Published in final edited form as:

Schizophr Res. 2014 August ; 157(0): 63–69. doi:10.1016/j.schres.2014.05.014.

Impairment in Emotional Modulation of Attention and Memory in Schizophrenia

Julie Walsh-Messinger, PhD^{a,b,1,*}, Paul Michael Ramirez, PhD^a, Philip Wong, PhD^a, Daniel Antonius, PhD^{b,c,d}, Nicole Aujero, BA^b, Kevin McMahon, BA^b, Lewis A. Opler, MD, PhD^e, and Dolores Malaspina, MD, MSPH^{b,f}

^aDepartment of Psychology, Long Island University, Brooklyn, NY

^bInSPIRES, Department of Psychiatry, NYU School of Medicine, New York, NY

^cUniversity at Buffalo, State University of NY, Buffalo, NY

^dErie County Forensic Mental Health Services, Buffalo, NY

^eDepartment of Psychiatry, Columbia University, New York, NY

^fCreedmoor Psychiatric Center, NY State Office of Mental Health, Queens, NY

Abstract

Emotion plays a critical role in cognition and goal-directed behavior via complex interconnections between the emotional and motivational systems. It has been hypothesized that the impairment in goal-directed behavior widely noted in schizophrenia may result from defects in the interaction between the neural (ventral) emotional system and (rostral) cortical processes. The present study examined the impact of emotion on attention and memory in schizophrenia. Twenty-five individuals with schizophrenia related psychosis and 25 healthy control subjects were administered a computerized task in which they were asked to search for target images during a rapid serial visual presentation of pictures. Target stimuli were either positive, negative, or neutral images presented at either 200ms or 700ms lag. Additionally, a visual hedonics task was used to assess differences between the schizophrenia group and controls on ratings of valence and arousal from the picture stimuli. Compared to controls, individuals with schizophrenia detected fewer emotional images under both the 200ms and 700ms lag conditions. Multivariate analyses showed that the schizophrenia group also detected fewer positive images under the 700 lag condition and

***Corresponding Author:** Mental Illness Research, Education, and Clinical Center (MIRECC), James J Peters VA Medical Center, 130 West Kingsbridge Road, 6th Floor, Suite 6A-41C, Bronx, New York 10468, Phone: (718) 584-9000 x3705, Fax: (718) 364-3576, julie.walshmessaging@mssm.edu.

¹Present Affiliations: Mental Illness Research, Education, and Clinical Center (MIRECC), James J Peters VA Medical Center, Bronx, NY and Department of Psychiatry, Icahn School of Medicine at Mount Sinai, New York, NY

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Contributors: Julie Walsh-Messinger, in collaboration with Dolores Malaspina, Paul Michael Ramirez, Philip Wong, Lewis Opler, and Daniel Antonius, designed the study and wrote the protocol. Julie Walsh-Messinger, Daniel Antonius, Nicole Aujero, and Kevin McMahon conducted the study and collected data. Julie Walsh-Messinger undertook the statistical analysis and wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of Interest: The authors report no financial conflicts of interest.

fewer negative images under the 200 lag condition. Individuals with schizophrenia reported higher pleasantness and unpleasantness ratings than controls in response to neutral stimuli, while controls reported higher arousal ratings for neutral and positive stimuli compared to the schizophrenia group. These results highlight dysfunction in the neural modulation of emotion, attention, and cortical processing in schizophrenia, adding to the growing but mixed body of literature on emotion processing in the disorder.

Keywords

Schizophrenia; Emotion; Cognition; Negative Symptoms

1. Introduction

Emotional disturbances have been considered a core symptom of schizophrenia since early conceptualizations of the disease (Bleuler, 1950/1908; Kraepelin, 1971/1919). Yet, efforts to understand and categorize these disturbances have produced more questions than answers. Although most self-report studies support a disturbance in the phenomenological experience of emotion in schizophrenia, laboratory studies that use emotion induction demonstrate similar in-vivo experiences of emotion in individuals with schizophrenia and controls (reviewed in Cohen and Minor, 2010; Kring and Moran, 2008). Together, these studies suggest intact in-vivo experience of emotion, but leave open the possibility of memory impairment in processing emotional experiences. Additionally, persons with schizophrenia appear to be impaired in their ability to generate behavioral motivation from pleasurable experiences (Heerey and Gold, 2007; Trémeau et al., 2010), known as anticipatory anhedonia. It is hypothesized that this impairment results from deficient interactions between affective and cognitive processes.

Emotion plays a major role in cognition and goal-directed behavior via complex interconnections between the emotional and motivational systems (Panksepp, 2003). According to Panksepp's theory, emotions serve to signify the value of a stimulus, directing attention to that stimulus, resulting in enhanced cognitive processing (Dolan, 2002). Similarly, biased competition theory (Desimone and Duncan, 1995) suggests that the information-processing system can only handle a limited amount of information at once, normally resulting in attention to important stimuli and rejection of nonsignificant stimuli (Yiend, 2010). When a stimulus is emotionally arousing, the processing system is cued to its importance and additional attentional resources are directed toward the stimulus. The enhancement of emotion on attention may have an evolutionary basis, as attending to threatening stimuli (thus inducing fear) would be advantageous to survival (Phelps, 2006).

The impact of emotion on cognition has been studied using an emotional attentional-blink paradigm. The 'attentional-blink' refers to a period of temporary impairment in attention when visual stimuli are presented in quick succession (Raymond et al., 1992). This phenomenon is most commonly tested using a paradigm where visual stimuli are presented in quick succession and participants are instructed to ignore most stimuli and attend only to target stimuli. If the second target stimulus (T2) is presented too quickly (200–500ms) after the first target stimulus (T1), participants have difficulty in detecting T2 (Raymond et al.,

1992; Shapiro et al., 1997). Chun and Potter (1995) propose a two-stage theory to explain this phenomenon. They suggest that the first stage involves detecting the presented stimulus, while the second stage involves consolidating the stimulus in working memory. If T2 is presented while T1 is in stage two, T2 is unable to enter stage two and attention is “blinked.”

Research findings suggest enhanced detection when T2 is an emotionally-laden stimulus (Anderson, 2005; Keil and Ihssen, 2004). Enhanced attention for emotional stimuli has also been demonstrated using a modified paradigm using emotional T1 words, showing the attentional-blink effect is greater for emotional T1 words when compared to neutral words (Mathewson et al., 2008; Smith et al., 2006), again demonstrating that emotional stimuli draw attentional resources from non-emotional stimuli. In some patient samples, however, emotion does not enhance detection of T2 stimuli, specifically those with amygdala lesions (Anderson and Phelps, 2001) and with autism spectrum disorders (Corden et al., 2008; Gaigg and Bowler, 2009).

Individuals with schizophrenia exhibit an a more pronounced attentional-blink effect compared to controls (Cheung et al., 2002; Li et al., 2002; Wynn et al., 2006), and at lag times considered outside the typical attentional-blink window of 200–500ms (Mathis et al., 2011). It also appears that individuals with schizophrenia exhibit differential neural activation when initially attending (Dichter et al., 2010) and sustaining attention to emotion stimuli (Ursu et al., 2011). Only one study to date has used an emotional attentional-blink task to probe cognitive-affective interactions in schizophrenia. The authors compared recall of word stimuli in an attentional-blink paradigm in controls, a high negative symptom schizophrenia group, and low negative schizophrenia group, finding reduced recall of T2 emotional words in the high negative symptom group, whereas the low negative symptom group was similar to controls (Strauss et al., 2013). In a second experiment by this group that used T1 emotional word stimuli, both controls and the low negative symptom group exhibited reduced accuracy for T2 stimuli following negatively valenced T1 stimuli; an effect not seen in the high negative symptom group. These findings are compelling and support the hypothesis of impaired cognitive-affective circuitry in schizophrenia.

Research data supports faster neural processing of emotional pictures than emotional words (De Houwer and Hermans, 1994). Additionally, an event-related fMRI study found stronger right-lateralized arousal-related amygdala activity for picture stimuli, while word stimuli resulted in stronger left-lateralized activity (Kensinger and Schacter, 2006). The authors also found greater medial response to positive compared to negative picture stimuli, but not for word stimuli. In controls, enhanced detection of T2 emotional stimuli has been demonstrated with both picture (Fox et al. 2005; Most et al. 2007; Ciesielski et al., 2010) and word (Anderson and Phelps, 2001; Anderson, 2005; Mathewson et al., 2008) stimuli, but individuals with schizophrenia have not been tested for pictures. The present study thus investigated whether emotion’s enhancement of attention and memory is impaired in schizophrenia, using a picture emotional attention-blink task. It was hypothesized that individuals with schizophrenia, as compared to controls, would not demonstrate enhanced detection and memory of T2 emotional pictures under the early lag condition (200ms) but would perform similarly under the longer 700ms condition.

2. Methods

2.1 Participants

Participants included 25 individuals diagnosed with DSM-IV (American Psychiatric Association, 2000) schizophrenia ($n=21$) or schizoaffective disorder ($n=4$) and 25 healthy controls. Individuals with schizophrenia were referred to the study by outpatient clinicians at a large hospital located in the Northeast of the United States. Controls were recruited via internet postings on Craigslis.org. The study was approved by the local Institutional Review Boards (IRB) and all participants signed informed consent forms prior to participation. Individuals with schizophrenia and controls were excluded from the study if they did not speak English. Additionally, controls were excluded if they met criteria for a DSM-IV Axis I or Axis II diagnosis within two years prior to enrollment in the study or had a family history of psychosis.

2.2 Measures

2.2.1. Diagnosis and Symptoms—Lifetime and current DSM-IV AXIS-I psychiatric diagnoses were assessed in individuals with schizophrenia and controls using the semi-structured *Diagnostic Interview for Genetic Studies* (DIGS; Nurnberger et al., 1994). The presence/absence and severity of current psychiatric symptoms were assessed with the *Positive and Negative Syndrome Scale* (PANSS; Kay et al., 2006) and the associated *Structured Clinical Interview for the PANSS* (SCI-PANSS; Opler et al., 1992). The 30 PANSS items were summed into one of three subscales that assess positive, negative and general psychopathology. In addition, five alternative subscales were computed to assess negative symptomatology, positive symptomatology, activation, dysphoria, and autistic preoccupation (White et al., 1997).

All interviews were conducted by clinicians with a Master's degree or Doctorate in psychology, trained to maintain a reliability criterion of at least .70. Clinical diagnoses were made by a consensus of at least two doctoral level research-clinicians (M.D. or Ph.D.) and the interviewer during regular consensus conferences.

2.2.2. Attentional-Blink Task—The experimental task utilized a modified Rapid Serial Visual Presentation (RSVP) paradigm (Raymond et al., 1992) developed using E-prime (Psychology Software Tools). Picture stimuli, employed to eliminate any potential confounding verbal deficit in the schizophrenia group, were selected from the International Affective Picture System (IAPS; Lang et al., 2008) database. The task consisted of 3 practice trials followed by 28 experimental trials. For each trial, thirteen distracter pictures (white borders) and two target pictures (black borders) were sequentially and briefly presented (100ms each) in the center of a laptop computer screen (total trial length 1500ms). The first target picture (T1) was a low arousal, neutral picture presented randomly in serial positions 2–7. The second target (T2) was one of 14 neutral (e.g. basket, key-ring, coffee cup) or 14 emotional pictures (e.g. fire, pointed gun, puppies, embraced couple). Pictures were chosen based on normative data (Lang et al., 2008) and the emotional pictures varied in valence (positive or negative) and were high in normative ratings of arousal. Valance/arousal ratings were as follows: Positive $M=7.95/5.33$; Negative $M=2.25/6.61$; Neutral

$M=5.10/2.98$. The temporal lag between T1 and T2 was either 200ms or 700ms, randomized across the trials, and selected based on previous research demonstrating that the attentional-blink effect lasts from approximately 200–500ms and diminishes by 700ms (Raymond et al., 1992).

Participants were instructed to ignore all of the pictures with white borders and to focus on the two pictures with black borders. At the end of the presentation, participants were asked how many of the pictures in the set had black borders. They were then shown a randomized series of five pictures, the two target pictures from the trial, plus a novel neutral, positive, and negative distracter picture. Each of these pictures were presented for 1000ms, after which, the participants were asked whether or not the picture they had just seen had a black border in the previous set of pictures.

2.2.3 Visual Hedonics—A visual hedonic rating task was used to examine differences between the schizophrenia group and controls in emotional reaction to the target images. After completion of the experimental task, participants were shown the 28 T2 pictures from the task and were asked to rate, the pleasantness and unpleasantness of the pictures using two five-point Likert scales that ranged from, “not pleasant/unpleasant” to “very pleasant/unpleasant.” Participants also provided arousal ratings using a five-point Likert scale ranging by “very calm” to “very arousing.”

2.3 Data Analysis

Independent samples t-tests and chi-squares were used to test for differences between individuals with schizophrenia and controls in demographic characteristics, hedonic and arousal ratings of visual stimuli and accuracy in identifying the number of target images in trial. To minimize the potential confound of random responding on the experimental task, a D-prime (d') score was computed for T1 accuracy and T2 accuracy for each valance and lag by subtracting the z-score of false positives from the z-score of hits. To examine whether emotion enhanced detection of emotional images compared to neutral images, we also computed difference scores, subtracting neutral d' from emotional, positive, and negative d' for both lags. Group differences were examined using one-way analysis of covariance (ANCOVA; T1 d') and mixed model ANCOVA (T2 d' , difference scores), controlling for age. Pearson correlations examined associations between psychiatric symptoms and image ratings of pleasantness, unpleasantness, and arousal, as well as the attentional-blink d' and difference scores.

3. Results

3.1 Demographics

Demographic measures for the samples are presented in Table 1. Individuals with schizophrenia and controls were nearly matched for sex, however the schizophrenia group was significantly older and less educated than controls. The schizophrenia group was comprised of largely chronic and psychiatrically stable patients, with relatively low to moderate levels of psychiatric symptoms.

3.2 Self-report Ratings of Pleasantness, Unpleasantness, and Arousal

The schizophrenia group reported significantly higher pleasantness and unpleasantness ratings overall, and specifically for neutral images, but they did not differ from controls in pleasantness and unpleasantness ratings of negative and positive stimuli (Table 2). The groups also did not differ in terms of their arousal ratings of negative stimuli, but controls reported significantly higher overall arousal ratings, and for neutral and positive stimuli.

3.3 Effect of Emotion on Memory of Picture Stimuli

Controls were more accurate than individuals with schizophrenia in identifying that they had viewed two target pictures (black borders) for neutral ($t=3.13$, $p=.003$, $d=0.89$) and emotional ($t=4.53$, $p=.000$, $d=1.28$) images under the 700ms condition, but did the groups did not differ for either of these in the 200ms condition. Controls had significantly higher T1 d' compared to individuals with schizophrenia ($F=5.71$, $p=.021$, partial $\eta^2=.108$). However, accurate detection of T1 in both groups was low (Table 3), suggesting that the task did not successfully induce an attentional-blink effect. Thus, we analyzed all trials regardless of whether T1 was detected. Therefore, the following analyses examine the effect of emotion on memory of picture stimuli, although they are not analyses of the attentional-blink effect due to issues with T1 detection.

We then conducted a two (schizophrenia, control) $\times$ two (neutral, emotional) $\times$ two (700ms, 200ms) mixed model ANCOVA, controlling for age, to examine group differences across valance and lag (Figure 1). The overall main effect for Condition was significant Wilks' Lambda=.841, $F(3,45)=2.84$, $p=.048$, partial $\eta^2=.149$ (for guidelines on interpreting partial η^2 see Pierce et al., 2004). The within-subjects effect for Condition was not significant $F(2.74,128.7)=2.28$, $p=.088$, partial $\eta^2=.046$; although there was a significant Condition $\times$ Group interaction $F(2.74,128.7)=3.58$, $p=.019$, partial $\eta^2=.071$. The between-subjects effect for Group was significant $F(1,47)=9.21$, $p=.004$, partial $\eta^2=.164$. Post-hoc tests indicated that the schizophrenia group had significantly lower d' scores for emotional images under both the 200 ms $F(1,47)=11.89$, $p=.001$, partial $\eta^2=.202$ and the 700ms $F(1,47)=8.15$, $p=.006$, partial $\eta^2=.148$ conditions than controls.

To examine group and lag differences in emotion-neutral difference scores we ran a 2 (schizophrenia, control) $\times$ 2 (200ms, 700ms) mixed-model ANCOVA, controlling for age (Figure 2). The overall main effect was not significant Wilks' Lambda=.994, $F(1,47)=0.27$, $p=.609$, partial $\eta^2=.006$. The within-subjects effect was also not significant $F(1,47)=0.27$, $p=.609$, partial $\eta^2=.006$, but there was a significant between-subjects difference $F(1,47)=6.72$, $p=.013$, partial $\eta^2=.125$. Post-hoc tests indicated that the schizophrenia group had significantly lower difference scores at 200ms $F(1,47)=6.93$, $p=.011$, partial $\eta^2=.129$, suggesting that emotion did not improve image detection at 200ms in schizophrenia.

In keeping with the literature supporting different neurocircuitry for processing positive versus negative emotion (Kim and Hamann, 2007), we conducted more nuanced exploratory analyses to probe whether or not these effects differed for emotional valence of the target images, using a two (schizophrenia, control) $\times$ three (neutral, negative, positive) $\times$ two (700ms, 200ms) mixed model ANCOVA, controlling for age (Figure 3). The overall main

effect for Condition was not significant Wilks' Lambda=.839, $F(5,43)=1.64$, $p=.169$, partial $\eta^2=.161$; however, there was a significant overall Condition $\times$ Group interaction Wilks' Lambda=.668, $F(5,43)=4.27$, $p=.003$, partial $\eta^2=.332$. The within-subjects effect for Condition was also not significant $F(4.17,195.94)=1.08$, $p=.370$, partial $\eta^2=.022$; however, there was a significant Condition $\times$ Group interaction $F(4.17,195.94)=4.44$, $p=.002$, partial $\eta^2=.086$. The between-subjects effect for Group $F(1,47)=16.24$, $p=.000$, partial $\eta^2=.257$ was significant. Post-hoc tests indicated that individuals with schizophrenia, as compared to controls, had significantly lower d' scores for positive images under the 700ms $F(1,47)=16.33$, $p=.000$, partial $\eta^2=.258$ and negative images under the 200ms $F(1,47)=7.24$, $p=.010$, partial $\eta^2=.134$ conditions.

Next, we ran a 2 (schizophrenia, control) $\times$ 2 (positive-neutral, negative-neutral) $\times$ 2 (200ms, 700ms) mixed-model ANCOVA, controlling for age to test difference scores (Figure 4). The overall main effect was not significant Wilks' Lambda=.993, $F(3,45)=0.11$, $p=.954$, partial $\eta^2=.007$. The within-subjects effect was also not significant $F(2.87,135)=0.13$, $p=.938$, partial $\eta^2=.003$, but there was a significant Condition $\times$ Group interaction $F(2.87,135)=3.04$, $p=.033$, partial $\eta^2=.061$. The between-subjects effect was significant $F(1,47)=8.91$, $p=.004$, partial $\eta^2=.159$. Post-hoc tests indicated that the schizophrenia group had significantly lower positive-neutral 200ms $F(1,47)=4.20$, $p=.046$, partial $\eta^2=.082$, positive-neutral 700ms $F(1,47)=10.50$, $p=.002$, partial $\eta^2=.183$, and negative-neutral 200ms $F(1,47)=4.16$, $p=.047$, partial $\eta^2=.081$, suggesting that detection was only improved in the schizophrenia group for negative images at 700ms.

3.3 Associations with Symptoms

Analyses of psychiatric symptoms, conducted only in the schizophrenia group ($n = 23$), showed no PANSS subscales were associated with ratings of pleasantness, unpleasantness, and arousal. However higher PANSS Negative factor scores were associated with increased pleasantness ratings in response to negative stimuli ($r=.529$, $p=.009$) and increased unpleasantness ratings in response to neutral stimuli ($r=.422$, $p=.039$). Higher PANSS Activation ratings were associated with increased overall unpleasantness ratings ($r=.528$, $p=.010$), increased unpleasantness ratings in response to positive stimuli ($r=.623$, $p=.002$), and decreased arousal ratings in response to negative stimuli ($r=-.426$, $p=.043$). The significance of these correlations did not withstand Bonferroni corrections and none of the PANSS subscales or factors were associated with any d' or difference scores from the computer task.

4. Discussion

This study demonstrates dysfunction in the neural modulation of emotion, attention, and subcortical processing in schizophrenia. Individuals with schizophrenia detected fewer T2 emotional images than control subjects in all conditions, as well as fewer positive T2 images under the longer time lag condition (700ms) and fewer negative T2 images under the shorter lag condition (200ms). Individuals with schizophrenia had higher pleasantness and unpleasantness ratings for neutral images, while the controls had a significantly higher arousal for neutral and positive stimuli. These results, add to the growing, but mixed, body of literature on emotion processing in the disorder.

4.1 Emotion's Influence on Attention and Memory

An interpretation of these results is that the shorter and longer lag conditions are sensitive to different deficits in the neural emotional system. The decreased detection accuracy for negative T2 images is consistent with the hypothesis that in schizophrenia, the amygdala, most known for processing fear and negative affect, is not quickly detecting and responding to negatively valenced stimuli and communicating efficiently to other neural systems that attentional resources should be allocated towards the negative stimuli. In contrast, decreased detection accuracy of positively valenced stimuli under the 700ms condition is consistent with a deficit in positive affect. The ventral striatum has connections to the limbic region and is associated with the positive emotion of anticipation (Berridge and Robinson, 1998) and anhedonia (Goldstein and Volkow, 2002; Wise, 1982) and may be implicated by this finding. It is possible that individuals with schizophrenia did not show decreased detection for positive stimuli in the 200ms condition as positive stimuli may not activate the amygdala in the same way as negative stimuli. Alternatively, it is also possible that the 200ms condition was too short to allow for complex neurocircuitry interactions, as individuals with schizophrenia may be less efficient at processing non-emotional visual stimuli. Thus the emotional salience of the stimulus may not improve detection at such a short lag time (Weiner et al., 1990).

Our results may help explain why research findings on emotional modulation of memory in schizophrenia are mixed, with the majority of studies finding no differences between controls and individuals with schizophrenia, but some studies suggesting reduced memory for positive, negative, or both stimuli (reviewed in Dieleman and Roder, 2013). Our results suggest that the sequential timing of image presentation could influence enhanced detection differently depending on valence, which could contribute to conflicting results across studies.

It is difficult to directly compare the results of the present study with the Strauss et al. (2013) findings as our task did not induce the desired attentional-blink effect. Similarly, relatively low negative symptom levels in our schizophrenia group did not allow for us to split the sample into high and low negative groups. Given the differences Strauss and colleagues found across high and low negative symptoms, it is possible that these effects were lost in our sample. Additionally, our task used pictures compared instead of word stimuli, and it is possible that the study results differ due to differences in cortical processing of picture versus word stimuli. Still, our data are somewhat consistent with regard to decreased enhancement of detection for negative emotional stimuli at 200ms in Strauss et al.'s high negative symptom group and in our schizophrenia group.

4.2 Emotion and Arousal Ratings

The schizophrenia group self-reported higher pleasantness and unpleasantness ratings in response to neutral images. These results are partially consistent with previous studies finding that individuals with schizophrenia report increased negative emotion in response to neutral stimuli (Cohen et al., 2009, Trémeau et al., 2009, Ursu et al., 2011). However, our finding of increased pleasantness ratings in response to neutral stimuli was unexpected. It is possible that the use of unipolar rating scales instead of the more commonly used bipolar

ratings contributed to this difference, and suggests a need for future research to directly compare results of different rating methodology.

The controls unexpectedly reported higher arousal ratings for neutral and positive stimuli compared to the schizophrenia group. This suggests more emotional reactivity in the controls, a departure from the idea of elevated threat response in schizophrenia (Gur et al., 2007) and in contradiction with a meta-analysis of self-reported arousal in schizophrenia, in which controls and individuals with schizophrenia were comparable on self-reported ratings of arousal in response to pleasant and unpleasant stimuli, but elevated in response to neutral stimuli (Llerena et al., 2012). Llerena and colleagues (2012) identified the type of rating scale used in each study as a moderator with regard to unpleasant stimuli, finding that individuals with schizophrenia reported lower arousal ratings in response to unpleasant stimuli when the scale ranged from “calm” to “excited” but did not differ from controls when the scale ranged from “low” to “high.” They suggest that this methodological difference may result from the calm-excited scale requiring participants to evaluate their physiological state when determining their arousal ratings, and that patients may not experience as strong a physiological reaction in response to unpleasant stimuli. Although our results differ from their conclusions, we concur in the sense that our patients with higher PANSS activation scores reported less arousal in response to negative images.

Llerena et al. (2012) also found that males were more likely to report higher arousal ratings for neutral stimuli, but sex effects are an unlikely explanation for our findings. Our sample included more males than females, yet it did not demonstrate higher arousal ratings for neutral stimuli. Our sample was too small, however, to meaningfully examine sex effects. Although the controls were younger than the schizophrenia group, it is unlikely that our results are merely an age effect, as the literature generally supports no differences between age groups (Mather and Knight, 2005; Mikels et al., 2005; Wieser et al., 2006), or higher ratings of arousal in older individuals (Gruhn and Scheibe, 2008; Smith et al., 2005).

Although the present results are not consistent with previous literature, and therefore further replication is needed, they could partially explain the decrease in motivated behavior exhibited in schizophrenia, despite reports of intact emotional experience in the moment. If individuals with schizophrenia are unable to experience arousal in association with anticipated pleasure, they may be less likely to follow through on the associated behavior. Similarly, if attention isn't captured by emotionally salient stimuli individuals with schizophrenia are not likely to exhibit an appropriate behavioral response.

4.3 Limitations

It must be noted that there are some limitations with the present study that could potentially have impacted the results. The emotional and neutral images used in the study were not matched for lower level visual features, such as luminance, complexity, and color saturation, and therefore we cannot be certain that the differences between the groups are not confounded by basic visual processing deficits. While the groups were closely matched for gender, they were not matched for age or education. The disparity in years of education is consistent with the literature and is likely an artifact of the disease (Resnick, 1992), therefore matching for education may actually remove some of the variance across the

groups we studied (Meehl, 1970). Thus, education was not included as a covariate in our analyses., although we did control for age. Another limitation of the study was the small sample size, which did not allow for exploration of sex effects.

Finally, it must be noted that the sample was comprised of non-institutionalized individuals with schizophrenia who were relatively stable with regard to psychiatric symptoms, willing to participate in a research study, and able to attend multiple data collection sessions. These qualities are not characteristic of the large majority of individuals with schizophrenia suggesting some unique characteristics of this patient sample relative to the overall disease, and therefore limiting the generalizability of these results. However, the type of patient able and willing to participate in this study may be more likely to participate in and potentially respond to treatment and therefore the results should be considered in the development of future treatments despite their limited generalizability.

5. Conclusion

This study adds to the growing but mixed body of literature on emotion processing in schizophrenia, providing further evidence for deficits in connections between the neural-emotional system and subsequent cortical processing. The finding of overall reduced identification of emotional T2 images in the schizophrenia group is intriguing and is an area for further exploration, ideally with the addition of fMRI. Additionally, replication of our findings of reduced arousal responses to positive and neutral stimuli in schizophrenia is needed as it may be a substantial component of avolition. Finally, our results highlight the need for future investigations into treatments that might improve neural-emotional circuitry in schizophrenia. Meditation based interventions have been shown to alter neurocortical functioning (Desbordes et al., 2012) and adaptations of this type of intervention should be considered, in addition to pharmacological interventions, to improve neurocortical dysfunction in schizophrenia.

Acknowledgments

The writing of this manuscript was supported by the Department of Veterans Affairs Office of Academic Affiliations Advanced Fellowship Program in Mental Illness Research and Treatment, the Medical Research Service of the Veterans James J Peters Veterans Affairs Medical Center, and the Department of Veterans Affairs VISN 3 Mental Illness Research, Education, and Clinical Center (MIRECC). The authors would like to acknowledge Tara Malone for her assistance with participant recruitment.

Role of the Funding Source: This work was supported by the National Institute of Mental Health grants RC1MH088843 (DM) and 2K24MH00169 (DM).

References

- Anderson AK, Phelps EA. Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature*. 2001; 411(6835):305–309. [PubMed: 11357132]
- Anderson AK. Affective influences on the attentional dynamics supporting awareness. *J Exp Psychol Gen*. 2005; 134(2):258–281. [PubMed: 15869349]
- American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. Washington D.C.: APA; 2000. (4th Edition-Text Revision)
- Berridge KC, Robinson TE. What is the role of dopamine in reward: hedonic impact, reward learning, or incentive salience? *Brain Res Brain Res Rev*. 1998; 28(3):309–369. [PubMed: 9858756]

- Bleuler, E. *Dementia praecox or the group of schizophrenias* (J Zinkin, Trans.). New York, NY: International Universities Press; 1950. (Original work published 1908)
- Chun MM, Potter MC. A two-stage model for multiple target detection in rapid serial visual presentation. *J Exp Psychol Hum Percept Perform*. 1995; 21(1):109–127. [PubMed: 7707027]
- Cheung V, Chen EY, Chen RY, Woo MF, Yee BK. A comparison between schizophrenia patients and healthy controls on the expression of attentional blink in a rapid serial visual presentation (RSVP) paradigm. *Schizophr Bull*. 2002; 28(3):443–458. [PubMed: 12645676]
- Ciesielski BG, Armstrong T, Zald DH, Olatunji BO. Emotion modulation of visual attention: categorical and temporal characteristics. *PLoS One*. 2010; 5(11):e13860. [PubMed: 21079773]
- Cohen AS, St-Hilaire A, Aakre J, Docherty N. Understanding anhedonia in schizophrenia through lexical analysis of natural speech. *Cogn Emot*. 2009; 23(3):569–586.
- Cohen AS, Minor KS. Emotional experience in patients with schizophrenia revisited: meta-analysis of laboratory studies. *Schizophr Bull*. 2010; 36(1):143–150. [PubMed: 18562345]
- Corden B, Chilvers R, Skuse D. Emotional modulation of perception in Asperger's syndrome. *J Autism Dev Disord*. 2008; 38(6):1072–1080. [PubMed: 17990090]
- Davidson RJ. Darwin and the neural bases of emotion and affective style. *Ann N Y Acad Sci*. 2003; 1000:316–336. [PubMed: 14766646]
- De Houwer J, Hermans D. Differences in the affective processing of words and pictures. *Cogn Emotion*. 1994; 8(1):1–20.
- Desbordes G, Negi LT, Pace TW, Wallace BA, Raison CL, Schwartz EL. Effects of mindful-attention and compassion meditation training on amygdala response to emotional stimuli in an ordinary, non-meditative state. *Front Hum Neurosci*. 2012; 6:292. [PubMed: 23125828]
- Desimone R, Duncan J. Neural mechanisms of selective visual attention. *Annu Rev Neurosci*. 1995; 18:193–222. [PubMed: 7605061]
- Dichter GS, Bellion C, Casp M, Belger A. Impaired modulation of attention and emotion in schizophrenia. *Schizophr Bull*. 2010; 36(3):595–606. [PubMed: 18843096]
- Dieleman S, Roder CH. Emotional memory modulation in schizophrenia: an overview. *Acta Psychiatr Scand*. 2013; 127(3):183–194. [PubMed: 23216101]
- Dolan RJ. Emotion, cognition, and behavior. *Science*. 2002; 298(5596):1191–1194. [PubMed: 12424363]
- Fox E, Russo R, Georgiou GA. Anxiety modulates the degree of attentive resources required to process emotional faces. *Cogn Affect Behav Neurosci*. 2005; 5(4):396–404. [PubMed: 16541810]
- Gaigg SB, Bowler DM. Illusory memories of emotionally charged words in autism spectrum disorder: further evidence for atypical emotion processing outside the social domain. *J Autism Dev Disord*. 2009; 39(7):1031–1038. [PubMed: 19296212]
- Goldstein RZ, Volkow ND. Drug addiction and its underlying neurobiological basis: neuroimaging evidence for the involvement of the frontal cortex. *Am J Psychiatry*. 2002; 159(10):1642–1652. [PubMed: 12359667]
- Green SA, Rudie JD, Colich NL, Wood JJ, Shirinyan D, Hernandez L, Tottenham N, Dapretto M, Bookheimer SY. Overreactive brain responses to sensory stimuli in youth with autism spectrum disorders. *J Am Acad Child Adolesc Psychiatry*. 2013; 52(11):1158–1172. [PubMed: 24157390]
- Gruhn D, Scheibe S. Age-related differences in valence and arousal ratings of pictures from the International Affective Picture System (IAPS): Do ratings become more extreme with age? *Behav Res Methods*. 2008; 40(2):512–521. [PubMed: 18522062]
- Gur RE, Loughhead J, Kohler CG, Elliott MA, Lesko K, Ruparel K, Wolf DH, Bilker WB, Gur RC. Limbic activation associated with misidentification of fearful faces and flat affect in schizophrenia. *Arch Gen Psychiatry*. 2007; 64(12):1356–1366. [PubMed: 18056543]
- Heerey EA, Gold JM. Patients with schizophrenia demonstrate dissociation between affective experience and motivated behavior. *J Abnorm Psychol*. 2007; 116(2):268–278. [PubMed: 17516760]
- Hempel RJ, Tulen JH, van Beveren NJ, van Steenis HG, Mulder PG, Hengeveld MW. Physiological responsivity to emotional pictures in schizophrenia. *J Psychiatr Res*. 2005; 39(5):509–518. [PubMed: 15992560]

- Hempel RJ, Tulen JH, van Beveren NJ, Mulder PG, Hengeveld MW. Subjective and physiological responses to emotion-eliciting pictures in male schizophrenic patients. *Int J Psychophysiol.* 2007; 64(2):174–183. [PubMed: 17350125]
- Kay, SR.; Opler, LA.; Fiszbein, A.; Ramirez, PM.; Opler, MGA.; White, L. Positive and Negative Syndrome Scale. Toronto: Multi-Health Systems; 2006.
- Keil A, Ihssen N. Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion.* 2004; 4(1):23–35. [PubMed: 15053724]
- Kensinger EA, Schacter DL. Processing emotional pictures and words: effects of valence and arousal. *Cogn Affect Behav Neurosci.* 2006; 6(2):110–126. [PubMed: 17007232]
- Kim SH, Hamann S. Neural correlates of positive and negative emotion regulation. *J Cogn Neurosci.* 2007; 19(5):776–798. [PubMed: 17488204]
- Kraepelin, E. Dementia Parecox and Paraphrenia (RM Barclay, Trans.). Robertson, GM.; Livingstone, S., editors. New York, NY: Robert E Kreiger; 1971. (Original work published 1919)
- Kring AM, Moran EK. Emotional response deficits in schizophrenia: insights from affective science. *Schizophr Bull.* 2008; 34(5):819–834. [PubMed: 18579556]
- Lang, PJ.; Bradley, MM.; Cuthbert, BN. International affective picture system (IAPS): Affective ratings of pictures and instruction manual Technical Report A-8. Gainesville, FL: University of Florida; 2008.
- Li CS, Lin WH, Yang YY, Huang CC, Chen TW, Chen YC. Impairment of temporal attention in patients with schizophrenia. *Neuroreport.* 2002; 13(11):1427–1430. [PubMed: 12167767]
- Llerena K, Strauss GP, Cohen AS. Looking at the other side of the coin: a meta-analysis of self-reported emotional arousal in people with schizophrenia. *Schizophr Res.* 2012; 142:1–3. 65–70. [PubMed: 23116885]
- Mathewson KJ, Arnell KM, Mansfield CA. Capturing and holding attention: the impact of emotional words in rapid serial visual presentation. *Mem Cognit.* 2008; 36(1):182–200.
- Mather M, Knight M. Goal-directed memory: the role of cognitive control in older adults' emotional memory. *Psychol Aging.* 2005; 20(4):554–570. [PubMed: 16420131]
- Mathis KI, Wynn JK, Breitmeyer B, Nuechterlein KH, Green MF. The attentional blink in schizophrenia: isolating the perception/attention interface. *J Psychiatr Res.* 2011; 45(10):1346–1351. [PubMed: 21550051]
- Meehl, PE. Nuisance variables and the ex post facto design. In: Radner, M.; Winokur, S., editors. *Minnesota Studies in the Philosophy of Science.* University of Minnesota Press; Minneapolis: 1970. p. 373-402.
- Mikels JA, Fredrickson BL, Larkin GR, Lindberg CM, Maglio SJ, Reuter-Lorenz PA. Emotional category data on images from the International Affective Picture System. *Behav Res Methods.* 2005; 37(4):626–630. [PubMed: 16629294]
- Most SB, Chun MM, Widders DM, Zald DH. Attentional rubbernecking: cognitive control and personality in emotion-induced blindness. *Psychon Bull Rev.* 2005; 12(4):654–661. [PubMed: 16447378]
- Most SB, Smith SD, Cooter AB, Levy BN, Zald DH. The naked truth: positive, arousing distractors impair rapid target perception. *Cogn Emotion.* 2007; 21(5):964–981.
- Numberger JI Jr, Blehar MC, Kaufmann CA, York-Cooler C, Simpson SG, Harkavy-Friedman J, Severe JB, Malaspina D, Reich T. Diagnostic interview for genetic studies. Rationale, unique features, and training. NIMH Genetics Initiative. *Arch Gen Psychiatry.* 1994; 51(11):849–859. discussion 863–844. [PubMed: 7944874]
- Opler, LA.; Kay, SR.; Lindenmayer, JP.; Fiszbein, A. Structured Clinical Interview for the PANSS (SCI-PANSS). Toronto: Multi-Health Systems; 1992.
- Panksepp J. At the interface of the affective, behavioral, and cognitive neurosciences: decoding the emotional feelings of the brain. *Brain Cogn.* 2003; 52(1):4–14. [PubMed: 12812799]
- Pierce CA, Block RA, Aguinis H. A cautionary note on reporting eta-squared values from multifactor ANOVA designs. *Educational and Psychological Measurement.* 2004; 64:916–924.
- Phelps EA. Emotion and cognition: insights from studies of the human amygdala. *Annu Rev Psychol.* 2006; 57:27–53. [PubMed: 16318588]

- Raymond JE, Shapiro KL, Arnell KM. Temporary suppression of visual processing in an RSVP task: an attentional blink? *J Exp Psychol Hum Percept Perform.* 1992; 18(3):849–860. [PubMed: 1500880]
- Resnick SM. Matching for education in studies of schizophrenia. *Arch Gen Psychiatry.* 1992; 49(3): 246. [PubMed: 1567279]
- Shapiro KL, Raymond JE, Arnell KM. The attentional blink. *Trends Cogn Sci.* 1997; 1(8):291–296. [PubMed: 21223931]
- Smith DP, Hillman CH, Duley AR. Influences of age on emotional reactivity during picture processing. *Journals of Gerontology.* 2005; 60B:49–56.
- Smith SD, Most SB, Newsome LA, Zald DH. An emotion-induced attentional blink elicited by aversively conditioned stimuli. *Emotion.* 2006; 6(3):523–527. [PubMed: 16938093]
- Smith SD, Most SB, Newsome LA, Zald DH. An emotion-induced attentional blink elicited by aversively conditioned stimuli. *Emotion.* 2006; 6(3):523–527. [PubMed: 16938093]
- Strauss GP, Catalano LT, Llerena K, Gold JM. The processing of emotional stimuli during periods of limited attentional resources in schizophrenia. *J Abnorm Psychol.* 2013; 122(2):492–505. [PubMed: 23421529]
- Taylor SF, Phan KL, Britton JC, Liberzon I. Neural response to emotional salience in schizophrenia. *Neuropsychopharmacology.* 2005; 30(5):984–995. [PubMed: 15689961]
- Trémeau F, Antonius D, Cacioppo JT, Ziwich R, Jalbrzikowski M, Saccente E, Silipo G, Butler P, Javitt D. In support of Bleuler: objective evidence for increased affective ambivalence in schizophrenia based upon evocative testing. *Schizophr Res.* 2009; 107:2–3. 223–231.
- Trémeau F, Antonius D, Cacioppo JT, Ziwich R, Butler P, Malaspina D, Javitt DC. Anticipated, on-line and remembered positive experience in schizophrenia. *Schizophr Res.* 2010; 122:1–3. 199–205. [PubMed: 20655178]
- Tripe RH, Hewig J, Heydel C, Hecht H, Miltner WH. Attentional Blink to emotional and threatening pictures in spider phobics: electrophysiology and behavior. *Brain Res.* 2007; 1148:149–160. [PubMed: 17367765]
- Ursu S, Kring AM, Gard MG, Minzenberg MJ, Yoon JH, Ragland JD, Solomon M, Carter CS. Prefrontal cortical deficits and impaired cognition-emotion interactions in schizophrenia. *Am J Psychiatry.* 2011; 168(3):276–285. [PubMed: 21205806]
- Weiner RU, Opler LA, Kay SR, Merriam AE, Papouchis N. Visual information processing in positive, mixed, and negative schizophrenic syndromes. *J Nerv Ment Dis.* 1990; 178(10):616–626. [PubMed: 2230746]
- White L, Harvey PD, Opler L, Lindenmayer JP. Empirical assessment of the factorial structure of clinical symptoms in schizophrenia. A multisite, multimodel evaluation of the factorial structure of the Positive and Negative Syndrome Scale. The PANSS Study Group. *Psychopathology.* 1997; 30(5):263–274. [PubMed: 9353855]
- Wieser MJ, Muhlberger A, Kenntner-Mabiala R, Pauli P. Is emotion processing affected by advancing age? An event-related brain potential study. *Brain Res.* 2006; 1096(1):138–147. [PubMed: 16750819]
- Wise RA. Neuroleptics and operant-behavior – the anhedonia hypothesis. *Behav Brain Sci.* 1982; 5:39–53.
- Wynn JK, Breitmeyer B, Nuechterlein KH, Green MF. Exploring the short term visual store in schizophrenia using the attentional blink. *J Psychiatr Res.* 2006; 40(7):599–605. [PubMed: 16890242]
- Yiend J. The effects of emotion on attention: A review of attentional processing of emotional information. *Cognition & Emotion.* 2010; 24(1):3–47.

Figure 1.
Mean D-Prime Values for Emotional and Neutral Pictures Under the 200ms and 700ms Lag Conditions

Figure 2.
D-Prime Difference Scores for Emotion-Neutral Images under the 200ms and 700ms Lag Conditions

Figure 3.
Mean D-Prime Values for Positive, Negative, and Neutral Pictures Under the 200ms and 700ms Lag Conditions

Figure 4.
D-Prime Difference Scores for Positive-Neutral and Negative-Neutral Images under the 200ms and 700ms Lag Conditions

Table 1

Demographic Information for Individuals with Schizophrenia and Controls.

	Controls			Schizophrenia			<i>t</i>	<i>p</i>
	<i>n</i>	<i>M</i>	(<i>SD</i>)	<i>n</i>	<i>M</i>	(<i>SD</i>)		
Age	25	36.72	(11.28)	25	45.72	(8.16)	-3.19	.003**
Education	25	14.96	(1.43)	25	13.28	(2.15)	3.25	.002**
PANSS Ratings								
Positive ¹	-	-	-	23	14.44	(5.55)		
Negative ¹	-	-	-	23	13.35	(4.33)		
General Psychopathology ¹	-	-	-	23	27.70	(7.71)		
Negative Factor ²	-	-	-	23	15.18	(3.95)		
Positive Factor ²	-	-	-	23	10.70	(5.01)		
Activation Factor ²	-	-	-	23	8.39	(2.45)		
Dysphoric Factor ²	-	-	-	23	12.17	(5.00)		
Autism Factor ²	-	-	-	23	9.96	(3.44)		
	<i>n</i>	%		<i>n</i>	%		χ^2	<i>p</i>
Gender (Male/Female)	14/11	56/44		16/9	64/36		0.33	.564
Racial/Ethnic Background							4.05	.256
Caucasian	10	40		5	20			
Hispanic	4	16		4	16			
Black/African American	10	40		16	64			
More than one race	1	4		0	0			

¹ Original PANSS Subscales (Kay et al. 2006)² Revised PANSS Factors (White et al., 1997)* *p* < .05.** *p* < .01.

Table 2

Means and Standard Deviations of Visual Hedonics and Arousal Ratings Measures for Schizophrenia Cases (n=25) and Healthy Controls (n=25)

	Controls		Schizophrenia		<i>t</i>	<i>p</i>	<i>d</i>
	<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)			
Pleasantness Total	32.24	(9.23)	40.04	11.50	-2.645	.011*	-0.748
Neutral Images	11.68	5.41	17.95	8.60	-3.089	.004**	-0.873
Negative Images	1.60	2.96	2.40	2.50	-1.033	.307	-0.292
Positive Images	18.96	4.90	19.69	4.05	-0.571	.571	-0.162
Unpleasantness Total	23.62	7.76	30.62	12.03	-2.447	.018*	-0.697
Neutral Images	3.46	4.22	7.45	6.58	-2.556	.014*	-0.723
Negative Images	19.52	5.85	21.00	4.91	-0.969	.337	-0.274
Positive Images	0.64	1.29	2.17	5.04	-1.474	.152	-0.416
Arousal Total	56.55	15.17	43.64	(20.51)	2.531	.015*	0.716
Neutral Images	21.92	(7.11)	15.02	(9.66)	2.878	.006**	0.814
Negative Images	19.84	(6.05)	18.00	(7.50)	0.955	.345	0.270
Positive Images	14.79	(6.35)	10.62	(7.87)	2.063	.045*	0.583

* $p < .05$.

** $p < .01$.

Table 3

Mean Hit Rate Percentage, False Positive Percentage of Neutral and Emotional Images under the 200 ms and 700 ms lag times in Schizophrenia (N=25) and Healthy Controls (N=25)

	Control			Schizophrenia		
	MH %	MFP %		MH %	MFP %	
T1	17%	9%		30%	32%	
T2 Neutral 200ms	13%	11%		14%	31%	
T2 Neutral 700ms	17%	7%		34%	29%	
T2 Emotional 200ms	15%	10%		30%	35%	
T2 Emotional 700ms	15%	7%		22%	35%	
T2 Negative 200ms	11%	7%		28%	33%	
T2 Negative 700ms	8%	6%		34%	31%	
T2 Positive 200ms	21%	14%		33%	36%	
T2 Positive 700ms	20%	8%		13%	37%	