Based on prior research indicating that scores above 17 correspond with clinically significant experiences of depression (Kendall, Hollon, Beck, Hammen, & Ingram, 1987), participants scoring above 17 were assigned to the depression symptom group (DS; i.e., those reporting depression symptoms while not necessarily meeting diagnostic criteria for MDD). In addition, participants had to endorse symptoms

consistent with either sad mood or anhedonia, corresponding to diagnostic criteria for a major depressive episode (American Psychiatric Association, 1994). Participants scoring between 1 and 8 on the BDI were assigned to the non-depressed group (ND). Following the Kendall et al. (1987) recommendations, people with a BDI score of 0 were excluded from the ND group as such a low level of depression symptoms may be associated with other forms of psychopathology. Participants' BDI scores were assessed at two time points: (1) as part of a pre-screening survey completed a mean of 4.3 weeks prior to laboratory session; and (2) at the laboratory session. Participants that changed group status between their BDI 1 and BDI 2 scores were excluded from analyses ($n = 13$).

Seven participants were excluded (six of the seven from the DS group) due to a lack of startle response in more than half of trials (Blumenthal et al., 2005). Thus, the final number of participants was 33 in the ND group (18 female) and 27 in the DS group (15 female). All participants had normal hearing and normal or corrected-to-normal vision.

Stimuli. Sixty pictures (20 positive, 20 neutral, and 20 negative and 3 habituation slides) were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005; see Appendix 1). Pictures were selected based on published rating norms (Lang et al., 2005) such that mean arousal ratings for positive and negative pictures were comparable (mean = 5.01 and 5.27, respectively). Neutral pictures, such as common household items, were selected based on normative valence ratings placing them midway between positive and negative pictures. Men and women were shown the same set of pictures except for a selection of positive pictures that were selected to ensure comparable normative ratings of arousal and valence between genders.

Procedure. The experimental sessions took place in a dimly lit and quiet laboratory room. After participants provided informed consent, they were positioned in a comfortable chair approximately

0.5 m from a 36 cm LCD laptop computer screen. Experimenters blind to participants' group membership prepared the skin, placed electrodes for recording startle responses, and checked impedance (following recommendations from Berg & Balaban, 1999). After electrode application, participants were asked to complete the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988) a measure that includes two 10-item scales that assess the experience of positive and negative affect over the prior week. Participants were then asked to wear a pair of headphones and were told that they would hear noises over the headphones, but that they could ignore the noises. The acoustic startle probes were digitally generated WAV files of a 50-ms burst of white noise with instantaneous rise time. The startle probes were amplified to 105 dB by a Radio Shack SA-155 Integrated Stereo Mini-Amplifier and binaurally presented through Sennheiser HD 490 headphones. Probe stimuli were calibrated before each test session. Participants were told that a series of cues and pictures would be presented on the screen and that cues would indicate the type of upcoming picture they would see. The cues indicated the valence of the pictures that would be subsequently presented: plus sign (+) for positive; minus sign (−) for negative; and a circle (○) for neutral. Participants were told that they would be asked to rate how they felt after viewing each picture. To make these ratings, participants used the Self-Assessment Manikin (SAM; Levenston, Patrick, Bradley, & Lang, 2000), a nonverbal pictorial assessment technique that measures valence and arousal. After viewing each picture, participants were asked to make two ratings: (1) Valence—how they felt while viewing the picture on a 9-point scale from “*unhappy*” to “*happy*”; and (2) Arousal—how much arousal they felt while viewing the picture on a 9-point scale from “*calm*” to “*aroused*”. Participants completed a series of four practice trials to familiarise themselves with the procedure, with three of those trials containing a startle probe. A study assistant walked each participant through the first practice sequence detailing the study procedure, and then participants completed three trials on their own to

ensure clarity of study procedures. Presentation of pictures and probes were controlled by VPM software (Cook, Atkinson, & Lang, 1987).

Following the practice and habituation trials, participants began the experimental protocol consisting of 60 trials. Each trial began with a blank screen followed by a 0.5 s cue (+, −, or ○), followed by a 5 s blank screen anticipation period during which participants were asked to anticipate the upcoming picture. Pictures were then displayed for 6 s followed by a screen that asked participants to make the two experienced emotion ratings on the computer using the SAM. Inter-trial intervals (ITIs) varied between 5 and 7 seconds. Startle probes were pseudo-randomly ordered and presented during either the anticipatory period (2,500 ms after the anticipatory cue and prior to picture onset), during the picture presentation period (3,500 ms after picture onset), or during the ITI. Unprobed trials were used to minimise predictability. Startle probes were presented in 50 of the 60 trials, 24 in the anticipatory period and 24 during the picture viewing period, and 2 ITIs. No more than one startle probe was presented during a trial and no more than two pictures of the same valence were presented sequentially. Three picture orders were created and used sequentially (there were no differences between order therefore analyses were collapsed across orders).

Physiological recording and data reduction. Electrode placement and skin preparation followed guidelines for human startle research (Blumenthal et al., 2005). Electromyography (EMG) electrodes were filled with electrolyte gel and placed in the orbicularis oculi region, one directly below the pupil of the left eye and one lateral to this. A third electrode was placed in the middle of the forehead as a grounding electrode. Impedances were kept below 15 kΩ.

EMG signal was filtered using a 13–1,000 Hz passband and amplified using a Coulbourn V75-04 Isolated Bioamplifier with Bandpass Filter. EMG was sampled at 1,000 Hz for the 50 ms prior to probe onset and ending 300 ms after probe onset. The signal was digitally refiltered offline with a 28–500 Hz passband (Van Boxtel,

Boelhouwer, & Bos, 1998) and digitally rectified and integrated using a 30 ms time constant.

Research assistants visually confirmed and scored the EMG data segments using blink scoring software. Blinks were only scored if they fell 20 ms to 150 ms after probe onset. Mean blink magnitude (in microvolts) for each valence (positive, neutral, negative) and time point (anticipatory, in-the-moment) was computed for each individual.¹ Habituation trials were not included in blink scoring or data analysis.

Data reduction and analysis plan. For SAM valence and arousal ratings, 2 (Group: DS, ND) \times 3 (Valence: positive, neutral, negative) repeated-measures multivariate analyses of variance (MANOVAs) were conducted with Valence as a within-subject factor and Group as a between-subjects factor. For blink magnitude, a 2 (Group: DS, ND) \times 2 (Probe Time: anticipatory, in-the-moment) \times 3 (Valence: positive, neutral, negative) repeated-measures MANOVA was conducted with Probe Time and Valence as within-subject factors and Group as a between-subjects factor. A Greenhouse–Geisser correction was used when appropriate. When applicable, follow-up pairwise comparisons were conducted using a Bonferroni correction. All estimates of effect size are reported as partial eta squared (η_p^2). In preliminary analyses, gender and ethnicity were entered as between-subject variables but no main effects or interactions with either variable were significant so gender and ethnicity were collapsed in all presented results.

Results

Participant characteristics. Demographic and symptom information are presented in Table 1. A chi-square test for ethnic status and gender

(p s = .62 and .73, respectively) and a t -test for age (p = .72) revealed no significant group differences. As planned, the DS group had significantly higher levels of depression symptoms than the ND group as measured by the BDI, $t(58) = 17.83$, $p < .0001$. The mean BDI score for the DS group was comparable to clinically depressed samples (Cox, Enns, & Larsen, 2001) and indicates moderate levels of depressive symptomatology (Kendall et al., 1987). Consistent with prior work on depression (e.g., Watson, Clark, & Carey, 1988) the DS group reported significantly higher levels of negative affect, $t(58) = 6.45$, $p < .001$, and lower levels of positive affect, $t(58) = 3.30$, $p < .001$, than the ND group.

Self-reported emotional experience. For SAM valence ratings (see Table 2), the Valence main effect was significant, $F(1, 58) = 267.68$, $p < .001$, $\eta_p^2 = .82$. All participants reported experiencing more pleasant emotion after seeing positive pictures compared to neutral ($p < .001$) or negative pictures ($p < .001$). All participants reported experiencing more unpleasant emotion after seeing negative compared to neutral pictures ($p < .001$). The Group main effect was not significant ($p = .55$), but there was a significant Group \times Valence interaction, $F(2, 57) = 35.91$, $p < .001$, $\eta_p^2 = .39$. Follow-up between-group analyses revealed that the DS group rated their experience while viewing positive pictures as less pleasant than the ND group, $t(58) = 4.90$, $p < .001$, and experience while viewing negative pictures as less unpleasant, $t(58) = 5.10$, $p < .001$. There were no differences between groups in the rating of experience while viewing neutral pictures ($p = .32$). Thus, contrary to the ECI hypothesis, people with depression symptoms reported emotion experience that varied by valence. However, when compared to those without depression symptoms, people with depression

¹We also conducted the startle analyses using measures standardised within each individual (i.e., T scores). Specifically, blink magnitude means and standard deviations were computed across the valence conditions (positive, negative, neutral) but within each probe time and converted to T scores ($M = 50$; $SD = 10$). The standardisation procedure did not change the relative pattern of participants' responses across the picture types and probe times. Reported results did not differ with the use of T scores in Study 1. Although the direction and pattern of results were similar for Study 2, however, the reported interactions were now outside standard conventions of statistical significance ($p = .12$)

Table 1. Demographic and symptom characteristics for participants in Studies 1 and 2

Characteristic	Group			
	Study 1		Study 2	
	DS	ND	DS	ND
Number (<i>n</i>)	27	33	31	26
Age	20.1 (2.3)	20.5 (5.4)	19.8 (1.4)	19.6 (1.9)
Ethnicity (<i>n</i>)				
Asian	14	17	15	15
Caucasian	9	11	14	4
Latino	2	3	3	5
African American	2	2	1	0
Did not disclose	0	0	1	1
BDI	21.0 (5.1)	3.6 (2.1)	26.6 (5.9)	5.74 (2.5)
PA	31.1 (8.1)	37.2 (6.2)	27.4 (6.1)	35.52 (6.8)
NA	31.9 (7.3)	21.0 (5.8)	30.8 (7.2)	19.6 (6.1)

Notes: Standard deviations in parentheses. DS = Depression symptom group; ND = Non-depression symptom group; BDI = Beck Depression Inventory; PA = Positive Affect Scale; NA = Negative Affect Scale.

symptoms reported less pleasant experience to positive and less unpleasant experience to negative pictures.

For SAM arousal ratings, the Valence main effect was significant, $F(2, 58) = 89.25$, $p < .001$, $\eta_p^2 = .76$. All participants reported more arousal while viewing positive and negative pictures than while viewing neutral pictures, a significant quadratic effect, $F(1, 58) = 171.75$, $p < .001$. The Group main effect was not significant, but there was a significant Group \times Valence interaction, $F(2, 58) = 4.74$, $p < .05$. Follow-up analyses

Table 2. SAM valence and arousal ratings in Study 1

	Valence		Arousal	
	DS	ND	DS	ND
Positive	5.54 (0.79)	6.49 (0.71)	5.14 (1.22)	5.52 (1.51)
Neutral	4.98 (0.49)	5.11 (0.45)	2.81 (1.31)	3.73 (1.34)
Negative	3.64 (1.13)	2.39 (0.76)	5.05 (1.39)	5.49 (1.46)

Notes: Tabulated values are means (standard deviations in parentheses). DS = Depression symptom group; ND = Non-depression symptom group. Ratings ranged from 0 to 9 with higher numbers indicating more pleasant or arousing feelings.

revealed that the DS group reported less arousal to neutral pictures compared to the ND group, $t(58) = 2.70$, $p < .01$. Ratings of arousal experience to positive and negative pictures did not differ by group ($p > .25$).

Blink magnitude. The Valence main effect was significant, $F(2, 114) = 10.22$, $p < .001$, $\eta_p^2 = .27$, revealing a pattern wherein blink magnitude in response to negative pictures was larger than to either positive ($p < .001$) or neutral pictures ($p < .001$). The Probe Time main effect was also significant, $F(1, 58) = 8.52$, $p = .005$, $\eta_p^2 = .13$, indicating that blink magnitude during anticipation of pictures was significantly greater than during picture viewing. There was no main effect for Group; however, there was a significant Group \times Probe Time \times Valence interaction, $F(1, 57) = 9.47$, $p = .003$, $\eta_p^2 = .15$.

To examine blink magnitude during both anticipation and picture viewing, additional 2 (Group: DS, ND) \times 3 (Valence: positive, neutral, negative) repeated-measures MANOVAs were conducted at each probe time. During anticipation, the Valence main effect was significant, $F(2, 58) = 13.85$, $p < .001$, $\eta_p^2 = .33$. Post hoc pairwise comparisons indicated that blink magnitude in response to cues signalling forthcoming negative pictures was significantly larger than response to positive and neutral cues ($p < .005$), and blink magnitude to positive cues was significantly larger than response to neutral cues ($p < .05$). Neither the Group main effect ($p = .76$) nor the Group \times Valence interaction ($p = .95$) was significant. Thus, both groups showed potentiated blink response during the anticipation of positive and negative pictures compared to the anticipation of neutral pictures.

During picture presentation, the Valence main effect, $F(2, 58) = 15.94$, $p < .001$, $\eta_p^2 = .22$, and Group \times Valence interaction, $F(2, 58) = 7.33$, $p = .009$, $\eta_p^2 = .11$, were significant. As shown in Figure 1, the ND group exhibited greater blink magnitude in response to negative pictures compared to neutral or positive ($ps < .01$). Blink magnitude to positive pictures was smaller than magnitude to neutral pictures ($p < .01$). The DS

group, however, did not show this pattern of emotion-modulated startle. This group exhibited no difference in blink magnitude while viewing positive, neutral or negative pictures ($p > .32$). Between groups, there were no differences in blink magnitude while viewing positive ($p = .30$), neutral ($p = .86$) or negative pictures ($p = .32$).

Discussion

Study 1 sought to investigate the time course of emotion in those with and without depression symptoms and asked the question of whether anticipation and in-the-moment emotion responses are characterised by emotion context insensitivity. Findings from Study 1 support several of our hypotheses. As predicted, the ND group showed emotion-modulated blink responses during picture presentation, while participants in

the DS group did not. That is, people without depression symptoms exhibited larger blink magnitudes to negative pictures compared to either neutral or positive pictures, and smaller blink magnitudes to positive compared to neutral pictures. However, people with depression symptoms did not exhibit emotion modulation, a pattern of findings consistent with the ECI hypothesis. Although not all studies of emotion and depression find group differences in reported experience, participants in the DS group differed from the ND group in the present study in that the DS group reported experiencing less pleasantness while viewing the positive pictures, less unpleasantness while viewing the negative pictures, and less arousal while viewing neutral pictures.

Contrary to our hypothesis, we found no difference in blink magnitude between the ND

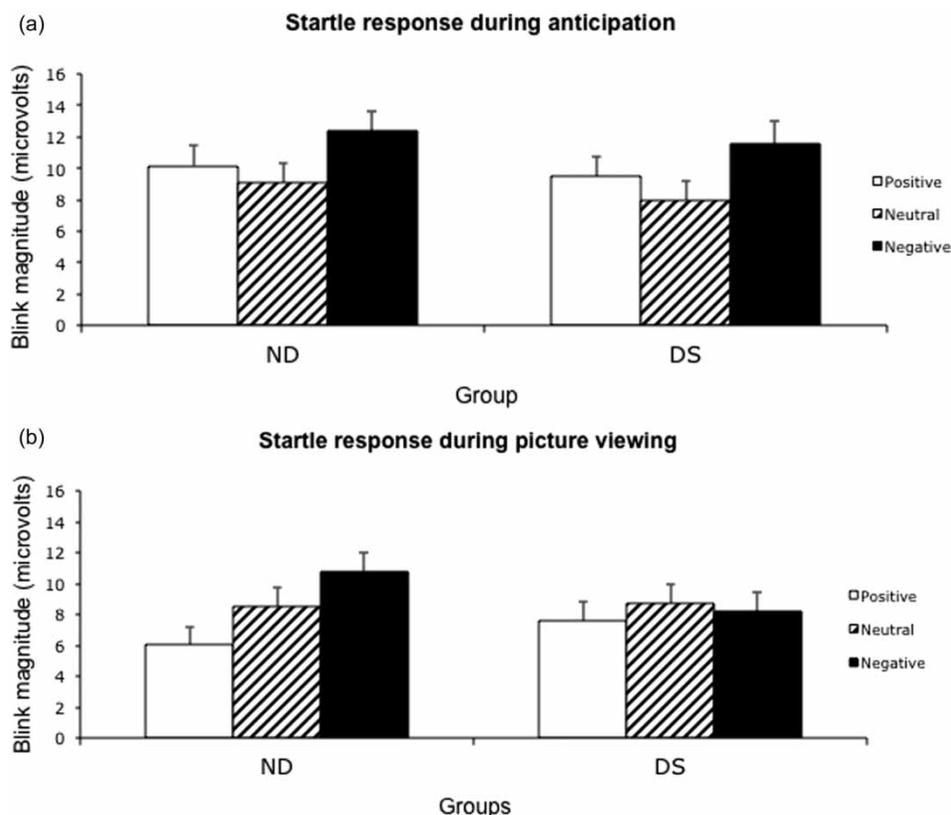


Figure 1. Mean blink magnitudes before and during picture presentation in Study 1.

and DS groups during the anticipation of pictures. That is, while individuals with depression symptoms showed diminished blink modulation during picture viewing, their responses were comparable to individuals without depression symptoms during anticipation. Both groups showed a pattern wherein blink magnitude to negative anticipatory cues was largest, followed by response to positive and neutral cues. Our findings are consistent with those of Larson and colleagues (2007), who found no differences in anticipatory blink response between participants with and without anhedonic depression symptoms, but inconsistent with Dichter and Tomarken (2008), who found attenuated blink responses during the anticipation of positive and negative pictures (compared to neutral) in those diagnosed with MDD. It may be the case that the inconsistency in findings is due to severity of symptoms such that those in Dichter and Tomarken's study were diagnosed with MDD and involved in a depression treatment study while those in the present study and in Larson et al.'s study had moderate levels of depression symptoms. In addition, symptom severity between the samples cannot be easily compared because symptoms were measured differently: BDI in the current study versus Mood and Anxiety Symptom Questionnaire in the Larson et al. study.

Basic research with the SEM paradigm points to meaningful psychological differences at different probe times. Long lead times in anticipation (e.g., 2,000 ms prior to picture presentation) and short lead times during picture viewing (e.g., 300 ms after picture onset) are purported to represent arousal and/or attention in preparation of a response, while short lead times during anticipation (e.g., 750 ms prior to picture presentation) and long lead times after picture presentation (e.g., 2,500 ms during picture viewing) are associated with valenced emotional responses. Our findings of intact arousal modulated blink responses in anticipation at a later probe time (2,500 ms prior to picture onset) coupled with diminished emotion modulated startle at a later probe time (3,500 ms after picture onset) are broadly consistent with those of Dichter et al. (2004), who found a significant difference in startle response between those with and without

MDD during a late probe time (i.e., 3,500 ms during picture viewing), but no difference during an early picture probe time (i.e., 300 ms).

In summary, Study 1 findings suggest that depression is associated with a deficit in the in-the-moment emotion responses, consistent with the ECI hypothesis. In contrast, our findings did not support the extension of ECI to the anticipation of emotion.

STUDY 2

In Study 2, we asked: what happens to an emotional response after the offset of an emotionally meaningful event? Findings from studies of people without depression have shown that emotional modulation of the startle response is maintained following picture presentation, such that blink magnitude following the offset of unpleasant emotional stimuli is larger than blink magnitude following the offset of pleasant emotional stimuli (Bradley et al., 1996; Germans Gard & Kring, 2007; Jackson et al., 2003; Larson, Sutton, & Davidson, 1998; Schupp, Cuthbert, Bradley, Birbaumer, & Lang, 1997). As reviewed earlier, prior studies have found evidence for ECI when positive and negative emotional stimuli are removed from view (e.g., Larson et al., 2007; Siegel et al., 2002).

As in Study 1, we measured emotion-modulated startle responses and self-reported emotional experience in individuals with high and low levels of depression symptoms. However, in Study 2, we extended the time course to examine startle responses after the evocative pictures were removed from view. Furthermore, we included participants with higher levels of depression symptoms to assess a broader range of symptoms. In Study 2, we tested two hypotheses. First, consistent with ECI (Rottenberg, Gross, & Gotlib, 2005) and findings from Study 1, we predicted that participants with higher depression symptoms would demonstrate fewer valence modulated startle responses during picture presentation than those without depression

symptoms. That is, we expected that the ND group, but not the DS group, would exhibit emotion-modulated startle responses, such that blink magnitude to positive pictures would be attenuated and blink magnitude to negative pictures would be potentiated relative to neutral pictures. Second, given that studies of healthy people have found continued emotion modulation of blink response after picture offset, we expected that the ND group would continue to exhibit emotion-modulated startle responses after picture offset. However, we predicted that the DS group would not show this modulation pattern, as predicted by ECI, but would instead show potentiated startle response to positive pictures after offset.

Methods

Participants. Similar to Study 1, DS and ND groups were created based on Kendall et al.'s (1987) recommendations. A total of 99 women completed the BDI during an initial pre-screening and again during the experimental session (on average 1 month later) in order to address stability of symptoms over time as well as status of symptoms at the time of the experiment. We limited the Study 2 sample to women because depression is more prevalent among women than men and because we did not observe any gender differences in Study 1. In addition, we opted to include participants with BDI scores of 20 or higher for the DS group at both assessments so that we could include participants with moderate depression symptoms based on Kendall et al.'s (1987) guidelines. As in Study 1, participants in the DS group had to endorse a 2 or 3 on either the item assessing sad mood or anhedonia since having one of these two symptoms is required for a diagnosis of depression according to the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 1994). In addition, participants with scores between 1 and 8 at both assessments comprised the ND group. Participants that changed group status between their BDI 1 and BDI 2 scores ($n = 39$)

were excluded from analyses. Following these procedures, 32 participants met criteria for the ND group, and 28 participants met criteria for the DS group. However, distribution analyses of the raw blink data resulted in exclusion of 1 participant from the DS group and 2 participants from the ND group due to outlying scores (> 3 *SDs* above mean). Thus, the final sample size was 31 ND and 26 DS participants. As in Study 1, all participants had normal hearing and normal or corrected-to-normal vision.

Stimuli. Fifty-seven pictures (18 positive, 18 negative, 18 neutral, 3 habituation) from the IAPS set were displayed in one of six orders. Pictures were selected based on normative female self-report valence and arousal ratings (Lang et al., 2005) such that positive and negative pictures were comparable on arousal ($M = 6.36$ and 6.45 , respectively) but at opposite valence extremes, and neutral pictures had low arousal ratings with valence ratings between those of the positive and negative pictures. Most of the pictures ($n = 44$) in Study 2 were not shown in Study 1, thus giving us the opportunity to examine the generalisability of our findings to different evocative stimuli (see Appendix 2). Pictures were presented for 6 s each, separated by ITIs of 6,500–8,000 ms.

Procedure. Informed consent, electrode application, and practice trial procedures were the same as in Study 1. Participants received course credit for participating. As in Study 1, participants completed the PANAS, reporting on their experienced positive and negative affect in the past week.

For the experimental trials, participants were told that they would be presented with a series of pictures and were instructed to look at each picture the entire time that the picture was on the screen. They were also told that they would be prompted to make a rating of how they felt while viewing the picture after each picture presentation using the computer. In Study 2, we used the 20-point version of the Self Assessment Manikin (Hodes, Cook Iii, & Lang, 1985), with ratings ranging in value from 0 to 20 with higher ratings

reflecting more positive valence or higher arousal. Participants were presented with a sample acoustic probe and were informed that they would hear this noise over the headphones periodically during the task but that they could ignore these noises.

The acoustic startle probes were the same as in Study 1, but the probe times varied. Specifically, probes were presented either during picture presentation (3,500 ms after picture onset; $n = 20$) or after the picture was removed (2,500 ms after picture offset; $n = 20$). No more than one probe was presented per trial. Fourteen trials with no probes or with ITI probes were also included to reduce the predictability of probe presentation. These trials were not included in data analyses. Six stimulus orders were used to counterbalance the presentation of the acoustic probes and picture valence across participants within groups. Pictures of the same valence occurred no more than twice consecutively and trials involving the same probe time occurred no more than three times in a row. No order effects were observed and we thus collapsed across order for the analyses.

Electrode placement, eyeblink measurement, quantification, and scoring procedures and parameters were the same as in Study 1. Mean blink magnitude (microvolts) for each valence (positive, neutral, negative) and time (during picture; after offset) were computed for each individual. Practice and habituation trials were not included in data analysis.

Data reduction and analysis plan. For SAM ratings of pleasantness and arousal separate 2 (Group: DS, ND) \times 3 (Valence: positive, negative, neutral) repeated-measures MANOVAs were conducted. Significant interactions were further evaluated by conducting a parallel set of follow-up analyses as was done in Study 1. For blink responses, a 2 (Group) \times 2 (Probe Time) \times 3 (Valence) repeated-measures MANOVA was conducted with Probe Time (during, after) and Valence (positive, neutral, negative) as within-subject factors and Group (DS, ND) as a between-subjects factor. A Greenhouse–Geisser correction was used when appropriate. When applicable, follow-up pairwise comparisons were

conducted using a Bonferroni correction. All estimates of effect size are reported as partial eta squared. In preliminary analyses, ethnicity was entered as between-subject variable but no main effects or interactions with ethnicity were significant so ethnicity was collapsed in all presented results.

Results

Participant characteristics. Demographic and symptom information for both groups are presented in Table 1. A chi-square test for ethnic status and t -test for age did not reveal any significant group differences ($ps = .21$ and $.67$, respectively). As planned, the DS group had significantly higher levels of depression symptomatology than the ND group as measured by the BDI, $t(55) = 17.83$, $p < .001$. The mean BDI score for the DS group was comparable to clinically depressed samples (Cox et al., 2001) and indicates moderate to severe levels of depressive symptomatology (Kendall et al., 1987). Consistent with prior work on depression (e.g., Watson, Clark, & Carey, 1988) and findings from Study 1, the DS group reported significantly higher levels of negative affect, $t(55) = 6.41$, $p < .001$, and lower levels of positive affect, $t(55) = 4.73$, $p < .001$, than the ND group.

Self-reported emotional experience. For SAM valence ratings, there was a significant main effect for Valence, $F(2, 54) = 109.42$, $p < .001$, $\eta_p^2 = .80$. As expected, participants reported experiencing more pleasant emotion in response to positive pictures than neutral pictures, $t(55) = 10.92$, $p < .001$, and negative pictures, $t(55) = 14.95$, $p < .001$, and they reported experiencing more negative emotion in response to negative compared to neutral pictures, $t(55) = 13.09$, $p < .001$. Neither the Group main effect nor the Group \times Valence interaction was significant ($ps = .88$ and $.89$, respectively). For SAM arousal ratings, there was a significant main effect for Valence, $F(2, 114) = 102.25$, $p < .001$, $\eta_p^2 = .79$. Positive and negative pictures elicited more self-reported arousal than neutral pictures, quadratic

effect, $F(1, 55) = 202.05$, $p < .001$. There was also a significant linear effect indicating that negative pictures elicited significantly more arousal than positive pictures, which elicited more arousal than neutral, $F(1, 55) = 9.85$, $p < .01$ (see Table 3).

Blink magnitude. A 2 (Group: DS, ND) \times 2 (Probe Time: during picture, after picture) \times 3 (Valence: positive, neutral, negative) repeated-measures MANOVA yielded no significant main effects for Group, Probe Time, or Valence and no significant three-way interaction. However, both the Probe Time \times Valence interaction, $F(2, 54) = 4.98$, $p = .01$, $\eta_p^2 = .16$, and the Group \times Valence interaction, $F(2, 54) = 3.48$, $p = .038$, $\eta_p^2 = .12$, were significant (see Figure 2).

Generally speaking, the Probe Time \times Valence interaction indicated that both groups showed greater valence modulation during picture presentation compared to the offset period, consistent with prior studies (Forbes et al., 2005). That is, during picture presentation, both groups exhibited smaller blink magnitude to positive pictures compared to either neutral or negative pictures ($ps < .001$), though the difference between negative and neutral was not significant. By contrast, after picture offset, the only significant difference was smaller magnitude after the offset of positive compared to negative pictures ($p = .014$). However, the Group \times Valence interaction indicated that individuals in the ND group showed greater valence modulation across the time points compared to individuals in the DS group. That is, collapsing across probe times, participants in the ND group exhibited smaller

blink magnitudes during and after positive pictures compared to neutral and negative pictures ($ps = .05$ and $.005$, respectively). Unexpectedly, blink magnitude did not differ between neutral and negative pictures either during or after picture presentation. By contrast, participants in the DS group did not exhibit significantly different blink magnitudes during or after positive, neutral and negative pictures, consistent with the ECI hypothesis. Although blink magnitudes were smaller in the DS group compared to the ND group, these differences were not significant (all $ps > .10$).

Discussion

Results from Study 2 replicate and extend the findings from Study 1. As in Study 1, participants in the ND group exhibited smaller blink magnitude while viewing positive pictures compared to while viewing neutral and negative pictures whereas participants in the DS group did not. Extending the time course of responding to after picture offset, the ND group continued to exhibit valence differentiation, with smaller blink magnitudes after positive pictures compared to negative and neutral pictures, but the DS group did not exhibit significant positive attenuation or negative potentiation after picture offset. Therefore, it appears that individuals with moderately high levels of depression symptoms exhibit diminished valence modulation of the startle response both during and after the presentation of emotionally evocative pictures. The overall magnitude of startle responses across probe times was also smaller, albeit non-significantly so in the DS group, possibly indicating less overall psychophysiological responsivity to an aversive stimulus (i.e., the acoustic probe) in individuals with depression symptoms.

Although participants with depressive symptoms demonstrated diminished overall emotion-modulated startle responses, they exhibited valence-appropriate positive and negative responsivity in their self-reported experience ratings. Therefore, at the experiential level, but not the physiological level, individuals with depression

Table 3. SAM valence and arousal ratings in Study 2

	Valence		Arousal	
	DS	ND	DS	ND
Positive	12.24 (1.76)	12.22 (1.33)	11.38 (1.70)	12.26 (1.33)
Neutral	9.69 (0.96)	9.76 (0.70)	7.95 (1.81)	8.71 (1.46)
Negative	5.92 (2.85)	5.76 (1.76)	13.11 (2.46)	12.66 (1.98)

Notes: Tabulated values are means (standard deviations in parentheses). DS = Depression symptom group; ND = Non-depression symptom group. Ratings ranged from 0 to 20 with higher numbers indicating more pleasant or arousing feelings.

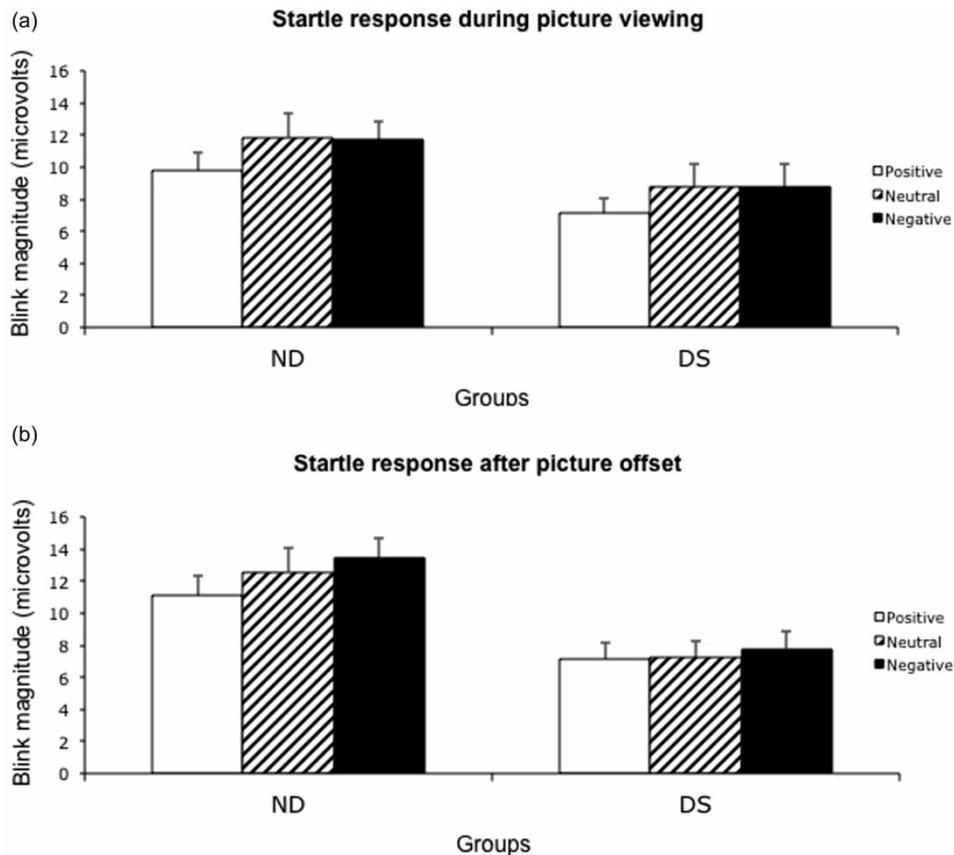


Figure 2. Mean blink magnitudes during and after picture presentation in Study 2.

symptoms responded with valence-specific activity. This finding is consistent with previous studies (e.g., Allen et al., 1999; Berenbaum & Oltmanns, 1992; Dichter & Tomarken, 2008; Dichter et al., 2004; Forbes et al., 2005; Gehricke & Shapiro, 2000; Katsikitis & Pilowsky, 1991) and may indicate that depression involves a decoupling of these response systems.

Somewhat surprisingly, while the ND group exhibited potentiated blink magnitude in response to negative compared to positive pictures, they did not show such potentiation compared to neutral pictures. It is unclear why this pattern was found though prior studies have failed to find significant differentiation between valences (e.g., Germans Gard & Kring, 2007). All participants in Study 2 were women, however, analyses conducted with

just the women from Study 1 did not reveal the lack of differentiation between negative and neutral blink magnitude during picture viewing. It seems unlikely that the different pictures used in Study 2 could account for this difference as these pictures have been used in many other SEM studies.

GENERAL DISCUSSION

The present studies sought to investigate the time course of emotion in those with and without depression symptoms. While previous studies of emotion in depression have examined emotional responding in the presence of emotional pictures, we sought to understand emotion during the

anticipation and maintenance periods. We utilised both self-reported emotional experience and the startle emotion modulation paradigm to measure emotional response. In addition, we sought to extend the ECI hypothesis to different aspects of emotional responding.

Our results confirmed that individuals with depression symptoms exhibit deficits in emotional responsivity compared to asymptomatic individuals. As hypothesised, emotion-modulated blink response was robust among people without depression symptoms. However, people with depression symptoms exhibited significantly less differentiated blink response while viewing positive and negative pictures compared to those without symptoms, thus supporting ECI (Rottenberg et al., 2005). The current studies extend and replicate prior work investigating emotional response in those with depression and suggest that ECI is applicable not just to those diagnosed with MDD, but also to those reporting moderate to high depression symptoms. As Bylsma and colleagues (2008) reported in their meta-analysis, ECI is among the most well-replicated theories of emotion in depression, and the current studies extend this to those with depression symptoms. Diminished emotion-modulated responses have also been observed with respect to outward expression in response to emotional stimuli (e.g., Greden, Genero, Price, Feinberg, & Levine, 1986; Rottenberg et al., 2005).

Our findings differed somewhat with respect to self-reported emotional experience in those with depression symptoms. In Study 1, symptomatic individuals reported feeling less pleasant in response to positive pictures and less unpleasant in response to negative pictures compared to individuals without symptoms. Thus, in Study 1 both startle responsivity and emotional experience during picture viewing showed a pattern consistent with ECI. In contrast, while we found a difference in emotion modulated startle between symptomatic and asymptomatic groups in Study 2, we did not find differences in self-reported emotional experience during picture viewing. Therefore, at the experiential level, but not the

physiological level, female participants with moderately severe depression symptoms in Study 2 responded with valence-specific activity.

The two studies differed in a couple of ways that may help to account for these differences. First, participants in Study 2 were all women. While no gender differences were observed in Study 1, it may be that women are more likely to show this decoupling of emotion responses, though there is limited empirical support for this notion. Second, the evocative pictures used in Study 2 had higher normed ratings of valence and arousal. Though we can only speculate on how these factors may have contributed to differences in self-reported valence across studies, it may be the case that the greater valence and arousal of the Study 2 pictures was strong enough to elicit emotion modulation at the experiential level among those with depression symptoms. Future studies might test this hypothesis by utilising emotion stimuli of varying levels of intensity to observe whether ECI varies by the intensity of the evocative stimuli.

The difference in depression severity between studies, though small, was nonetheless significantly different ($p < .001$). Thus, dissociation of response modalities (i.e., self-report, startle) may be more apparent in those with slightly more severe symptomatology. While some, but not all, studies of non-depressed participants report response system dissociations (see Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005, for a review), emotion response system dissociations are commonly observed in the depression literature, particularly among people with more severe symptoms or a diagnosis of MDD (e.g., Allen et al., 1999; Berenbaum & Oltmanns, 1992; Brown, Schwartz, & Sweeney, 1978; Dichter et al., 2004; Forbes et al., 2005; Gehricke & Shapiro, 2000; Katsikitis & Pilowsky, 1991; Mneimne et al., 2008; Rottenberg et al., 2005; Sloan & Sandt, 2010). If intensity of experience is associated with coherence between systems (Mauss et al., 2005), it may be that dampening of emotion response suggested by ECI is linked with dissociations between emotion-response systems.

Anticipation of emotion in depression

Participants with depression symptoms showed no deficit during the anticipation of emotional pictures as measured by startle eyeblink response. Because the anticipatory startle response is purported to be a measure of attentional arousal, our findings suggest that those with moderate depression symptoms have intact arousal-modulated responses. The pattern of anticipatory startle responses observed in this study is similar to the potentiated startle responses in studies that ask participants to imagine emotional scenes (Miller, Patrick, & Levenston, 2002). In fact, researchers have suggested that this potentiated response during the anticipation of positive and negative stimuli may indicate a period wherein participants are imagining the upcoming stimuli (Dichter & Tomarken, 2008; Lipp et al., 2001). Though speculative, our findings suggest that people with depression symptoms may be imagining forthcoming emotional stimuli in a manner that is similar to those without depression symptoms.

Nevertheless, our finding of intact anticipatory processes is in contrast to other studies using different methods, such as the anticipation of future events (e.g., Bjarehed et al., 2009; MacLeod & Salaminiou, 2001). In the current studies, we presented standardised emotional pictures and cues, whereas MacLeod and Salaminiou (2001) asked participants to generate future personal positive experiences. Anticipating future positive experiences differs from our task in a number of ways, including having a greater cognitive demand and a greater degree of self-relevance.

While cognitive demand may well be greater in tasks that require generation of future emotional experiences, perhaps the key difference is the use of self-relevant future emotional experiences. Several cognitive theories of depression have long held that depression is characterised by hopelessness related to the self, which in turn influences a person's hopelessness about the future (e.g., Abramson et al., 1989; Beck & Sunderland, 1967). Thus, the anticipation of self-relevant emotional scenarios may reveal a deficit during

anticipation in those with depression that was not seen in the current study. Indeed, Rottenberg (2005) found that people with depression reported greater negative emotion in response to personally relevant imagery than to normative negative emotion films. Miller and colleagues (2002) found that in healthy controls self-relevant positive imagery was associated with greater startle potentiation compared to general positive imagery. Taken together, these findings suggest the possibility of a distinct physiological pattern of response depending on relation of emotional stimuli to the self. Future studies should investigate the distinction between self-relevant and normative emotion eliciting stimuli in those with depression symptoms to clarify whether the anticipation of self-relevant stimuli would show distinctions in emotion response.

Still, our findings suggest that those reporting moderate symptoms of depression show an intact ability to engage attentional resources to anticipate positive and negative evocative pictures. This replicates findings by Larson and colleagues (2007) who found no differences in anticipatory blink magnitude between people with and without anhedonic depression symptoms. While it is difficult to compare the two samples given that the present study looked at overall depression symptoms, and Larson's study utilised a measure of anhedonic depression that looks to differentiate depression symptoms not related to anxiety, it is noteworthy that both studies suggest a similar finding suggestive of intact anticipatory responses.

In contrast, Dichter and Tomarken (2008) found that those with MDD had a deficit in anticipatory responding. Given that the anticipation of positive emotion is linked to motivated behaviour (Baumeister, Vohs, & Nathan DeWall, 2007; Gard, Gard, Kring, & John, 2006; Klein, 1984), and is associated with well-being (e.g., Quoidbach, Wood, & Hansenne, 2009; Sohl & Moyer, 2009; Vilhauer et al., 2011), the anticipatory period remains an important area of focus for depression. Should it be the case that the anticipation of emotion remains relatively intact in those with moderate symptoms of depression, including anhedonia, while more severe depression

is associated with a deficit, further investigation of anticipatory deficits is in order. Should early interventions be able to target deficits in emotion prior to deficits in anticipation are seen, we may be able to prevent future depression episodes. Additionally, understanding the linkages between the time course of emotion would help explain the ways in which diminished responding in-the-moment impacts maintenance and future anticipation of emotion.

Maintenance of emotion in depression

Our findings from Study 2 suggest that participants with depression symptoms exhibited a deficit in the maintenance of emotion, a pattern also consistent with the ECI hypothesis. While the non-depressed group continued to show valence-differentiated responses after emotional pictures were removed from view, those with depression symptoms showed an undifferentiated emotion response. Given that people with depression symptoms did not exhibit differentiated responses during picture viewing in either Study 1 or Study 2, it may not be all that surprising that they did not show emotion-modulated responses during the maintenance period. Nevertheless, it may be the case that the ability to continue to respond to motivationally salient emotional information in the moments after the information is removed is an adaptive quality that individuals with depression symptoms do not benefit from.

Larson et al. (2007) found that participants within the anhedonic depression symptom group exhibited larger blink magnitude 1.5 s after the removal of negative pictures compared to neutral pictures. However, there were no other within or between group differences after the 1.5 s probe time. In addition, there were no within- or between-group differences at 3 s or 6 s probe times following picture offset. Given that the present study measured blink magnitude 2.5 s after picture offset, it may be the case that timing of the startle probe is an important factor to consider when examining emotion maintenance. It could also be the case that there is something distinct about those reporting anhedonic depress-

ion symptoms that contributes to the delayed and then rapid diminution of blink responses following the offset of negative pictures. Future studies should investigate these distinctions further by assessing linkages between types of depression symptoms, anhedonia, and more specific timing of responses following the removal of evocative stimuli.

While some of the current studies findings appear inconsistent with some of the aforementioned findings of sustained processing of negative information in depression (Rottenberg et al., 2002; Siegel et al., 2001, 2002), it is worth noting that prior studies employed measures that also assessed attentional resources involved in responding to emotional material. Rottenberg et al. (2002) noted that respiratory sinus arrhythmia (RSA) modulation is significantly associated with attentional allocation and Siegel et al. (2001) noted that pupil dilation is influenced by attention. Thus, these previous findings may point to sustained attention to negative information in depression, but the current findings suggest that depression is not associated with sustained *emotion modulation* to negative information. It would be informative to simultaneously assess attentional and emotional deficits in depression to gain a more integrated understanding of the interactions between cognition and emotion in depression.

Another difference between these previous studies and Study 2 is the diagnostic status of participants. It may be the case that individuals diagnosed with MDD show sustained emotional responding (Rottenberg et al., 2002; Siegel et al., 2001, 2002) while individuals with moderately severe depression symptoms do not. In other words, it may be the case that severity of depression is related to the potentiation of negative emotion, while those with moderately severe depression symptoms continue to show an overall dampening of emotion response. However, this explanation seems unlikely considering the current sample showed similar levels of depression symptoms comparable to samples diagnosed with MDD (e.g., Dichter et al., 2004).

Our failure to find the maintenance of negative emotion seconds after removal of negative pictures

may be somewhat surprising given the extensive literature showing that depression is associated with rumination (see Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008, for a review). Rumination, or the persistent focus on feelings of distress and the reasons and consequences for distressed feelings, has been shown to predict future depression in those with depression symptoms (e.g., Nolen-Hoeksema, 2000) and continued experience of depression (e.g., Kuehner & Weber, 1999; Nolen-Hoeksema, 1991). However, rumination is a self-focused cognitive pattern, and our stimuli may not have evoked a similar internal negative focus. As was the case during anticipation, self-relevant stimuli may evoke a different pattern of emotional response and thus future studies should assess the maintenance of emotion following self-relevant and general, normed emotional stimuli. Should maintenance of negative emotion follow self-relevant emotion stimuli specifically, it provides further support for cognitive models of depression and suggests that emotion following negative stimuli may only be maintained when the stimulus or experience is self-focused.

Although our time course hypotheses were not fully borne out by the data, the SEM findings are significant in that they demonstrate that individuals with moderate to severe levels of depression symptoms exhibit similar emotional deficits as people diagnosed with MDD. In particular, symptomatic individuals demonstrated decreased sensitivity to changes in emotional contexts, a pattern previous studies have shown in clinically depressed individuals (e.g., Dichter et al., 2004; Kaviani et al., 2004; Rottenberg et al., 2002). Given that this pattern of reduced response to emotional stimuli has been linked to poorer concurrent and prospective functioning in clinically depressed samples (e.g., Rottenberg et al., 2002), the findings from this study bring attention to the importance of studying emotional deficits in individuals with moderate to high levels of depression symptoms, regardless of their diagnostic status. When expanding our focus to the time course of emotion, the current findings suggest that those with depression symptoms have intact responses to cues signalling forthcoming emotional stimuli but

diminished emotion modulation both during and after stimuli are removed from view. Should anticipation be relatively intact, interventions targeting the in-the-moment experience and maintenance of emotion may be key to avoiding the development of deficits in anticipatory emotion. In other words, interventions aimed at the experience of emotion in-the-moment along with the savouring of emotion may be crucial to the treatment of depression given that dampened emotion response consistent with ECI has been linked to poorer outcome and future depression episodes (e.g., O'Brien-Simpson, Di Parsia, Simmons, & Allen, 2009; Rottenberg et al., 2002).

Limitations and future directions

It is important to acknowledge several limitations to the present studies. While our sample sizes were comparable to other studies, they were not particularly large and thus additional replication of these findings is important. Second, measures of emotion experience and responsivity were measured at only one time point during each period of the time course of emotion (i.e., anticipation, in-the-moment, and maintenance). Continuous measurements of response systems could provide additional insight into the temporal patterns of emotional responses in depression. Third, while we utilised well-established emotion eliciting pictures, stimuli other than pictures and measurement of the time course of emotion outside of the laboratory are needed to better understand the real-world implications of the current study. Finally, while this was a study of those with depression symptoms, we did not assess for medication status or past depression symptoms, though other studies have found no effect of medications on startle response (Dichter et al., 2004).

Despite these limitations, the current studies replicate and extend prior work in this area by demonstrating that similar emotional deficits are present in individuals with moderate to high levels of depression symptoms as have been found in clinically depressed populations. In particular, symptomatic individuals demonstrated a lack of

sensitivity to changes in emotional contexts as compared to asymptomatic individuals both during and after the presentation of emotional material. These findings suggest a deficit in the ability of individuals with depression symptoms to respond adaptively to motivationally significant emotional material and underscore the importance of studying emotional deficits in a varying range of depression symptoms. In addition, our findings suggest that those reporting depression symptoms show an intact ability to engage arousal systems during the anticipation of positive and negative stimuli. The current studies also highlight the importance of better understanding the relationship between different response systems as well as underlying mechanisms linked to the time course of emotional responding when investigating the impact of depression symptoms on emotional responsiveness.

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APPENDIX 1

IAPS picture numbers used in Study 1

POSITIVE 4001m, 4150, 4538f, 4240m, 4542f, 4572f, 4599, 4608f, 4611m, 4640, 4651m, 4656, 4660, 4677, 5621, 5629, 8030, 8034, 8080, 8161, 8178, 8200, 8370, 8490.

NEUTRAL: 2393, 2440, 2480, 2840, 5510, 5800, 7000, 7004, 7020, 7034, 7035, 7036, 7041, 7150, 7175, 7179, 7185, 7217, 7491, 7950.

NEGATIVE: 1022, 1300, 1930, 2683, 3051, 3168, 3400, 3500, 3530, 6260, 6312, 6530, 6570, 9040, 9252, 9253, 9300, 9400, 9500, 9570.

HABITUATION: 7211, 9050, 4650.

Note: f denotes pictures shown only to women; m denotes pictures shown only to men.

APPENDIX 2

IAPS picture numbers used in Study 2

POSITIVE: 4656*, 4660*, 4670, 4677*, 4680, 4681, 4538, 4572, 4687, 5621*, 5626, 5629*, 8161*, 8180, 8185, 8210, 8300, 8400.

NEUTRAL: 2190, 2440*, 2480*, 2570, 5120, 7009, 7025, 7031, 7034*, 7060, 7090, 7110, 7170, 7224, 7234, 7235, 7700, 9360.

NEGATIVE: 1050, 1525, 3051*, 3061, 3080, 3530*, 6242, 6243, 6250, 6260*, 6300, 6370, 6510, 6550, 6561, 6570*, 6571, 9250.

HABITUATION: 7211*, 9050*, 4650*

Note: * indicates picture was also used in Study 1.