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Spatial, object, and affective working memory in social anhedonia: an exploratory study

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Abstract

The domain-specificity of working memory was examined in psychosis-prone individuals with elevated social anhedonia scores. A group of individuals with deviant scores on the revised Social Anhedonia Scale ($n=43$) were compared with a normal control group ($n=39$) on delayed match-to-sample tasks involving spatial, identity, and affective information. The social anhedonia group performed less well on the spatial and emotion delayed match-to-sample tasks relative to the normally hedonic group. The two groups did not differ in terms of their performance on the identity delayed match-to-sample task. Although the social anhedonia group reported less positive affect, greater negative affect, and more alexithymic tendencies relative to the control group, there were no significant associations between these personality traits and working memory performance. In summary, the findings suggest that poorer working memory performance is not domain-specific in socially anhedonic individuals. The authors conclude that the socially anhedonic group's relatively poor performance on the emotion delayed match-to-sample task reflects difficulty and/or inefficiency in handling cognitively taxing tasks.

Keywords: Working memory; Social anhedonia; Emotion; Alexithymia

1. Introduction

Working memory refers to a system used for the temporary storage and manipulation of information. This system involves several different processes, including active maintenance, updating, and comparative functions (Baddeley, 1986). In spatial working memory tasks, participants are required to hold information about the location of a target in mind over a delay period. Since the seminal study by Park and Holzman (1992), there have been many independent replications of spatial working memory impairments in schizophrenia patients (c.f. Carter et al., 1996; Keefe et al., 1997, Fleming et al., 1997; Spindler et al., 1997; Gooding and Tallent, 2001). There have been reports of spatial working memory deficits in schizotypal personality disordered patients (Roitman et al., 2000), schizoaffective disordered patients (Gooding and Tallent, 2002), and first-degree relatives of schizophrenia patients (Park et al., 1995; Keri et al., 2001). In contrast, spatial working memory task performance appears to be relatively intact in patients with bipolar disorder (Park and Holzman, 1992; Gooding and Tallent, 2001) and in their first-degree relatives (Keri et al., 2001). Thus, spatial working memory impairments appear to be specific to individ-

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uals at heightened risk for schizophrenia and schizophrenia-spectrum disorders.

In his model of working memory, Baddeley (1986) distinguished spatial working memory from verbal working memory. A central executive, namely, an attentional control system, operates in conjunction with two subsystems in order to maintain and manipulate visual and spatial information (via a visuospatial sketchpad) on one hand, and auditory and speech-based information (via the phonological loop) on the other (Baddeley, 1986, 1998). Neuroimaging data (c.f. Rama et al., 2001) supports the notion that there is a functional dissociation within the neural system so that the maintenance of verbal and spatial visual information is handled separately.

Single-cell recording studies in nonhuman primates (c.f. Wilson et al., 1993; Goldman-Rakic, 1999), as well as human neuroimaging studies (c.f. Belger et al., 1998; Haxby et al., 1994), have demonstrated that in addition to spatial and verbal working memory, there appears to be a form of object working memory. That is, findings suggest that non-spatial features of a stimulus are processed separately from its spatial attributes. Object working memory tasks assess short-term storage of object information, such as identity or color. Relative to studies of spatial working memory, there have been fewer investigations of nonspatial working memory in schizophrenia patients.

To date, findings with schizophrenia patients have been mixed for the other types of working memory. Although Park and Holzman (1992) found that schizophrenia patients did not display verbal working memory deficits, subsequent studies (Gold et al., 1997; Wexler et al., 1998; Conklin et al., 2000; Huguelet et al., 2000) have demonstrated that with more cognitively demanding tasks, schizophrenia patients show deficits on auditory verbal tasks. Spindler et al. (1997) observed deficits in object working memory as well as spatial working memory among schizophrenia patients, though Tek et al. (2002) did not observe deficits in the former domain.

Observations of working memory impairments in unmedicated as well as medicated schizophrenia patients and in their first-degree relatives suggests that working memory deficits may be an endophenotypic marker for the schizophrenia diathesis. Although working memory impairments may be part of the core deficit underlying schizophrenia, the extent to which the working memory deficit may be domain-specific is unclear. If working memory is an indicator of an underlying genetic diathesis for schizophrenia, then it has the potential to be a premorbid indicator of illness. However, the study of schizophrenia patients is limited in terms of its ability to inform us about the development of the disorder and premorbid indicators of heightened risk for the disorder.

One strategy for studying the viability of premorbid indicators of underlying risk is to assess individuals determined to be at heightened risk on the basis of their genetic relationship to a clinically affected person or on the basis of psychometrically defined or clinically defined characteristics (Gooding and Iacono, 1995). Analysis of the Chapmans' longitudinal study of psychosis-prone individuals (Kwapil, 1998) revealed that individuals with abnormally high scores on the revised Social Anhedonia Scale are at heightened risk for the later development of schizophrenia-spectrum disorders. This finding instigated a growing number of investigations of socially anhedonic individuals. To date, there has been only one study of working memory performance in socially anhedonic persons. In a study using a visuospatial working memory task, we (Tallent and Gooding, 1999) observed that individuals with social anhedonia performed less well than comparison subjects. The goal of the present study was to determine whether socially anhedonic individuals would also display subtle impairments in the storage and maintenance of nonspatial visual information. Thus, in addition to a spatial working memory task, we included an object working memory task in the present study.

Social anhedonia, by definition, involves a deficit in affective experience. Previous neurocognitive studies (Luh and Gooding, 1999; Kerns and Berenbaum, 2000) suggest that individuals reporting social anhedonia process affective information differently. These findings, along with a report of normative emotion-modulated startle response in socially anhedonic individuals (Gooding et al., in press), are consistent with the notion that the observed affective abnormalities reflect cortical involvement. Thus, we were interested in investigating whether socially anhedonic individuals would differ from normally hedonic individuals in terms of their ability to store, maintain, and manipulate affective information.

The nature of social anhedonia and its role in terms of the development or potentiation of schizotypy is poorly understood. One goal of the present study was to evaluate the relationship between social anhedonia and trait dimensions of anxiety, approach tendencies, positive affect, negative affect, and alexithymia. Given that the Social Anhedonia Scale was developed to be independent of social anxiety, we expected that there would be little, if any, correlation between social anhedonia and social anxiety. Indeed, in an earlier investigation (Gooding et al., in press) we found that socially anhedonic individuals did not differ from normal controls in terms of either social anxiety or physical anxiety.

In Meehl's (1962) conceptualization of hedonic capacity, hypohedonia is related to aversive drift. Previous research (Blanchard et al., 1998) has indicated that social anhedonia in schizophrenia is associated with low positive affect and high negative affect. Recently, we (Gooding et al., in press) observed that socially anhedonic individuals report less positive affect and greater negative affect than normally hedonic individuals. Thus, it was expected that in this new sample of socially anhedonic individuals, social anhedonia would be inversely associated with positive trait affect and positively associated with negative trait affect.

The system that underlies appetitive and approach behavior has been alternately referred to as a behavioral approach system (Gray, 1982, 1994), a behavioral activation system (Fowles, 1992), and a behavioral facilitation system (Depue and Iacono, 1989). Fowles (1992) provides a model of how disturbances in behavioral activation may comprise a nonspecific risk factor for schizophrenia. In discussing the relationship between schizophrenia and personality factors, Berenbaum and Fujita (1994) assert that a disturbance in this behavioral facilitation system may be associated with introversion, which in turn may be associated with negative symptoms such as anhedonia. Given the relationship between social anhedonia and heightened liability for schizophrenia-spectrum disorders, we hypothesized that socially anhedonic individuals might differ from normally hedonic persons in terms of the strength of their behavioral approach system.

The relationship between anhedonia and alexithymia, the impaired ability to verbally express emotion (Taylor et al., 1990), is largely unexplored. Prince and Berenbaum (1993) reported that alexithymia was related to social anhedonia but not physical anhedonia. Moreover, they found that alexithymia was associated with lower levels of hedonic capacity, even after the effects of negative affect were controlled for. Thus, we hypothesized that the socially anhedonic group would show greater likelihood of alexithymic traits than the controls. Finally, we were interested in examining whether these personality traits would be associated with affective working memory performance.

2. Method

2.1. Participants

This was a nonclinical university sample drawn from English-speaking undergraduates at a large midwestern university. Subjects were selected from among the 1201 males and 2022 females who completed a 179-item psychological questionnaire entitled "Survey of Attitudes and Experiences". The "Survey of Attitudes and Experiences" questionnaire was composed of a random mixture of all items from the Chapman Psychosis-proneness Scales, namely, Perceptual Aberration, Magical Ideation, revised Physical Anhedonia, and revised Social Anhedonia Scales (Chapman et al., 1976, 1978; Eckblad and Chapman, 1983; Eckblad et al., 1982). In order to rule out random responding, we included the Chapman Infrequency Scale (Chapman and Chapman, 1983).

Two groups of individuals were studied, namely, a control group and a group of socially anhedonic (SocAnh) individuals. The SocAnh group was made up of individuals who obtained scores at or beyond 2 SD from the same-sex sample mean on the revised Social Anhedonia Scale. The control group was comprised of a randomly selected set of individuals whose scores on all four Chapman scales were no higher than 0.5 SD above the same-sex sample mean.

Following psychometric screening, subjects were invited to participate in a multiple-session study of "individual differences and brain functioning". Individuals who gave their informed consent were screened for personal or family history of emotional and/or physical conditions using a nonpatient version of the SCID (Spitzer et al., 1996) and a medical history questionnaire. Any subjects who had a history of epilepsy, and/or traumatic brain injury were excluded from subsequent analyses. Potential participants were also screened for the following: current mood disorder, psychoactive substance use disorder, present or past psychotic episodes, and a history of psychotic illness in their first-degree relatives. The means and standard deviations of the psychosis-proneness measures obtained from this study's screening sample (provided in Table 1) are commensurate with those of previous Chapman samples (Chapman et al., 1980; Gooding, 1999). The final sample consisted of 43 SocAnh participants (18 male, 25 female), and 39 controls (11 male, 28 female). The sample was largely Caucasian (95%), reflective of the overall student population.

2.2. Materials

The Chapman scales were designed to tap personality traits which indicate a predisposition to psychosis. The psychometric properties of these psychosis-proneness scales have been reported elsewhere (Chapman et al., 1995). The Perceptual Aberration Scale taps transient body image and perceptual distortions, with items such as "I have sometimes felt that some part of my body no longer belongs to me" (keyed true). The Magical Ideation Scale assesses belief in causality that is not valid (e.g., "Good luck charms don't work", keyed false).

The revised Social Anhedonia Scale measures social withdrawal, a lack of interest in social relationships and/or lack of pleasure derived from interpersonal relationships (e.g., "I sometimes become deeply attached to people I spend a lot of time with", keyed false). The revised Physical Anhedonia Scale was designed to measure a deficit in the ability to experience pleasure. It includes items such as "The beauty of sunsets is greatly overrated" (keyed true). The Chapman Infrequency Scale (Chapman and Chapman, 1983) was included to identify and eliminate those participants who responded randomly. It contains items such as "There have been times when I have dialed a telephone number only to find that the line was busy" (keyed false); we excluded any participants who endorsed 3 or more such items.

Full-scale IQ was estimated to ensure that any possible group differences in terms of working memory performance could not be attributed to differences in intellectual ability. Time constraints precluded the use of the entire revised Wechsler Adult Intelligence Scale (WAIS-R; Wechsler, 1981). Vocabulary and Block Design subtests were administered in order to obtain an estimate of participants' full scale IQ. This two-subtest short form of the WAIS-R (Silverstein, 1982) yields scores that are highly correlated with full scale scores, though they overestimate full scale IQ by an average of 2 points (Ryan et al., 1988). Due to subject attrition, two participants (one from each group) were not given the WAIS-R subtests.

Table 1
Demographic and clinical characteristics

Variable	Group	
	Control ($n=39$)	SocAnh ($n=43$)
	M (SD)	*M* (SD)
Age	18.69 (0.69)	18.72 (1.03)
Estimated IQ	110.47 (9.76)	115.24 (9.75)
Perceptual aberration	2.92 (2.4)	7.91 (5.7)
Magical ideation	5.95 (2.1)	10.72 (4.6)
Social anhedonia	4.00 (2.5)	20.53 (3.4)
Physical anhedonia	6.74 (2.8)	16.79 (7.6)

Means (standard deviations) are given for age, estimated IQ, and Chapman Psychosis-proneness scale scores.

2.3. Measures of working memory

Working memory was assessed using computerized delayed match-to-sample tasks developed in our laboratory. In these tasks, a target stimulus was displayed for 200 ms on the computer screen. Immediately after the stimulus disappeared, there was a 10 s delay period in which a distractor task was presented. The distractor task was included to prevent rehearsal during the delay period and to ensure that participants remained focused on the computer screen. During the distractor task, individual words from the categories of "fruit", "color", or "metal" were presented for 1 s and participants were instructed to click a mouse when the categories changed. Distractor words were based on the category norms of Battig and Montague (1969). After the delay, a screen with five response choices appeared and participants were instructed to press a key corresponding to one of the five reference squares; the answer was contingent upon the task condition. In each delayed match-to-sample task, participants were required to hold information "on-

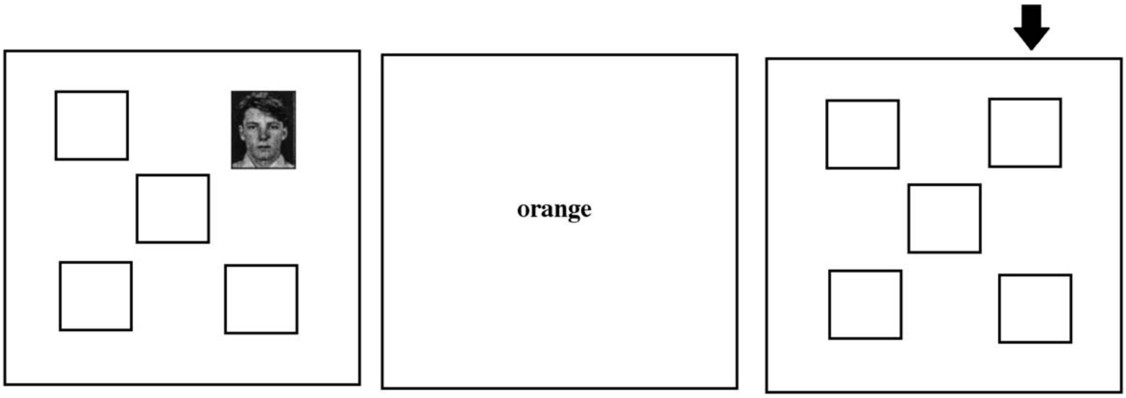

Fig. 1. Example of the spatial delayed match-to-sample task with a neutral face as the target. In this task, the participants were instructed to press the key matching the prior spatial location of the target. The arrow indicates the correct response for that trial.

line" during a delay and to continually update their mental set. As in other delayed-response tasks (e.g., Goldman-Rakic, 1994), the information relevant to correctly answer a given trial is irrelevant for successfully completing the following trial.

For each task, the target consisted of a facial stimulus. The facial stimuli were taken from the Matsumoto and Ekman (1988) faces series, namely, Japanese and Caucasian Facial Expressions of Emotion (JACFEE) and Neutral Faces (JACNeuF). Accordingly, the posers were Caucasian, Asian, male, or female. The photos selected were those that had the highest percent of judges giving the intended emotion term (percent judgments ranged from 75% to 99%, Biehl et al., 1997). All the faces were presented in black and white.

In the spatial delayed match-to-sample task (see Fig. 1), the target stimulus, a neutral face, was randomly displayed for 200 ms in one of five squares representing different spatial locations. In this condition, after a delay period (which included the distractor task), the participant was instructed to press the key matching the prior spatial location of the target. An identity delayed match-to-sample task was used to assess object working memory. In the identity delayed match-to-sample task (see Fig. 2), the target (a neutral face) was displayed in the center of the screen. After the distractor task described above, a set of five pictures of neutral faces appeared on the screen. In each trial, all of the response options were the same gender as the target stimulus. In the identity condition, the participant was instructed to press the key corre-

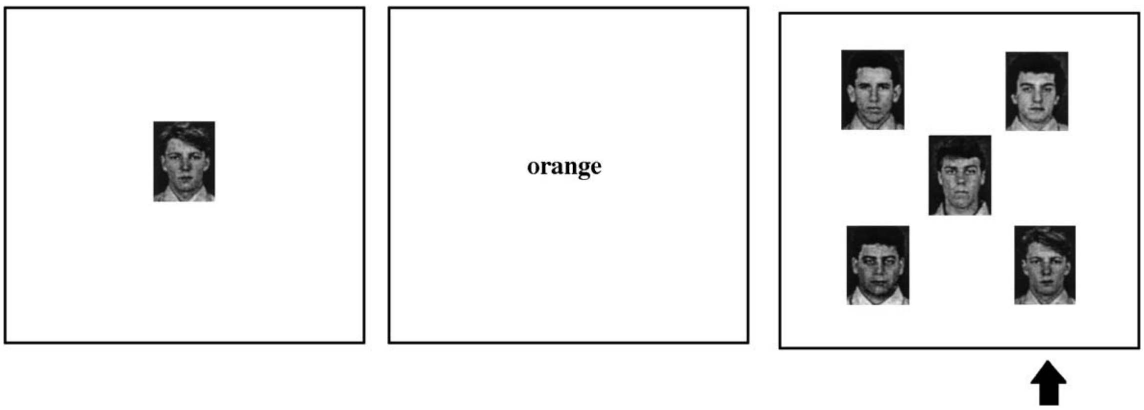

Fig. 2. Example of the identity delayed match-to-sample task with a neutral face as the target. In this task, the participants were instructed to press the key corresponding to the identity of the target previously displayed. The arrow indicates the correct response.

sponding to the identity of the target face previously displayed.

In the emotion delayed match-to-sample task (see Fig. 3), the target was a face displaying an emotion. There were six possible emotions displayed, namely, anger, disgust, sadness, fear, surprise, and happiness. Each of these emotions was displayed by posers whose neutral visages were used as stimuli in the identity condition (see Fig. 3). Of the 25 target stimuli, 6 (24%) depicted anger, 5 (20%) depicted happiness, and the remainder showed fear ($n=3$), disgust ($n=3$), sadness ($n=4$) or surprise ($n=4$). As in the identity task, the target for the emotion task was displayed in the center of the screen. After the distractor task, a set of five emotive faces appeared on the screen. The participant was instructed to press the key matching the emotion that was previously displayed; although the posers in the response set were different, one of the emotions expressed was the same as the target. For the emotion delayed match-to-sample task, the subject could match the target stimulus to the five photos according to gender, ethnicity, or emotion, though the subject was instructed to match according to emotion.

Tasks were run on a standard Macintosh PC computer using PsyScope (Cohen et al., 1993). For each task, there were three practice trials to ensure that participants understood task instructions. The faces used during the practice trials were different from those used during the experimental tasks. Presentation order of the three delayed match-to-sample tasks was counterbalanced across participants. The identity task was always the second task administered, with the spatial and emotion tasks alternating between first and last in order. There were 25 trials in each of the three tasks. Accuracy and response latency for each trial were recorded for each of the conditions.

2.4. Personality measures

Each participant was individually administered a set of self-report personality questionnaires at the beginning of the experimental session. The Behavioral Inhibition/Activation Scales (BIS/BAS; Carver and White, 1994) were administered to examine the strength of the two biobehavioral systems described by Gray (1994). The BIS/BAS Scales consist of 24 items (including four filler items) rated on a four-point Likert-type scale where 1 indicates "very true for me" and 4 indicates "very false for me". The BIS scale assessed the strength of the behavioral inhibition system (coefficient $\alpha=0.74$ for present sample). The BAS Scale consists of three subscales, namely, Reward Responsiveness, Drive, and Fun Seeking. The internal consistency reliability (coefficient α) for the BAS was moderate, $\alpha=0.77$.

Trait positive affect and trait negative affect were measured with the trait version of the Positive and Negative Affect Schedule (PANAS-Trait; Watson et al., 1988; coefficient $\alpha=0.84$ for trait positive affect and 0.84 for trait negative affect among the present sample). The PANAS consists of 20 affect words, 10 positive (e.g., enthusiastic, active, proud) and 10 negative (e.g., irritable, frightened, ashamed). Partic-

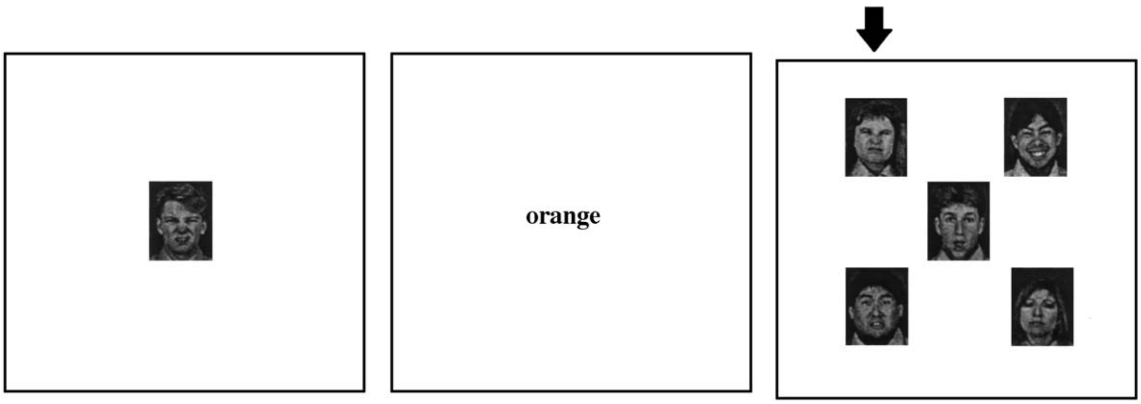

Fig. 3. Example of the emotion delayed match-to-sample task with an emotive face as the target. The participants were instructed to press the key corresponding to the emotion that matched the one previously displayed. The arrow indicates the correct response.

ipants are instructed to rate the extent to which they generally feel or experience each of the 20 emotions on a five-point scale (1 = very slightly or not at all, 2 = a little, 3 = moderately, 4 = quite a bit, 5 = extremely). The PANAS PA-scale and PANAS NA-scale are scored so that higher scores are indicative of greater degrees of positive and negative affect, respectively.

The Activity Preference Questionnaire (APQ; Lykken et al., 1973; Lykken, 1978) was administered in order to obtain a nonobtrusive measure of trait anxiety (c.f. O'Leary et al., 1974). The APQ is a 74-item forced-choice questionnaire in which the participant is provided with two paired experiences and asked to choose the one which he imagines to be least unpleasant. For each item, an anxiety-provoking scenario involving either elements of physical danger or social embarrassment is paired with an onerous alternative. The physical anxiety scale measures apprehension of physical danger, whereas the social anxiety scale assesses social timidity. For the entire sample, the coefficient α for the APQ was 0.75.

The Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994) was administered in order to assess whether there was a specific association between alexithymia, impoverished affective self-description, and diminished ability to hold affective information on-line. The 20 TAS items are rated on a five-point scale to indicate the extent to which the participant agrees with the statement. The TAS-20 has three factors, namely, the ability to identify feelings, ability to communicate feelings, and the degree to which an individual exhibits concrete, externally oriented thinking. Higher scores on the TAS-20 are indicative of alexithymic tendencies. For the entire sample, the coefficient α for the TAS-20 was 0.87.

3. Results

The two groups did not differ in terms of age, $t(80) = 0.15$, or gender, $\chi^2\ (1) = 1.67$, n.s. Although the SocAnh group had a significantly higher estimated IQ than the control group, $t(78) = 2.18$, $p < 0.05$, IQ scores were not significantly associated with any of the working memory tasks for either group (r's ranged from -0.01 to 0.29, and -0.01 to 0.15, n.s., for the SocAnh and control groups, respectively).

3.1. Working memory performance

Nonparametric statistics were used in all task analyses due to violation of the assumption of homogeneity of variance. Between-group comparisons were made using the Mann–Whitney U-test (Siegel, 1956). The results for all three working memory tasks are shown in Table 2 and Fig. 4.

Overall, both groups performed very well on the spatial delayed match-to-sample task. Scores for the entire sample ranged from 92% to 100% correct. Despite the high performance of both groups, the controls performed significantly better on the spatial delayed match-to-sample task than the SocAnh group, $Z = -2.17$, $p < 0.05$. The effect size estimate (Cohen's d) for this task was 0.58, which is considered a moderate effect size (Cohen, 1988). There was no significant between-group difference in terms of reaction time on the spatial task, $Z = -0.61$, n.s.

The control and SocAnh groups also performed well on the identity delayed match-to-sample task, with scores ranging from 80% to 100% correct for the entire sample. However, we observed no significant differences between the control and social anhedonia participants in terms of either their accuracy or reaction time on the identity task [$Z = -1.22$ and -0.39, n.s., respectively].

There was a considerable range in performance on the emotion delayed match-to-sample task. Overall, the accuracy scores ranged from 40% to 100%. We

Table 2
Mean scores on the neuropsychological test measures

Delayed match-to-sample task	Control ($n = 39$)	SocAnh ($n = 46$)	
	M (SD)	M (SD)	Z
Spatial			
Percent correct	99.38 (1.46)	98.14 (2.81)	− 2.17*
Reaction time	1365.74 (225.69)	1405.84 (260.97)	− 0.61
Identity			
Percent correct	95.38 (5.31)	94.23 (5.19)	− 1.22
Reaction time	3780.05 (1019.51)	3901.57 (1019.0)	− 0.39
Emotion			
Percent correct	80.00 (9.27)	73.21 (12.8)	− 2.17*
Reaction time	4646.46 (1221.26)	4538.04 (976.07)	− 0.55

Groups were compared with the Mann–Whitney U-test with U transformed into the normally distributed Z statistic.

* $p < 0.05$.

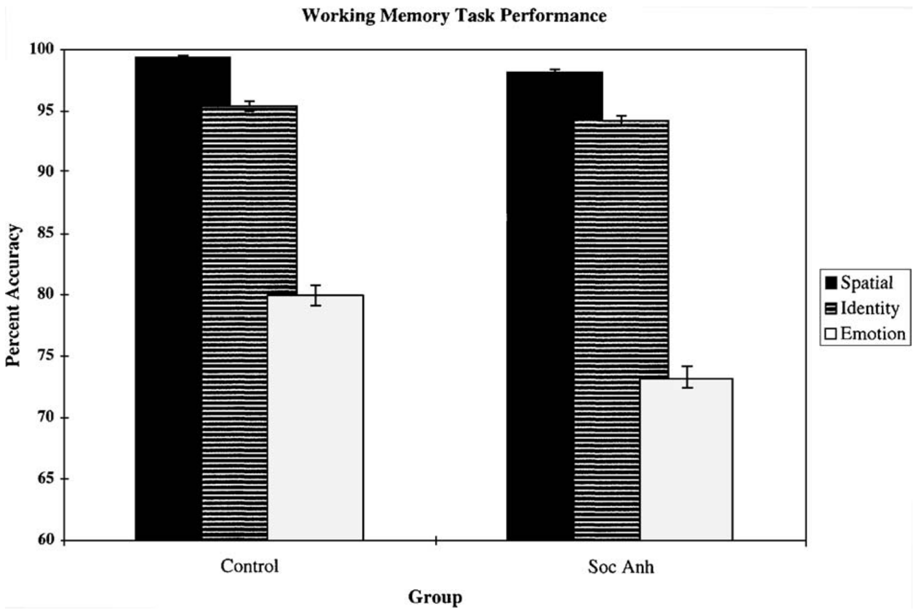

Fig. 4. Graph depicting the working memory task performance for the spatial, identity, and emotion conditions for the control and social anhedonia groups, respectively.

observed significant group differences, with the SocAnh group displaying significantly poorer accuracy in matching the facial emotions than the controls, $Z = -2.17$, $p < 0.05$. The estimated effect size for the emotion delayed match-to-sample task was 0.62, which is in the medium range (Cohen, 1988). In contrast to the groups' accuracy on the emotion working memory task, there were no differences in terms of their mean response latencies, $Z = -0.55$, n.s. For the entire sample, performance on the emotion delayed match-to-sample task and identity delayed match-to-sample tasks were significantly associated, $r_s = 0.37$, $p < 0.01$. Performance on the spatial delayed match-to-sample task was not significantly associated with performance on the other two tasks, $r_s = 0.06$ and 0.18, n.s.

3.2. Multiple indicators of psychosis-proneness and their association with working memory performance

Previous work (Park et al., 1995; Tallent and Gooding, 1999) indicates that individuals with deviant scores on the Perceptual Aberration scale, a combined Perceptual Aberration–Magical Ideation scale, or the revised Social Anhedonia Scale display poorer working memory performance than controls. As noted earlier, the two groups in the present study differed in terms of their mean scores on each of the Chapman psychosis-proneness scales. Thus, one might conjecture that differences observed in terms of spatial and affective working memory task performance were attributable to low rates of perceptual aberrations, magical ideation, and physical anhedonia in the control group, rather than due to the high rates of social anhedonia in the putatively at-risk group. In order to test this, we compared the working memory scores of SocAnh subjects above and below the group median in terms of Perceptual Aberration scores. The socially anhedonic individuals with low Perceptual Aberration scores ($n = 23$) did not differ significantly from those with high Perceptual Aberration scores ($n = 20$) in terms of either the spatial delayed match-to-sample task or the emotion delayed match-to-sample task, $Z = -0.16$ and -0.11, n.s., respectively. Similarly, comparisons between SocAnh subjects above ($n = 23$) and below ($n = 20$) the group median in terms of Magical Ideation scores revealed no significant differences in terms of the spatial delayed match-to-sample task or the emotion delayed match-to-sample task, $Z = -0.92$ and -0.10, n.s., respectively. Finally, the 22 SocAnh participants with low Physical Anhedonia

Table 3
Self-report questionnaire scores

Variable	Control	SocAnh	t
PANAS PA	35.08 (4.65)	31.98 (5.30)	2.80**
PANAS NA	17.33 (4.92)	21.12 (6.50)	−2.95**
BAS reward responsiveness	17.69 (2.08)	16.79 (2.05)	1.97
BAS drive	11.15 (2.49)	10.53 (2.46)	1.13
BAS fun seeking	12.41 (1.83)	11.70 (2.21)	1.58
BIS	20.36 (3.90)	20.63 (4.23)	0.30
APQ social anxiety	14.64 (4.67)	15.67 (4.57)	−1.01
APQ physical anxiety	18.26 (6.10)	15.40 (5.66)	2.20*
TAS-20	39.56 (8.08)	51.28 (12.10)	−5.21***

Means and standard deviations for self-report scales: PANAS PA = PANAS Positive Affect, PANAS NA = PANAS Negative Affect (Watson et al., 1988); BIS = Behavioral Inhibition Scale (Carver and White, 1994); BAS = Behavioral Activation Scale (Carver and White, 1994); APQ = Activity Preference Questionnaire (Lykken, 1978); TAS-20 = the 20-item Toronto Alexithymia Scale (Bagby et al., 1994).

* $p<0.05$.

** $p<0.01$.

*** $p<0.001$.

scale scores did not differ significantly from the 21 SocAnh participants with high Physical Anhedonia scale scores on the spatial or emotion delayed match-to-sample tasks, $Z = -1.25$ and -0.49, respectively.

3.3. Self-report personality measures

Descriptive data for the self-report personality measures are presented in Table 3. All of the scales demonstrated adequate internal reliability. The SocAnh group differed significantly from the control group in terms of their level of self-reported positive affect, negative affect, physical anxiety, and alexithymic tendencies.

The SocAnh group reported significantly lower levels of positive trait affect and significantly higher levels of negative trait affect, as measured by the PANAS. We observed a trend whereby the socially anhedonic group reported less reward responsiveness, as measured by BAS, $t(80) = 1.97$, $p = 0.052$. However, the two groups did not differ in terms of their self-reported Drive or Fun-Seeking scores. The two groups did not differ in terms of their strength of behavioral inhibition, as measured by the BIS. Although the two groups did not differ in terms of social anxiety, as assessed by the APQ, the controls reported significantly greater physical anxiety than the SocAnh participants.

The control group reported significantly fewer alexithymic tendencies, as measured by the TAS-20, than the SocAnh group. On the basis of the literature (c.f. Bagby and Taylor, 1997), individuals with TAS-20 total scores greater than or equal to 61 are considered alexithymic. None of the controls and 10 (23%) of the SocAnh group were classified as alexithymic.

Table 4 provides the zero-order correlations between the various personality measures for the entire sample, collapsing across groups. Positive affect, as measured by the PANAS, was inversely associated with negative affect and alexithymic tendencies. Self-

Table 4
Intercorrelations of personality measures

	PA	NA	BAS1	BAS2	BAS3	BIS	APQ-S	APQ-P
PA								
NA	−0.27*							
BAS1	0.36**	−0.12						
BAS2	0.38***	−0.03	0.49***					
BAS3	0.10	−0.13	0.30**	0.35**				
BIS	−0.19	0.32**	0.15	−0.12	−0.17			
APQ-S	−0.11	0.25*	−0.09	−0.09	−0.23*	0.17		
APQ-P	0.07	0.06	−0.15	−0.09	−0.18	0.37**	0.27*	
TAS	−0.46***	0.40***	−0.29**	−0.17	−0.03	0.10	0.26*	0.04

For abbreviations, see Table 3.

* $p<0.05$.

** $p<0.01$.

*** $p<0.001$.

reported positive affect was associated with reward responsiveness and drive, as measured by the BAS. Negative affect, as measured by the PANAS, was associated with the strength of the Behavioral Inhibition System and alexithymic tendencies. Social anxiety, as measured by the APQ, was significantly associated with physical anxiety as well as alexithymic tendencies.

We were also interested in the association between individuals' scores on self-report personality measures and their performance on the three delayed match-to-sample tasks. In the control group, accuracy on the emotion working memory task was associated with total score on the Behavioral Inhibition Scale (BIS), $r_s = 0.33$, $p < 0.05$. We observed a trend whereby the controls' accuracy on the spatial working memory task was associated with their score on the BIS, $r_s = 0.31$, $p = 0.06$. For the SocAnh group, accuracy on the emotion working memory task was associated with BAS reward responsiveness scores, $r_s = 0.42$, $p < 0.01$. In addition, for the socially anhedonic individuals, their performance on the identity working memory task was inversely associated with their BIS scores, $r_s = -0.31$, $p < 0.05$. No other self-report measures were associated with performance on the working memory tasks.

4. Discussion

In the present study, we sought to replicate our previous findings of poorer working memory performance in social anhedonics and also to extend those findings. Consistent with the findings of Tallent and Gooding (1999), the SocAnh group had significantly less accurate spatial working memory performance relative to controls. However, the mean accuracy scores for the spatial delayed match-to-sample task were higher than the mean accuracy scores observed in our earlier sample. The difference in accuracy rates is attributable to differences in task difficulty. In the spatial task used in our present study, participants chose among five possible responses per trial, whereas in our previous study, the task required participants to chose among eight possible responses. It may have been easier to retain the location of the target in our present spatial delayed match-to-sample task due to its lower number of response options. In addition, the target used in the present spatial task was a facial stimulus; this target was more motivationally salient than the target (the letter "X") that was used in our previous study. Despite the methodological differences across studies, our present findings are consistent with the prior results, suggesting that socially anhedonic individuals perform less well on spatial working memory tasks than controls.

The primary goal of our study was to compare socially anhedonic and normally hedonic individuals in terms of their performance on a nonspatial (object) working memory task. One strength of the present study is that the targets for the spatial and object working memory tasks were the same, namely, neutral faces. Like others (c.f. Barch et al., 1997), we operationalized task difficulty in terms of behavioral performance. Thus, the task used to assess object working memory, namely, the identity delayed match-to-sample task, was more difficult than the task used to assess visuospatial working memory. However, the identity delayed match-to-sample task was not so difficult that floor effects were a potential confound. Despite this, we observed no significant between-group difference in terms of object working memory performance. If these two tasks had been the only tasks included in our assessment battery, we could have concluded that socially anhedonic individuals showed poorer performance than controls on only visuospatial working memory tasks.

However, we also included a third measure of working memory, namely, the emotion delayed match-to-sample task. A second goal of the present study was to explore socially anhedonic individuals' ability to maintain affective information over a delay. When the socially anhedonic and normally hedonic groups were compared in terms of their accuracy on the emotion task, we found significant differences. When considered together, the groups' performance on the three delayed match-to-sample tasks could be interpreted in at least two different ways; these accounts differ in terms of the way in which the emotion task is interpreted. The emotion delayed match-to-sample task could be considered a measure of a distinct form of working memory (i.e., affective working memory) or a form of object working memory.

If the emotion task is measuring another form of working memory, namely, affective working memory, then it appears that socially anhedonic individuals perform less well on measures of spatial working memory and measures of affective working memory, but show no differences in terms of object working memory. If the emotion task can be considered a measure of object working memory, then one could conclude that socially anhedonic individuals perform more poorly than controls on measures of object working memory when the tasks are sufficiently difficult.

Perhaps the emotion task was measuring another form of working memory, namely, affective working memory. It is possible that the socially anhedonic individuals had greater difficulty in maintaining and manipulating affective information relative to the controls. In a previous study using a different sample of socially anhedonic individuals (Luh and Gooding, 1999), we observed that the SocAnh group did not differ from controls in terms of their perceptual responses to the gender stimuli, though they did differ in terms of their response to the emotion stimuli. Similarly, in the present study, the SocAnh subjects did not differ from the controls in terms of their handling of the identity task, though they performed significantly worse on the emotion task. It may be that the socially anhedonic individuals, a subset of whom had scores on the TAS-20 which classified them as alexithymic, handle affective information less efficiently. At present, there is no independent evidence suggesting the existence of affective working memory as a separate and distinct form of working memory. Neuroimaging data would be useful in terms of demonstrating whether the working memory construct should be differentiated further. It is not clear whether affective working memory can be functionally dissociated from other forms of working memory.

The emotion delayed match-to-sample task may be tapping a specialized, more difficult form of object working memory. This alternative account for the findings appears likely when one considers the pattern of associations between the three tasks. Performance on the identity and emotion delayed match-to-sample tasks were significantly associated with each other, while performance on the spatial delayed match-to-sample task was not significantly associated with either of the other two tasks. Both the identity and emotion tasks presented nonspatial visual information. However, the identity task was easier than the emotion task because in the former task, all the response options were the same gender and all the expressions were neutral. In the emotion task, the stimuli differed in more ways, and each of the five response options (i.e., emotional expressions) was different. It is also noteworthy that the identity delayed match-to-sample task required storage of information, whereas the emotion delayed match-to-sample task required storage and executive processing of the information. If the emotion task is regarded as a measure of object working memory with a higher cognitive load than the identity task, then one could conclude that socially anhedonic individuals perform more poorly than controls on measures of object working memory when the tasks are sufficiently difficult.

One limitation of the present study is that verbal working memory was not directly assessed. The targets in all three of our tasks could have been verbally encoded. In the emotion delayed match-to-sample task, all of the affective targets could be named (e.g., "angry", "sad", "happy"). There was also a limited number of verbal labels for the targets in the spatial delayed match-to-sample task (e.g., "center", "top left", "bottom right", etc.). Although there was a wider range of verbal descriptors for the posers in the identity delayed match-to-sample task, verbally encoding the identity of the posers was still feasible. Future studies would be enhanced by the inclusion of a pure assay of verbal working memory as well as a nonverbal object working memory task.

The inclusion of personality measures in this study provided an opportunity to further examine the nature of affective deficits in social anhedonia as well as explore its possible role in terms of the development or potentiation of schizotypy. We replicated our previous finding (Gooding et al., in press), namely, that socially anhedonic individuals report lower levels of positive affect and higher levels of negative affect compared to normally hedonic individuals. This association between social anhedonia, low positive affect and high negative trait affect in individuals complements the Blanchard et al. (1998) observation of the relationship in schizophrenia patients. Within the SocAnh group, we observed an association between behavioral inhibition system functioning and negative affect. This finding, considered along with Fowles' (1992) model, suggests that disturbances in behavioral inhibition as well as behavioral activation system disturbances may be nonspecific risk factors for schizophrenia and/or spectrum disorders. Finally, our results complement an earlier (Prince and Berenbaum, 1993) reported association between social anhedonia and alexithymia.

We were also interested in examining the association between certain personality traits and working memory task performance. Despite significant group differences between the SocAnh and control groups in terms of positive affect, negative affect, and alexithymic tendencies, we observed no significant associations between these personality traits and working memory performance in either group. Similarly, there was not a significant relationship between working memory task performance and strength of either the behavioral activation system or the behavioral inhibition system.

A limitation of this study was that we relied upon a high-functioning group. The college status of our sample as well as the relatively high IQ in both groups may limit the generalizability of the findings. Given prior work suggesting that lower IQ is associated with schizophrenia risk (c.f. Davidson et al., 1999) as well as data indicating that individuals who do not attend college have lower functioning and are at greater risk for psychiatric disorders (Newman et al., 1998; Robins et al., 1984), our sample of social anhedonics may reflect the positive-outcome end of the continuum of individuals who self-report social anhedonia. Future research using community-derived samples who presumably display a greater range of cognitive ability may shed further light in terms of the associations between vulnerability, as demonstrated by heightened scores on the Social Anhedonia Scale and poorer working memory performance, and clinical outcome.

The present results complement the extant findings which indicate that individuals at risk for, and/or affected by, schizophrenia-spectrum disorders show poorer performance on visuospatial working memory tasks. The present data also suggest that socially anhedonic individuals may perform more poorly than normally hedonic individuals on object working memory tasks with a sufficiently high cognitive load. Overall, our sample performed very well, so it would not be appropriate to discuss deficits in this context. Nonetheless, the data suggest that working memory impairments, when present, are less likely to be domain-specific. We view these findings as promising and hope that they will stimulate further research regarding whether the working memory performance impairments observed in individuals at risk for, or affected by, schizophrenia and spectrum disorders are domain-specific.

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