Individual Differences in Spatial Working Memory in Relation to Schizotypy

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With a delayed-response task, spatial working memory function was assessed in normal students who were selected for schizotypy. The Wisconsin Card Sorting Test was also administered. Twenty-eight undergraduate students who scored high on the Perceptual Aberration Scale (PerAb) and 23 who scored low on this scale participated in this study. High PerAb students performed less accurately compared with the low PerAb controls on the delayed-response task, and they were more than twice as likely as low PerAb students to be impaired. The groups did not differ in the number of perseverative errors or number of categories achieved on the Wisconsin Card Sorting Test, but, as predicted, high PerAb students were less able to maintain set than were the low PerAb students. Neuropsychological implications of these data are discussed.

Studies suggest (see L. J. Chapman & Chapman, 1985) that hypothetically "psychosis-prone" individuals within the general population may carry a latent liability for schizophrenia although they may never become ill (see Lenzenweger & Loranger, 1989a; Meehl, 1990). Schizotypic individuals (identified by various means) show subtle deficits in sustained attention (Lenzenweger, Cornblatt, & Putnick, 1991), cognitive inhibition (Beech & Claridge, 1987), and Wisconsin Card Sorting Test (WCST) performance (Lenzenweger & Korfine, 1991, 1994), even though they are not clinically affected. Hence, some cognitive and neuropsychological performance features of schizophrenia seem to be present, albeit in a diluted form, in the general population.

Evidence has been presented that some schizophrenic symptoms may reflect at least a dysfunctional frontal system, among other systems (e.g., Goldman-Rakic, 1991; Levin 1984a, 1984b; Weinberger, Berman, & Zee, 1986). Moreover, Lenzenweger and Korfine (1994) recently suggested the possibility of frontal system abnormalities in nonpsychotic individuals who display schizotypic characteristics. Baddeley (1986, p. 34) conceptualized working memory as a system for temporarily maintaining and managing information needed to perform a variety of cognitive tasks "such as comprehension, learning and reasoning." This short-term maintenance of information is presumably accomplished by an active attention control system. Baddeley calls the "central executive," which, in turn, is aided by subsystems that help to maintain the memory as a guide for adaptive action. Dysfunctions of the central executive lead to behaviors that are stereotypic, perseverative, or insensitive to the action requirements of the moment.

On the basis of neuroanatomical and neurophysiological data, Goldman-Rakic (1987, 1991) proposed that a fundamental deficit of schizophrenia may be a disruption of all behaviors guided by working memory, which in rhesus monkeys is mediated by the dorsolateral prefrontal cortex. Lesions in this area of the prefrontal cortex of the rhesus monkey result in severe working memory deficits, as assessed by an oculomotor spatial delayed-response task, as well as many symptoms that resemble some features of schizophrenia, such as distractibility and perseveration. Park and Holzman (1992, 1993) demonstrated that

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schizophrenic patients show similar working memory deficits in the oculomotor spatial delayed-response tasks. Bipolar patients, however, showed no impairments on the same delayed-response tasks. In addition, about half of the healthy relatives of schizophrenic patients also displayed impaired spatial delayed response (Park, Holzman, & Levy, 1993). Spitzer (1993) found spatial delayed-response impairments in schizophrenic patients. The tasks used were modelled after the oculomotor delayed-response tasks that were used to investigate spatial working memory function in rhesus monkeys (Funahashi, Bruce, & Goldman-Rakic, 1989, 1990, 1993). To rule out the possibility that this deficit may have been due to a sensorimotor impairment, a control task was included that was identical to the memory task except that the target never disappeared. The patient was required simply to make an eye movement to a visible target after the delay period. It seemed reasonable, therefore, to see whether there is an association between spatial working memory and schizotypy.

In the present study, we examined the spatial working memory function of normal individuals who were assessed on an inventory tapping experiences of perceptual aberrations, which are one of the manifestations of schizotypy (L. J. Chapman, Chapman, & Raulin, 1978). We were interested in knowing whether normally functioning young adults who score high on the Perceptual Aberration Scale (PerAb) show many errors on a delayed-response task, which assesses spatial working memory. In addition to the delayed-response test, we administered the WCST in order to assess the perseverative tendencies and the ability to maintain set. Deficits in WCST performance have been found repeatedly in schizophrenic individuals, most typically in the form of increased perseverative tendencies and poor category performance (see Wagan & Wagan, 1992, for a review). However, the WCST performance of schizotypic individuals (Condray & Steinhauser, 1992; Lenzenweger & Korfine, 1991, 1994; Raine, Sheard, Reynolds, & Lenz, 1992) and the biologic relatives of schizophrenic patients (Frake, Maier, Hardt, & Hain, 1993; Scarone, Abbruzzese, & Gambini, 1993) has yielded a mixed pattern of findings with respect to perseverative and category performance. In using the WCST we focused on the Failure to Maintain Set index that has been shown to differentiate schizotypic individuals from normal controls (Lenzenweger & Korfine, 1991, 1994; Lyons, Merla, Young, & Kremen, 1991) and predicted a priori that schizotypic individuals would display an elevated number of failure to maintain set errors.

Method

Participants

Participants for the present study were drawn from a randomly ascertained sample of first-year undergraduates at Cornell University who voluntarily completed a 250-item psychological inventory entitled “Attitudes, Feelings, and Experiences Questionnaire” that included the Perceptual Aberration Scale (L. J. Chapman et al., 1978). We chose this approach in order to maximize diversity within our pool of potential study participants and to minimize the effects of both participant self-selection factors and group-related test-taking attitudes often found in introductory psychology course-based sampling procedures.

Two thousand individuals were initially selected at random from a university roster of all first-year students who entered during a recent fall semester (approximately 3,000 students per year). A team of research assistants individually approached each of the potential study participants and asked him/her to voluntarily complete the psychological inventory noted above. The students were informed that their inventory responses would remain completely confidential and would be used for research purposes only. They were asked to complete the inventory within 48 hours, and the completed inventories were picked up by study staff in sealed envelopes. Of the 2,000 potential participants, 1,684 (51% women, 49% men) completed the inventory. The response rate of 84% is consistent with representative sampling (Kalton, 1983).

To control for pseudorandom responding and invalid test-taking attitudes, a 14-item version of Jackson’s (1984) Infrequency Scale from his Personality Research Form was included in the 250-item screening inventory. Students who scored greater than 3 on the Infrequency Scale were dropped from the sample; 35 (2%) were excluded from our sample on this basis. Three additional students were dropped because of extensive missing data on the inventory. The final sample consisted of 1,646, from which two groups were composed for the experimental assessments described below. Separate group means and standard deviations for men and women on the PerAb were computed and served as the basis for selecting. Following L. J. Chapman and Chapman (1985), high PerAb students were required to have scored at least two standard deviations above the group mean on the PerAb, whereas normal controls were required to have scored no higher than one-half of a standard deviation above the group mean. Students for each of the two groups were selected at random from the two sub-samples of students meeting the specified criteria. Twenty-three (12 women) normal control students and 28 (14 women) high PerAb students were tested. The proportions of male and female students across the two groups did not differ significantly, x2 (1, N = 57) = 0.000, n.s. The mean ages of the high and low PerAb students were 19.00 years (SD = .52) and 18.96 years (SD = .53), respectively. The mean PerAb scores of the high and low PerAb students were 19.00 (SD = 6.35) and 0.77 (SD = 0.99), respectively. The two groups did not differ in terms of agreement to participate in the study.

Although the individuals included in the pool of 1,646 potential study participants had been preselected initially for academic achievement (i.e., university admission), academic ability does not preclude a risk for psychopathology (cf. Depe, Krauss, Spoon, & Arbor, 1989; Rimmer, Halikas, & Schuckit, 1987; Stangler, & Printz, 1980). The population from which the sample was drawn was most probably somewhat biased against particularly early-onset variants of severe psychopathology. However, one would not necessarily anticipate any diminution in the prevalence of schizophrenia spectrum-related personality disorders in the undergraduate population studied.

Clinical Measure: The Perceptual Aberration Scale (PerAb)

The PerAb is a 35-item true–false self-report measure of disturbances and distortions in perceptions of body image and other objects (L. J. Chapman et al., 1978). It includes items such as “Occasionally I have felt as though my body did not exist” (keyed true) and “I have never felt that my arms or legs have momentarily grown in size” (keyed false). Internal consistency analyses typically reveal coefficient alphas around .90, and stability of PerAb scores is high (r = .75; L. J. Chapman & Chapman, 1985).

We chose the PerAb for this study because of the importance attached to body image and perceptual distortions in theoretical views of schizotypy (Meehl, 1964; Rado, 1960). As a measure of body image distortions and perceptual aberrations, we are suggesting that the PerAb taps at least one component of schizotypy. In clinical and university samples, individuals who achieve high scores on the PerAb exhibit psy-
choticlike symptoms (Allen, Chapman, & Chapman, 1987; L. J. Chapman, Edell, & Chapman, 1980), cognitive slippage (i.e., mild thought disorder), communication deficits (Allen, Chapman, Chapman, Vuchetich, & Frost, 1987), decreased target identifications on a backward masking task (Balogh & Merritt, 1985), evidence of reaction time crossover (Simons, MacMillan, & Ireland, 1982), smooth pursuit eye movement dysfunction (Simons & Katkin, 1985), and sustained attentional dysfunction (Lenzenweger et al., 1991; Obiols, Garcia-Domingo, de Trincheria, & Domenech, 1993). Chapman, Chapman, Kwapisl, Eckblad, and Zinser (1994) report that a 10-year follow-up examination of college students with initially high PerAb (or Magical Ideation, or both) scores showed significantly elevated rates of schizotypal symptoms, numbers of psychotic relatives, and even psychosis, although not necessarily schizophrenia. In nonpsychotic psychiatric patients, elevated PerAb scores are closely associated with schizotypal symptoms and anxiety as well as an increased risk for treated schizophrenia among first-degree relatives (Lenzenweger & Loranger, 1989a, 1989b). Thus, multiple converging lines of evidence show that the PerAb is a valid, though imperfect, psychometric indicator of an aspect of schizotypy and proneness to psychosis (cf. Cronbach & Mehl, 1955).

However, the potential for false-positive classification in detecting schizotypy with the PerAb has been recognized (L. J. Chapman & Chapman, 1985). Moreover, although the utility of the psychometric screening strategy is well established, we note that a two-stage selection procedure for case detection that might have used a structured interview to assess further those selected as high and low on the PerAb would have optimized the sensitivity and specificity of the measure, and thereby reduced the number of false-positive and false-negative detections (e.g., Dohrenwend & Shrut, 1981; cf. Raine, 1991).

**Psychological State Measures**

*Beck Depression Inventory (Beck, Ward, Mendelsohn, Mock, & Erbaugh, 1961)*

This instrument, a well-known 21-item self-report inventory, was used to measure depressive–dysphoric symptoms in study participants.

*State–Trait Anxiety Inventory (Form Y; Spielberger, 1983)*

This instrument, a widely used 40-item self-report inventory, was used to measure state and trait anxiety in the study participants.

**Intellectual Functioning Measures**

A general assessment of the intellectual functioning level of the study participants was assessed by the Digit Symbol subtest of the Wechsler Adult Intelligence Scale–Revised (WAIS–R; Wechsler, 1981). In addition, participants provided us with a formal release of information that allowed us to obtain their official Scholastic Aptitude Test (SAT) verbal and quantitative scores from their Cornell University record. There were no differences between the high and low PerAb groups on the verbal or quantitative SAT scores or the raw score of the Digit Symbol subtest.

All participants were given the self-administered computerized screening version of the Diagnostic Interview Schedule (Robins, Helzer, Croughan, & Racliffe, 1981) to assess the lifetime presence of several psychopathological conditions, namely major depression–dysthymia, mania–hypomania, and schizophrenia–schizotypy psychosis. None of the participants in the low PerAb group met lifetime criteria for any of these conditions. In the high PerAb group, there were no “definite” detections for any of these conditions. However, although there were no “definite” cases of affective disorder among the high PerAb students, eight individuals received a “possible” lifetime diagnosis for depression–dysthymia, and three of these eight also met criteria for “possible” lifetime mania–hypomania. No high PerAb student met criteria for schizophrenia or schizophreniform disorder.

**Procedures and Performance Measures**

Potential study participants were contacted by telephone and were invited to participate voluntarily in a study of “Young Adult Development,” for which they would receive $50. All study staff were blind to a potential participant’s group membership throughout recruitment, testing, and scoring. The order of administration of the delayed-response test and WCST was counterbalanced across participants. They were tested in a quiet darkened room, and all of them gave informed consent.

**Oculomotor Delayed-Response Task**

The students sat with their heads stabilized on a chin and head rest, and they were asked to look at a stimulus display screen. The fixation point in the center of the screen was a small red dot (0.5° of visual angle). The target was a small black circle (2° of visual angle). The location of the target varied from trial to trial. There were 8 possible target locations, each separated by 45°, on the circumference of an imaginary circle. The distance between the fixation point and any target location was 12° of visual angle. Target locations were presented in random order.

The students were asked to look at the fixation point in the center of the screen. When they were ready to begin the experiment, the experimenter clicked a mouse, which initiated a trial. In the oculomotor spatial memory task, a target (black circle) was flashed on the screen for 200 ms at one of the eight positions. During this brief period, the student was asked to fixate at the center. Immediately afterward, there was a 10-s delay period, during which the student read words that appeared successively at the fixation point and decided whether they belonged to the same semantic category or not. This procedure prevented rehearsal and also required the student to fixate at the center of the screen during the 10-s delay period.

After the delay period, the fixation point and eight “reference” circles appeared on the screen. Students were required to move their eyes to the position that the target circle had occupied prior to its disappearance. If their eyes looked at the correct target position, the screen cleared and the central red fixation point replaced the reference circles. The next trial could then begin. If the student did not look at the correct position, the reference circles remained on the screen until he or she looked at the correct position. The eye positions during this period were recorded every 20 ms. If the subject did not look at the correct location within 10 s, the reference circles disappeared and the red fixation point reappeared, indicating that a new trial could begin. Students were allowed to rest after every 16 trials, and their eye positions were recalibrated. This oculomotor memory task assessed the working memory function.

A control for the sensorimotor component of the oculomotor spatial delayed-response task was an oculomotor spatial sensory control task, which was identical to the oculomotor memory task except that the target remained on the screen at all times and therefore, no working memory was required for the correct performance. Students read the series of words at the fixation point for 10 s (the same as in the oculomotor memory task) and then immediately after the delay period, they were required to move their eyes to the black target. Figure 1 shows the schematic diagram of the experiment. Presentation order of the memory and the sensory control tasks was counterbalanced across students. There were 32 trials on the memory task and 32 trials on the sensory task. Sufficient time was taken to be certain that each student understood the task; practice trials were given before the experiment was begun.
PROCEDURE

Oculomotor Memory Task

Subject Fixates

Target Display

Target flashes (200 msec)

Target is absent during delay, distractor task prevents rehearsal

Delay Period
10 Sec

Response

Move eyes to remembered target position

Oculomotor Sensory Task

Target on

Target is present during delay distractor task

apple

apple

Move eyes to target

Figure 1. Schematic diagram of the two oculomotor delayed-response tasks: oculomotor memory task (left) and oculomotor sensory control task (right). The sequence of events is identical in both tasks except for the presence or absence of the target during the delay period.

Apparatus for the oculomotor delayed-response task. An infrared light source was placed in front of the stimulus display monitor, facing the student. The reflected infrared light from the student's right eye was recorded by a video camera with an infrared filter. The video camera was connected to an ISCAN RK-426 pupil–corneal reflection tracking system that records the center of the pupil and a bright corneal reflection moving over the pupil. The spatial difference between the pupil and the corneal reflection remains constant if head movement is small (about 1 cubic inch), but it changes with eye movement. This method yields a linear representation of the student's eye position within 15° of visual angle. Within the linear range, the accuracy is better than 1°.

The pupil–corneal tracking system was connected to a Macintosh II...
computer, which recorded and stored the eye position information \((x, y)\) coordinates, and a TV monitor, which allowed the experimenter to observe the right eye during the experiment. To take account of small head movements, the pupil–corneal tracker was connected to an ISCAN RK-520 autocalibration system, which calculated the student's point of regard with respect to the stimulus.

Calibration was performed by asking students to fixate on five experimenter-defined positions on the stimulus display screen, successively: center, upper left, lower left, upper right, and lower right. We used the autocalibration system, which coordinates the eye position information and experimenter-defined calibration position information, to compute the point of regard for subsequent eye movements.

After the calibration, the students were given practice trials to be sure they understood the procedure. Eye movements were monitored on the eye monitor screen to ensure that each student was fixating at the center when the trial began.

**Scoring for the oculomotor spatial delayed-response task.** A response was scored as correct only if the eye moved within 1.5° of the target position and if the eye moved there directly. If the eye moved to a wrong position first and then later moved to the target position, the trial was counted as incorrect. The percentage of correct trials was calculated as the accuracy score. Response times of the correct trials were also computed.

**Wisconsin Card Sorting Test**

A computerized WCST was administered according to the standard guidelines specified in the test manual (Heaton, Chelune, Talley, Kay, & Curtiss, 1993) and scored using a computerized version of the test (Harris, 1988). The WCST measures abstraction ability and cognitive flexibility and is alleged to be associated with functioning of the dorsolateral prefrontal cortex (e.g., Milner, 1963; Nelson, 1976; Weinberger et al., 1986; however, the specificity of this relationship has been challenged by several studies, e.g., Heaton et al., 1993; Wagman & Wagman, 1992). On each trial, students are required to match a response card to the four stimulus cards along one of the three dimensions (color, form, or number), but they are not told the sorting rule. They must deduce the sorting principle from feedback given after they have made a response. The sorting principle shifts during the test; each time the rule changes, the students must learn the new rule from feedback given after each trial. Testing continues until they achieve six categories or all 128 trials are administered.

Five WCST performance indexes were scored using a computerized scoring program (Harris, 1988): (a) number of categories achieved, which represent overall success; (b) percentage of perseverative errors, which measures perseverative tendencies; (c) failure to maintain set, which assesses loss of the correct sorting principle while completing the test; (d) trials to complete first category, which indexes conceptual ability; and (e) learning to learn, which measures the efficiency with which an individual successfully learns how to complete the test.

**Statistical Analyses**

Consistent with our a priori hypotheses that high PerAb students should perform worse than low PerAb ones, we examined all of our variables for group differences using separate one-tailed variance estimate \(t\) tests (due to nonhomogeneity of variance). Pearson product-moment correlation coefficients were used to evaluate degree of associations, and the chi-square test was used to evaluate differences in proportions (one-tailed). Specifically, we hypothesized that high PerAb students should perform less accurately on the oculomotor delayed-response task, but the two groups should not differ on the sensory control task. On the basis of previous results, we anticipated that high PerAb students should show an elevated rate of failures to maintain set errors on the WCST. Finally, high PerAb students should present higher levels of depression and anxiety; however, these state variables should not be significantly correlated with the performance measures.

### Table 1

<table>
<thead>
<tr>
<th>Measure</th>
<th>High PAS ((n = 28))</th>
<th>Low PAS ((n = 23))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(M)</td>
<td>(SD)</td>
</tr>
<tr>
<td><strong>Oculomotor delayed-response tests</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% correct</td>
<td>90</td>
<td>8</td>
</tr>
<tr>
<td>RT (ms)</td>
<td>572.30</td>
<td>69.90</td>
</tr>
<tr>
<td><strong>Sensory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% correct</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>RT (ms)</td>
<td>548.10</td>
<td>74.20</td>
</tr>
<tr>
<td><strong>Wisconsin Card Sorting Test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Categories</td>
<td>5.61</td>
<td>1.26</td>
</tr>
<tr>
<td>Perservative errors (%)</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Failure to maintain set</td>
<td>1.11</td>
<td>1.49</td>
</tr>
<tr>
<td>Trials to first category</td>
<td>16.56</td>
<td>8.32</td>
</tr>
<tr>
<td>Learning to learn</td>
<td>0.44</td>
<td>4.34</td>
</tr>
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</table>

*Note.* The two groups were compared using directional \(t\) tests (one-tailed). All percentages have been rounded off. PAS = Perceptual Aberration Scale; RT = reaction time.

\(* p < .05.\)

on the WCST. Finally, high PerAb students should present higher levels of depression and anxiety; however, these state variables should not be significantly correlated with the performance measures.

**Results**

**Delayed-Response Task Results**

The high PerAb group was less accurate than the normal controls on the Delayed Response Test, \(t(49) = 1.79, p < .04\), which suggests that high PerAb students are less able to hold information in working memory than are the control students (see Table 1). The effect size estimate for the spatial memory delayed-response task difference is .49 (Cohen’s \(d\); Cohen, 1988), a “medium” effect size.1 But there was no difference between the two groups on the sensory control task, \(t(49) = 0.292, p > .70\), which suggests that the spatial delayed-response test deficit observed is not due to a simple sensorimotor factor. All students performed at about the same speed. There was no difference in the response time of correct responses on the oculomotor memory task and on the sensory control task, \(t(49) = 0.70, p > .48\), and \(t(49) = 0.134, p > .89\), respectively.

We examined the types of errors committed by the students. In a previous article, Park and O'Driscoll (in press) distin-

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1 The significance levels (but not the effect sizes) are, of course, affected by the power of this relatively small sample to detect a valid difference, if indeed one exists. A nonparametric statistic (Mann-Whitney) that tests the difference between the high and low PerAb on percentage accuracy is significant at \(p = .085\).
guished between errors that are corrected after one incorrect eye movement, which we labelled E₁, and those that are not corrected at all in the 10 s allotted for response, which we labelled Eₐ. Most individuals correct their errors after their first unsuccessful attempt by making an eye movement to the correct position. These initial errors apparently reflect temporary inefficiencies of various origins such as inattention. Eₐ errors, however, apparently reflect failure to maintain spatial representation of the target. For the low PerAb group, mean Eₐ errors = 1.91 (SD = 1.95); for the high PerAb group it was 2.79 (SD = 2.89). The difference between the groups (Mann–Whitney) is not significant (p > .13). Mean Eₐ errors for the low PerAb group was .652 (SD = 1.61), whereas for the high PerAb group it was 1.5 (SD = 2.19). This difference is statistically significant (Mann–Whitney, p < .044).

We conducted an analysis designed to detect a subgroup of particularly deviant performers on the delayed-response test. We used a cutoff score of 86% accuracy (the lowest accuracy score in Park and Holzman’s, 1992, normal sample) to designate deviant performance on the delayed-response test memory task. Using this cutoff score, 9 (32%) of the high PerAb students and 3 (13%) of the low PerAb students were classified as poor performers on the delayed-response test. The difference between the low and the high PerAb students was of borderline significance, χ²(1) = 2.56, p < .055. High PerAb students, however, were two and one-half times more likely to be included in the impaired category than the normal controls.

**Wisconsin Card Sorting Test Results**

With respect to the WCST, high PerAb students did not differ from the control students on the number of categories achieved, the percentage of perseverative errors, the number of trials to first category, or learning to learn. However, consistent with our prediction, the high PerAb students differed significantly from the normal controls in the failure to maintain set variable, t(49) = 1.99, p < .027. Table 1 presents these results. The effect size estimate for the failure to maintain set difference is .54 (Cohen’s d; Cohen, 1988), a “medium” effect size. The failure to maintain set score can be viewed as an index of one’s ability to discern the correct sorting principle and actually maintain it as a guide from trial to trial; a low failure to maintain set score indicates better performance. This pattern of findings is consistent with prior research showing deviant failure to maintain set scores among schizotypal individuals (Lenzenweger & Korfine, 1991; Lyons et al., 1991).

We computed the correlation between the delayed-response test memory accuracy score and the WCST. The number of errors, perseverative errors, and categories achieved did not correlate significantly with the memory delayed-response test performance; however, memory delayed-response test performance and the failure to maintain set score were (significantly) inversely but modestly correlated, r = −.34, p < .02.

As one would expect, high PerAb students showed higher levels of depression and state-anxiety (all ps < .001; see Table 2). These mental state variables, however, were not associated with the WCST or the delayed-response test performance. Furthermore, the groups did not differ on the Digit Symbol task or the SAT scores, which suggests that the spatial memory delayed-response impairment is not due to a generalized deficit, a suggestion supported by the good academic standing of all the students at the time of these experiments. There was no effect of handedness or gender on the ocularmotor delayed-response tasks. In addition, there was no correlation between delayed-response performance and clinical state variables such as anxiety and depression.

### Table 2

<table>
<thead>
<tr>
<th>Measure</th>
<th>High PAS (n = 28)</th>
<th>Controls (n = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Beck Depression</td>
<td>10.14</td>
<td>5.71</td>
</tr>
<tr>
<td>State Anxiety</td>
<td>38.96</td>
<td>10.24</td>
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<tr>
<td>Trait Anxiety</td>
<td>45.57</td>
<td>10.19</td>
</tr>
<tr>
<td>SAT</td>
<td></td>
<td></td>
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<tr>
<td>Quantitative Verbal</td>
<td>671.71</td>
<td>76.50</td>
</tr>
<tr>
<td>Verbal</td>
<td>597.93</td>
<td>87.03</td>
</tr>
<tr>
<td>WAIS–R Digit Symbol</td>
<td>70.64</td>
<td>8.59</td>
</tr>
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</table>

*Note.* The two groups were compared using directional *t* tests (one-tailed). PAS = Perceptual Aberration Scale; SAT = Scholastic Aptitude Test; WAIS–R = Wechsler Adult Intelligence Scale—Revised. **p < .001.

### Discussion

In this study, we found an association between a measure involving spatial working memory and high PerAb scores, such that a subgroup of normal individuals with high PerAb scores performed less accurately on a spatial memory delayed-response task than did the control individuals. We previously reported that schizophrenic patients and about 40% of first-degree relatives of schizophrenic patients show similar spatial delayed-response impairments (Park & Holzman, 1992, 1993; Park et al., 1993). The high PerAb students in this study were neither medicated nor clinically ill. This result contributes indirect evidence that the putative working memory deficit of schizophrenic patients reported in our earlier studies cannot be attributed to medication effects.

We also found that the high PerAb students displayed a significantly elevated rate of “failure to maintain set” on the WCST. This finding replicates the previous work of Lenzenweger and Korfine (1994), which also studied high PerAb individuals, and is consistent with that of Lyons et al. (1991), which reported elevated failure to maintain set errors in clinically identified schizotypal individuals. These data are also consistent with the concept of “loss of set” notion embodied in the early work by Shakow (1962) on “segmental set” and Harrow,
Lanin-Kettering, Prosen, and Miller's (1983) research on "intermingling and loss of set."

It may be tempting to interpret our findings as implicating a possible dorsolateral prefrontal cortically mediated deficit in psychometrically identified schizotypic individuals. Caution should be observed with respect to such attempts at localization, however. Although working memory deficits have been seen after lesions were made in the principal sulcus of monkeys (Funahashi et al., 1989, 1990, 1993; Goldman-Rakic, 1987, 1991), the students in our study did not have focal lesions of the prefrontal cortex. Furthermore, although high PerAb students showed failure to maintain set, they were not impaired on any other WCST scores in this study.

Although we cannot assert that there are prefrontal cortical abnormalities in our students analogous to those seen in monkeys (e.g., Goldman-Rakic, 1991), we must consider whether the delayed-response test performance of the high PerAb students are reflections of inattention or of generalized deficit. The nature of the performance on the delayed-response test by the high PerAb students suggests the influence of two hypothetical processes. The first is a temporary inefficiency, reflected in the number of errors corrected after one mistake. The second process, reflected in the larger number of never-corrected errors, suggests that in these academically well-functioning college students, there may be a phasic, detectable dysfunction in the efforts to hold a spatial memory representation on line for adaptive use. Probably in the ordinary course of events, these students can overcome this dysfunction by making use of what Baddeley (1986) called "slave systems," the recruitment of attentional or visualization systems that provide focussed rehearsals of information to be retained. Our experimental design removed the possibility for use of these auxiliary aids to working memory, and therefore significant impairments emerged. Similar dysfunctions in spatial working memory and the presence of mild instances of formal thought disorder have been noted in first-degree relatives of schizophrenic patients in the absence of psychosis (Park et al., 1993; Shenton, Holzman, & Solovay, 1989). These considerations are consistent with a hypothesis that there is an involvement not only of prefrontal areas, but also of circuitry involving the thalamus, limbic system, the prefrontal cortex, and other areas, which merits further careful investigation.

We anticipated relatively subtle (cf. effect size estimates) yet statistically reliable differences between the groups on the working memory and card sorting tasks for reasons related to our student selection strategy and the high-risk research method. First, we selected our groups using an imperfect psychometric measure of schizotypy (i.e., the PerAb). This inventory most likely generates an admixture of compensated schizotypies, only some of whom will ever overcompensate (and some will remain compensated though vulnerable across the life span), and a proportion of individuals at no elevated risk (i.e., false positives). In this respect, the experiences assessed by the PerAb are associated with other disorders besides schizotypic personality (cf. L. J. Chapman et al., 1994). For example, the experience of body-image distortion bears some resemblance to features found in depersonalization, such as emotional numbness and feelings of unreality about oneself and that one's voice, actions, or feelings are not under one's control. All of these experiences can occur among people in the general population who have not identified themselves as needing treatment (Dixon, 1963) and can occur as a consequence of sleep deprivation, acute intoxifications, being in strange places, and after serious accidents (Noyes, Hoenk, Kuperman, & Slymen, 1977). These experiences also are associated with various organic conditions such as temporal lobe epilepsy, brain tumors, and migraine aura, to name only a few. Thus, through the psychometric high-risk approach using the PerAb, we most likely identified not only schizotypic individuals, but also a diversity of others, and as a group they displayed a range of subtle cognitive deficits. This consideration is probably reflected in that the PerAb identifies many more people as "deviant" than does the delayed-response test.

Second, our finding of a subtle difference in spatial memory delayed response and one score on the WCST performance between groups is consistent with modal "high-risk" findings (cf. Cornblatt & Erlenmeyer-Kimling, 1985; Hanson, Gottesman, & Meehl, 1977). Clearly, the goal of the high-risk approach in psychopathology research is the isolation of reliable objective markers (e.g., biobehaviors) that might aid in more efficient identification of schizophrenia (or psychosis) liability. Even if such objective markers reflect relatively subtle deviance, taken together they should advance us toward understanding the nature of the psychopathology reflected in the clinical phenotype of schizophrenia and associated conditions.

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