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Anticipating the Future and Remembering the Past: The Time Course of Emotion in
Schizophrenia

By

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University of California, Berkeley

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Abstract

Anticipating the Future and Remembering the Past: The Time Course of Emotion in Schizophrenia

by

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Doctor of Philosophy in Psychology

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While people with schizophrenia report just as much emotion in the presence of emotional evocative stimuli, evidence suggests that they may show deficits in the anticipation of positive emotion. However, no work to date has directly tested this notion utilizing standardized stimuli across multiple methods of measurement. The present study took a multi-method approach by examining reported experience and emotion modulated startle response in people with ($n = 27$) and without ($n = 27$) schizophrenia as they anticipated and subsequently viewed evocative pictures. In addition, given that anticipation relies, in part, on our ability to remember the past, we assessed memory for emotional stimuli immediately and one-week later. Results indicated that people with schizophrenia had a deficit in the anticipation of both positive and negative emotion. Furthermore, anticipatory responses, especially to positive cues, were related to symptoms and functioning in schizophrenia. Results also suggested that while delayed recognition of emotional stimuli is intact, those with SZ showed a deficit in immediate recall that was associated with anticipation and cognitive difficulties.

Keywords: schizophrenia, emotion, startle, blink response, anticipation, memory

Whether it's the feeling of pleasure when seeing a playful puppy or when drinking a cold glass of lemonade on a hot summer day, people with schizophrenia (SZ) report experiencing just as much positive emotion as healthy controls (CTL) when in the presence of putatively enjoyable things (see Kring & Moran, 2008 for review). While this "in the moment" experience of positive emotion may be intact, affective science has highlighted the importance of studying the time course of emotion in SZ (Kring & Caponigro, 2010; Strauss, 2013). Indeed, emotion does not just occur in the presence of emotional stimuli. Instead the course of emotion unfolds over time and may hold important information about where emotion goes awry in schizophrenia. To date only a handful of studies have examined the time course of emotion in SZ. The present study sought to systematically examine emotion in SZ as it unfolds over time. Specifically, we investigated the anticipation and in the moment experience of emotion as well as memory for emotional events to pinpoint where across the time course emotion may go awry in SZ. In addition, no studies to date have examined the anticipation of negative emotion in SZ, thus the present study was the first to examine the time course of both positive and negative emotion.

In the Moment Experience of Emotion in SZ

Whether in response to emotionally evocative film clips (e.g., Blanchard, Bellack, & Mueser, 1994; Earnst & Kring, 1999), pictures (e.g., Heerey & Gold, 2007; Herbener, Rosen, Khine & Sweeney, 2007), tastes (e.g., Berenbaum & Oltmanns, 1992; Horan, Green, Kring, & Nuechterlein, 2006), faces (e.g., Holt et al., 2005; Habel et al., 2004), sounds (e.g., Tremeau, 2010) or even smells (e.g., Doop & Park, 2006; Crespo-Facorro et al., 2001), people with SZ report experiencing just as much, if not more, emotion relative to controls (see Cohen & Minor, 2010 for meta analysis). Findings of intact emotional responses are not just observed in studies assessing self-reported emotion experience. Indeed, studies assessing physiological responses in the presence of evocative stimuli suggest a similar pattern as studies assessing reported emotion experience. For example, utilizing the emotion modulated startle eyeblink paradigm, studies have found no significant differences between people with and without SZ in blink modulation in response to evocative stimuli (Curtis, Lebow, Lake, Katsanis, & Iacono, 1999; Kring, Germans Gard, & Gard, 2010; Schlenker, Cohen, & Hopmann, 1995; Volz, Hamm, Kirsch, & Rey, 2003). Similarly, studies assessing skin conductance reactivity found that people with SZ exhibited similar, or even elevated, skin conductance relative to controls in the presence of evocative stimuli (e.g., Kring & Neale, 1996; Hempel, Tulen, van Beveren, Mulderm, & Hengeveld, 2007; Hempel et al., 2005; Volz, et al., 2003; Williams, et al., 2004). In sum, regardless of the stimuli used or method of measuring emotional response, findings suggest that in the moment emotional responses are preserved in SZ.

Time Course of Emotion in SZ: Anticipation and Memory

Why, then, is it that SZ has long been associated with anhedonia, which is defined as the diminished experience of pleasure? One explanation can be seen on the face and in the vocal intonations of those with SZ. People with SZ often exhibit flat affect (e.g., Kring,

Kerr, Smith, & Neale, 1993) which is characterized by relatively unchanging facial expressions or vocal intonations. We now know that this reasoning is incomplete, however, given that emotions are made up of multiple components including expression, experience, and physiological responses (e.g., Levenson, 1994). Thus, while one component of emotion may go awry, not all aspects of emotion are disrupted in SZ. Another explanation for this persistent idea comes from trait-level reports of pleasure, which are demonstrably lower for people with SZ compared to people without SZ (e.g., Blanchard, Mueser, & Bellack, 1998). To report on noncurrent emotion, it is necessary to retrospectively recall past experiences or anticipate future emotional experiences (Strauss, 2013). In other words, instead of assessing in the moment experience of emotion, trait measures of anhedonia rely on a person's ability to remember the past and anticipate the future.

Indeed, the experience of emotion does not begin and end while walking across the graduation stage. Instead, we experience pleasure while anticipating our upcoming graduation day as well as after the day when we are reminded of our big day. If we have trouble anticipating the pleasure we will feel while graduating, we may be less likely to actually pursue the graduation.

Anticipation

Anticipation of future positive events is thought to guide future motivated behavior, while anticipation of future negative events alerts us to prepare for (and possibly avoid) aversive events (Carver & White 1994; Schultz, 2002). Anticipatory emotion has been conceptualized as having two distinct components: 1) the prediction of future emotional experience and 2) the experience of emotion while anticipating future events (e.g., Kring & Caponigro, 2010; Lowenstein, Weber, Hsee, & Welch, 2001). Investigation of each component is crucial for a more refined understanding of anticipatory emotion.

Treameau and colleagues (2010) found no group differences between SZ and CTL participants when asked to predict their enjoyment to seeing a group of positively valenced pictures and sounds. Participants were only asked to predict their emotional response one time with one item, rather than multiple times throughout the experiment, and thus this study did not comprehensively address anticipation. Gard and colleagues (2007) conducted an experience sampling study wherein SZ participants and controls (CTL) were paged several times a day for a week and were asked to report on both their in the moment experience of emotion along with their predicted future emotional experience. Results showed comparable rates of in the moment experience of pleasure between SZ and CTL, but a group difference in predicted emotion ratings. SZ participants predicted less pleasure for future goal directed behavior compared to CTL participants.

To assess emotional experience during anticipation, Gard and colleagues designed the Temporal Experience of Pleasure Scale, a measure that assesses self-reported experience in the moment (i.e., consummatory pleasure) along with emotional experience during the anticipation of future pleasurable events (TEPS; Gard, Germans Gard, Kring, & John,

2006). As hypothesized, they found no group difference in self-reported pleasure in the moment, however they found a group difference in self-reported experience of pleasure while anticipating future activities (Gard et al., 2007).

Replicating Gard's findings in a cross-cultural sample, Chan and colleagues (2010) found that SZ patients with negative symptoms showed a deficit in anticipatory pleasure compared to SZ patients without negative symptoms as measured by the Chinese version of the TEPS (see also Favrod, Ernst, Giuliana, & Bonsack, 2009, but see Strauss et al. 2011 for no group differences on the TEPS). One limitation to the TEPS findings is that they are entirely self-report, and thus it is important to carefully study anticipatory emotion using a variety of methods.

Taken together, the literature suggests a possible deficit in both the experience of pleasure while anticipating future positive experiences as well as in the prediction of future pleasure. It also suggests that further studies are needed to systematically investigate emotional responses during anticipation to expand the literature beyond measures of self-report. In addition, no prior studies have investigated the anticipation of negative emotion in SZ, thus the present study sought to fill this gap. The anticipation of negative emotion has been found to be important in understanding other clinical groups such as those with a variety of anxiety disorders (e.g., social phobia, Davidson, Marshall, Tomarken, & Henriques, 2000; panic disorder, Grillon, 2008; post traumatic stress disorder, Grillon, et al., 2009) and major depression (e.g., Abler, Erk, Herwig, & Walter, 2007; MacLeod & Rutherford, 1999). Thus, it is important to examine anticipation of negative emotion in SZ to more fully understand anticipatory deficits.

Memory

Memory for emotional experience is another important point in the time course of emotion. Harvey and colleagues (2009) suggest that impairments in memory may be a potential mechanism to account for the distinction between intact in the moment experiences of emotion and reports of anhedonia on self-report measures. That is, the ability to remember and reflect on positive and negative experiences in the past is different than the ability to view an emotionally evocative stimulus and report on emotional experience in the moment. Indeed, neuroimaging research suggests that our ability to anticipate the future relies on our ability to remember the past (Atance & O'Neill, 2001; D'Argembeau & Van der Linden, 2004; Okuda et al., 2003), wherein a similar network of brain regions are recruited when remembering the past and anticipating future experiences (for a review see Schacter, Addis, & Buckner, 2007).

A plethora of research has found that CTLs have enhanced memory for positive and negative emotional stimuli relative to non-emotional stimuli (see Hamann, 2001; LaBar & Cabeza, 2006 for reviews). In SZ, findings of enhanced memory for emotional stimuli are not as robust. While a handful of studies have found no differences in emotional memory between CTL and SZ groups (Horan, et al., 2006; Koh, Kayton, & Peterson, 1976; Whalley et al., 2009), other studies have found impairments in emotional memory in SZ compared to CTLs (e.g., Caley & Edelist, 1993; Hall, Harris, McKirdy, Johnstone,

& Lawrie, 2007; Herbener et al., 2007; Lakis, Jimenez, Mancini-Marie, Stip, & Lavoie, 2011; Mathews & Barch, 2004; Neumann, Blairy, Lecompte, & Philippot, 2007). However, the effects of emotional valence have been inconsistent. For example, some studies have found that people with SZ showed enhanced memory for negative stimuli, but not positive stimuli (Calev & Edelist, 1993; Herbener et al., 2007). In contrast, others found enhanced memory for positive relative to neutral or negative stimuli (Koh, Kayton, & Peterson, 1976; Koh, Grinker, Marusarz, & Foraman, 1981). Still others found that people with SZ did not show an enhanced memory for positive and negatively valenced stimuli (Danion, Kazes, Huron, & Karchouni, 2003; Hall et al., 2007).

There are a number of factors that might contribute to the mixed findings. It may be the case that differences in recognition memory are due to the difference in delay period (e.g., immediate, 24 hours, 48 hours) and that by extending the recognition delay period, the emotional enhancement for recognition of negative stimuli is diminished. Indeed, Herbener (2008) suggested that length of delay may be an important factor for understanding mixed findings on emotion memory in SZ. Studies that used immediate or short delays (e.g., 30 – 60 seconds up to four hours) have reported no group differences in memory between SZ and CTLs (Horan, et al., 2006; Koh, Grinker, Marusarz, & Forman, 1981; Koh, et al., 1976; Whalley, et al., 2009). Another explanation could be the fact that recognition and recall are different measures of memory (see Libby, Yonelinas, Ranganath, & Ragland, 2013 for review). While recognition is said to rely prominently on memory, recall relies on memory as well as executive functioning skills involved in describing pictures. In fact, some studies assessing recognition have found no group differences in overall accuracy ratings (e.g., Koh, et al., 1981; Mathews & Barch, 2004) suggesting that differences in memory relate to more global measures of cognitive functioning. Indeed, while the investigation of recognition memory in those with SZ has produced inconsistent findings, difficulties in recall memory have been well replicated (e.g., Libby et al., 2013).

In sum, the emotion memory literature in SZ has produced inconsistent findings regarding whether emotion enhances memory. Some find no enhancement of memory while others find enhancement for negative stimuli compared to neutral and positive. Given that anticipation of the future is linked to one's ability to remember the past, understanding memory for emotional experiences remains an important question for clarifying the time course of emotion in SZ.

Studying the Time Course of Emotion

One method particularly well suited to studying the time course of emotion is the startle eyeblink modulation (SEM) paradigm (e.g., Bradley, Lang, & Cuthbert, 1993; Codispoti, Bradley, & Lang, 2001; Dichter, Tomarken, & Baucom, 2002; Gard, et al., 2007; Grillon, Ameli, Woods, Merikangas, & Davis, 1991; Lang, Bradley, & Cuthbert, 1990; Lipp, Cox, & Siddle, 2001; Nitschke et al., 2002; Skolnick & Davidson, 2003). In this paradigm, the eyeblink component of the startle reflex response in reaction to an abrupt stimulus (e.g., a burst of white noise or a burst of bright light) is measured during presentation of emotionally evocative stimuli. The eyeblink response, sensitive to the

approach and avoidance motivational systems, varies by emotional experience such that the magnitude of the blink is potentiated when a person is experiencing negative emotion, and attenuated when a person is experiencing positive emotion. In other words, a linear pattern of blink response is most often observed with responses to positive stimuli being smaller than responses to neutral stimuli, which are in turn smaller than responses to negative stimuli (e.g., Dichter, Tomarken, Shelton, & Sutton, 2004; Lang, 1994, 1995; Sabatinelli, Bradley, & Lang, 2001). The SEM paradigm has been utilized to study anticipation, in the moment, and maintenance (i.e., after emotional stimulus is removed) emotion responses.

SEM studies of anticipation (e.g., Grillon, et al., 1991; Lipp, et al., 2001; Nitschke, et al., 2002) typically find larger blink responses to cues signaling emotional stimuli (positive and/or negative) compared to cues signaling neutral stimuli (but see Allen, Wong, Kim, & Trinder, 1996 who found a linear pattern of response during anticipation). This pattern of responses suggests that anticipatory blink responses may be sensitive to emotional arousal rather than valence. That is, positive and negative cues are likely more arousing than neutral cues, and if the magnitude of blink responses is large to positive and negative cues, the responses may reflect anticipation of forthcoming arousing stimuli.

Five studies have used the SEM paradigm in schizophrenia, and all have found that people with schizophrenia exhibit the same pattern of blink modulation in the presence of evocative stimuli as do people without schizophrenia (Curtis et al., 1999; Kring, Germans Gard, & Gard, 2011; Schlenker, Cohen, & Hopmann, 1995; Yee et al., 2010). No study has examined anticipation using the SEM paradigm in schizophrenia.

Present Investigation

The present study sought to examine anticipation and in the moment experience of emotion using both a measure of self-reported experience and the emotion modulated blink response. In addition, because emotional memory may be tightly linked to anticipation, we sought to examine the role emotional memory plays in the time course of emotion in SZ. As such, the present study had several aims:

Aim 1: In the Moment Responses

The first aim was to replicate prior findings of intact emotional responses during the presentation of emotionally evocative pictures. Specifically, we predicted that people with and without SZ would report feeling more positive in response to positive pictures, followed by neutral, and finally negative pictures. We also predicted that people with and without SZ would report more arousal while viewing the positive and negative pictures, relative to neutral pictures. In addition, we predicted that both the SZ and CTL groups would show a linear pattern of blink responses such that blink response while looking at positive pictures would be smallest, followed by neutral, and then negative pictures.

Aim 2: Anticipatory Responses

For our second aim, we examined group differences during the anticipation of evocative pictures. For reported emotional experience, we predicted that the CTL group's anticipated experience would vary by valence such that they would report feeling more positive in response to positive cues, followed by neutral cues, and finally negative cues. For anticipated arousal we predicted that the CTL group's ratings would vary by valence such that they would report feeling more arousal in response to positive and negative cues, relative to neutral. In contrast, we hypothesized that the SZ group would not report valence or arousal modulated emotion experience during the anticipation of emotional stimuli but would instead report similar anticipated valence and arousal, regardless of the evocative cue (i.e., positive = neutral = negative). For anticipatory blink response, and consistent with prior literature (e.g., Sabatinelli, et al., 2001), we predicted that CTLs would show a quadratic blink response during anticipation such that blink responses during the anticipation of positive and negative pictures would be larger than blink responses during anticipation of neutral pictures. By contrast, we predicted that people with SZ would not show valence modulated blink responses during the anticipation of emotionally evocative stimuli (i.e., positive = neutral = negative).

Aim 3: Emotional Memory

Our third aim was to examine group differences in immediate recall and delayed recognition of emotion stimuli. We predicted that people with SZ would recall fewer pictures, regardless of valence, relative to controls. Given the conflicting findings in the literature on emotion and memory in SZ, we explored whether people with SZ would show enhanced recall or recognition for emotional pictures compared to neutral pictures. In addition, we assessed the linkages memory for emotional stimuli and general cognitive abilities, including working memory (Digit Span), executive functioning (Trails B), verbal fluency (Categories) or IQ (WTAR).

Aim 4: Symptom and Functioning Correlates of Emotion Responses a

For our fourth aim we sought to examine the relationship between emotion responses (emotion experience and blink response) and clinical symptoms and functioning.

Methods

Participants

A total of 32 people diagnosed with schizophrenia ($n = 25$) or schizoaffective disorder ($n = 7$) and 33 health controls participated in this study. Four participants (2 SZ; 1 CTL) were excluded due to equipment failure, and 7 participants (3 SZ; 4 CTL) were excluded due to a lack of blink response in more than half of trials (Blumenthal et al., 2005). One additional CTL was removed for not completing both sessions of the experiment. Thus, the final number of participants was 27 in the SZ group and 27 in the CTL group.

People with SZ were recruited from outpatient treatment facilities in the Bay Area as well as from local board and care facilities. Healthy control participants were recruited via

fliers placed around the community or online advertisement (e.g., www.craigslist.org) from around the Bay Area, California. Exclusion criteria for both groups included a history of head trauma, substance dependence or abuse within the last six months, current episode of major depression or mania, or an IQ less than 70 as measured by the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). In addition, control participants were excluded if they had a family history of schizophrenia or bipolar disorder, if they had 1 or more episodes of mania, or if they had more than 2 lifetime episodes of depression. Demographic and clinical characteristics are listed in Table 1.

Measures

Diagnostic evaluation and symptoms. Diagnoses were determined based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; APA, 1994) using the Structured Clinical Interview for DSM-IV Axis I disorders (SCID; First, Gibbon, Spitzer, & Williams, 1996). Participants in the SZ group were interviewed for general psychiatric symptoms using the Brief Psychiatric Rating Scale (BPRS; Lukoff, Nuechterlein, & Ventura, 1986). BPRS items were rated on a 7-point scale from 1 (*not present*) to 7 (*extremely severe*). Both a positive symptom scale (sum of unusual thought content, disorientation, hallucinations, and suspiciousness items) and a negative symptom scale (sum of the blunted affect, emotional withdrawal, and motor retardation) were computed. Negative symptoms were also assessed using the Clinical Assessment Interview for Negative Symptoms (CAINS; Kring et al. 2013). The CAINS is scored with two scales: motivation and pleasure (MAP) and emotional expressiveness (EXP). The Role Functioning Scale (RFS; Goodman, Sewell, Cooley, & Leavitt, 1993) was used to assess current functioning in 4 broad domains: work, living, family and social. For analyses, we computed a total functioning score, averaging score across all 4 domains.

Cognitive measures. Participants also completed several measures of cognitive functioning. The Wechsler Test of Adult Reading (WTAR; Wechsler, 2008) was used as an estimate of premorbid IQ. To assess episodic memory, participants completed the California Verbal Learning Test-II (CVLT-2; Delis, Kramer, Kaplan, and Ober, 2000) a frequently used and well-validated measure. We used the short delay free recall variable from the CVLT-2 in analyses. To assess working memory, participants completed the Digit Span Backward subtest from the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1997). The number of digits recalled was used as our dependent variable. To measure verbal fluency, participants completed the frequently used Categories subtest, which asks participants to state as many things as they can think of within 3 categories. Participants' scores were averaged across all three trials for a single fluency measure. Finally, participants also completed Trails B, a well-validated measure of executive functioning. Trails B was scored for number of seconds taken to complete the task, not for errors made.

Stimuli

Sixty pictures (20 positive, 20 neutral, and 20 negative and 5 habituation slides) were selected from the International Affective Picture System¹ (IAPS; Lang, Bradley, & Cuthbert, 2005). 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 = 6.46 and 6.50, 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

Startle Task. After obtaining informed consent, trained clinical psychology graduate students administered the SCID-IV, BPRS, CAINS, RFS, and cognitive tasks. The startle task was designed to assess emotional experience and blink response during the anticipation of evocative pictures as well as blink responses during the presentation of evocative pictures. The task took place in a dimly lit and quiet laboratory room. Participants were positioned in a comfortable chair approximately .5 meters from a 36 cm LCD laptop computer screen. Experimenters prepared the skin, placed electrodes for recording blink responses, and checked impedance (following recommendations from Berg & Balaban, 1999). Participants were asked to wear a pair of headphones and told that they would hear noises over the headphones, but that they could ignore the noises. Participants were told that a series of cues and pictures will be presented on the screen and that cues will indicate the type of upcoming picture they will see. The cues indicated the valence (plus sign (+) for positive, minus sign (-) for negative, and a circle (O) for neutral) of the pictures that were subsequently presented. Participants were next asked to rate how they felt while anticipating the upcoming 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. During the anticipatory period, participants were asked to make two ratings (1) valence: how do you feel right now while anticipating the upcoming picture on a 9-point scale from “unhappy” to “happy” and (2) arousal: how much arousal do you feel right now while anticipating the upcoming picture on a 9-point scale from “calm” to “aroused.” Participants completed a series of five practice trials to familiarize themselves with the procedure, with three of those trials containing a startle probe. A study assistant walked each participant through the first two practice sequences detailing the study procedure.

Following the practice trials, participants began the experimental protocol consisting of 60 trials. Each trial began with a blank screen followed by a 0.5s cue (+, -, or o), followed by a 4s blank screen anticipation period during which participants were asked to anticipate the

¹ IAPS Slide Numbers: 1050, 1525, 2190, 2215, 2383, 2440, 2446, 2480, 2570, 2811, 3000, 3051, 3530, 4006m, 4225m, 4310m, 4320m, 4538f, 4542f, 4599, 4656f, 4660, 4670f, 4677f, 4681, 4690m 5120, 5621, 5629, 6243, 6260, 6300, 6370, 6510, 6540, 6571, 7009, 7025, 7034, 7060, 7090, 7110, 7170, 7211, 7224, 7234, 7235, 7700, 8030, 8080, 8179, 8185f, 8186, 8190, 8200, 8400m, 8490, 8496, 8499, 9250, 9410, 9424, 9425, 9611, 9635, 9910. Note: f denotes pictures shown only to women; m denotes pictures shown only to men.

upcoming picture. Participants were then asked to make the two anticipatory experience ratings on the computer using the SAM. Following the anticipation ratings, pictures were displayed for 6 seconds. Intertrial intervals varied between 5 and 7 seconds. Startle probes were pseudo-randomly ordered and presented during either the anticipatory period ($n=21$; 2500 ms after the anticipatory cue and prior to picture onset), during the picture presentation period ($n=21$; 3500 ms after picture onset), or during the intertrial interval ($n=8$; 3000 ms after picture offset). Unprobed trials ($n=10$) were used to minimize predictability. 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 used to allow assessment of order effects.

In the moment Experience Task. Following the blink task, participants were shown the same 60 IAPS pictures and asked to rate their in the moment emotional experience while looking at the pictures. Participants used the SAM ratings to report on (1) how they felt while looking at the picture from unhappy to happy and (2) how they felt while looking at the picture from calm to excited. Pictures were displayed for 6 seconds and were pseudorandomly ordered such that no more than 2 pictures of a similar valence were shown in sequence. An ITI of 2 to 3 seconds was used between each picture. Stimulus presentation and timing was controlled by E-prime software (Psychology Software Tools Inc, Pittsburgh, PA).

Immediate Recall Task. Following picture ratings, participants completed an immediate recall task. Participants were given 5 minutes to recall as many pictures as they could. They were given the following directions: *I am going to give you 5 minutes to describe as many pictures as you can remember. You can recall them in any order. To do this I'd like you to describe the pictures in a word or a few words so that I or somebody else would know what picture you are describing.* Participants recalled the pictures aloud and were audio recorded for later transcription.

Delayed Recognition Task. The delayed recognition task took place approximately 1 week (mean number of days = 6.92, $SD = 1.60$) after the initial visit to the lab. The task was run via E-Prime. Following 2 practice trials, participants were presented with 120 pictures, 60 pictures (20 positive, 20 neutral, 20 negative) they had seen during the startle and in the moment experience tasks and 60 new pictures (20 positive, 20 neutral, 20 negative). New pictures were comparable based on normative valence and arousal ratings as the initial set of 60 pictures. Each picture was presented along with the question: did you see this image during session one of the experiment (yes/no).

Startle Response 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 kOhm. 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. Presentation of pictures and probes was controlled by VPM software (Cook, Atkinson, & Lang, 1987).

EMG signal was filtered using a 13-1000 Hz passband and amplified using a Coulbourn V75-04 Isolated Bioamplifier with Bandpass Filter. EMG was sampled at 1000 HZ for 350 ms, starting 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 et al., 1998) and digitally rectified and integrated using a 30 ms time constant.

Raters 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. Intra-class correlations (ICCs) for agreement between the raters for half of the participants ($n = 27$) was high ($= .94$). Following the current recommendations for startle research (Blumenthal et al., 2005), blink data were standardized within each individual to produce a metric of responsivity (T scores) comparable across participants. Specifically, each individual's blink magnitudes were converted to t scores ($M=50$; $SD=10$). Mean blink magnitude for each valence (positive, neutral, negative) and time (anticipatory, in the moment) were computed for each individual.

Memory Data Reduction

Immediate recall data were rated as accurate or inaccurate by 2 trained raters. Intra-class correlations (ICCs) for agreement between the raters for all participants was high ($= .96$). Accuracy for the immediate recall task was calculated as hit rates computed separately for each valence immediate recall task, computed separately for each valence. Recognition data were coded for accuracy -- hit rate and false alarm rate --within each valence. Accuracy measures were calculated for each valence (positive, neutral, negative). Following signal detection theory, we computed d -prime (d'), a measure of sensitivity that removes bias to create a measure of overall accuracy (Wickens, 2001). D -prime is computed by subtracting the z -score of each persons false alarm rate from the z -score of each persons hit rate.

Data Analytic Plan

Repeated-measures multivariate analyses of variance (MANOVA) were used for the analyses. All results were examined for quadratic and linear effects. A Greenhouse-Geisser correction was used to correct for multiple comparisons when appropriate. When applicable, follow up pairwise comparisons were conducted using a Bonferroni correction. Estimates of effect size are reported as partial Eta squared (η_p^2).

Results

Preliminary Analyses

First, we assessed whether groups differed on any demographic variables. As shown in Table 1, parental education was the only demographic variable that was significantly different by group. However, parental education was not related to any emotional response or memory measures ($ps > .26$). Second, we examined potential task order effects by including order as a between-subjects variable. We found no main effects or interaction with task order, thus order was not included in further analyses. Third, we conducted all preliminary analyses with sex as a between-subjects variable. There was neither a significant main effect of sex nor any significant interactions involving sex in the analyses involving in the moment responses. Significant sex differences were observed in the anticipatory period, however, and we thus included sex in these analyses. Fourth, given group differences in measures of cognitive functioning (described below), we examined the relationship between emotional responses and cognitive measures; none of these correlations were significant ($ps > .32$), thus the cognitive measures were not included in analyses investigating emotional responses.

Aim 1: In The Moment Responses

Our first aim was to replicate previous findings of intact in the moment emotional responses in SZ in both reported emotional experience and blink response while viewing evocative pictures. We conducted three separate 2 (Group: SZ, CTL) X 3 (Valence: Positive, Neutral, Negative) MANOVAs for reported valence, reported arousal, and blink response.

Valence. As predicted and shown in Table 1, we found a main effect of valence ($F(1,52) = 126.79, p < .001, \eta_p^2 = .71$). Neither the group main effect nor the Group X Valence interaction emerged as significant ($ps > .19$). Posthoc pairwise comparisons revealed that each pair of valence conditions was significantly different from one another ($ps < .001$). Thus, all participants reported feeling most pleasant after seeing positive pictures followed by neutral and negative pictures.

Arousal. We found a significant valence effect ($F(1,52) = 29.66, p < .001, \eta_p^2 = .36$), and follow-up tests indicated that all participants reported experiencing greater arousal while viewing positive and negative pictures relative to neutral ($ps < .01$). We also found a significant group main effect ($F(1,52) = 7.27, p < .01, \eta_p^2 = .12$) wherein people with SZ reported greater levels of arousal compared to CTLs in response to all pictures.

Blink Responses. For blink response during picture viewing, we found a significant valence main effect ($F(1,52) = 51.42, p < .001, \eta_p^2 = .50$). Posthoc pairwise comparisons revealed that each pair of valence conditions was significantly different from one another ($ps < .007$), confirming that blink magnitude while viewing positive pictures were smallest, followed by neutral, followed by viewing negative pictures (see Figure 1). As hypothesized and consistent with prior studies, no main effect of group or Group X Valence interaction emerged ($ps > .15$).

Aim 2: Anticipatory Responses

Our second aim was to examine group differences in emotional experience and blink response during the anticipation of emotionally evocative pictures. We conducted three separate 2 (Group: BD, CTL) X 2 (Sex: Men, Women) X 3 (Valence: Positive, Neutral, Negative) MANOVAs for reported valence, reported arousal, and blink responses.

Valence. For reported valence during anticipation, we found a significant valence main effect ($F(1,50) = 50.64, p < .001, \eta_p^2 = .50$), indicating that all participants reported feeling most pleasant when anticipating positive pictures followed by neutral and negative pictures ($ps < .001$). However, as hypothesized, this was qualified by a significant Group X Valence interaction ($F(1,50) = 4.62, p < .05, \eta_p^2 = .09$). Unpacking this interaction, the data suggest that the CTL group anticipated more pleasantness in anticipation of positive pictures and more unpleasantness in anticipation of negative pictures, relative to the SZ group. In other words, the spread, or valence modulation during anticipation appears larger in CTLs than SZ. We also found a significant sex main effect ($F(1,50) = 5.56, p < .05, \eta_p^2 = .10$), indicating that regardless of diagnostic group and picture type, women reported experiencing more pleasantness during anticipation.

To further examine the Group X Valence interaction and sex main effect, we conducted follow-up posthoc MANOVAs and t-tests for men and women separately (see Figure 2). For men, we found a significant valence main effect ($F(1,24) = 34.26, p < .001, \eta_p^2 = .59$), but neither a group main effect ($p = .10$) nor a Group X Valence interaction ($p = .22$). For women, we again found a main effect of valence ($F(1,26) = 17.23, p < .001, \eta_p^2 = .40$). The Group X Valence interaction approached significance ($F(1,26) = 3.24, p = .08, \eta_p^2 = .11$). Follow-up t-tests revealed that women without SZ showed significant valence modulation ($ps < .01$) in reported valence experience during anticipation (i.e., pos > neu > neg). However, women with SZ did not (pos = neu = neg) ($ps > .11$).

Arousal. For anticipatory arousal, we found a significant valence main effect ($F(1,52) = 8.59, p < .01, \eta_p^2 = .14$), consistent with participants experiencing greater arousal while anticipating positive and negative pictures relative to neutral. We also found a significant group main effect ($F(1,52) = 8.34, p < .01, \eta_p^2 = .14$) indicating that people with SZ reported greater arousal during anticipation relative to CTLs. No other effects were significant.

Blink Responses. For blink response during anticipation, a main effect of valence emerged ($F(1,50) = 8.85, p < .01, \eta_p^2 = .15$). However, as hypothesized this was qualified by a significant Group X Valence interaction ($F(1,50) = 7.32, p < .01, \eta_p^2 = .13$). Posthoc within group comparisons revealed a lack of valence modulation in the SZ group across conditions ($ps > .73$). In contrast, the CTL groups' anticipatory blink response showed the expected pattern wherein blink magnitude during the anticipation of positive and negative conditions was significantly larger than during anticipation of neutral ($ps < .005$), while positive and negative conditions were not significantly different from each other ($p = .98$). We also found a significant Sex X Valence interaction ($F(1,50) = 4.10, p$

< .05, $\eta_p^2 = .08$). Neither the group ($p = .12$) or sex ($p = .99$) main effects were significant or any other two- or three-way interactions.

To further examine interactions involving group and sex, we conducted follow-up posthoc MANOVAs and t-tests for men and women separately and for the SZ and CTL groups separately (see Figure 3). For men, we found a significant valence main effect ($F(1,24) = 17.19, p < .001, \eta_p^2 = .42$) and a Group X Valence interaction ($F(1,24) = 5.60, p < .05, \eta_p^2 = .19$). Within group comparisons indicated that men without SZ showed the expected quadratic response during the anticipation of positive and negative pictures relative to neutral ($ps < .01$). In contrast, men with SZ did not exhibit significantly different blink responses by valence during the anticipation of evocative pictures ($ps > .31$). For women, we did not find a main effect of valence ($F(1,26) = .37, p = .37, \eta_p^2 = .01$) or a Group X Valence interaction ($F(1,26) = 2.66, p = .11, \eta_p^2 = .09$). Within group follow-up t-tests revealed that women without SZ showed a heightened blink response during the anticipation of negative pictures, relative to neutral ($p < .05$). However, they did not show the expected blink response during the anticipation of positive pictures relative to neutral ($p = .27$). Women with SZ did not exhibit significantly different blink responses by valence during the anticipation of evocative pictures ($ps > .55$). Thus, as hypothesized, men and women with SZ did not show a blink response that varied by valence during the anticipation of evocative pictures. Surprisingly, women without SZ did not show a heightened blink response during the anticipation of positive pictures, relative to neutral.

Aim 3: Emotional Memory

Our third aim sought to examine group differences in immediate recall and delayed recognition of evocative pictures in those with and without SZ. We conducted two separate 2 (Group: SZ, CTL) X 3 (Valence: Positive, Neutral, Negative) MANOVAs for recall and recognition memory. Hit rates were used for examining recall and d' was used for recognition.

For immediate recall, we found a significant main effect of valence ($F(1,52) = 64.34, p < .001, \eta_p^2 = .56$). Posthoc pairwise comparisons revealed that each pair of valence conditions was significantly different from one another ($ps < .05$). Thus, all participants showed an emotion enhancement effect for recalled pictures such that they recalled more negative pictures, followed by positive and neutral pictures (see Table 3). We also found a significant group main effect ($F(1,52) = 7.84, p < .001, \eta_p^2 = .13$) indicating that across valences, people with SZ recalled fewer pictures than CTLs.

For delayed recognition, all participants showed a high rate of recognition with an overall mean hit rate of 87% and a false alarm rate of 12%. For our MANOVA assessing delayed recognition using d' , we found no effects of valence or interactions with group suggesting that all participants recognized all pictures equally well. Contrary to our hypothesis, we did not find a significant valence main effect in delayed recognition ($p > .20$), thus suggesting a lack of an emotion enhancement effect in delayed recognition for both groups (see Table 3). In other words, people with and without SZ similarly recognized emotional and neutral pictures following a week delay.

Memory and Cognitive Measures. We first assessed group differences in cognitive functioning by conducting independent sample t-tests. As shown in Table 1, we found that people with SZ performed more poorly on Trails B, a measure of executive functioning relative to controls, and Digits Backwards, a measure of working memory. Somewhat surprisingly, the groups did not differ on Categories, a measure of verbal fluency, or the delayed recall index of the CVLT.

To assess the relationship between measures of emotional memory and cognitive functioning, we computed correlations within each group. However, because the pattern of findings was similarly significant in both groups individually, we present correlations collapsed across groups. Because we were interested in emotional memory, we only computed correlations for emotional positive and negative pictures. For both people with and without SZ, we found that the immediate recall of positive and negative pictures was significantly related to Trails B (see Table 4). This result suggests that the better their executive functioning, the more positive and negative pictures they recalled during the immediate memory task. We also found a significant correlation with measures of Fluency, such that better verbal fluency was associated with greater recall of positive and negative pictures. This finding is important given that our recall task involved recalling pictures aloud. Immediate recall was not related to estimated IQ or Digits Backward, a measure of working memory.

For delayed recognition, we found a significant relationship between Trails B and d-prime, suggesting that this measure of executive functioning is also related to delayed recognition of emotional stimuli. Fluency was not significantly related to delayed recognition, however, suggesting that fluency is perhaps more tightly linked to our immediate recall task. Delayed recognition was not related to estimated IQ or Digits Backward.

Aim 4: Symptom and Functioning Correlates of Emotion Responses in SZ

Finally, we explored the relationships between symptoms, functioning, and emotion responses. As shown in Table 5, we found that anticipatory emotion responses were related to measures of symptoms and functioning. Reports of pleasantness while anticipating positive pictures was significantly, and inversely, related to BPRS positive symptoms such that the less pleasure participants experienced while anticipating positive pictures, the more positive symptoms they reported. Similarly, anticipatory pleasantness for positive pictures was significantly related to CAINS MAP. In other words, the less pleasure experienced in the anticipation of positive pictures, the more negative symptoms experienced in the domains of motivation and pleasure. Both experienced pleasantness and blink response in anticipation of positive pictures were significantly and positively related to real world functioning such that more pleasure experienced and larger blink response were both related to higher levels of functioning as measured by the RFS. Reported experience while viewing negative pictures was significantly correlated with CAINS EXP, such that the more pleasantness experienced when viewing negative pictures, the higher their deficits in expressed emotion as measured by the CAINS EXP.

That is, the valence atypical response (i.e., greater pleasure to negative stimuli) was related to less expression in those with SZ.

Discussion

The present study replicates and extends previous research investigating the time course of emotion in people with and without SZ. Specifically, we sought to investigate emotional responses during the anticipation and in the moment experience of emotion. In addition, recent research has suggested that our ability to anticipate the future relies on our ability to remember the past (e.g., Schacter, Addis, & Buckner, 2007). Given this link between memory and anticipation, we also investigated the memory of emotional stimuli. By examining each of these time windows we will be able to see where emotion goes awry in SZ and thus have a better ability to design targeted treatment interventions to ameliorate emotional responses in SZ.

Consistent with our hypotheses and previous research, people with and without SZ showed a similar pattern of reported emotional experience and blink response in the presence of emotionally evocative stimuli (e.g., Curtis et al., 1999; Kring et al., 2011; Volz et al., 2003). That is, participants across both groups showed a linear pattern of blink response in the moment while viewing evocative stimuli. Across groups participants also reported experiencing more pleasure while viewing the positive pictures followed by the neutral then negative pictures. The present study provides further evidence demonstrating that regardless of whether measuring self-reported emotional experience or a physiologic measure such as the emotion modulated blink response, those with SZ show intact emotion responses in the presence of evocative stimuli.

In contrast to our hypothesis, we found that those with SZ reported experiencing more arousal in the moment while viewing pictures, relative to those without SZ. While comparatively few studies have assessed experienced arousal, prior findings suggest those with and without SZ show similar rates of arousal in the moment while viewing emotionally evocative stimuli (e.g., Kring et al., 2011; Herbener, 2008; Burbridge & Barch, 2007). It may be the case that our finding of heightened arousal is akin to studies finding greater experienced valence in people with SZ relative to controls. Indeed, several studies have reported that people with SZ have reported greater positive (e.g., Doop & Park, 2006; Kring et al., 1993) and negative emotion (Earnst & Kring, 1999; Kring & Neale, 1996; Kring & Earnst, 1999; Myin-Germeys, Nicolson, & Delespaul, 2001) relative to controls. In addition, a handful of studies assessing skin conductance in response to evocative stimuli have found that those with SZ show a greater physiological response relative to controls (Kring & Neale, 1996; Williams, et al., 2004; Williams et al., 2007). Given that skin conductance has been shown to be sensitive to emotional arousal (e.g., Bradley & Lang, 2000; Lang, Bradley, & Cuthbert, 1998), our findings may be consistent with prior findings of heightened skin conductance in SZ. Further studies should examine both valence and arousal to provide additional support for these findings. It will be important for future studies to clarify whether heightened arousal is related to unique emotional responses and clinical presentations within SZ.

Anticipatory Responses

The present study extends previous research by examining the experience of emotion during anticipation. While previous research has assessed self-reported experience during the anticipation of positive experiences, the present study assessed emotional responses during the anticipation of positive, neutral, and negative evocative stimuli. Our results suggest important differences in emotional responses during anticipation that vary by both group and sex. First, we found that the experience of emotion during anticipation did not vary by valence for women with SZ. That is, regardless of whether they were anticipating a positive, neutral, or negative picture, women with SZ reported experiencing similar levels of pleasantness. Second, men with SZ reported valence modulated experience during anticipation; however, the magnitude of these differences was less than that seen in women or men without SZ. Thus, while men with SZ reported more pleasantness in response to a positive cue than they did in response to a neutral or negative cue, the magnitude of these differences was smaller than in men and women without SZ. While all participants demonstrated that they understood anticipatory cues prior to beginning the task, it may be the case that our cues indicating valence of the upcoming picture (i.e., plus, circle, minus) may not have carried as much signaling power in those with SZ. Future studies should investigate this further utilizing other cues during anticipation. For example, words indicating valence or even the theme (e.g., puppies; mutilation) of upcoming pictures may elicit a more evocative anticipatory response. By varying the signaling value of anticipatory cues we can observe the boundaries of anticipatory deficits in SZ.

Our results for blink responses during anticipation suggest a similar story wherein men and women with SZ failed to show a valence modulated blink response in anticipation of evocative pictures. This lack of valence modulated blink response during anticipation is suggestive of a pattern consistent with context insensitivity during the anticipation of emotion in SZ. In other words, people with SZ did not change according to context (i.e., the cues signaling forthcoming pictures), such that they showed a similar blink response regardless of whether they were anticipating positive, neutral, or negative pictures. Sensitivity to emotional context has been hypothesized as a critical aspect of emotional life and hypothesized as important in helping to adjust adaptively to the environment (e.g., Keltner & Gross, 1999) and psychological adjustment (Bonano et al., 2007; Coifman & Bonanno, 2010). Further, emotion context sensitivity has been linked to emotion dysfunction and psychopathology. For example, emotion context insensitivity (ECI; see Rottenberg, Gross, & Gotlib, 2005 for review) is a predominant theory describing in the moment emotional responses in those with major depression (see Bylsma, Morris, & Rottenberg, 2008 for review) and those reporting symptoms of depression (e.g., Moran, Mehta, & Kring, 2012). Indeed, those with major depression, who show a pattern of responses consistent with context insensitivity have been found to have lower levels of psychosocial functioning and lower responses to treatment (e.g., Rottenberg, Kasch, et al., 2002). Coifman and Bonanno (2010) found that following life stress, ability to display context sensitive negative emotion in negative contexts predicted reduced depression symptoms at 18 months. The present study extends these findings and suggests that emotion context insensitivity during anticipation in SZ was related to a

higher number of positive and negative symptoms along with lower real world functioning.

Our anticipatory blink findings were qualified by an important sex interaction, which suggested that women without SZ showed an amplified blink response during the anticipation of negative pictures, relative to neutral pictures. However, their blink response during the anticipation of positive pictures did not significantly differ from neutral. While not one of our original hypotheses, these findings raise important questions about anticipatory deficits in SZ and important sex differences that must be further explored. To our knowledge, there is only one other study reporting sex differences in the anticipation of emotion in SZ. Tremeau and colleagues (2010) found that women with SZ predicted more pleasure than female controls and male SZ participants. This finding seems opposite to what we found. However, important distinctions between the two studies may help understand these differences. First, Tremeau et al. (2010) asked participants to *predict* how much pleasure they would feel in the moment while looking at evocative pictures and listening to sounds. In contrast, the present study assessed emotional experience and blink response *in anticipation*. While the distinction between these two questions may appear small, they may be differentially impacted in SZ. Second, Tremeau and colleagues assessed predicted emotion once, while the present study assessed anticipatory responses multiple times throughout the study protocol (i.e., anticipatory experience assessed during every trial; anticipatory blink assessed 21 times). Third, the percentage of women with and without SZ in the present study is higher than that found in the Tremeau study (i.e., 48% of women in the present SZ group vs. 16% in the Tremeau study). Given our findings of sex differences during anticipation, this may represent an important difference between the samples and findings. Further studies are needed to disentangle the prediction and experience of emotion during anticipation across men and women with SZ.

An additional explanation for the sex differences may be in the stimuli used. For the present study, positive pictures were selected from the frequently used IAPS picture collection (Lang et al., 2005), which contain positive stimuli differentiated broadly into categories of action/adventure and erotic. While efforts were made to select pictures to minimize sex differences in normative ratings of valence and arousal, it may be the case that the pictures elicited a mix of different emotions by gender. Indeed previous research suggests that while men report more enjoyment of erotic pictures, women rate their experience as involving both excitement and disgust (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Koukounas & McCabe, 1997). Thus, even though there were no sex differences or interactions while men and women viewed the evocative stimuli, it may be the case that during anticipation, women felt more ambivalence about the forthcoming pictures, particularly the positive pictures. To clarify this issue it will be important for future studies to utilize a variety of stimuli that consistently show strong elicitors of emotion in both men and women.

In sum, people with SZ, particularly women, displayed emotional responses that did not vary by cue during the anticipation of positive and negative evocative stimuli. Further, emotional responses during anticipation were linked to current symptom measures as

well as current measures of real-world functioning. That is, in the SZ group, those that reported more positive emotion during anticipation, showed higher levels of functioning along with lower positive and negative symptoms. Thus, our findings suggest that anticipation of emotion, especially positive emotion, is an important aspect of the time course of emotion that has real world clinical significance. These findings also have important implications for treatment in both schizophrenia and across other emotional disorders. For example, in SZ, psychosocial treatments could be designed to emphasize the importance of anticipation and future experiences of pleasure while also bolstering emotion regulatory strategies allowing them to work on responding flexibly in context appropriate ways. Our findings also suggest that emotional responses during anticipation vary by sex such that women show less overall modulation relative to men. This finding should be clarified by future studies investigating whether women show less modulation during anticipation across other measures of emotional response and during the anticipation of other evocative stimuli.

Group Differences in Emotional Memory

Towards our third aim we investigated group differences in immediate recall and delayed recognition in those with and without schizophrenia. Contrary to our hypotheses, we found that people with SZ showed an enhancement for emotional memory in immediate recall such that they recalled positive and negative images more than neutral images. However, SZ participants had poorer recall than controls suggesting that overall, those with SZ did not recall as many pictures as controls. Importantly, we found that across all participants, immediate recall was related to a measure of executive function and fluency suggesting that the overall deficit in immediate recall may be related to cognitive difficulties, rather than emotion responses. However, we found that more pleasure experienced in anticipation of positive pictures was related to immediate recall of positive pictures. Thus, it may be the case that both deficits during anticipation and cognitive difficulties, account for overall deficits in immediate recall. It may be the case that by increasing anticipatory emotional responses, we may help improve recall for emotional stimuli.

In contrast, we found no group differences in our delayed recognition task, such that those with and without SZ showed a high level of accuracy when recognizing stimuli one week later. These results are somewhat surprising given that group differences in recognition have been found in studies assessing memory at 24 and 48 hrs after their initial session, whereas in the present study we assessed delayed recognition approximately 1 week later. There are several potential reasons for our findings. First, stimuli in the present study were selected to be highly arousing positive and negative images. In contrast, Herbener and colleagues (2007) excluded pictures that were normatively rated as extremely positive (e.g., sexually explicit) and negative (e.g., mutilation). It may be the case that by utilizing pictures rated as highly arousing, we made the task easier for participants to remember. Indeed, in the present study, people with SZ reported experiencing more arousal when anticipating and viewing the pictures. Second, participants in the present study viewed evocative pictures twice: during the startle task and during the in the moment experience task. Having two opportunities to

encode the pictures likely aided in helping participants remember them on follow-up. Finally, prior studies suggest that emotional responses during anticipation predict memory for stimuli (e.g., Mackiewicz, Sarinopoulos, Cleven, & Nitschke, 2006). It may be the case that by asking participants to anticipate upcoming pictures, we inadvertently aided in their ability to remember the evocative stimuli. Future studies should attempt to disentangle this question. For example, future studies could provide anticipatory cues for some but not all trials. Should it be the case that anticipation aids in memory for evocative stimuli, it may point to novel methods of intervening to promote anticipation and memory.

It is important to acknowledge the limitations of the present study. First, the sample sizes were relatively modest and analyses may have had insufficient power to reject the null hypotheses. However, we did have sufficient power to detect between-group effects and predictions. Nevertheless, future studies should replicate these findings in a larger sample size to confirm findings. Second, the current investigation utilized standardized emotional pictures, thus limiting the ability to generalizability of the present findings to happenings outside the laboratory setting. In addition, the stimuli used (namely the positive pictures) may have impacted our findings of sex differences. Thus, future studies should utilize other stimuli, especially those that may be more personally salient to allow for greater generalizability.

Third, people in the SZ group were on a variety of medications including typical and atypical antipsychotics and antidepressants. While this is common among people with SZ, it is difficult to understand the impact of medication on emotional responses. Curtis and colleagues (1999) found that different medication types of those with SZ did not effect blink response. Similarly, others have reported no significant relationship between antidepressant medications and blink response (Dichter et al., 2004; Dichter & Tomarken, 2008). Still, a more direct test of medication effects is needed to further clarify the relationship between medications and blink response. Fourth, despite a week-long delay period, recognition rates were high in both groups. It is likely the case that recognition rates were high in the present study given that stimuli were presented twice: during the blink task and while rating emotional responses during picture viewing. Future studies might consider extending the delay period or reducing the exposure to stimuli such that participants aren't given prolonged encoding periods

In summary, although SZ was once thought to involve a lack of emotional experience, recent work suggests that this is not the case. Affective science has highlighted the importance of examining the time course of emotion to identify where emotion goes awry in SZ. In the face of emotionally evocative stimuli, people with and without schizophrenia show similar emotional responses. However, prior to picture presentation, during the anticipation of upcoming evocative stimuli, people with schizophrenia, particularly women, showed a lack of valence modulation suggestive of disruptive emotional responses during anticipation. While people with and without schizophrenia recognized emotional pictures at a similar rate, those with schizophrenia recalled fewer evocative pictures. Given that recall of positive pictures was related to experiencing more

pleasure while anticipating positive pictures, our findings suggest that anticipation, particularly of positive events, may be important in memory.

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Table 1

Demographic and Clinical Participant Characteristics

	SZ (<i>n</i> = 27)	CTL (<i>n</i> = 27)	Statistic
Age (Yrs)	46.69 (10.73)	46.22 (11.23)	<i>t</i> = .16
Gender (male:female)	(14:13)	(12:15)	$\chi^2 = .30$
Ethnicity, <i>n</i>			$\chi^2 = 3.09$
Caucasian	17	15	
African American	4	5	
Asian	4	4	
American Indian	1	0	
Multiethnic	0	1	
Latino	1	2	
Education (Yrs)	14.58 (2.49)	15.61 (2.31)	<i>t</i> = 1.57
Parental Education (Yrs)	14.92 (2.39)	13.17 (3.53)	<i>t</i> = 2.08*
WTAR	105.85 (11.27)	105.30 (10.93)	<i>t</i> = .18
Trails B	89.60 (32.55)	68.38 (30.33)	<i>t</i> = 2.36*
Fluency	15.37 (3.89)	17.12 (3.61)	<i>t</i> = 1.66
Digits Backward	7.48 (1.90)	8.69 (2.05)	<i>t</i> = 2.19*
CVLT Delay Recall	5.48 (1.94)	6.46 (1.70)	<i>t</i> = 1.92
Antipsychotic medication (<i>n</i>)			
Typical	4		
Atypical	19		
Both	2		
None	2		
BPRS			
Total Score	43.19 (11.21)		
Positive Symptoms	10.96 (5.17)		
Negative Symptoms	7.81 (2.45)		
CAINS			
MAP	14.96 (5.81)		
EXP	5.50 (3.64)		
RFS (<i>n</i> = 21)	4.64 (1.01)		

Note: SZ = Schizophrenia group; CTL = Healthy control group; WTAR = Wechsler Test of Adult Reading; BPRS = Brief Psychiatric Rating Scale; Cains MAP = Motivation and Pleasure Subscale of the Clinical Assessment Interview for Negative Symptoms; CAINS EXP = Expression Subscale; RFS = Role Functioning Scale. Mean values are displayed with standard deviations in parentheses where applicable.

* *p* < .05

Table 2

Reports of Experienced Emotion in Response to Evocative Pictures

	Group	
	Schizophrenia	Control
Positive pictures	5.99 (1.38)	6.44 (1.31)
Neutral pictures	4.63 (1.10)	4.91 (1.08)
Negative pictures	2.97 (1.46)	4.91 (1.08)

Note: Tabled values are means with standard deviations in parentheses. Scores range from 0 to 9, lower values indicate more unpleasantness and higher values indicate more pleasantness.

Table 3

Memory Task Performance

	Group	
	Schizophrenia	Control
Immediate Recall Hit Rates		
Positive pictures	.36 (.15)	.43 (.11)
Neutral pictures	.21 (.15)	.30 (.12)
Negative pictures	.40 (.18)	.49 (.16)
Delayed Recognition Hit Rates		
Positive pictures	.85 (.18)	.88 (.11)
Neutral pictures	.87 (.13)	.85 (.12)
Negative pictures	.86 (.18)	.90 (.12)

Note: Tabled values are mean hit rates with standard deviations in parentheses.

Table 4

Correlations between memory and cognitive variables

Immediate Recall Hits	Trails B	Fluency	Digits Backward	CVLT
Positive Pictures	-.52**	.55**	.19	.18
Negative Pictures	-.34*	.48**	.07	.27
Delayed Recognition Hit Rates				
Positive pictures	-.39**	.20	.18	.16
Negative pictures	-.30*	.21	.10	.16

** $p < .005$

* $p < .05$

Table 5

Symptom and Functioning Correlates of Emotion Responses in SZ

	BPRS-N	BPRS-P	MAP	EXP	RFS
Anticipatory Responses					
Positive Experience	-.12	-.40*	-.38*	-.29	.51*
Negative Experience	.21	.22	.46*	.07	-.30
Positive Blink	.03	-.04	.37 [^]	-.07	.49*
Negative Blink	.10	-.01	-.21	-.06	.18
In the Moment Responses					
Positive Experience	.01	-.20	-.18	-.37	.19
Negative Experience	.37 [^]	.05	.36 [^]	.46*	-.32
Positive Blink	-.03	.03	.22	.01	-.30
Negative Blink	.02	.12	.22	-.14	.18

Note: BPRS-N = BPRS Negative Symptom Scale; BPRS-P = BPRS Positive Symptom Scale; MAP = CAINS Motivation and Pleasure Scale; EXP = CAINS Expression Scale; RFS = Role Functioning Scale.

* $p < .05$

[^] $p = .06$

Figure 1. Mean blink magnitudes during picture presentation

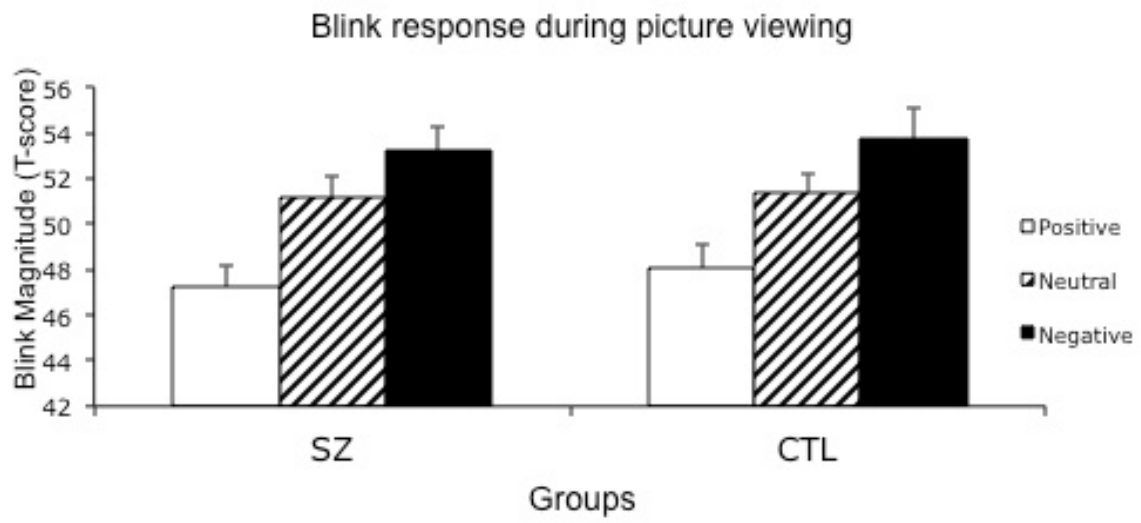


Figure 2. Mean emotion valence ratings during anticipation

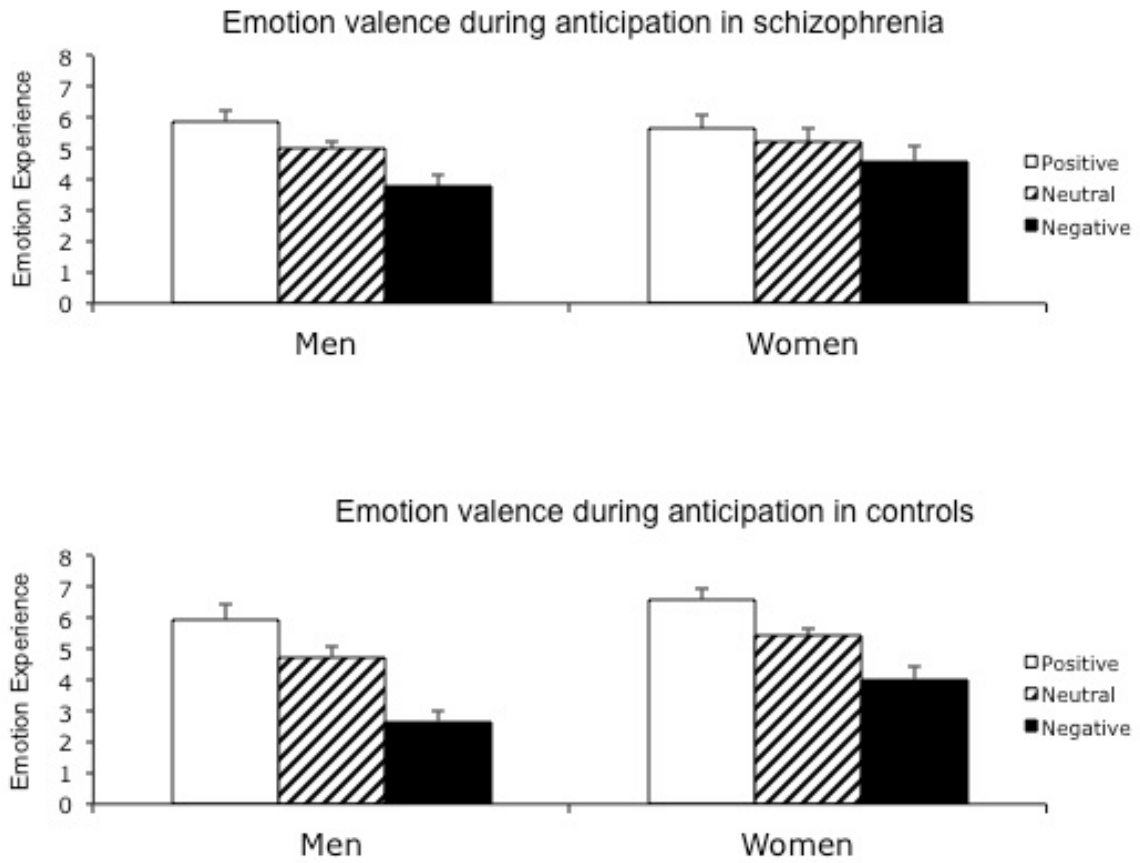


Figure 3. Mean startle responses during anticipation

