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Sex Differences in the Time Course of Emotion

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Conventional wisdom holds that women are more "emotional" than men. However, research evidence suggests that sex differences in emotion are considerably more complex. The authors tested hypotheses about sex differences in the engagement of the approach and avoidance motivational systems thought to underpin emotional responses. The authors measured reported emotional experience and startle response magnitude both during the presentation and after the offset of emotional stimuli that engage these motivational systems to assess whether men and women differ in their patterns of immediate response to emotional stimuli and in their patterns of recovery from these responses. Our findings indicated that women were more experientially reactive to negative, but not positive, emotional pictures compared to men, and that women scored higher than men on measure of aversive motivational system sensitivity. Although both men and women exhibited potentiation of the startle response during the presentation of negative pictures relative to neutral pictures, only women continued to show this relative potentiation during the recovery period, indicating that women were continuing to engage the aversive motivational system after the offset of negative emotional pictures.

Keywords: sex differences, emotion, affective startle modulation, approach and avoidance motivational systems

In popular Western culture, conventional wisdom holds that women are the more "emotional" gender.[1] Stereotypes of women as being more "in touch" with their emotions and as more emotionally responsive and sensitive are endorsed by both men and women (e.g., Belk & Snell, 1986). In the past decade, research has increasingly focused on sex differences in emotion; however, inconsistent findings have left the precise nature of these putative differences an open question

Despite debates regarding the boundary conditions of emotion (e.g., Rosenberg, 1998; Russell & Barrett, 1999), there is considerable agreement that emotional responses are relatively brief, phasic events that are organized along two opposing, overarching approach and avoidance motivational systems (e.g., Davidson, 1995; Dickinson & Dearing, 1979; Konorski, 1967; Lang, 1995). Engagement of these approach or avoidance motivational systems is thought to facilitate goal-directed behavior toward something desirable or away from something noxious, respectively. Although contextual factors may further shape the overt manifestations of emotion, these motivational systems may be considered as neurally rooted circuits that fundamentally drive emotional behavior (e.g., Lang, 1995). There is also important variability in the time course, or chronometry, of emotional responses, and this variability is becoming the focus of increasing empirical and theoretical attention (e.g., Davidson, 1994, 1998). That is, emotional responses are not wholly temporally constrained by the presence of an eliciting stimulus, but instead vary in their peak and duration in ways that may hold important information about individual differences in emotional responding.

Previous research has indicated that differences between men and women in "emotionality" may reflect differences in one or more components of emotion, such as emotional experience and expression. A good deal of evidence supports the notion that women are more expressive than men (for a review, see Brody & Hall, 2000). Similarly, a number of studies using a variety of emotion elicitation paradigms have found that women report more frequent or more intense positive and negative emotional experience (e.g., Barrett, Robin, Pietromonaco, & Eyssell, 1998; Grossman & Wood, 1993; Tobin, Graziano, Vanman, & Tassinary, 2000; Vrana & Rollock, 2002; but see Kring & Gordon, 1998). However, other research suggests that women experience more

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[1] Note that the use of the term gender here is intentional. The importance of distinguishing between the terms "sex" and "gender" has been argued along several lines (e.g., Deaux, 1993; Lewine, 1994; Unger, 1979). In the present context, we adopt the perspective that sex is considered to reflect the different demographic categories of men and women and gender to refer to socioculturally constructed roles relevant to masculinity and femininity. The term sex will be used here as a default when men and women are compared, and the term gender will be invoked when previous research provides evidence that gender roles and gender stereotypes regarding emotion play an important role in understanding the observed differences in emotional responding.

negative but not positive emotion than men (e.g., Bradley, Codispoti, Sabatinelli, & Lang, 2001; Fischer, Rodriguez Mosquera, van Vianen, & Manstead, 2004; Hillman, Rosengren, & Smith, 2004; Tobin et al., 2000).

In the present study we considered sex differences in motivational system sensitivity and the time course of emotional responses. These two facets have remained largely unexplored in the examination of sex differences in emotion, yet they may yield important information about the nature of sex differences. It is unclear whether there are sex differences at the level of the fundamental motivational building blocks of emotion or whether these differences emerge only in more contextually driven emotional behavior. Furthermore, examination of sex differences in the time course of emotion allows for the exploration not only of the mean response in a given channel during the presence of an eliciting stimulus, but the recovery process after the stimulus offset.

Sex Differences in Motivational System Sensitivity

Only a handful of previous studies have examined sex differences in motivational system sensitivity. For example, there is some evidence showing that women score higher than men on the Behavioral Inhibition System (BIS) scale (Carver & White, 1994; Heponiemi, Keltikangas-Jarvinen, Puttonen, & Ravaja, 2003; Jorm et al., 1999) and on the Reward Responsivity subscale of the Behavioral Activation System (BAS) scale, suggesting that women are more sensitive than men to cues of both punishment and reward (Carver & White, 1994).

Sensitivity of approach and avoidance motivational systems has also been examined by using the affective startle modulation paradigm. In this paradigm, activation of motivational systems exert a modulatory influence on defensive startle responses, such that presentation of negatively valenced affective material engages an avoidance motivational system and primes associated behaviors (e.g., Lang, 1994, 1995; Lang, Bradley, & Cuthbert, 1990, 1997). Thus, a defensive startle reflex elicited (e.g., by a burst of white noise) during the engagement of the aversive motivational system will be more potent than the same reflex engaged in the absence of this motivational activation. By contrast, presentation of positively valenced affective material engages an approach motivational state and primes appetitive behaviors. A defensive reflex, such as the startle response elicited in an approach motivational context, will be attenuated because of its incompatibility with the primed appetitive behaviors.

Using this paradigm, Bradley et al. (2001) found that although both men and women had the largest startle responses to images depicting imminent attack, women reacted more consistently than men to all negatively valenced images, even those that were reportedly less arousing, suggesting a broader responsivity to a wide range of aversive content. A similar pattern of sex differences has been observed in children as young as 7 years old, with girls responding more potently than boys to negatively valenced stimuli (McManis, Bradley, Berg, Cuthbert, & Lang, 2001). Yet, other affective startle modulation studies have not found sex differences in responding to aversive material (e.g., Dichter, Tomarken, & Baucom, 2002; Hillman et al., 2004). The reason for this inconsistency remains unclear, but may possibly be attributable to the limited breadth of the picture content used or the relatively small sample size for each sex. It is interesting that, although Hillman et al. (2004) did not find sex differences in affective startle modulation, women showed significantly more postural sway away from negatively valenced pictures compared to men, suggesting heightened engagement of the avoidance motivation system for women.

Taken together, these data converge to suggest a pattern in which women may engage the aversive motivational system more intensely than men. It remains less clear, however, whether there are sex differences in the engagement of the approach motivational system. In the Bradley et al. (2001) study, women showed less sensitivity in the engagement of the approach system than men in that they did not show startle attenuation during positive, as compared to neutral, images, while men did. On the other hand, other studies find that women score higher on at least one subscale of the BAS scales as reviewed earlier.

Sex Differences in the Time Course of Emotional Response

Two key elements of the temporal dynamics of an emotional response are the time from the onset to the peak intensity of the response, and the recovery time, or the time it takes for the emotional response to resolve (Davidson, 1994, 1998). Recent studies have examined the recovery time of reported negative emotional experience (e.g., Frost & Green, 1982; Garrett & Maddock, 2001), corrugator electromyographic activity (e.g., Bradley, Cuthbert & Lang, 1996; Sirota, Schwartz, & Kristeller, 1987), pupillary dilation (e.g., Siegle, Granholm, Ingram, & Matt, 2001), amygdalar activity (Siegle, Steinhauer, Thase, Stenger, & Carter, 2002), electroencephalogram asymmetry (Larson & Davidson, 2001), and affective modulation of the startle response (e.g., Bradley, Cuthbert, & Lang, 1993; Bradley et al., 1996; Dichter et al., 2002; Larson & Davidson, 2001; Larson, Sutton, & Davidson, 1998). With few exceptions (e.g., Bradley et al., 1993; Dichter et al., 2002), emotional responses persist beyond the offset of the eliciting stimulus, and individuals differ in the duration of this persistence. Larson et al. (1998) found that higher scores on BAS subscales were related to increased reactivity to positive stimuli after stimulus offset, suggesting that greater sensitivity of the approach motivational system is linked to the continued processing of positive emotional information. Thus, individual differences in the time course of emotional responses may hold information about dispositional tendencies to activate and maintain approach or avoidance motivational systems.

Little attention has been paid to sex differences in the time course of emotional responses. Several of the studies summarized earlier used only female participants (e.g., Garrett & Maddock, 2001; Sirota et al., 1987), and many of those that did include men and women did not examine sex effects (Bradley et al., 1993, 1996; Larson et al., 1998; Siegle et al., 2002). None of the remaining studies targeted sex as a focus of hypotheses, only examining interactions with sex or using sex as a covariate in analyses of the dependent variables of interest (Dichter et al., 2002; Siegle et al., 2001). Although neither of these two studies found significant contributions for sex, the sample size for each sex was fairly small and therefore there may have been inadequate power to detect sex differences in the particular paradigms used.

The Present Study

The aims of the present study were twofold. First, we sought to replicate and extend previous investigations of sex differences in the motivational underpinnings of emotion by examining both self-reported sensitivity of approach and avoidance motivational systems as well as affective modulation of the startle response during the presentation of emotionally evocative pictures. We also examined reported experience of emotion in response to the valenced pictures to replicate previous findings of sex differences in momentary ratings of emotional experience. Second, we sought to explore sex differences in the time course of approach and avoidance motivational engagement by examining affective modulation of startle after the offset of emotional stimuli to obtain an index of recovery of emotional processes.

Based on previous studies, we hypothesized that women would show more robust response to negative emotional material in terms of their momentary self report and reported motivational system sensitivity. We expected that both women and men would engage the avoidance motivational system during the presentation of negative pictures, manifesting as potentiated startle responses during negative pictures compared to neutral. However, given the evidence that women are more responsive to negative emotional stimuli across multiple channels and more readily and robustly engage the avoidance motivational system, we hypothesized that women would also take longer to disengage the avoidance motivational system. More specifically, we hypothesized that women would continue to show startle potentiation after the offset of negative stimuli, while men would not. Although there is some evidence from previous research suggesting that men may engage the approach motivational system more robustly than women, other research indicates that women report greater sensitivity of the approach motivational system. Therefore, it is difficult to predict with confidence whether men or women will show greater engagement of the approach motivational system. However, this underscores the importance of examining this potential sex difference using both self-report and physiological measures, both during presentation and after stimulus offset.

Method

Participants

The participants for this study were 58 male and 53 female undergraduates who received course credit for their participation. Individuals were excluded if they had impaired vision (not corrected by glasses or contact lenses) or impaired hearing, or if they had participated in a similar research study. One female participant was excluded after she volunteered that she had been diagnosed with major depressive disorder, resulting in *n*s of 58 male and 52 female participants. The sample was quite diverse, with 50% Asian American; 29% Caucasian; 8% Latino/a; 3% African American, 3% Middle Eastern, and 7% reporting other or mixed ethnicity. Male and female participant groups did not significantly differ on age, education, or ethnic composition.

Picture Stimuli

Sixty emotionally evocative pictures (20 positive, 20 neutral, and 20 negative) were selected from the International Affective Picture System collection (Center for the Study of Emotion & Attention, 1999).[2] Pictures were selected on the basis of published self-report ratings (Lang, Bradley, & Cuthbert, 1999), such that positive and negative pictures were both similar on arousal, and neutral pictures were of a valence between that of negative and positive images. Similar to Bradley et al. (2001) and to facilitate between-sex comparisons of responses to a given emotionally evocative stimulus, men and women viewed the same pictures with the exception of erotic images, which were selected separately for men and women. Positively valenced pictures included images of action/adventure scenes and other-sex erotica. Negatively valenced pictures included images of mutilations and threatening animals and humans. Neutral pictures included images of household objects.

Procedure

After participants provided informed consent, electrodes were applied and impedance was checked. Participants were told that they would see a series of pictures presented on the computer screen and that they should look at each picture the entire time that the picture was on the screen. They were told that after each picture, they would be prompted to make a rating of how they felt while they were viewing the picture. Participants were also told that they would occasionally hear noises over the headphones, but that they could ignore these noises. To familiarize them with the procedure and the startle probe, participants then completed an introductory task comprising 11 pictures during which 9 startle probes were presented. Acoustic startle probes were digitally generated white noise bursts of 50 ms in duration, with instantaneous rise and fall times. Startle probes were amplified by a Radio Shack SA-155 Integrated Stereo Mini-Amplifier to 100 dB and binaurally presented through Sennheiser HD 490 headphones. Probe stimuli were calibrated before each test session.

After the introductory task, participants completed 60 experimental trials. The trial complex consisted of an image presented for 6 s, followed by a 5-s delay, during which "recovery" probes were presented on select trials. After this delay, participants rated their experienced pleasantness and arousal at the end of each trial using a computerized version of the Self-Assessment Manikin (SAM; Hodes, Cook, & Lang, 1985; Lang, 1980). The rating form displayed a cartoon figure that participants adjusted, using computer keys, to indicate (1) how "happy" or "unhappy" and 92) how "calm" or "aroused" they felt during the presentation of each picture. After completing the SAM rating, there was an intertrial interval (randomly timed between 2.5 to 5 s) before to the onset of the next picture. After all the experimental trials, participants completed the Behavioral Inhibition and Behavioral Activation Scales (BIS/BAS, Carver & White, 1994) to index sensitivity of approach and avoidance motivational systems.

[2] IAPS picture numbers: positive: 4660, 5460, 8380, 8370, 7502, 8300, 8080, 4533, 4608, 8470, 4640(f), 4652(m), 5629, 4572(f), 8260(m), 8034, 8200, 8180, 8501, 5621, 8210, 8190; neutral: 2190, 5510, 7233, 7217, 7185, 7010, 7020, 7050, 7950, 2570, 7235, 7004, 7006, 7175, 7035, 7090, 7491, 5740, 7009, 7080; negative: 9570, 3530, 9921, 6510, 3071, 3170, 3080, 3100, 1050, 9252, 6550, 3053, 6230, 3500, 3110, 3102, 2730, 6313, 3060, 3130.

Stimulus Presentation

A Pentium class microcomputer determined the presentation of the digitized images by digitally pulsing a yoked computer outfitted with a 36-cm LCD display positioned approximated 0.5 m from the participant at a visual angle subtending 15.9 degrees. Pictures were presented in a fixed order such that all valences and probe times were evenly distributed throughout the sequence of trials (pairwise comparisons of mean serial positions for trials in each Valence X Probe Time cell yielded $t < 1$). Based on previous research, startle probes were presented either 3,500 ms after picture onset (during picture presentation) or 2,500 ms after picture offset (recovery period). Within sex, for each valence, pictures probed during picture presentation and after offset were comparable on valence and arousal ratings from published norms (Lang, Bradley, & Cuthbert, 1999). Eight trials of each valence were probed at each probe time, and four trials of each valence were left unprobed. No more than one probe was presented per trial. No more than two pictures of the same valence and no more than three of the same probe times were presented sequentially.

Startle Response Recording and Data Reduction

Stimulus presentation and data acquisition were controlled by VPM software (Cook, Atkinson, & Lang, 1987). The EMG signal was filtered through a 13- to 1,000-Hz pass band and amplified by a gain of 10,000 by using a Coulbourn V75-04 Isolated Bioamplifier with Bandpass Filter. EMG was sampled at 1000 Hz by a Labmaster DMA A/D board for 250 ms, starting at startle probe onset. Electrode placement and skin preparation followed current guidelines for human startle research (Berg & Balaban, 1999; Blumenthal et al., 2005). Raw electromyographic (EMG) activity was collected using two Med-Associates Na-NaCl mini (4.2 mm sensor) Beckman-style reusable mini electrodes placed over the orbicularis oculi on the left eye, with one sensor directly under the pupil and the other lateral to this. The sensors, which were filled with Teca electrolyte gel, were placed just above the orbital ridge. Interelectrode distance was approximately 15 mm. A third sensor was placed in the middle of the forehead as a ground. Before recording electrodes were placed, the skin was cleansed using distilled water and a light abrasion with fine sandpaper to lower impedance. Impedance was checked, and efforts were made to keep all impedances under 10 Kohms.

The EMG signal was digitally refiltered offline through a 28- to 500-Hz pass band (van Boxtel, Boelhouwer, & Bos, 1998) and digitally rectified and integrated using a 30-ms time constant. Trained research assistants scored the integrated EMG data segments using the EYEBLINK subroutine in VPM, which is based on the Balaban algorithm (Balaban, Losito, Simons, & Graham, 1986). Response amplitude (in A/D units) was computed by subtracting EMG activity at response onset from that at response peak. Because of extreme interindividual differences in average blink magnitude, data were standardized within each individual to produce a metric of responsivity (t scores) that was comparable across participants. Specifically, blink magnitude means and standard deviations were computed across the valence conditions (positive, negative, neutral) and converted to t scores ($M = 50$; $SD = 10$). The standardization procedure did not change the relative pattern of participants' responses across the picture types. This form of standardization is part of the current recommendations for startle research (Blumenthal et al., 2005) and has been used in a number of prior studies using the emotion modulated startle paradigm (e.g., Forbes, Miller, Cohn, Fox & Kovacs, 2005; Levenston, Patrick, Bradley, & Lang, 2000; Miranda, Myerson, Meyers, & Lovallo, 2003; Patrick, Bradley, & Lang, 1993; Sutton, Vitale, & Newman, 2002).

Responses on the eight trials within each valence $\times$ probe time cell were averaged to form a mean for each individual for each cell. The dependent variable for analyses was response magnitude. Four participants (2 men and 2 women) did not generate sufficient startle responses to score the psychophysiological record. In addition, SAM rating data for two participants (1 man; 1 woman) was lost to computer malfunction. Thus, final *n*s for statistical analysis were as follows: for startle data: 56 men, 50 women; for SAM data: 57 men, 51 women.

Results

Repeated measures mixed-model analyses of variance (ANOVAs) were used for the analyses. In cases when sphericity was violated, the Huynh-Feldt correction for degrees of freedom was used when estimates of sphericity were greater than 0.75; the Greenhouse-Geisser correction was used when estimates of sphericity were less than 0.75 (Girden, 1992). Post hoc comparisons of all pairwise valence combinations were examined using Sidak's adjustment of significance level for multiple comparisons. Given our use of t scores for the startle data, direct comparisons between men and women's responses to the individual valence conditions are not appropriate. Therefore, in the analyses of startle data, significant interactions involving sex were followed up with within sex pairwise contrasts to examine the pattern of blink responses to the different valence conditions separately for men and women.

Emotional Experience

Pleasantness ratings. Descriptive statistics for all self-report measures are presented separately for men and women in Table 1. A 3 (valence: positive, neutral, negative) $\times$ 2 (sex: male, female) repeated measures ANOVA of pleasantness ratings revealed main effects for valence, $F(1.16, 122.84) = 459.37$, $p < .001$ and sex, $F(1, 106) = 10.52$, $p = .002$, as well as a valence by sex interaction, $F(1.16, 122.84) = 9.12$, $p = .002$. For both men and women, pleasantness ratings were highest for positive pictures, followed by neutral and then negative pictures. Both linear and quadratic contrasts were significant, $F(1, 106) = 502.64$, $p < .001$; $F(1, 106) = 182.57$, $p < .001$, respectively. Examination of the sex main effect and the valence by sex interaction revealed that when valence ratings were averaged across all pictures, women reported experiencing more negative emotion in response to the pictures than men, $F(1, 106) = 8.66$, $p = .004$, but post hoc pairwise comparisons revealed that, as predicted, women only rated their experience to negative pictures as more negative than men, $t(106) = 3.80$, $p < .001$ and actually rated their experience of neutral pictures as more positive than men, $t(106) = -2.26$, $p = .026$. Men and women did not differ on their reported pleasantness of positive pictures.

Arousal ratings. Similar to the findings for pleasantness ratings, we found main effects for valence, $F(1.44, 152.97) = 259.59$,

Table 1
Emotional Experience and Motivation System Sensitivity Ratings

	Women M (SD)	Men M (SD)	p
BIS/BAS Scales			
BIS	22.82 (3.49)	20.64 (3.00)	.001
BASRR	18.32 (1.61)	17.59 (1.82)	.03
BASD	11.55 (2.48)	11.43 (2.45)	.76
BASFS	12.20 (2.14)	12.09 (1.85)	.80
BASTOT	41.98 (5.13)	41.11 (4.77)	.37
Pleasantness ratings			
Positive pictures	12.75 (2.03)	12.62 (1.53)	.474
Neutral pictures	10.18 (0.62)	9.90 (0.66)	.024
Negative pictures	3.68 (2.64)	5.49 (2.30)	.000
Arousal ratings			
Positive pictures	12.40 (1.64)	12.31 (1.68)	.541
Neutral pictures	8.07 (2.27)	8.10 (2.09)	.943
Negative pictures	14.91 (2.62)	13.33 (2.16)	.001

Note. Pleasantness and arousal ratings range in value from 0 to 20. For the pleasantness rating, lower values indicate more unpleasantness and higher values more pleasantness, with a rating of 10 as neither unpleasant nor pleasant. For the arousal rating, lower values indicate more calm and higher values more aroused or energized. BIS = Behavioral Inhibition System; BAS = Behavioral Activation System.

$p < .001$ and sex, $F(1, 106) = 4.53$, $p = .036$, as well as a valence by sex interaction, $F(1.44, 152.97) = 5.45$, $p = .011$. For both men and women, the negative pictures were experienced as the most arousing, followed by the positive and then neutral pictures. Both linear and quadratic contrasts were significant, $F(1, 106) = 79.95$, $p < .001$; $F(1, 106) = 331.57$, $p < .001$, respectively. Examination of the sex main effect and the valence by sex interaction revealed that when ratings were collapsed across valence, women reported experiencing the pictures as more arousing than men, $F(1, 106) = 5.68$, $p = .019$, but post hoc pairwise comparisons revealed that this was driven by women's greater reported arousal than men during negative pictures, $t(106) = 3.43$, $p = .001$. Men and women did not differ on their reported arousal of positive or neutral pictures.

Approach and Avoidance Motivation Sensitivity

BIS/BAS scales. As predicted and consistent with prior research, women scored higher than men on the BIS scale, $t(106) = 3.50$, $p = .001$. Women also scored higher on the BAS Reward Responsivity Subscale, $t(106) = 2.21$, $p = .03$, which is also consistent with prior research. There were no differences between men and women on the other BAS subscales or the BAS total scale (see Table 1).

To examine the relationship between reported emotional experience during the pictures and measures of approach and avoidance motivational sensitivity, correlations between SAM ratings and BIS/BAS scales were computed separately for men and women. For both men and women, pleasantness ratings during negative pictures were correlated with the BIS (men: $r = -0.38$, $p = .04$; women: $r = -0.39$, $p = .008$), such that higher BIS scores were linked with more aversive experience (lower reported pleasantness). There were no significant correlations between the BAS scales and self-reported pleasantness for men. For women, however, the BAS Fun Seeking and Drive subscales and BAS total score were correlated with experience ratings during the positive pictures (BAS FS: $r = 0.39$, $p = .006$; BAS D: $r = 0.38$, $p = .008$; BAS total: $r = .37$, $p = .01$) such that higher BAS scores were linked with more pleasant experience.

Startle magnitude. A 3 (valence: positive, neutral, negative) × 2 (sex: male, female) × 2 (probe time: during picture, recovery) mixed model repeated measures ANOVA revealed a main effect for valence, $F(1.94, 197.92) = 27.17$, $p < .001$, a Valence × Probe time interaction, $F(1.95, 198.77) = 3.61$, $p = .03$, and a Valence × Probe time × Sex interaction, $F(1.95, 198.77) = 3.81$, $p = .025$. No other main effects or interactions were significant.

Follow-up analyses for the Valence × Probe time interaction revealed smaller startle magnitude in the recovery period after positive pictures compared to those elicited during the presentation of positive pictures, $F(1, 103) = 8.19$, $p = .005$. Startle magnitude for negative and neutral valences did not differ across probe time. To examine patterns of valence modulation of startle magnitude during picture presentation and during the recovery period, additional repeated measures ANOVAs were conducted for each probe time. For startle responses elicited during picture presentation, both a linear and a quadratic trend fit the data; linear: $F(1, 104) = 12.0$, $p = .001$; quadratic: $F(1, 104) = 8.83$, $p = .004$. Post hoc pairwise comparisons indicated that startle magnitude significantly differed between neutral and negative, $t(104) = 4.06$, $p < .001$ and positive and negative, $t(104) = 3.47$, $p = .002$ valence conditions, but not between positive and neutral valence conditions. For startle responses elicited during the recovery period, only the linear effect of valence was significant, $F(1, 104) = 41.59$, $p < .001$. Post hoc pairwise comparisons revealed significant differences in startle magnitude for each pair of valence conditions (all p values $< .01$). The smallest startle responses occurred after the offset of positive pictures, and the largest startle responses occurred after the offset of negative pictures.

To examine patterns of valence modulation of startle magnitude within each sex, repeated measures ANOVAs were computed for each probe time within each sex (see Figure 1). During picture presentation, men showed a significant linear effect of valence, $F(1, 53) = 13.3$, $p = .001$. Subsequent pairwise comparisons revealed that, for men, startle magnitude during negative pictures was greater than magnitude during neutral, $t(53) = 2.68$, $p = .03$, and positive, $t(53) = 3.65$, $p = .002$, pictures. Startle magnitude during positive pictures did not differ from magnitude during neutral pictures. By contrast, women showed a quadratic effect of valence modulation during picture presentation, $F(1, 49) = 9.57$, $p = .003$. Post hoc pairwise comparisons revealed that, for women, startle magnitude during negative pictures was greater than during neutral pictures, $t(49) = 3.12$, $p = .009$. Startle magnitude during positive pictures did not differ from magnitude during either neutral or negative pictures.

During the recovery period (see Figure 1), men showed a linear effect of valence, $F(1, 54) = 14.28$, $p < .001$. Subsequent pairwise comparisons indicated that startle magnitude after positive pictures was smaller than after neutral, $t(54) = 2.65$, $p = .031$, and after negative, $t(54) = 3.77$, $p = .001$, pictures. However, startle magnitude after neutral did not differ from magnitude after negative pictures. Women also showed a linear effect of valence during the recovery period, $F(1, 49) = 28.83$, $p < .001$. Pairwise comparisons revealed that, for women, startle magnitude after negative

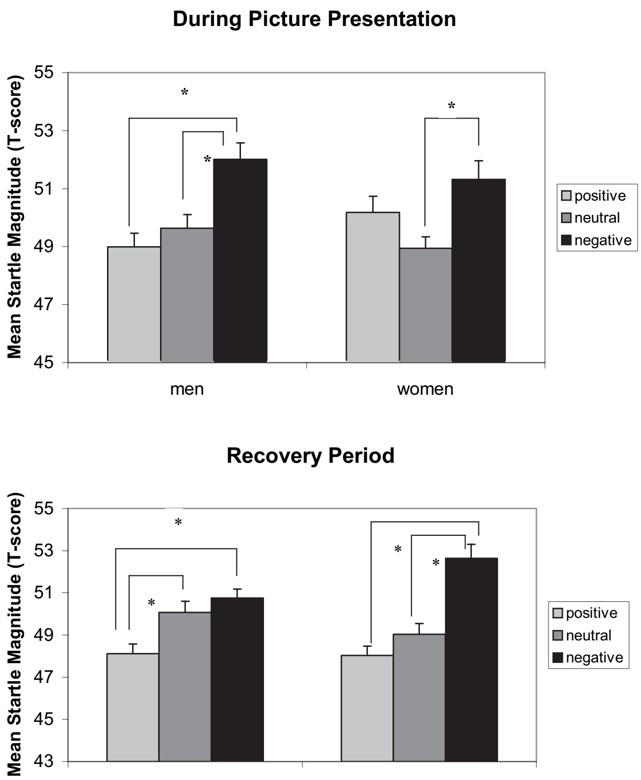

Figure 1. Mean startle magnitude (+ *SE*) by valence for each sex at each probe time.

pictures was greater than after neutral, $t(49) = 3.72$, $p = .002$, and positive pictures, $t(49) = 5.37$, $p < .001$. Magnitude after positive and neutral pictures did not differ.

To summarize, during picture presentation, both men and women showed potentiation to negative pictures relative to neutral pictures. By contrast, during the recovery period, women continued to show greater potentiation to negative relative to neutral pictures, but men did not. With respect to positive pictures, neither men nor women showed attenuation to positive pictures relative to neutral during picture presentation. However after picture offset, men showed greater attenuation to positive pictures relative to both negative and neutral pictures, whereas, women showed attenuation to positive pictures relative to negative, but not neutral pictures.

Discussion

The present study replicates and extends previous research on sex differences in emotion by examining approach and avoidance motivational underpinnings of emotion and how the engagement of these motivational systems differs over time. Results from the present study provided support for our hypotheses of a more robust and prolonged responsivity to negative emotional stimuli for women compared to men. Specifically, similar to previous studies (e.g., Bradley et al., 2001; Fischer et al., 2004; Hillman et al., 2004; Tobin et al., 2000), and consistent with our hypotheses, women were more experientially reactive to negative, but not positive emotional pictures compared to men. Also consistent with previous research (e.g., Carver & White, 1994) and our hypotheses, women scored higher than men on the BIS scale, suggesting that they experience greater sensitivity of the aversive motivational system.

Consistent with previous studies of sex differences in affective startle modulation in adults (Bradley et al., 2001), both men and women showed potentiation to the negative pictures during picture presentation relative to the neutral pictures. In the present study, we only used the most aversive negative pictures (mutilation pictures and human and animal threat), in many ways a stronger test of linkages to the aversive motivational system. However, this may have precluded our seeing any sex differences in the pattern of startle modulation during negative picture presentation.

Although women and men both exhibited potentiation of the startle response during the presentation of negative pictures relative to the presentation of neutral pictures, only women continued to show this relative potentiation during the recovery period, as we hypothesized. If women, but not men, are continuing to engage the aversive motivational system after the offset of the eliciting stimulus, what might be driving this continued activation? It is possible that women's prolonged response to negative emotional material after stimulus offset reflects an effort to cope with the negative emotional experience. Indeed, there is evidence that women use different strategies than men to cope with negative emotional events (e.g., Garnefski, Teerds, Kraaij, Legerstee, & van der Kommer, 2004; Nolen-Hoeksema, Morrow, & Fredrickson, 1993). For example, women are more prone than men to rumination, and this sex difference in rumination is seen both in adult and young adolescent samples (Nolen-Hoeksema & Girgus, 1994). Thus, women's prolonged responding during the recovery period may reflect an attempt to cope with or regulate their responses to the stimuli themselves. While rumination is typically considered as occurring on the order of hours, days or weeks, results from the present study raise the question of whether such ruminative processes are initiated more immediately after the offset of an eliciting event.

An alternate interpretation of the sex differences in the pattern of responding during recovery from a negative emotional event might be that men are recovering more quickly, rather than women recovering more slowly, from such an event. Indeed, there is no measure of what "normative" recovery might be against which each sex might be compared. However, a couple of factors argue against this interpretation. First, although men's responses to negative pictures did not differ from their responses to neutral pictures in the recovery period, they continued to show a significant linear effect of valence in the recovery period. Thus, men were continuing to engage the aversive motivational system after negative stimulus offset and were not simply "shutting off" this response. Second, interpretation of this finding as more broadly reflective of women's increased responsivity to negative stimuli would be consistent with data across prior empirical studies using multiple measures of emotion, including expressive behavior (e.g., Rotter & Rotter, 1988), self reported emotional experience (e.g., Hillman et al., 2004), physiological responses (e.g., Bradley et al., 2001), and neural responses (e.g., Wrase et al., 2003).

We also examined whether men and women differed in the engagement of the approach motivation system. Here, our findings regarding sex differences are mixed. Women scored higher than men on the BAS Reward Responsivity subscale, a finding consistent with previous research. Women did not differ from men in their reported emotional experience following the presentation of positive pictures; however, their reports of pleasantness were related to three of the four BAS scales. By contrast, men's reported pleasantness in response to the pictures was unrelated to their BAS scores. The pattern of valence modulation of the startle response was similar for men and women during picture presentation. Specifically, neither men nor women showed inhibition of the startle response during the presentation of positive pictures relative to neutral, although men showed inhibition during the presentation of positive pictures relative to negative pictures. During the recovery period, both men and women showed inhibition of the startle response after the positive pictures relative to the negative pictures, but only men showed inhibition after the positive pictures relative to the neutral pictures.

Our findings regarding engagement of the approach motivation system suggest a bit of a disconnect between dispositional sensitivity to rewards in that women reported greater sensitivity than men, yet women exhibited comparable patterns of approach motivation sensitivity in their reactions to the emotionally evocative stimuli. By contrast, men appeared to hang onto their positive reactions, at least as reflected by the inhibition of their startle responses to positive pictures relative to neutral during the recovery period, yet they did not differ from women in their reported sensitivity of the approach motivation system. One possible account for these disconnects is that women are more sensitive to particular types of rewarding stimuli, and that we did not tap these particular stimuli in the contents of the pictures we presented. The positive pictures presented in the present study consisted of erotica and action-adventure themes, which may be less inherently rewarding to women (and more rewarding for men). Inclusion of a greater breadth of positive picture content (e.g., nature scenes, families) might have enabled us to detect startle modulation evidence of elevated approach motivational sensitivity in women.

Indeed, this raises the question of whether the sex differences observed in the present study are merely a function of the particular stimuli used, and whether using other emotionally evocative stimuli might result in a different pattern of sex differences or no differences at all. Although this question cannot be answered conclusively without examining all possible variants of emotion-eliciting stimuli, results from a previous study suggests that the pattern of sex differences observed in the present study are not an artifact of the stimulus set. Specifically, Bradley et al. (2001) examined sex differences in responses to a wide range of thematic contents within positive and negative valences, including nature, food, and other-sex erotica in the positive valenced images and pollution, loss and animal attack in the negatively valenced images and found that women were more consistently responsive than men to aversive stimuli, across various thematic contents. In addition, women's startle responses to positive pictures did not differ from their responses to neutral pictures, a finding consistent with the present study's results. Nevertheless, we included a limited range of picture contents that may have precluded the observation of additional sex differences. Previous research has suggested that there are particular contents that appear to activate the approach and avoidance systems more robustly than others (e.g., Bradley et al., 2001; Gard, Germans Gard, Mehta, Kring, & Patrick, 2006), and sex differences in the pattern of emotional responding may be most clearly evident for specific picture contents, such as erotica or less arousing negative themes such as contamination.

Although the findings reported here extend our understanding of sex differences in emotional responding in a number of ways, we must acknowledge a few limitations. First, only one time point was used for the assessment of the recovery of emotional responses. This allows for only a snapshot of the recovery process, and does not provide a picture of the full chronometry of emotional responding in men and women. On the other hand, it is one of the first studies to examine responding both during and after stimulus presentation. To better map out sex differences in the chronometry of emotional responses, future studies might employ multiple measures of emotion (e.g., measures of autonomic physiology, facial expression, continuous self report ratings via rating dial, as well as startle modulation) and sample at multiple time points during picture presentation and after picture offset to examine both peak and recovery of emotional responses. Second, we did not counterbalance the picture presentations, thus leaving open the possibility that the specific pictures are responsible for the observed effects. We chose instead to ensure that men and women had maximally similar experimental environment, taking pains to ensure that each valence category was equally distributed throughout the protocol and therefore not unequally subject to the effects of potentially confounding variables such as habituation or participant fatigue. Third, we did not explicitly examine adherence to gender stereotypes, which may influence the degree to which sex differences in emotion are observed (e.g., Barrett et al., 1998; Grossman & Wood, 1993; LaFrance, Hecht, & Levy Paluck, 2003; but see Kring & Gordon, 1998). Therefore, it is difficult to say with certainty that the present findings reflect sex, rather than gender differences in emotion. Future studies might include a measure of adherence to gender roles to examine whether evident differences between men and women are more consistent with sex or gender, as well as a measure of rumination to better assess whether women's prolonged response to negative stimuli is indeed linked to ruminative processes. Finally, we did not collect data on the menstrual cycle of female participants. Recent studies have shown that the phase of the menstrual cycle may account for observed sex differences in a different type of startle modulation paradigm. Specifically, the startle eyeblink response is reliably inhibited modulated when a weak stimulus (prepulse) is presented just before (i.e., 30–500 ms) the onset of the startling stimulus; this phenomenon is called prepulse inhibition (PPI). Women have been found to exhibit less PPI than men (e.g., Kumari, Gray, Gupta, Luscher, & Sharma, 2003; Swerdlow, Hartman, & Auerbach, 1997), but this effect appears to be limited to the luteal phase of the menstrual cycle (Jovanovic et al., 2004). To our knowledge, no study has examined how the phase of the menstrual cycle may (or may not) contribute to sex differences in affect modulated startle responses, thus this remains an important avenue for future research.

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