Visual-spatial learning and memory in schizotypal personality disorder: Continued evidence for the importance of working memory in the schizophrenia spectrum

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Abstract

Verbal episodic memory deficits, a well-established feature of the schizophrenia spectrum, have also been found in individuals with schizotypal personality disorder (SPD), although visual-spatial episodic memory has proven harder to examine. To address this, we administered the Visual Object Learning Test (VOLT), a measure of visual-spatial learning and memory, as well as the California Verbal Learning Test (CVLT) and a verbal working memory test, to 50 individuals with SPD, 19 with other personality disorders (OPD), and 17 healthy volunteers. Compared to both other groups, individuals with SPD learned verbal and visual-spatial information at a reduced rate and recalled fewer words and objects after a long delay. Verbal working memory performance eliminated diagnostic differences in these episodic memory domains. These findings suggest that it is possible to detect both auditory and visual processing episodic memory abnormalities in the spectrum and that these deficits are uniformly a function of verbal working memory impairments.

Keywords: Schizotypal personality disorder; Visual memory; Verbal memory; Working memory; Schizophrenia spectrum

Disturbances of memory, attention, reasoning, and judgment are among the most well documented cognitive deficits in schizophrenia. Impaired cognition frequently precedes the onset of other symptoms and persists even after other symptoms resolve (Bowie & Harvey, 2005; Heinrichs, 2005). These cognitive limitations, which appear to be stable over time and unrelated to positive symptoms (Aleman, Hijman, de Haan, & Kahn, 1999), have also been found in first-degree relatives of schizophrenic individuals (Toulopoulou, Rabe-Hesketh, King, Murray, & Morris, 2003). Many cognitive deficits found in schizophrenic individuals, in domains such as recognition memory (Cadenhead, Perry, Shafer, & Braff, 1999), working memory (Roitman et al., 2000), cognitive inhibition (Moritz & Mass, 1997), and sustained attention (Roitman et al., 1997), are also present in individuals with schizophrenia spectrum disorders, such as schizotypal personality disorder (SPD). Furthermore, several studies have demonstrated impairment in verbal
episodic memory in individuals with SPD (Bergman et al., 1998; Voglmaier, Seidman, Salisbury, & McCarley, 1997; Voglmaier et al., 2000, 2005).

An understanding of these cognitive limitations is particularly important as an increasing body of evidence emerges demonstrating that the functional outcomes of individuals with schizophrenia are closely related to cognitive disturbances (Bowie, Reichenberg, Patterson, Heaton, & Harvey, 2006; Green, Kern, & Heaton, 2004; Harvey et al., 1998; Kurtz, Moberg, Ragland, Gur, & Gur, 2005; Lowery et al., 2003). In fact, this link is so strong that the recent NIMH initiative, the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) New Initiatives Conference, focused on the development of an assessment battery to understand the nature of these cognitive deficits as one of its primary goals (Neuchterlein et al., 2004).

The MATRICS consensus conference lead to the identification of seven cognitive domains as important for understanding cognition in schizophrenia: Speed of Processing, Attention/Vigilance, Working Memory, Verbal Learning and Memory, Visual Learning and Memory, Reasoning and Problem Solving, and Social Cognition (Neuchterlein et al., 2004). Although all of these domains are known to be related to the functional outcome of individuals with schizophrenia spectrum disorders, they have not received equal attention in the research literature.

One area that has been notably under-examined is Visual Learning and Memory. Although deficits in Verbal Learning and Working Memory have been demonstrated in numerous studies of individuals with schizophrenia (Aleman et al., 1999; Heinrichs, 2005; Heinrichs & Zakzanis, 1998; Toulopoulou et al., 2003; Tracy et al., 2001) and individuals with SPD (Bergman et al., 1998; Siever et al., 2002; Voglmaier et al., 2005), the systematic investigation of the visual memory domain has not kept pace with the investigation of deficits in other domains.

There is evidence of impaired Visual Learning and Memory in the spectrum; however, the lack of adequate measures to assess these deficits has proven to be a substantial hindrance across neuropsychiatric conditions (Glahn et al., 1997). The majority of studies examining Visual Learning and Memory in the spectrum have focused on visual perception (Farmer et al., 2000) or memory for faces or complex figures (Toulopoulou et al., 2003). Finally, stimuli in these visual learning tests are almost always verbalizable (Glahn et al., 1997), which is often administered to understand the relationship between Visual and Verbal Learning and Memory, are not matched in terms of difficulty with verbal items, making the simultaneous examination of these domains difficult (Tracy et al., 2001). Finally, stimuli in these visual learning tests are almost always verbalizable (Glahn et al., 1997), confounding the direct examination of the visual domain.

The Visual Object Learning Test (VOLT; Glahn et al., 1997) was developed to address some of these limitations. The VOLT is modeled after the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987), and stimuli are complex and unfamiliar geometric designs that are unpronounceable. Like the CVLT, the VOLT has multiple learning trials, although the VOLT consists of four rather than five, followed by an interference list, similar to the “Tuesday” CVLT list, as well as short delay and long delay trials. An initial study of the VOLT’s reliability and validity demonstrated excellent internal consistency, convergent and divergent validity, in both healthy volunteers and individuals with schizophrenia (Glahn et al., 1997).

As cognition in schizophrenia is closely related to functional outcome, a broad understanding of the nature of all domains identified by MATRICS across the entire spectrum is clearly warranted. We therefore chose to examine Visual Learning and Memory domain using this newer instrument in three groups of unmedicated individuals: a group of individuals with SPD, a group of healthy volunteers, and a group of individuals with other, non-schizophrenia-related personality disorders (OPD). We administered both the VOLT and the CVLT in order to compare the domains of visual and verbal learning. In addition, as our group previously found that impairments in verbal working memory might account for the entire signature of cognitive deficits in SPD (Mitropoulou et al., 2005), we also administered the Paced Auditory Serial Addition Test (PASAT), so that we would better understand the impact of verbal working memory on the visual episodic memory domain. This is also an important issue, as the MATRICS domains are described as “separable” domains of cognition and the results of the Mitropoulou et al. paper suggest a potentially unitary underlying feature of cognitive impairment that drives the entire signature of impairment in SPD.
1. Methods

1.1. Participants

Participants were 50 individuals with DSM-IV SPD, 19 individuals with other personality disorders (OPD), and 17 healthy volunteers. The individuals with SPD and OPD were ascertained either through recruitment from the outpatient clinics at the Mount Sinai Medical Center and Bronx Veteran Affairs Medical Center, by advertisements in local newspaper, or by referral from psychiatrists and psychologists in the local community. The healthy controls were recruited from the local community through newspaper advertisements. Participants were excluded for: (a) lifetime diagnosis of substance dependence or substance abuse disorder within 6 months of testing; and (b) a positive urine toxicology screen. All participants were assessed for Axis I psychopathology using the Structured Clinical Interview for DSM-IV (First et al., 1995) by two experienced raters who did not know the participants’ cognitive task performance. In addition, participants were assessed for Axis II pathology using the Structured Interview for the DSM-IV Personality Disorders (Pfohl, Blum, & Zimmerman, 1995). When possible, an individual close to the participant was also interviewed to provide additional information. Consensus diagnoses were reached in a meeting of all raters with an expert diagnostician ($k = .73$ for SPD). SPD and OPD individuals were excluded if they currently met criteria for an Axis I psychotic disorder or for Bipolar I disorder. OPD participants were excluded if they met diagnostic criteria for either paranoid or schizoid personality disorders, or if they met more than two of the SPD diagnostic criteria. Healthy volunteers were excluded if they had either a personal or family history of any Axis I disorder, or a personal history of an Axis II disorder. All participants were unmedicated at the time of assessment (although no patient’s medication was discontinued so that they could participate) and signed informed consent forms in accordance with the Institutional Review Boards of Mt. Sinai and the Bronx VA.

1.2. Memory tests

1.2.1. Visual Object Learning Test

The VOLT (Glahn et al., 1997), as discussed above, is a computer-based assessment of visual learning and memory consisting of four learning trials, one interference list trial, and both a short and a long delay (20 min) trial of the original shapes. Each trial contains ten complex, Euclidean, partially shaded figures, two each from five classes of shapes (for a full description of the development of the stimuli, see Glahn et al., 1997). Following the presentation of shapes for each trial, participants are presented with 20 pairs of shapes (10 targets and 10 recognition foils) and are asked to press “1” if they have seen the shape and to press “2” if they have not. An initial investigation of the VOLT’s psychometric properties found excellent internal consistency over trials (Cronbach $\alpha = .92$), as well as very good convergent and divergent validity (Glahn et al., 1997) (Fig. 1).

1.2.2. California Verbal Learning Test

The CVLT (Delis et al., 1987) involves five presentations of a list of sixteen words (four words each from four semantic categories), with recall after each presentation. Following the learning trials, an interference list is presented,
followed by a short delay and a long delay (after 20 min) free and cued recall of the original list. Numerous studies have demonstrated that the psychometric properties of the CVLT are very good (Spreen & Strauss, 1998).

1.2.3. Paced Auditory Serial Addition Test

The PASAT (Stuss, Stethem, & Pelchat, 1988) is a test of auditory verbal working memory. In this version of the test participants listen to a tape recorded voice presenting a series of numbers (50 numbers at a rate of one digit per 2 s) and are asked to add each adjacent pair of numbers and respond by verbalizing the sum. The split-half reliability \( r = .9 \) and the internal consistency (Cronbach \( \alpha = .9 \)) of the PASAT are excellent, as is the validity (Spreen & Strauss, 1998).

1.3. Procedure

Following a baseline diagnostic assessment, participants were administered these tasks during a single testing session. Task order was counterbalanced across participants. Sixteen of the participants (eight in the SPD group, two in the OPD group, and six in the HC group) were also reported on in the previous Mitropoulou et al. (2005) paper (which did not include the VOLT analyses). These sixteen participants were compared on each of the dependent variables of the CVLT and PASAT to the participants in the current study who were not included in the Mitropoulou et al. analyses and were found to have comparable scores.

1.4. Data analysis

Demographic and other background characteristics were compared using analysis of variance (ANOVA) models and Chi-square tests. Internal consistency of tests was evaluated using Cronbach’s Alpha. Analysis of variance models were used to compare individuals with SPD, OPD and healthy controls on indices of memory performance. Consistent with earlier reports, we used raw scores to examine the internal consistency of the measures. In order to make direct comparisons of the groups across the VOLT and the CVLT, which vary in the number of learning trials and stimuli, we calculated percent correct scores for each trial. Data were analyzed using SPSS 14.0 for Windows.

2. Results

2.1. Demographics

Demographic and clinical characteristics of both groups are shown in Table 1. There were significant overall group differences on age, \( F(2, 83) = 4.381, p = .02 \), as the healthy volunteers were younger than both the SPD (\( p = .01 \)) and OPD groups (\( p = .02 \)); however, the SPD and OPD groups did not differ on age (\( p = .91 \)). There was also an overall difference on WAIS-III Vocabulary, \( F(2, 83) = 4.169, p = .02 \), as the OPD group’s Vocabulary scores were higher than the SPD group (\( p = .01 \)); there was not a significant difference between the OPD and healthy control groups (\( p = .43 \)), nor was there a difference between the SPD and healthy control groups (\( p = .10 \)). There was no significant difference

<table>
<thead>
<tr>
<th>Group</th>
<th>Schizotypal PD</th>
<th>Other PDs</th>
<th>Healthy controls</th>
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<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
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<tr>
<td>Age (in years)</td>
<td>39.2</td>
<td>11.0</td>
<td>38.8</td>
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<tr>
<td>Sex (% male)</td>
<td>78.0</td>
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<td>47.4</td>
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<tr>
<td>Education (in years)</td>
<td>14.6</td>
<td>2.5</td>
<td>15.3</td>
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<tr>
<td>Vocabulary scores</td>
<td>10.5</td>
<td>2.3</td>
<td>12.4</td>
</tr>
<tr>
<td>Block Design scores</td>
<td>9.7</td>
<td>2.8</td>
<td>10.7</td>
</tr>
<tr>
<td>Handedness (% right)</td>
<td>86.0</td>
<td></td>
<td>89.5</td>
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between groups for education, $F(2, 83) = 1.165, p = .31$, or WAIS-III Block Design scores, $F(2, 83) = 1.419, p = .25$. The groups were also comparable in terms of handedness, $\chi^2(2) = .20, p = .91$.

### 2.2. Internal consistency of measures

For comparability to previous results, raw and percentage scores are presented in Table 2. We examined the internal consistency of both the VOLT and the CVLT learning trials. The VOLT demonstrated very good internal consistency overall ($\alpha = .82$) and across groups (SPD $\alpha = .82$, OPD $\alpha = .78$, HC $\alpha = .87$). The internal consistency for the CVLT was excellent overall ($\alpha = .93$) and across groups (SPD $\alpha = .93$, OPD $\alpha = .88$, HC $\alpha = .94$).

### 2.3. Neuropsychological performance

In order to directly examine possible differences in the rates of learning verbal and visual information, we conducted a three (diagnostic group) by four (percentage scores for the first four learning trials) by two (stimulus type) repeated measures analysis of variance. We found an overall main effect for diagnosis, $F(2, 83) = 3.354, p = .04$. As would be expected, there was also a main effect for trial, $F(3, 83) = 136.5, p < .0001$, as all participants demonstrated increased retention of information across successive learning trials. As would be expected when comparing recognition memory (VOLT) to recall memory (CVLT), there was a very substantial main effect for stimulus type, $F(1, 83) = 393.4, p < .0001$, with participants recognizing more visual information, compared with recall of verbal information. The trials by diagnosis interaction was nonsignificant, $F(6, 164) = .948, p = .46$, as was the interaction between stimulus type and diagnosis, $F(2, 83) = .316, p = .73$. This suggests that participants in all groups were able to learn verbal and visual-spatial information across the first four learning trials of both measures, although individuals with SPD learned less information than the other groups (see Fig. 2).

As the CVLT has five learning trials, we then conducted a three (group) by five (learning trials) analysis of variance with the CVLT percentage scores to understand verbal learning across all learning trials. We found that there was a main effect for diagnosis which approached significance $F(2, 83) = 2.603, p = .08$. Post hoc analysis revealed that individuals in the SPD group learned the verbal information at a rate that was statistically lower than individuals in the HC group ($p < .05$) and different from the OPD group at a trend level that approached significance ($p = .09$).

Our next analysis involved an examination of retention performance. We again used a repeated measures analysis of covariance, this time with a three (diagnostic group) by three (percentage scores for the final learning, short delay and long delay trials) by two (stimulus type) design. Again, there was a main effect for diagnosis, $F(2, 83) = 3.442, p = .04$. 

<table>
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<tr>
<th>Table 2</th>
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<tbody>
<tr>
<td>Raw and percentage scores across groups</td>
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<tr>
<td>Raw scores ($M (SD)$)</td>
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<tr>
<td>SPD</td>
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<tr>
<td><strong>VOLT</strong></td>
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<tr>
<td>Trial 1</td>
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<td>Trial 2</td>
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<td>Short delay</td>
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<td>Long delay</td>
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<td><strong>CVLT</strong></td>
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<td>Trial 1</td>
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<td>Trial 2</td>
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<td>Trial 3</td>
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<td>Trial 4</td>
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<td>Trial 5</td>
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<td>Short delay</td>
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<td>Long delay</td>
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<td><strong>PASAT</strong></td>
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There was also a main effect for trial, $F(2, 81) = 3.194$, $p = .05$, and for stimulus type, $F(1, 82) = 18.188$, $p < .0001$. The stimulus by diagnosis interaction was again nonsignificant, $F(2, 82) = .120$, $p = .89$; however, there was a statistically significant trial by diagnosis interaction $F(4, 164) = 4.107$, $p = .003$.

To better understand this trial by diagnosis interaction, we conducted a series of post hoc follow-up comparisons. First, we ran six univariate ANOVAs with each of the last learning trials, short delay and long delay percentage scores serving as the dependent variables. We found did not find significant group differences for the final learning trial for either visual, $F(2, 89) = 2.122$, $p = .13$, or verbal information, $F(2, 83) = 1.502$, $p = .09$. Group differences were also not detected following a short delay for either visual, $F(2, 89) = .69$, $p = .51$, or verbal, $F(2, 83) = 1.246$, $p = .29$, information. However, following a long delay, there was a significant group difference for both visual, $F(2, 89) = 5.775$, $p = .004$, and verbal, $F(2, 83) = 3.433$, $p = .04$, information, with individuals in the SPD group recognizing the least visual and recalling the fewest verbal stimuli.

As we previously found that verbal working memory accounted for substantial variance in cognitive performance in the schizophrenia spectrum, we attempted to examine the relationship between verbal working memory and both visual and verbal memory in our sample by entering the PASAT total score as a covariate into our models. Verbal working memory contributed significantly to the learning model, $F(1, 82) = 14.590$, $p < .0001$, and attenuated the main effect for diagnosis, $F(2, 82) = 1.622$, $p = .20$. Furthermore, when PASAT was entered into the retention model, verbal working memory again contributed significantly, $F(1, 82) = 18.61$, $p < .0001$, and attenuated the main effect of diagnosis, $F(2, 82) = 2.085$, $p = .13$. Finally, the same pattern occurred when verbal working memory was entered into the analysis of

![Visual Object Learning Test](image1)

![California Verbal Learning Test](image2)

Fig. 2. Panel (A): VOLT performance across groups and panel (B): CVLT performance across groups.
verbal learning for all five CVLT trials, with PASAT scores contributing significantly to the model, $F(2, 82) = 13.111$, $p = .001$, and eliminating the main effect of diagnosis, $F(2, 82) = 1.138$, $p = .33$. This suggests that verbal working memory impairments are responsible for multimodal episodic memory impairments in SPD.

3. Discussion

The current study was an initial examination of visual episodic memory using the VOLT, a measure that assesses visual learning and memory and can appropriately be compared to measures of verbal episodic memory. Overall, we found that the VOLT demonstrated very good internal consistency in our SPD, OPD and HC samples. Across all three groups, individuals tended to have higher visual scores than verbal, a finding that is not unexpected given that the verbal task required recall while the visual task required recognition. However, individuals with SPD in this sample demonstrated reduced rates of learning, both for verbal and visual information, compared to both individuals with other personality disorders and with healthy controls across the learning trials.

Furthermore, we found a tendency for individuals in the SPD group to retain less information, both verbal and visual, following a long delay. This pattern was not found in previous research using this measure with a sample of schizophrenic individuals, although Glahn et al. (1997) found a similar pattern in a nonpsychiatric sample when they compared the performance of older adults to younger adults on the VOLT. Both the CVLT and VOLT contain an interference list following the learning trials. However, as this group difference was not present for the short delay, which also follows the interference trial, it is unlikely to be an effect of the interference alone.

Also of note in the current study is continued evidence of the importance of verbal working memory in understanding the nature of cognitive deficits in the schizophrenia spectrum. Verbal working memory made a significant contribution when entered into all models and considerably attenuated the effect of diagnosis in both our learning and retention models. These findings support the primacy of verbal working memory deficits and strongly suggest that they continue to be examined to understand and eventually treat the cognitive limitations of individuals in the spectrum.

There are some limitations to the current study. Although the VOLT is a promising new instrument for measuring visual learning and memory, it lacks a direct comparability to instruments such as the CVLT, which is a recall measure, as it assesses recognition. As it is a new instrument, the VOLT also lacks the same level of established norms as the CVLT. Additionally, the unequal sample size of our groups and small numbers of HC and OPD participants may be a limiting factor in the current study, although, since the SPD participants were found to be different from the other two groups, any power limitations did not reduce our ability to find differences between the groups. Furthermore, the VOLT retention score is based on both true positive responses as well as true negative responses, making it unclear whether these group differences are due to lower rates of true positive or higher rates of true negative responses. We did not perform those analyses because of the small sample size in the OPD and HC groups. Finally, we were not able to assess prior computer literacy or exposure, which may have impacted participants’ performance on the VOLT, which is a computer-based assessment.

These results again demonstrate that cognitive deficits are prominent across the schizophrenia spectrum and that impairments in an understudied domain of cognitive functioning, visual memory, are also present. They also lend support to the importance of continued examination of verbal working memory as a central factor in the understanding of cognition within the schizophrenia spectrum. Additionally, they contribute to the growing body of evidence suggesting that the VOLT is a reliable and valid measure of nonverbal learning. These results are, to our knowledge, the first systematic examination of visual learning and memory in individuals with SPD using two comparison groups, individuals with other personality disorders and healthy volunteers. They also suggest that episodic memory deficits in the schizophrenia spectrum are unidimensional and uniformly related to verbal working memory impairments.

References


