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Associations between trait anhedonia and emotional memory deficits in females with schizophrenia versus major depression

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Abstract

Individuals with schizophrenia (SZ) and individuals with major depressive disorder (MDD) demonstrate impaired emotional memory and decreased enjoyment of pleasant experiences (e.g., anhedonia). However, it is unclear whether these impairments reflect similar or different processes in the two diagnostic groups. This study compared emotional memory performance in three groups of females – controls, MDD, and SZ. Given that physical and social trait anhedonia has been shown to differentiate course of illness and emotional functioning within each disorder, the present study also examined whether trait anhedonia related to emotional memory differently in the groups. Participants viewed emotional and neutral images and twenty-four hours later completed an incidental recognition test. SZ participants demonstrated a trend for the worst memory performance. Across all groups, high intensity and negative images were remembered most accurately, while groups were not differentially influenced by the valence of the stimuli. Physical anhedonia was predictive of reduced memory for negative stimuli across all diagnostic groups. Group specific findings indicated that higher levels of social anhedonia were predictive of poorer memory, but only in the SZ group. Effects remained significant when controlling for depressive symptoms. Results are considered in light of the differing role of anhedonia in SZ and MDD.

Keywords

physical anhedonia, social anhedonia, long-term memory; emotion; affective stimuli; arousal; sex differences

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1. Introduction

In the general population, emotional material with positive or hedonic content is particularly salient as people remember positive stimuli better than neutral stimuli (LaBar and Cabeza, 2006; Mickley and Kensinger, 2008) and overestimate positive emotions when recalling past experiences (Walker et al., 2003). Similarly, material that is negatively valenced and highly arousing is more memorable than neutral material (Cahill and McGaugh 1998). However, the facilitative effect of emotional valence on memory seen in the general population (e.g., Bradley et al., 1992) appears to be abnormal in schizophrenia (SZ). Individuals with SZ do not consistently show the enhanced recognition memory for positive stimuli seen in healthy controls (Koh et al., 1981; Calev and Edelist, 1993; Hall et al., 2002; Lakis et al., 2011), although some studies report this pattern (Harvey et al., 2009; Sergerie et al., 2010). While SZ participants show a robust negativity bias similar to controls (Calev and Edelist, 1993; Mathews and Barch, 2004), negative stimuli have also been shown to have a detrimental effect on memory in SZ (Hall et al., 2007). Also atypical is the pattern of superior memory for negative compared to positive stimuli observed in some studies in SZ (Calev and Edelist, 1993; Herbener et al., 2007). In sum, individuals with SZ evidence atypical emotional memory, albeit with considerable variability among the pattern of identified abnormalities.

1.1. Specificity of emotional memory deficits

Emotional memory impairments are also found in other mental disorders, most notably, major depressive disorder (MDD) (Mathews and MacLeod, 2005; Dere et al., 2010). For instance, depressed individuals show reduced memory enhancement for positive emotional stimuli and enhanced memory for negative material (Sloan et al., 2001; Ridout et al., 2003; Hamilton and Gotlib, 2008), when compared to controls. There do appear to be differences between SZ and MDD in emotional memory. For instance, enhanced memory for negative stimuli is more robustly found in MDD than in SZ. However, a number of factors in past studies – such a differences in methods, task parameters, and clinical presentation– make it difficult to reach conclusions about relative impairments in the two groups.

1.2. Emotional memory and clinical symptoms

Deficits in memory for positive experiences may be particularly important in both disorders, given that activities associated with past hedonic states are believed to motivate pursuit of similar activities in the present (Berridge and Robinson, 2003). Researchers in schizophrenia (Horan et al., 2006) and depression (Liu et al., 2012) have noted that hedonic deficits may be related to poor memory for pleasurable events. Trait anhedonia, which reflects stable diminished attitudes towards pleasurable social and physical/sensory experiences (Chapman et al., 1976), has long been recognized as a core feature of schizophrenia (Bleuler, 1911; Herbener and Harrow, 2002) and depression (Klein, 1987; Clark and Watson, 1991). It has also been hypothesized that trait anhedonia may broadly relate to deficient recruitment of neural regions responsible for signaling salient information, and supportive of this hypothesis, a number of past studies demonstrate that elevated anhedonia in SZ, MDD, and control samples is associated with less differentiated ventral striatal BOLD response to neutral versus emotional stimuli (Epstein et al., 2006; Dowd and Barch, 2010; Harvey et al., 2010). This diminished salience signaling could contribute to difficulties in prioritizing

emotional experiences for memory consolidation. Moreover, trait anhedonia is also strongly implicated in prefrontal regions responsible for reward guided decision making, regulation of positive emotion, and linking affect with goal directed behavior (Keedwell et al., 2005; Harvey et al., 2007; Wacker et al., 2009; Becerril and Barch, 2011; Ursu et al., 2011; Hooker et al., 2014). Collectively, deficient functioning in frontal-striatal networks may relate to trait anhedonia and emotional memory deficits.

Two elements of trait anhedonia, physical and social anhedonia (Chapman et al., 1976), may be relevant to distinguishing clinical features and emotional memory deficits in the two disorders. For instance, physical anhedonia (PA), including deficits in physical and sensory experiences, has been found to predict lower hedonic and emotional responses (Blanchard et al., 1994; Berlin et al., 1998) in both disorders. Moreover, PA is associated with worse overall course in both disorders including prolonged illness onset in SZ (Herbener and Harrow, 2002) and with severity of depressive symptoms and social impairment in MDD (Loas et al., 1992; Shankman et al., 2011). Social anhedonia (SA), the experience of decreased interest and enjoyment from social activities and relationships (Chapman et al., 1976), is also relevant to examining emotional memory deficits. For instance, SA has been reliably associated with reduced response to emotional and social stimuli in control samples (Mathews and Barch, 2006; Hooker et al., 2014). Reductions in neurocognitive performance are also evident in control (Cohen et al., 2006) and SZ participants (Horan and Blanchard, 2003). In comparison to PA, SA appears to be more strongly implicated in clinical outcomes for individuals with SZ versus MDD. For instance, SA is a robust trait marker for schizophrenia spectrum disorders (Blanchard et al., 2001) and subsequent conversion to schizophrenia illness (Kwapil 1998), whereas elevated SA in individuals with MDD is restricted to active depressive episodes (Blanchard et al., 2001). Altogether, PA and SA are relevant to emotional memory deficits in the two disorders, yet SA is likely to be particularly relevant to individuals with SZ.

However, data supporting the hypothesized relationship between anhedonia and emotional memory is equivocal. Associations with poor emotional memory are found for clinician-rated indices of negative symptoms among SZ (Mathews and Barch, 2004; Hall et al., 2007), but less so for self-reports of anhedonia (Horan et al., 2006; Harvey et al., 2009). Two separate studies (Mathews and Barch, 2006; Herbener et al., 2007) found associations between trait anhedonia (PA and SA) and immediate emotional responses to stimuli among controls, yet trait anhedonia was unrelated to memory for these stimuli. Although comparable studies are less frequently found in the depression literature, Liu and colleagues (2012) found associations between reduced recognition of positive words and trait anhedonia among a MDD sample.

In addition to trait anhedonia, the relative contribution of overall depressive symptoms to emotional memory in both disorders is also unclear. In MDD, heightened memory for negative stimuli has been associated with depressive mood (Ridout et al., 2003; Gotlib and Joorman, 2010). Depressive symptoms have also been associated with reduced emotional memory in SZ (Mathews and Barch, 2004), but not consistently (Hall et al., 2007; Neumann et al., 2007). Additionally, depressive symptoms are also found to impact general neurocognitive and non-emotional memory in both disorders (Brebion et al., 1997; Brebion

et al., 2009). Thus, the relative role of depressive symptoms and trait anhedonia in emotional memory performance in both SZ and MDD groups is unclear.

Based on this literature, we hypothesized that a) SZ and MDD groups would show general impairments in memory compared to controls, with the SZ group demonstrating greater memory impairment than the MDD group; b) both the SZ and MDD groups would show poorer memory for positive stimuli than controls; and c) the MDD group would demonstrate a heightened memory for negative stimuli in comparison to both the control and SZ groups. We also aimed to examine whether trait anhedonia and/or depressive symptoms contributed to emotional memory performance in the psychiatric samples. More specifically, physical anhedonia (PA) is suspected to impact memory performance in both SZ and MDD groups while social anhedonia (SA) is suspected to have a unique impact on performance in the SZ group.

2. Method

2.1 Participants

Twenty-five females with a diagnosis of schizophrenia, 18 females with a current diagnosis of major depressive disorder, and 33 female control participants were recruited at the University of Illinois at Chicago Medical Center, by physician referral and advertisements (see Table 1 for demographic information). Males were also recruited for the study, but analyses were limited to female subjects because men and women have been shown to exhibit different patterns of both emotional (Canli et al., 2002) and non-emotional memory (Andreano and Cahill, 2009) and sample sizes for males were extremely unbalanced across the three groups. Thirteen SZ participants and 15 controls were included in previously published data (Herbener et al., 2007).

Clinicians made diagnoses according to the Structured Clinical Interview for DSM-IV (First et al., 2002). One SZ participant met criteria for a comorbid anxiety disorder and 1 met criteria for a comorbid mood disorder. Six MDD participants met criteria for a comorbid anxiety disorder. All research participants were screened for a history of head trauma resulting in loss of consciousness, history of neurological injury or impairment, current substance abuse, and an IQ below 70 as assessed by the Wechsler Abbreviated Scale of Intelligence. Controls were excluded if they had a lifetime history of Axis I disorder or family history of SZ in first degree relatives. Chlorpromazine equivalent dosages were derived from Gardner and colleagues (2010) (see Table 2). All procedures were approved by the local institutional review board.

2.2 Assessments and measures

2.2.1. Clinical symptom measures—Severity of symptoms in SZ and MDD were assessed with the Positive and Negative Syndrome Scale (PANSS; Kay et al 1987), and the Hamilton Depression Rating Scale (HDRS; Hamilton, 1960). Ratings were completed by experienced doctoral-level clinicians trained to a kappa-reliability of 0.80 or higher.

2.2.2. Trait anhedonia—All participants completed the Physical and Social Anhedonia Scales (Chapman et al., 1976), a true/false self-report measure assessing enduring attitudes towards pleasurable experiences in physical and social domains.

2.3. Emotional memory task

The emotional memory task was a computer-based task with the incidental encoding task occurring on the first day and the recognition task occurring the following day.

2.3.1. Encoding—Participants were presented with a series of pictures and rated the intensity of their emotional response to each image as it was presented. Thirty positive, negative, and neutral images were selected from the International Affective Picture System (IAPS) database. Emotional images (positive and negative) were matched on arousal based on available norms (Lang et al., 2005). Each of the three valence categories included 20 images with, and 10 without, human content. Extreme images in the IAPS database (i.e., sexually explicit activities, mutilated bodies) were excluded.

Images were displayed on a 19-in. flat screen monitor positioned 24 in. from participants. Images were presented for 3-s each in blocks of 10 images of the same valence. A 15-s break period between blocks was included to reduce transfer of emotional states across valence blocks. Blocks were presented in a counterbalanced order as determined by a Latin square design. Participants rated the strength of their emotional response to each image, with responses dichotomized to low (mild or none) or high (moderate to strong) impact.

2.3.2. Recognition—Participants again viewed positive, negative, and neutral images presented in blocks by valence. Images were presented for 3-s each in blocks of 14, with a 15-s break between blocks. Order of blocks was counterbalanced as in the encoding task. Each block consisted of seven images presented the previous day (old images) and seven novel images. Participants were told to indicate whether they had seen the image on the previous day, or if it was novel. Novel images were matched on valence, arousal, and human content to images presented during the encoding task.

2.4. Statistical analyses

To test for group differences in sociodemographic and clinical variables, analyses of variance (ANOVA) were conducted. Kruskal-Wallis and Mann-Whitney tests were performed for demographic variables that were not normally distributed. Intensity of emotional response to the images during the encoding task was indicated by the proportion of total items given ratings of “high impact” by valence. To assess recognition accuracy, discrimination (Pr) was calculated according to the two-high threshold model (Snodgrass and Corwin, 1988). Discrimination measures the ability to correctly discriminate old from new stimuli and was defined as: proportion accurate recognition minus proportion false positives.

Mixed-design ANOVAs were used to assess effects of group and valence on encoding and recognition measures. In each analysis, diagnostic group (SZ, MDD, controls) was the between-subjects factor and image valence (positive, negative, neutral) was the within-

subjects factor. Pairwise comparisons were performed to follow up significant main effects and to test focused hypotheses. Pearson's r was calculated to determine effect sizes for contrasts involving group.

The relationship between anhedonia (both PA and SA) and emotional memory were examined using a series of moderated hierarchical regressions (Aiken and West, 1991). In these analyses, discrimination accuracy was used as the dependent variable, and trait anhedonia (centered) was entered in the first block, two dummy codes for diagnostic group (using controls as the reference group) in the second block, and the interaction of the dummy codes with anhedonia in the third block. Interactions were followed up using standard conditional moderator procedures. All regressions were run separately for each valence and for both types of trait anhedonia, PA and SA. To ensure that results were specific to anhedonia and not driven by the effect of overall depressive symptom severity, we repeated these analyses, but entered total HDRS scores (centered) in the first block, followed by trait anhedonia, diagnostic group (dummy-coded using MDD participants as the reference group), and the anhedonia by group interaction term. This analysis was limited to the MDD and SZ groups because control participants did not complete the HDRS.

3. Results

3.1 Demographic and clinical characteristics

The three groups did not differ on age, education, current or premorbid IQ. Diagnostic groups differed on social anhedonia, $H(2) = 12.74$, $P < 0.01$, such that MDD participants had the highest levels of social anhedonia compared to controls and SZ (P 's < 0.05), while SZ and controls did not differ from each other $U = 160.00$, $z = -1.60$, $P = 0.11$. A group effect at a trend level of statistical significance emerged for physical anhedonia, $F(2,71) = 2.49$, $P = 0.09$. MDD participants had significantly higher depressive symptoms (HDRS) than SZ participants, $H(1, 41) = 8.15$, $P < 0.01$, while SZ participants had higher positive symptoms (PANSS) than MDD participants, $H(1) = 19.81$, $P < 0.001$. The MDD and SZ participants did not differ on negative symptoms, $F(1, 41) = 0.24$, $P = 0.63$, or general symptoms, $F(1, 41) = 0.10$, $P = 0.75$. SZ participants had higher levels of Chlorpromazine equivalent dosages than MDD participants, $H(1) = 7.23$, $P < 0.01$, (see Tables 1-2).

3.2. Group differences for emotional memory task

3.2.1. Encoding—In order to examine the effect of image valence on emotional response during encoding, we compared ratings of the intensity of emotional response among the three groups. There was a significant main effect of group, $F(2, 72) = 3.73$, $P < 0.05$; follow-up analyses indicated that across all valences, the SZ participants reported stronger emotional responses than the MDD, $F(1,41) = 6.87$, $P < 0.05$, $r = 0.38$, and control participants, $F(1, 54) = 4.97$, $P < 0.05$, $r = 0.29$. MDD participants and controls did not significantly differ in their emotional response to the stimuli, $F(1, 47) = 0.24$, $P = .63$, $r = 0.07$, (see Figure 1). A main effect of valence, $F(2, 142) = 148.11$, $P < 0.001$, indicated that across groups, intensity of emotional response was highest for negative, followed by positive, and then neutral images (all P 's < 0.01). The group $\times$ valence interaction was not statistically significant ($F(4, 142) = 1.03$, $P = 0.39$).

3.2.2. Recognition—To determine if the clinical groups evidenced general impairments in emotional memory, we compared recognition memory (discrimination) among the three groups. Results revealed a main effect of group at a trend level of statistical significance, $F(2, 71) = 2.87, P = 0.06$. Given a priori hypotheses, we performed planned pairwise comparisons among the groups. Consistent with hypotheses, SZ participants had significantly lower discrimination values (across all valences) and thus worse memory than the controls, $F(1, 54) = 7.31, P < 0.01, r = 0.35$ (see Figure 2), while the MDD participants did not differ from controls, $F(1, 47) = 2.76, P = 0.10, r = 0.24$, or SZ participants, $F(1, 41) = 0.19, P = 0.66, r = 0.07$. Hypotheses regarding group differences in memory for the positive and negative stimuli were tested via the valence main effect and the group $\times$ valence interaction ($F(2, 142) = 1.32, P = 0.27$ and $F(1, 71) = 0.53, P = 0.72$, respectively). However, neither of these effects was statistically significant.

Given the group differences in *emotional response* during encoding, exploratory analyses were conducted to examine the effect of intensity of emotional response on subsequent memory. For this analysis, we calculated discrimination scores for items initially rated as evoking “high” versus “low” emotional responses for each subject. Due to the low number of neutral items that had elicited strong emotional responses – and thus the potential for confound between valence and emotional response – neutral stimuli were excluded from this analysis. We then ran a mixed design ANOVA using group as a between subjects variable, and emotional response (high vs. low) and valence (negative vs. positive) as within subjects variables, with discrimination as the dependent variable. A main effect of emotional intensity, $F(1,63) = 5.18, P < 0.05$, indicated that items rated as high intensity at encoding were more accurately identified than items rated as low intensity at encoding. Nonsignificant interactive effects for group $\times$ intensity, $F(2,63) = 0.05, P = 0.95$, indicated that intensity of emotional response did not impact subsequent memory differently in the three groups. A main effect of valence, and valence, $F(1,63) = 4.23, P < 0.05$, indicated that participants remembered negative images more accurately than positive images. Nonsignificant interactive effects for group $\times$ valence, $F(2,63) = 0.99, P = 0.38$, indicated that image valence did not impact subsequent memory differently in the three groups.

3.3. Relationship between anhedonia and emotional memory

We next examined whether trait anhedonia ratings predicted recognition memory (discrimination) of positive, negative, and neutral images using a series of hierarchical regressions. We found no significant main effects in analyses examining the main effect of social anhedonia (SA) in predicting discrimination (all P 's > 0.09). To examine the interactive effect of SA and group on emotional memory, we entered the two-way SA $\times$ group interaction in the third block. Results indicated that non-significant main effects were qualified by significant SA $\times$ group interactions for discrimination of positive, negative, and neutral images (all P 's < 0.05). In order to assess how SA predicted memory differently in the groups, we followed-up the SA $\times$ group interactions using conditional moderator variables and interaction terms (per Aiken and West, 1991). Results indicated that higher levels of SA predicted lower discrimination of positive, $\beta = -0.53, t(68) = -2.55, P < 0.05$, negative, $\beta = -0.63, t(68) = -3.02, P < 0.005$, and neutral images, $\beta = -0.52, t(68) = -2.41, P < 0.05$, among the SZ participants. However, SA was not associated with discrimination for

any of the three valences among the MDD participants (P 's >0.17) or controls (P 's >0.61) (see Figure 3).

To test whether results were specific to SA, versus a more general affective disturbance, we repeated the analyses including HRDS scores to assess the impact of mood effects. Again, no significant main effects were found for SA predicting discrimination (P 's >0.49). However, similar SA $\times$ group interactions were found for positive, negative, and neutral images (P 's <0.05). Results indicated that among SZ participants, higher levels of SA predicted lower discrimination of negative images, $\beta = -0.49$, $t(38) = -3.02$, $P < 0.05$, as well as positive, $\beta = -0.43$, $t(38) = -1.93$, $P = 0.06$, and neutral images, $\beta = -0.42$, $t(38) = -1.89$, $P = 0.07$, but at a trend level of significance. Again, SA was not associated with discrimination for any of the three valences among the MDD participants (P 's >0.22). Thus, the effects for SA remained for negative images and to a lesser extent for positive and neutral, ruling out the possibility that results were solely driven by concurrent depressive symptoms in the SZ and MDD groups.

In analogous analyses examining Physical Anhedonia (PA), a significant main effect was found for PA with higher levels of PA predicting lower discrimination of negative images ($P < 0.05$) but not positive or neutral images (P 's >0.16). To examine the interactive effect of PA and group on emotional memory, we entered the two-way PA $\times$ group interaction in the third block. Non-significant effects were found for the PA $\times$ group interaction for discrimination of positive, negative, and neutral images (all P 's >0.14). Due to non-significant effects, analyses examining the potential impact of mood effects were not conducted.

In summary, higher levels of physical anhedonia (PA) were predictive of reduced memory of negative images across all diagnostic groups. Consistent with hypotheses, social anhedonia (SA) had a unique impact on memory performance in the SZ group. Specifically, higher levels of SA predicted lower memory of both emotional and neutral images. The effect of SA on memory remained significant after controlling for depressive symptoms for negative images and to a lesser extent for positive and neutral images.

4. Discussion

To our knowledge, the present study is the first to compare emotional memory performance and examine associations with anhedonia in schizophrenia and depression. There were three main findings.

4.1. General memory impairments were specific to schizophrenia

SZ participants demonstrated significantly poorer memory performance than healthy participants, while MDD participant performance did not significantly differ from either the SZ or control participants. This is consistent with studies implicating identifiable albeit less profound neuropsychological deficits (Egeland et al., 2003) in depressed compared to schizophrenia samples. In contrast to our hypotheses, we did not find that stimuli valence had a different impact on memory performance as a function of diagnostic group. We discuss potential reasons for these findings below.

4.2. Relationship between memory deficits and trait anhedonia were specific to schizophrenia

An interactive effect of anhedonia and group revealed that higher levels of social anhedonia (SA) predicted poorer memory for the emotional and neutral stimuli among SZ participants. Physical Anhedonia (PA) was also predictive of poor memory, but exclusively memory for negative stimuli. Interactive effects of PA and group were not observed, reflective of a trans-diagnostic role of PA on memory for negative stimuli. Relationships between SA and memory performance were not observed in the control or MDD groups.

As noted earlier, SA is associated with reduced response to emotionally evocative stimuli and thus we predicted a particularly strong relationship between SA and abnormalities in memory for emotionally salient stimuli. Partially in line with these predictions, higher levels of SA predicted reduced memory for positive, negative, and neutral images. Notably, SA continued to be a robust predictor of reduced memory for *negative* images and to lesser extent positive and neutral images, when controlling for the effect of depressed mood. The less robust association of SA with memory for positive stimuli was unexpected considering a growing body of research implicating trait anhedonia with deficient recruitment of neural regions while processing positive information. For instance, inverse relationships between SA and neural activity in the caudate (Dowd & Barch, 2010) and ventral lateral prefrontal cortex (VLPFC) are found when control samples process positive and socially relevant stimuli (Hooker et al., 2014). We additionally found that higher levels of PA were predictive of reduced memory of negative images across all three diagnostic groups. Again, failure to find more consistent relationships between PA and emotional memory are surprising as elevated PA is associated with atypical neural response to positive stimuli in striatal and prefrontal regions among controls and SZ participants (Harvey et al., 2007; Dowd and Barch, 2010; Harvey et al., 2010), and with MDD participants (Keedwell et al., 2005; Epstein et al., 2006), albeit with measures of anhedonia typically used with depressed samples. One tentative explanation for our findings may relate to gender as this is known to influence emotional processing, and, potentially, emotional memory. Men and women have been shown to exhibit different patterns of emotional (Canli et al., 2002) and non-emotional memory (Andreano and Cahill, 2009). Moreover, females demonstrate enhanced physiological responding to negative stimuli (Gard and Kring, 2007) and remember more details of negative stories (Andreano and Cahill, 2009). Altogether, the current data suggest neural networks relating to trait anhedonia, salience signaling, and memory consolidation encompass processing of both positive *and* negative stimuli in women. However, neuroimaging studies involving direct comparisons of women and men are needed to examine this possibility.

Notably, memory performance was not specifically associated with trait anhedonia in the MDD group in this sample, even though MDD participants reported elevated levels of SA relative to SZ participants and comparable levels of PA and negative symptoms. One reason for this may be that the trait anhedonia scale taps a different construct in the groups – for example, MDD participants' ratings of anhedonia may be heavily influenced by clinical state and less reflective of core/stable affective deficits (Blanchard et al., 2001). Notably, all MDD participants were experiencing a current major depressive episode during study

participation. Consistent with this view, Shankman et al. (2010) documented significant relationships between severity of depressive symptoms and ratings of trait PA over time in individuals with MDD. Further, Shankman and colleagues (2010) found that, although PA was associated with some measures of functional performance, it tended to lose associative significance when depressive systems were included in analyses. In contrast, both SA (Blanchard et al., 2001) and PA (Herbener and Harrow 2002) remain consistent across SZ illness even when controlling for current (i.e., more state related) depressive symptoms. Further, trait anhedonia in SZ is consistently implicated in long-term cognitive and emotional functioning (Horan and Blanchard, 2003) and clinical outcome (Herbener et al., 2005).

Alternatively, the Chapman anhedonia scales have been criticized for confounding hedonic capacity, motivational processes, and attitudes and value assigned to pleasurable experiences (Leventhal et al., 2006). It may also elicit cognitive processes (memory for previous experiences of pleasure, affective forecasting) similar to those involved in general recollective experience (Harvey et al., 2009). Thus, co-occurrence of impairments in memory and trait anhedonia may be more apparent in SZ participants, where cognitive representations (i.e., the ability recall previous experiences and imagine future scenarios) are more broadly impaired.

4.3. Memory performance was not differentially influenced by valence across groups

Contrary to our predictions, and results from some prior studies (Koh et al., 1981; Calev and Edelist, 1993; Hall et al., 2002; Hamilton and Gotlib, 2008; Lakis et al., 2011), the three groups did not significantly differ in their recognition accuracy for positive, negative, and neutral stimuli. The absence of group differences related to valence in this sample may have been influenced by the gender of the sample. Neuroscience research has made it increasingly clear that gender influences multiple aspects of emotional response and neural processing. Compared to men, women have been shown to experience emotional stimuli as more arousing (Li et al., 2008) and activate distinct neural networks during encoding and recollection of emotionally salient stimuli (Cahill et al., 2001). Past schizophrenia research has suggested that females evidence preserved emotional processing in comparison to their male counterparts (Scholten et al., 2005; Campellone and Kring, 2013). Further, as Kring and colleagues (Gard and Kring 2007; Kring et al., 2010) have documented, there are gender differences in the time course of emotional responses in schizophrenia, which could influence memory processes dependent on salience signaling (Cahill and McGaugh, 1998). It may be that impairments in emotional memory are more characteristic of males with schizophrenia, and that preserved emotional processing in women with schizophrenia is protective of their emotional memory.

Methodological differences may also account for this finding. Previous research (Herbener, 2008; Dieleman and Röder, 2013) suggests the facilitative effect of emotional valence on memory is more often preserved in SZ on tasks involving intentional encoding, shorter delays, and stronger emotional stimuli. Comparatively, our study utilized an incidental task, a 24 hour delay, and excluded extreme images.

Last, the present results did not support a negative memory bias specific to the MDD group. Rather, all participants reported an enhanced response towards negative images during encoding and recognition. This may relate to the nature of the stimuli used. Many studies reporting emotional memory biases in MDD utilize *verbal*, self referential stimuli (e.g., adjectives) which activate a deeper level of processing during encoding and recognition (Wisco, 2009). These are presumably distinct to the emotional responses made to the *pictorial* stimuli in the present task. Accordingly, negative emotional biases in MDD are more consistently found for explicit memory tasks (Gotlib and Joorman et al., 2010), and implicit tasks involving conceptual processing (Watkins et al., 2000). While emotional and non-emotional memory deficits in SZ are more readily found for pictorial than verbal stimuli (Herbener, 2008), much of the research in MDD utilize verbal paradigms making such comparisons difficult.

4.4. Limitations

The major limitation of this study was that our sample sizes were relatively small (SZ = 25, MDD = 18), and thus replication studies are warranted to determine the generalizability of these effects. Additionally, gender hypotheses should be tested in larger samples that are sufficiently powered to detect interactions of gender, emotion, and memory performance.

4.5. Conclusion

In summary, we found that individuals with schizophrenia show greater memory impairment than do depressed individuals and controls. Physical anhedonia was predictive of reduced memory for negative stimuli across all diagnostic groups. In contrast, social anhedonia was only predictive of memory deficits in schizophrenia, and this association remained significant when controlling for depressive symptoms, suggesting specificity to the dimension of anhedonia. Future studies are needed to examine the specific mechanisms that underlie this association and to clarify the role of gender in this relationship.

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Highlights

- Females with schizophrenia (SZ), major depressive disorder (MDD), and controls (HC) completed an emotional memory task.
- Participants viewed emotional and neutral images and 24 hours later completed an incidental recognition test.
- SZ showed greater memory impairment than MDD and HC participants.
- Physical anhedonia was predictive of reduced memory for negative stimuli across all diagnostic groups.
- Social anhedonia was predictive of memory deficits, but only in SZ participants.
- This effect remained significant when controlling for depressive symptoms.

Figure 1. Percentage of positive, neutral, and negative International Affective Picture System images rated high intensity by schizophrenia (SZ), major depressive disorder (MDD), and control (HC) participants. Error bars depict standard error. $*P < .05$

Figure 2. Mean Discrimination Index for recognition of positive, neutral, and negative International Affective Picture System images seen by schizophrenia (SZ), major depressive disorder (MDD), and control (HC) participants. Error bars depict standard error. $*P < .05$

Figure 3.

Regression lines for relations between social anhedonia and discrimination of positive, negative, and neutral items as moderated by group status for schizophrenia (SZ), major depressive disorder (MDD), and control (HC) participants. β = standardized regression coefficient; * $P < .05$, ** $P < .01$.

Table 1

Demographic and Clinical Characteristics

	SZ [M ± S.D.] (min-max)	MDD [M ± S.D.] (min-max)	HC [M ± S.D.] (min-max)	Statistics
Age (years)	41.56 ± 10.85 (19-57)	35.94 ± 11.56 (18-55)	38.39 ± 11.18 (18-58)	$H(2) = 2.80, p = 0.25^b$
Education (years)	14.16 ± 4.68 (8-31)	13.67 ± 2.20 (10-19)	13.60 ± 1.80 (10-17)	$H(2) = 0.16, p = 0.93^b$
Premorbid Intelligence	90.92 ± 16.33 (66-119)	95.61 ± 15.51 (70-117)	97.65 ± 11.71 (72-113)	$H(2) = 2.46, p = 0.29^b$
IQ (WASI)	95.24 ± 19.45 (71-133)	100.11 ± 19.19 (70-136)	100.23 ± 12.16 (77-119)	$H(2) = 1.67, p = 0.43^b$
Comorbid Mood (N)	1	-	0	
Comorbid Anxiety (N)	1	6	0	
Total Anhedonia	31.08 ± 10.80 (13-51)	34.11 ± 13.15 (11-62)	23.23 ± 9.28 (5-41)	$F(2,71) = 6.81, p < 0.01^a$
Social Anhedonia	12.68 ± 5.69 (4-24)	16.06 ± 6.67 (6-28)	9.32 ± 5.04 (1-21)	$H(2) = 12.74, p < 0.01^b$
Physical Anhedonia	17.28 ± 6.45 (8-27)	17.44 ± 8.47 (4-39)	13.72 ± 6.23 (3-28)	$F(2,71) = 2.49, p = 0.09^a$
HDRS	8.76 ± 7.21 (0-26)	15.00 ± 6.87 (2-26)	-	$H(1) = 6.92, p < 0.01^b$
PANSS Positive	15.68 ± 4.82 (7-27)	9.00 ± 2.26 (7-14)	-	$H(1) = 19.81, p < 0.001^b$
PANSS Negative	13.84 ± 4.93 (7-25)	13.12 ± 4.24 (8-22)	-	$F(1,41) = 0.24, p = 0.63^a$
PANSS General	31.56 ± 7.41 (19-53)	32.29 ± 7.05 (20-42)	-	$F(1,41) = 0.10, p = 0.75^a$
PANSS Total	61.08 ± 13.67 (33-94)	54.06 ± 10.95 (39-76)	-	$F(1,41) = 3.25, p = 0.08^a$

Note. Premorbid IQ = WRAT-III Reading; WASI = Wechsler Abbreviated Scale of Intelligence; HDRS = Hamilton Depression Rating Scale; PANSS = Positive and Negative Syndrome Scale. Comorbid Mood/Anxiety = presence of comorbid DSM-IV diagnoses. SZ = schizophrenia, MDD = major depressive disorder, HC = control participants.

^aANOVA significance level

^bKruskal-Wallis significance level

Table 2

Medication Characteristics

	SZ [min-max]	MDD [min-max]	HC [min-max]	Statistics
Medication (N)				
Atypical Antipsychotics	19	4	0	
Typical Antipsychotics	4	0	0	
Antidepressants	11	13	0	
Mood Stabilizers	7	1	0	
Sedative/Hypnotics	8	3	0	
Stimulants	1	1	0	
Average Dose (CPZ Equivalents) (M ± S.D.)	314.58 ± 302.53 (25-1066.67)	64.58 ± 30.71 (25-100)	-	$H(1) = 7.23, p < 0.01^b$

Note. CPZ = Chlorpromazine

^b Kruskal-Wallis significance level