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# Working memory and the syndromes of schizotypal personality

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## Abstract

The aim of this study was to investigate dorsolateral prefrontal function, as assessed by a spatial working memory task, in relation to the syndromal features of schizotypal personality. We found a weak association between a self-report measure of schizotypy and the working memory performance. Those with a high score on the schizotypal personality questionnaire tended to make more errors on the spatial working memory task. One sub-scale of the schizotypal personality questionnaire that taps into social functioning was significantly correlated with working memory deficit. This result suggests the presence of subtle prefrontal deficit in a sub-group of psychometrically ascertained schizotypic individuals and renders support for the past reports of working memory deficit in schizophrenia and schizotypy. © 1997 Elsevier Science B.V.

*Keywords:* Working memory; Schizophrenia; Schizotypy; Frontal lobe; Social deficit; Negative symptoms

## 1. Introduction

Studies of schizotypal personality or schizotypy can be extremely useful in extending our understanding of the phenotype of schizophrenia. Schizotypic individuals are free of the possible confounds of medications and severe psychotic symptoms, yet they consistently show subtle abnormalities in cognitive, psychophysiological, neuropsychological and even morphological domains (see Raine et al., 1995).

Recent studies have reported the presence of subtle frontal lobe deficits in hypothetically 'psychosis-prone' individuals within the general population, who may carry a latent liability for

schizophrenia (e.g., Park et al., 1995; Lenzenweger and Korfine, 1994; Raine et al., 1992). These findings are intriguing because there is growing evidence to support the hypothesis that some of the symptoms of schizophrenia might arise from the dysfunctional frontal system (see, e.g., Weinberger et al., 1986; Goldman-Rakic, 1991; Levin, 1984). Based on extensive neuro-anatomical and neurophysiological data, Goldman-Rakic (1991) has proposed that a cardinal feature of schizophrenia may be a disruption of all behaviors guided by working memory, which is mediated by the dorsolateral prefrontal cortex in rhesus monkeys. Working memory may be conceptualized as a system for temporary maintenance information so that the information can be used to guide behavior or be transferred to a knowledge storage system (Baddeley, 1986, 1992a,b; Roitblat, 1987).

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Thus, working memory is 'a system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks such as comprehension, learning and reasoning' (Baddeley, 1986). In Baddeley's model of working memory, temporary maintenance of information is achieved by an active attention control system termed the *central executive*, aided by modality-specific sub-systems: the *phonological loop* and the *visuo-spatial sketchpad*. The phonological loop can hold auditory, phonological information via rehearsal processes. The phonological loop works together with the central executive to maintain auditory information in working memory by means of sub-vocal rehearsal in real time. It has been typically investigated with a variety of repetition tasks such as the digit span, although non-word repetition may be a better task for assessing the phonological loop than the digit span, since it is free of lexical confounds (Gathercole and Baddeley, 1989). The visuo-spatial sketchpad maintains and manipulates visuo-spatial images. Thus, working memory is not a single, unitary system but consists of separable, functional components and neural circuits which can be systematically and experimentally probed. In this study, we restrict our investigation of working memory to a simple spatial working memory task, which is highly sensitive to the maintenance of spatial location information.

Lesions in the dorsolateral prefrontal area of the rhesus monkey result in deficits in spatial working memory, as well as behavioral signs that resemble some features of schizophrenia, especially the negative symptoms. Several laboratories have demonstrated the presence of an analogous spatial working memory deficit in schizophrenia patients (e.g., Park and Holzman, 1992; Keefe et al., 1995; Spitzer, 1993; Carter et al., 1996) and a sub-group of schizotypic individuals (Park et al., 1995). In the latter study, healthy undergraduates who scored very highly on a psychometric scale of 'psychosis-proneness', the Perceptual Aberration Scale (Chapman and Chapman, 1985), showed deficits in spatial working memory and the Wisconsin Card Sort task in the absence of any DSM-III-R Axis 1 or Axis 2 diagnosis and medication. But perceptual aberration is only one of

several cardinal features of schizotypy and it is typically associated with the positive symptoms of schizophrenia, which are, in turn, hypothesized to reflect the abnormalities of the temporal or limbic systems. Since we did not use another psychometric scale to assess psychosis-proneness, it was not possible to compare the scales that may tap aspects of the negative syndrome.

It has been suggested that negative symptoms may be attributed partly to dysfunctions of the neural circuitry mediated by the frontal cortex (e.g., see Andreasen et al., 1992; Goldman-Rakic, 1987), but the role of the frontal cortex in negative symptoms is not clearly understood (Blanchard et al., 1994). One hypothesis is that reduced frontal function may result in both the negative symptoms and working memory deficits. There is some evidence for association of working memory deficit and negative symptoms in schizophrenia patients (Carter et al., 1996).

In the present study, we examined working memory function in healthy, young participants, comparable to the population studied by Park et al. (1995), in relation to the nine features of the schizotypal personality, as assessed by the Schizotypal Personality Questionnaire (SPQ) (Raine, 1991). We hypothesized that those individuals who have elevated scores on the sub-scales that tap 'withdrawn' or negative syndrome (e.g., blunted affect, absence of close friends, social anxiety) of the SPQ might show deficits in working memory.

## 2. Methods

### 2.1. Participants

Participants for the present study were recruited from a random sample of undergraduate students who were enrolled on an introductory psychology course. Those taking any medication, including non-prescription anti-histamines and nicotine, were excluded. They were screened for familial history of mental illness and head injury. Eighty-nine undergraduate students at Northwestern University participated (50 women). Mean age was 19.1 years. All participants completed the

Schizotypal Personality Questionnaire (SPQ) and the working memory task, described below. The order of presentation of the questionnaire and the working memory task was counterbalanced across participants.

## 2.2. *Schizotypal Personality Questionnaire (SPQ)*

The SPQ is a 72-item true–false self-report measure of schizotypal personality that taps into the nine components of the DSM-III-R schizotypal personality disorder (Raine, 1991). The nine subscales are perceptual aberration, ideas of reference, magical ideation, suspiciousness, constricted affect, no close friends, social anxiety, odd speech, and odd behavior. Factor analyses of the SPQ items indicate three major factors (e.g., Raine et al., 1994): positive, negative and disorganized features. This structure parallels the three-syndrome model of schizophrenia (Liddle, 1987). Moreover, 55% of participants scoring in the top 10% of SPQ scores meet clinical diagnosis of DSM-III-R schizotypal personality disorder (Raine, 1991).

## 2.3. *Working memory task*

### 2.3.1. *Procedure and apparatus*

Participants sat with their heads steady on a chin and head rest in front of a stimulus display monitor. The stimulus display monitor was fitted with a touch screen (AccuTouch™ Ellinor Technology, Berkshire, UK). The touch screen consisted of a glass plate covered with a tight fitting plastic cover sheet. Conductive coatings were applied to the glass plate and the plastic sheet so that light finger pressure caused internal electrical contact at the point of touch. This voltage was then digitized. Position accuracy was better than 4.6 mm (13 pixels), as measured on a multipoint sampling basis. Calibration procedure involved touching four reference points on the touch screen. Participants were calibrated before beginning the experiment. Participants fixated at the center of the screen and when they were ready to begin, the experimenter clicked a mouse to initiate a trial. In the visual–manual memory task, a target appeared on the screen for 200 ms. Immediately after the target presentation, there was a 10-s delay period, during which the participant performed the cate-

gory shift task, to prevent verbal rehearsal. After the delay period, the fixation point and eight ‘reference’ circles (empty, rather than black) appeared on the screen. Participants were required to touch the screen at the remembered position of the target. If they touched the correct target position, the screen cleared and the next trial could begin. If the participant did not touch the correct position, the reference circles remained on the screen until the participant chose the correct position, or until 9.98 s had elapsed, whichever was sooner (see Fig. 1).

In order to control for the sensorimotor component of the visual–manual memory task, a sensory control task was conducted. The sensory control task was identical to the memory task except for one aspect: the target remained on the screen at all times. Participants were required to touch the target itself after the delay period. This task required no memory, since the target was always present.

The order of presentation of the memory and the sensory conditions was counterbalanced across participants. There were 32 trials on the memory task and 32 on the sensory task, eight at each location in both tasks. All participants gave written informed consent. There were 16 practice trials before the main body of testing began, to ensure that the participants understood the task.

### 2.3.2. *Measures*

The accuracy (% correct) was recorded. A response was scored as correct only if the participant touched within 1.5° of the center of the target position and if the finger moved there directly. If the finger moved to a wrong position first, and then later moved to the correct target position, this response was counted as incorrect.

## 3. Results

The mean accuracy of working memory was 96.9% (SE=0.52). Nobody made any errors on the sensory task. These results are comparable to the data reported in previous studies of spatial working memory function in normal controls (see Park and Holzman, 1992; Park et al., 1995).

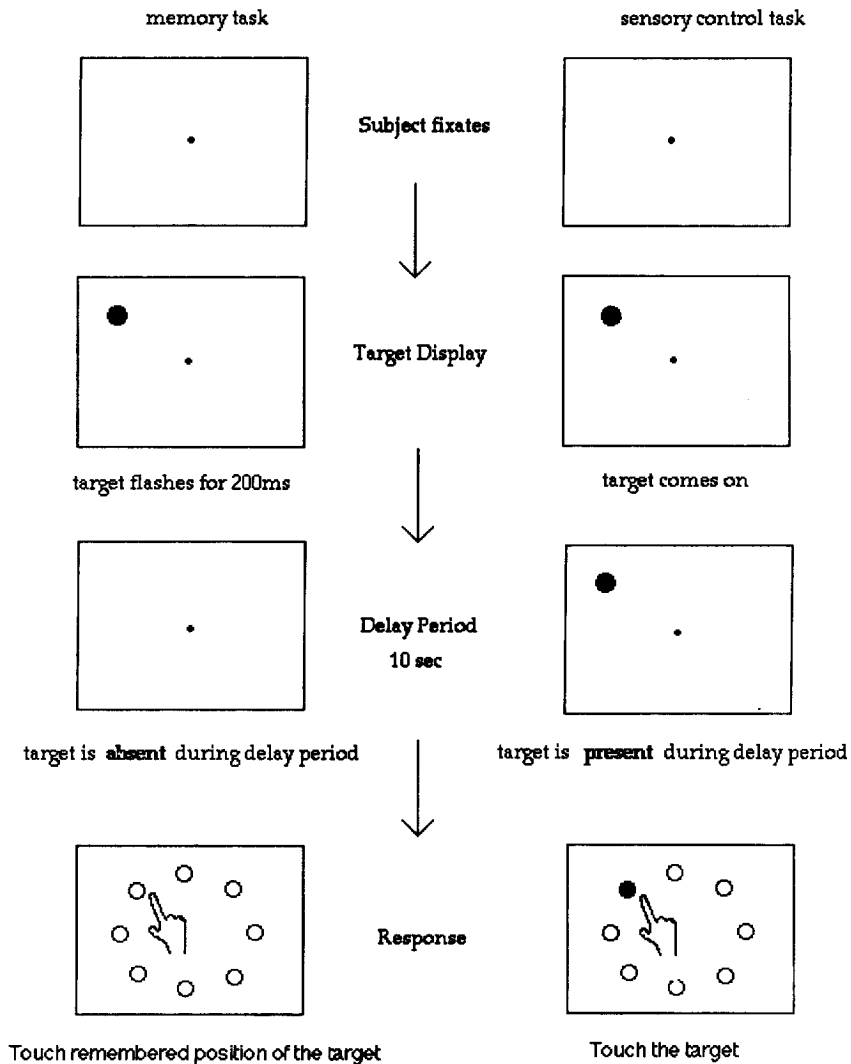


Fig. 1. The spatial working memory task.

Participants endorsed on average 21.6 items (SE = 1.5, range = 2–57) on the SPQ. This figure is comparable to the data reported by Raine (1991).

We examined the correlations between the SPQ scores and the working memory error scores. The total SPQ score was not significantly associated with the working memory score, but there was a trend ( $r = 0.14$ ,  $p < 0.05$ , one-tailed). We then examined the three factors of the SPQ: negative, positive and disorganized. The positive and disorganized factors did not correlate with the working

memory score. But there was a trend towards an association between the negative factor and the working memory score ( $r = 0.15$ ,  $p < 0.05$ , one-tailed).

We examined the nine scales of the SPQ separately and computed the correlations between the sub-scales and the working memory error scores. Only one sub-scale ('No close friends'), which is included in the negative syndrome factor, was significantly correlated with the working memory score ( $r = 0.29$ ,  $p < 0.01$ , two-tailed) (see Fig. 2).

**Correlation coefficients between working memory performance and the sub-scales of the SPQ**

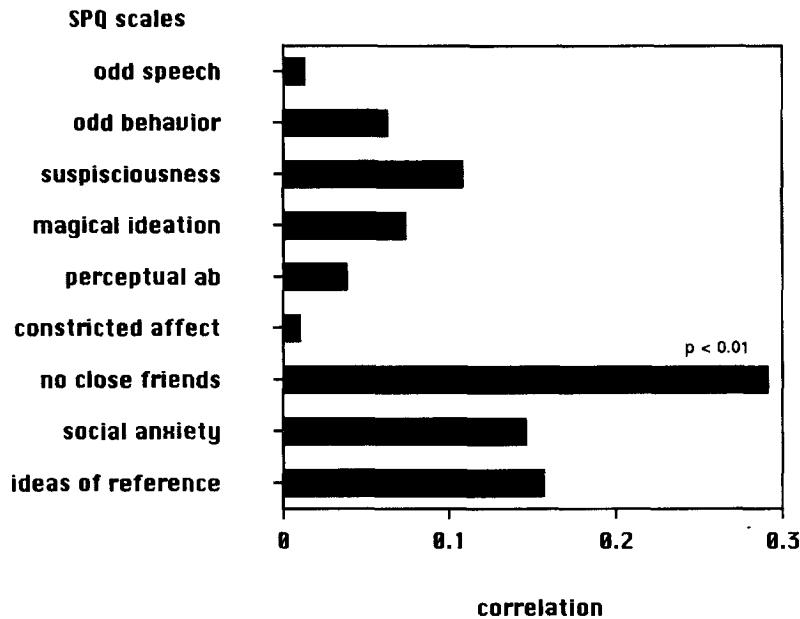


Fig. 2. Correlation coefficients between working memory performance and the sub-scales of the SPQ.

Raine (1991) reported that 55% of participants scoring in the top 10% of SPQ scores meet clinical diagnosis of DSM-III-R schizotypal personality disorder. We divided participants into two groups: those scoring above the 90th percentile on the SPQ were designated the 'schizotypal' group and those who scored below the 90th percentile were designated the 'control' group. According to this criterion, 14 participants, who endorsed more than 44 items out of 72, were designated to the schizotypal group. Schizotypal participants made more working memory errors compared with the control participants ( $F(1,87)=3.7$ ,  $p<0.03$ ) (see Fig. 3). Since the 'no close friends' scale was significantly correlated with the working memory performance, we divided participants into those who scored above the 90th percentile on the 'no close friends' sub-scale and those scored below the 90th percentile. Those who scored above the 90th percentile were less accurate on the working memory task (mean=93.0%, SE=3.8) compared with those

who scored below the 90th percentile (mean=97.3%, SE=0.4) ( $F(1,87)=6.7$ ,  $p<0.01$ ) (see Fig. 3).

#### 4. Discussion

Our results support earlier reports of association between schizotypy and subtle frontal lobe deficit, but the association between the total SPQ scores and the spatial working memory performance is rather weak and only amounts to a trend. A future study with a larger sample is necessary to decide whether there is a significant relationship. Raine's three factor model of schizotypal personality (Raine et al., 1994) includes the cognitive-perceptual, interpersonal and disorganized features. The cognitive-perceptual factor is suggested to be analogous to the positive symptoms of schizophrenia, whereas the interpersonal deficits factor is hypothesized to be a schizotypal analog of the negative

### Working Memory Performance

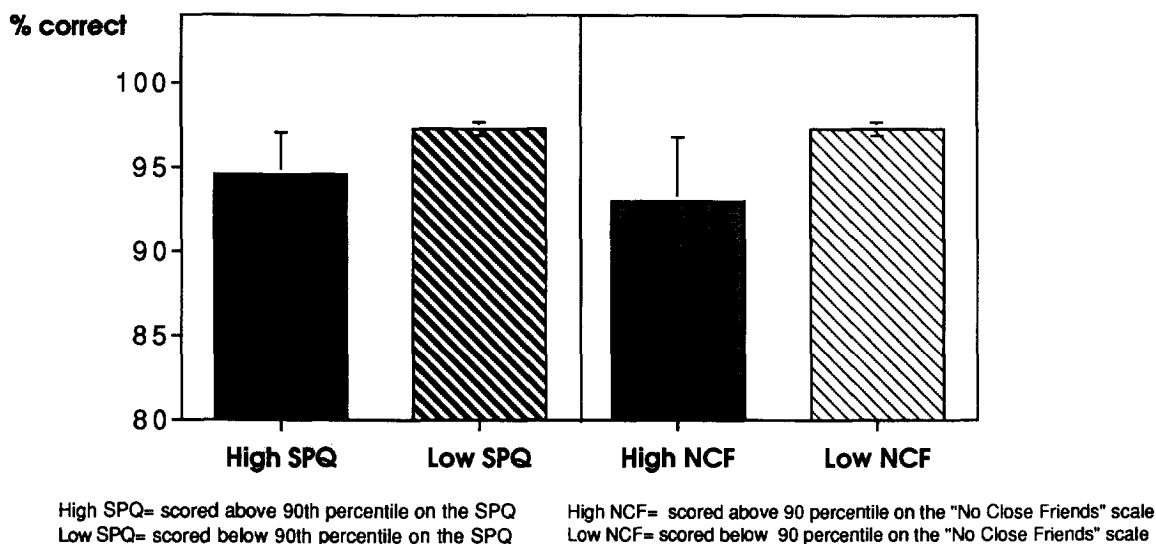


Fig. 3. Working memory performance.

symptoms in schizophrenia patients (Raine et al., 1994; Arndt et al., 1991). We found a trend towards an association between the negative syndrome score on the SPQ and the working memory performance and within the negative syndrome factor, one sub-scale tapping absence of close social relationships was significantly associated with the working memory performance.

This result suggests a testable hypothesis that one component of social deficit, such as an absence of close social relationships, may be mediated by a network involving the frontal lobe systems. A variety of sources, ranging from neurophysiological studies of monkeys to human neuropsychological data, point to evidence linking social functioning and the integrity of the frontal lobe systems (e.g., Jacobsen, 1935, 1936; Girgis, 1971; Eslinger and Damasio, 1985; Brewer et al., 1996). The prefrontal system controls and mediates emotional and visceral behavior (e.g., Girgis, 1971; Neafsey, 1990). It is particularly pertinent to recall that Jacobsen's classic study (Jacobsen, 1935, 1936) of bilateral frontal lobectomy in the monkey resulted in spatial delayed response deficits, and also in significant emotional changes, so much so

that Egon Moniz was compelled to develop frontal lobotomy as a psychiatric treatment strategy. The ways in which prefrontal cortex regulates emotional behaviors are multifaceted. The prefrontal cortex is involved in the brain reward mechanism (e.g., Routtenberg, 1971; Goeders et al., 1986) and, therefore, is likely to be implicated in anhedonic features of psychiatric patients (e.g., negative or deficit symptoms of schizophrenia). Anhedonic individuals are not likely to be actively engaged in social relationships. Another fascinating aspect of the prefrontal system is its role in social decision making. Nauta (1971) suggested that frontal lobe lesions lead to a loss in 'gut feelings', which then contributes to a loss of foresight. Finally, frontal lobe deficits are associated with diminished insight and poor psychosocial outcome in psychiatric and neurological patients (Prigatano, 1991).

In this study, we found that those individuals with poor working memory, as assessed by the spatial delayed response task, tend to be socially isolated. What processes, both biological and psychosocial, mediate the putative prefrontal deficit with the state of relative social isolation in an undergraduate population? We must emphasize

that the hypothesized connection between neuro-anatomical systems and social functioning is a rather tenuous one. To move beyond correlational links, specific mediating mechanisms must be identified and examined. Future studies with a larger sample of both psychometrically ascertained schizotypes and patients with schizophrenia, in addition to a developmental study of high-risk individuals, will be able to better elucidate the complex relationship between the syndromes of schizotypal personality and the components of frontal lobe functions.

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