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SCHIZOTYPAL TRAITS, ATTENTION AND EYE MOVEMENTS

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Abstract

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1. Subjects demonstrating high, average, or low schizotypal traits participated in saccade tasks of eye movements and attention including: a simple saccade task, an antisaccade task, and/or a cued saccade task measuring both facilitatory effects of cuing and inhibition of return (IOR).
2. Subjects were recruited based on their scores on the Rust Inventory of Schizotypal Cognitions (RISC) and then were given Raine's Schizotypal Personality Questionnaire (SPQ) (1991).
3. Subjects scoring high in schizotypy demonstrated increased errors on the voluntary eye movement task (antisaccade task) ($p<0.05$). Performance on the reflexive saccade task was not impaired in high compared to low schizotypals, but may have been enhanced as demonstrated by a negative correlation between scores on the SPQ and performance on this task. For the cued saccade task, there were no overall differences in cueing effects between schizotypal groups, however there was a laterality difference between low versus high scoring schizotypal subjects.
4. These results indicate distinct differences in tasks of overt orienting (saccade and antisaccade tasks) and covert orienting tasks (cued saccade task). The patterns of performance by our schizotypy subjects, including impaired voluntary saccade, enhanced reflexive saccade, and lateralized performance on the cued saccade task, are consistent with the performance of schizophrenic patient populations. Thus, our study supports the previous findings of a physiological relationship between schizotypal personality and schizophrenia.

Key Words: attention, eye movement, personality, saccade, schizotypy, laterality

Abbreviations: antisaccade (AS), inhibition of return (IOR), left visual field (LVF), right visual field (RVF), response time (RT), reflection tracking system (RTS), Rust Inventory of Schizotypal Cognitions (RISC), saccade (S), Schizotypal Personality Questionnaire (SPQ), stimulus onset asynchrony (SOA)

Introduction

Eye movement tasks are commonly used in schizophrenic and normal populations to examine reflexive and voluntary processes by using simple visually guided or symbolically indicated target locations. Abnormal performance on saccadic eye movement tasks have been demonstrated in medicated and non-medicated schizophrenic populations (Arolt, et al. 1998; Crawford, et al. 1995; Fukushima, et al. 1988, 1990a, 1990b; Karoumi, et al. 1998; Sereno and Holzman 1995; Thacker, et al. 1989). The eye movement deficits

reported in these tasks are not global, but seen specifically on voluntary tasks, such as the antisaccade task. Visually guided, or reflexive saccades show no impairments in these same patients.

One common manipulation in eye movement tasks is the inclusion of a "gap". The gap effect, previously described by Fischer and Ramsperger (1984), is the decrease in latency of standard saccadic response times when the central fixation point is extinguished before the onset of the target. The gap is shown to facilitate saccades (reflexive responses), but to increase the difficulty of antisaccades (voluntary responses) (Reuter-Lorenz, et al. 1991). In schizophrenic patients, the inclusion of a gap has been shown to differentially affect reaction times in patients as compared to normal controls (Sereno and Holzman 1993).

Reflexive and voluntary processes can also be examined using cues to orient attention in the absence of making an eye movement. In these paradigms a cue is presented in a peripheral location that acts to draw attention reflexively to that location (Posner and Cohen 1980; Posner et al. 1980). This type of cue is thus referred to as a "reflexive" cue, and is thought to activate an automatic attentional process. A voluntary cue, on the other hand, is typically presented in a central location, and only symbolically indicates the position of a target. The pattern of attentional response to a reflexive cue shows several differences from the effects of a voluntary cue. The use of a non-predictive peripheral (i.e. reflexive) cue has been shown to have a biphasic effect on response times to targets presented in the cued location. Targets appearing shortly after the onset of a cue, or in other words with short stimulus onset asynchronies (SOA), are responded to faster when they appear at the cued location. However, when the SOA is longer, there is then an inhibition of responses to the target when it appears at the cued location as compared to non-cued locations. The early enhancement is referred to as facilitation and the later inhibition as inhibition of return (Posner and Cohen, 1984).

Several studies have examined cued attention paradigms in schizophrenic populations (Posner, et al. 1988; Potkin, et al. 1989; Sereno and Holzman 1996; Carter et al. 1994; Huey and Wexler 1994). The majority of these studies, however, have utilized predictive cuing paradigms. Predictive cues are thought to invoke voluntary attentional mechanisms and typically do not produce inhibition of return. Two reports have, however, examined IOR in schizophrenic patients. One report in non-medicated patients, demonstrated reduced IOR in paranoid patients only (Carter et al. 1994). The other report used medicated subjects and examined a longer timecouse. This study demonstrated a delay in the shift from facilitation to inhibition induced by non-predictive exogenous cues (Huey and Wexler 1994).

Schizotypy, as it was first defined by Rado (1953), is the personality characteristics that are predictive of developing schizophrenia. Recent reports support this definition by showing a greater number of schizotypal traits in persons genetically at risk for developing schizophrenia (Torgersen 1985; Kendler 1985), and also by demonstrating that schizotypal traits can predict later onset of schizophrenia (Chapman and Chapman 1987). In addition, similar biochemical and behavioral patterns as are seen in schizophrenia have also been reported in schizotypals (Siever 1985). Our study will examine performance by subjects with high and low schizotypal traits on eye movement and attention tasks.

For our tasks, we have chosen to use a simple saccade (S) and antisaccade (AS) task, and a cued saccade task. The S and AS tasks require reflexive and voluntary eye movements respectively. The S and AS tasks will include gap and overlap conditions in order to further examine the effect of enhancing or inhibiting reflexive and voluntary processes. For the cued saccade task, or IOR task, we will examine the effects of reflexive attentional cues (i.e. non-predictive, exogenous cues) on RT. Performance on each of these tasks

by subjects with varying levels of schizotypal traits will determine whether schizotypal traits are associated with changes in reflexive and voluntary eye movements and attention as has been reported in schizophrenic populations.

Methods

Subjects

Forty subjects were recruited from Rutgers University and participated in eye movement and/or attention tasks. Thirty-six subjects participated in the saccade (S) and antisaccade (AS) tasks, and 28 subjects participated in the inhibition of return (IOR) task (see *Tasks* below). Subjects were recruited based on scores on the Rust Inventory of Schizotypal Cognitions (RISC), a standardized scale of schizotypy (Rust 1989) (see *Scales* below) . Subjects scoring within the bottom 10th percentile, a two point range in the middle, and in the top 90th percentile were contacted, and labeled as low, middle or high schizotypy, respectively. For the S and AS experiments, 16 subjects scoring high in schizotypy, 7 subjects scoring in the middle range, and 13 subjects scoring low in schizotypy participated. For the IOR experiment, 13 subjects scoring high in schizotypy, 8 subjects scoring in the middle range, and 7 subjects scoring low in schizotypy, as based on the RISC scale, participated. Each of these subjects except five (3 middle and 2 high) also participated in the S and AS experiments. None of the schizotypy groups differed significantly with respect to age, gender, smoking or handedness. Subjects participating in multiple experiments always ran in the S and AS tasks first. Subjects participating in only the IOR task did not differ in task performance, and therefore these subjects were included in our analysis. Subjects with a history of mental illness, or with immediate relatives with mental illness were excluded. In addition, subjects taking any prescription or over the counter drugs with known central effects were excluded (e.g. birth control pills, anti-histamines, etc.). Informed consent was obtained from all subjects before participating, and subjects were debriefed after completing the experiment.

Scales

The RISC is a 26 item forced choice scale measuring primarily positive symptoms of schizotypy. In addition, all of the subjects participating in the IOR task were given the Schizotypal Personality Questionnaire (SPQ) (Raine 1991). However, the first ten subjects who participated in the S and AS tasks, did not receive the SPQ. The SPQ is a 74 item scale based on the DSM III-R (American Psychiatric Association 1987) criteria for the diagnosis of schizotypal personality disorder. Nine subscales are measured by the SPQ including: 1. Ideas of reference, 2. Social anhedonia, 3. Odd beliefs/Magical thinking, 4. Unusual perceptual experiences, 5. Eccentric/Odd behavior and appearance, 6. No close friends, 7. Odd speech, 8. Constricted affect, and 9. Suspiciousness/Paranoid ideation. The addition of the SPQ, therefore, allowed us to examine if separate dimensions of schizotypy could account for the eye movement and attentional impairments.

Eye-Tracking Equipment

During testing, subjects were seated 72 cm from a computer screen and instructed to rest their head on a chin support. An infrared light source was directed at the left eye and video camera was focused on the same eye. The output of the camera is sent to a pupil corneal reflection tracking system (RTS), manufactured by ISCAN. The RTS acts by locating the pupil and the reflection of infrared rays from the

subject's cornea. Using the coordinates of these measures the ISCAN equipment is able to calculate eye position independent of both head position and small head movements, and does not require the subjects' head to be rigidly stabilized (e.g. by a bite bar).

At the beginning of each experiment, the subject is asked to look at 9 points on the screen. Using these 9 points as references, custom calibration software can calculate on-line the x- and y-axis screen coordinates corresponding to the current pupil position. As the experiment progresses, the computer presents stimuli on the screen, monitors eye movements, and records data on the accuracy and timing of eye movements. For these experiments we obtained a spatial resolution of approximately 0.5° and timing resolution of 6 msec. A small video monitor is also connected to the camera and displays the left eye of the subject. Thus the experimenter can tell where the subject is looking in real time. All experiments take place in a quiet darkened room.

Eye Movement Analyses

During the experiment, subjects were instructed to maintain fixation and to move their eyes to the target stimulus, or in the location directly opposite the target location, when it appeared on the screen. On line analysis collected three basic variables: latency, retrials, and errors.

Latency was recorded as the number of msec elapsed following the onset of the target until the beginning of the saccade. The latency to respond was determined by a fixation and target window. For each task the fixation window consisted of a 100 pixel box around the central fixation point. A saccade start depended on the subject being outside this fixation window. The target window was 100 pixels in the S and AS tasks, and 120 pixels in the IOR task. The saccade end was recorded when the subjects eye entered a target window.

For all experiments, incomplete trials resulted in a retrial. Retrials resulted in cancellation, and re-running of the trial. Retrials occurred in cases where the subject did not maintain fixation prior to the onset of any cue. This assured that the subject was focused on the central fixation point before the beginning of each trial. Trials were also re-run if the subject failed to respond to the target, or reach the a target window, within a 1,000 msec time limit.

Errors were eliminated from calculation of cell means for response times. Two types of errors were defined, anticipations and incorrect responses. Anticipations are eye movement responses that occur in non-physiological time intervals (less than 90 msec). Incorrect responses are any responses with latencies greater or equal to 90 msec that are made to the incorrect target location.

Tasks

Saccade and Antisaccade. Subjects were run through tasks involving both reflexive and voluntary eye movements. In both tasks a peripheral target is presented in one of two locations. Upon presentation of the target, subjects are required to make an eye movement either towards the target (reflexive task), or away from the target (voluntary task). Figures 1 and 2 illustrate our version of these paradigms.

Subjects were required to fixate the central point for 800 milliseconds before the onset of the target. The target consisted of a 4X4 pixel square presented in one of two locations, 300 pixels (7.2 °)to the left or right of fixation. Subjects were instructed to look towards or away from the target. A tone was sounded

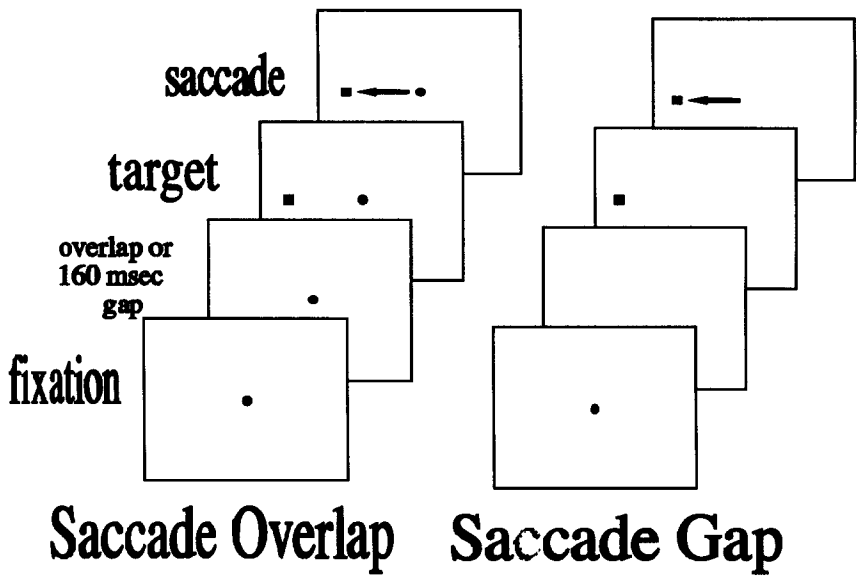

Fig 1. The saccade paradigm demonstrating the overlap and gap conditions. Subjects were required to fixate a central point, and to respond by making an eye-movement to a target, which appeared randomly to the left or right of fixation. The central fixation point either remained on throughout the trial (overlap condition), or was extinguished 160 msec before the target onset (gap condition).

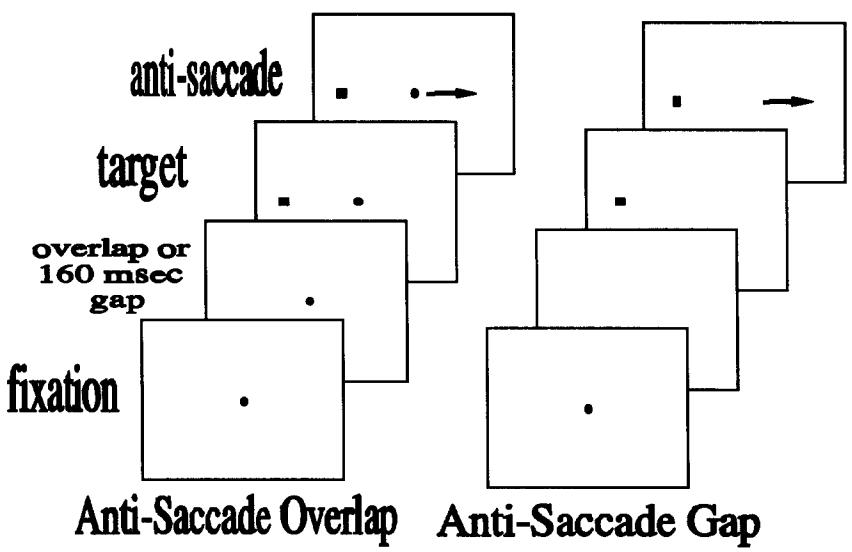

Fig 2. The antisaccade paradigm demonstrating the overlap and gap conditions. Subjects were required to fixate a central point, and to respond by making an eye-movement in the opposite location of a target, which appeared, randomly to the left or right of fixation. The central fixation point either remained on throughout the trial (overlap condition), or was extinguished 160 msec before the target onset (gap condition).

simultaneously with the onset of the target in order to alert the subject. Each block of trials used only one task condition and was comprised of 66 trials. Subjects were required either to look towards the target for one block (saccade) (Fig 1) or away from the target (antisaccade) (Fig 2). In addition the trial block either utilized a gap, or no-gap condition. To eliminate possible order effects, the order in which these blocks were run were randomly assigned.

Inhibition of Return. For our task of reflexive attention we use a modified version of the IOR task described by Posner and Cohen (1984). Figure 3 illustrates our version of this paradigm. For this task, subjects were instructed to fixate a central point on a computer screen with boxes indicating two possible target locations. Subjects initiated the start of each trial by fixating the central fixation dot. Subjects were instructed to keep their eyes at the center fixation until they saw the target stimulus (a green square) appear in one of the two locations. Prior to the target presentation, a cue was presented. The cue was a brief brightening (27 msec) of one of the peripheral boxes. Subjects were instructed not to respond to the cue, but to maintain fixation.

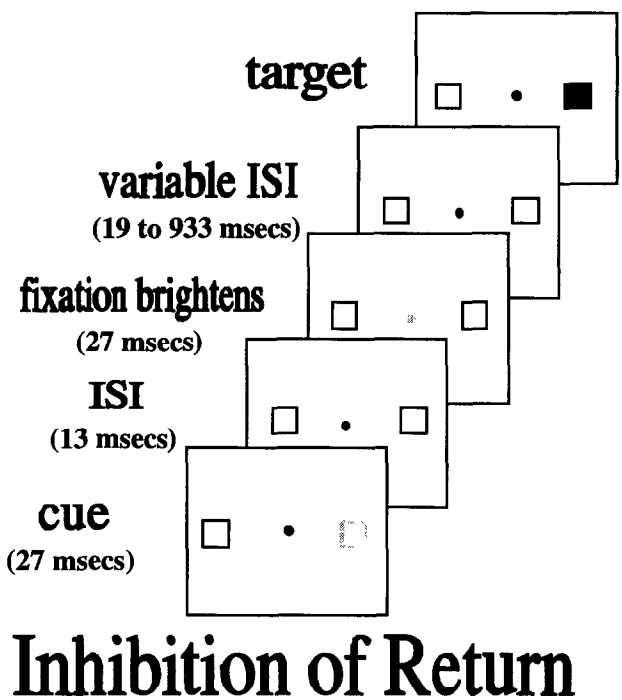

Fig 3. The Inhibition of Return task of attention. Subjects were required to fixate a central point during the presentation of a non predictive peripheral cue, and then to make an eye movement to a target stimulus appearing in one of two peripheral boxes. In this sample trial, the target has appeared in the same position as the peripheral cue; hence, this is a cued trial.

Presumably subjects' attention was drawn reflexively to the location of the cue, although no eye-movement was made. Thirteen msec following the cue presentation the center fixation brightened for 27 msec. This acted to draw the subject's attention reflexively back from the periphery. If fixation was broken at any point

during this sequence, the trial was re-run. After a variable interval the target was then presented in one of the two possible locations with equal probability, and the subject was required to make an eye movement to it. If the target appeared in the location where the cue was presented it is termed a cued trial (Fig 3). If the target appeared in the location opposite where the cue appeared it is termed an uncued trial (not-shown). Ten different delays were used between the fixation brightening and the target onset in order to obtain chosen stimulus onset asynchronies (SOAs) between the cue and target onsets of: 86, 97, 126, 153, 179, 246, 325, 525, 724, and 1,000 (Fig 3).

Data Analysis

Saccade/Antisaccade. Response time data was submitted to a 1 within factor and 1 between factor repeated measure ANOVA. The within factor was TASK (Saccade, Saccade gap, Antisaccade, Antisaccade gap). The between factor was SCHIZOTYPY (low, middle, high). Incorrect response errors were also analyzed using the same 1 within and 1 between factor ANOVA. A Fisher's Least Significant Difference post-hoc analyses were used to determine which factors were responsible for significant interactions. In addition, significant effects found based on RISC scores were compared to scores on the SPQ. A full correlation matrix was performed with factors including RISC, each of the SPQ measures, and performance on the S and AS tasks.

Inhibition of Return. Response time data was submitted to a 2 within factor, 1 between factor repeated measures ANOVA. Within factors included SOA (10 chosen SOAs) and CUING (cued and uncued) conditions. The between factor was SCHIZOTYPY (low, middle, high). Reaction time data was then converted to difference scores to examine the attentional effects of the cues. Difference scores (cued RT-uncued RT) were submitted to a 1 within and 1 between factor repeated measures ANOVA. The within factor was SOA, and the between factor was SCHIZOTYPY.

Lateralization. Due to the equal presentation of cues and targets in the left and right visual fields, we were able to analyze for any differences in RT and accuracy for visual field. Significant effects of visual field were examined by including an additional within factor, LATERALIZATION, for each of the previously described ANOVAs.

Results

Sample

Effects of uncontrolled factors, including age, gender, smoking behavior, and handedness, were examined with respect to performance on our separate eye movement tasks. Separate ANOVAs were performed to examine main effects and any interactions between sample factors and RISC scores with respect to performance (RT and errors) on the SAS and IOR tasks. None of these analyses demonstrated significant main effects or interactions. It is important to note that our experimental design was not intended to examine these factors, and the lack of findings probably represents the homogeneity of our population.

Saccade /Antisaccade

Response Times. The overall ANOVA was significant for the TASK condition, $F_{(3,99)} = 194.1$, $p = .0001$, (Fig 4).

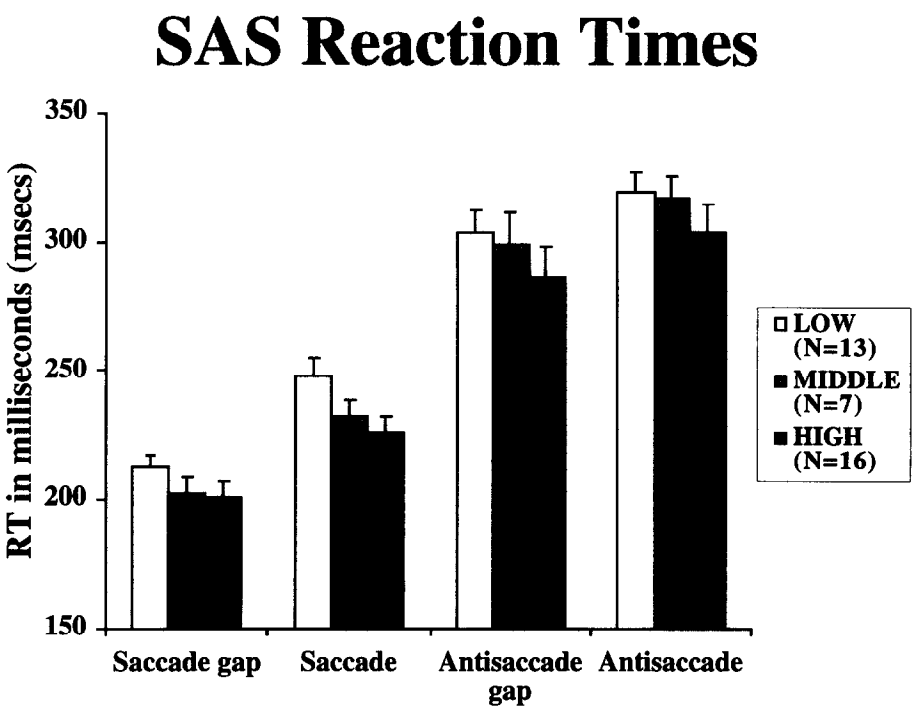

Fig 4. Reaction time data for the three levels of schizotypy on the four saccade tasks. There was no effect of schizotypy on reaction times in any of the conditions. All subjects were significantly faster in the saccade tasks compared to the antisaccade tasks, and significantly faster in gap condition paradigms compared to non-gap paradigms. Error bars indicate SEM.

In order to determine which of the tasks showed significant differences separate within factor ANOVAs were run. These indicated significant differences in mean response times for each of the four tasks, independent of schizotypy. From the fastest to the slowest mean RT, the saccade gap task demonstrated the fastest reaction times, (mean = 204.9), and was significantly faster than the saccade non-gap condition (mean = 234.9), $F(2,33) = 66.12$, $p<.0001$. The next fastest was the antisaccade task with a gap (mean = 301.5), this was significantly slower than the saccade task, $F(2,33) = 98.4$, $p = 0.0001$. The slowest RTs were noted in the antisaccade task with no gap (mean = 313.9), and this was significantly slower than the AS gap condition $F(2,33) = 5.3$, $p = 0.027$. There was no significant main effect of SCHIZOTYPY on RT, $F(2,33) = 1.58$, $p = 0.22$, although mean reaction times tended to be decreased in high schizotypal subjects in all conditions (Fig 1). There was also no interaction between TASK and SCHIZOTYPY, $F(6,99) = 0.35$, $p = 0.90$.

Errors. The overall ANOVA for errors was significant for TASK condition, $F(3,99) = 27.47$, $p = 0.0001$. In addition, there was both a main effect of SCHIZOTYPY, $F(2,33) = 3.3$, $p = 0.049$, and also a significant interaction between TASK and SCHIZOTYPY, $F(6,99) = 2.83$, $p = 0.038$ (Fig 5). To determine the cause of the significant interaction separate ANOVAs for each task condition were performed. These revealed a

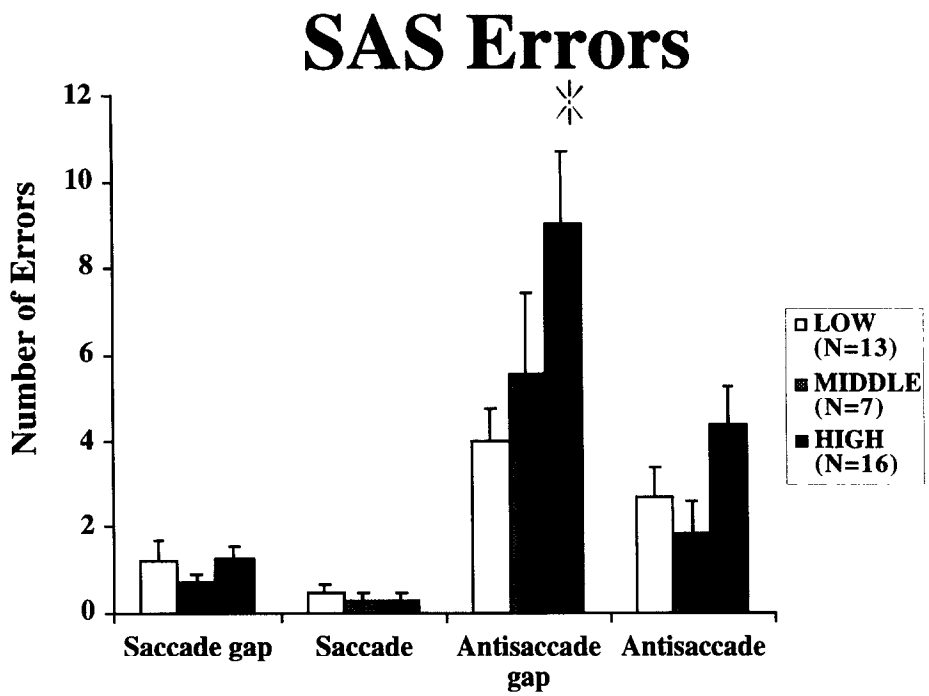

Fig 5. Error data for the three levels of schizotypy on the four saccade tasks. There was a significant effect of TASK on error rate, where subjects tended to make increased errors in antisaccade tasks, and tasks involving gap conditions. Also there was a significant effect of SCHIZOTYPY. Post-hoc analyses indicate an increase error rate on the antisaccade task with gap condition by subjects high in schizotypy compared to subjects low in schizotypy. Error bars indicate SEM.

significant interaction for the AS gap condition task only. A Fisher LSD post- hoc comparison on this condition revealed a significant increase in error rates in subjects with high as compared to low schizotypal traits ($p<0.01$).

Schizotypy. A correlation matrix for all subjects who participated in the S and AS and IOR tasks revealed a significant overall correlation between RISC score and SPQ score, $r = 0.706$, $p < 0.0001$. A significant correlation was observed for each of the SPQ dimensions. The strongest correlations were noted between RISC and SPQ variable 4 (unusual perceptual experiences, r=0.75) and SPQ variable 8 (constricted affect, r=0.66) and SPQ variable 3 (odd beliefs/magical thinking, r=0.62). The weakest correlations were noted between RISC and SPQ5 (eccentric/odd behavior and appearance, r=0.41), SPQ1 (ideas of reference, r=0.42), and SPQ7 (odd speech, r=0.43). No patterns between positive and negative symptoms are noted. To determine the role of the SPQ in relation to eye movement performance an additional correlation matrix was run comparing RT and error rates on the S and AS tasks, with respect to SPQ. There was a significant correlation between SPQ score and errors on the AS task with the gap condition. In order to determine which SPQ variables were related to this effect an additional correlation matrix was run examining these eye movement measures and each of the SPQ variables individually. This analysis revealed several significant effects (Table 1).

Table 1
Correlation Table for Each SPQ Factor and Performance on the S and AS Tasks.

SPQ factors	S	Sg	errS	errSg	AS	ASg	errAS	errASg
1.ideas of ref.	-0.28	-0.10	-0.21	-0.07	-0.12	-0.15	0.04	0.25
2.social anxiety	-0.29	-0.23	**(-0.36)**	**(-0.33)**	**-0.47****	**-0.52****	0.07	0.27
3.magical thinking	**-0.45***	-0.27	-0.01	-0.11	-0.21	-0.18	0.25	**0.40***
4.unusual percept.	**(-0.37)**	-0.28	-0.04	-0.15	-0.27	-0.31	0.04	0.13
5.odd behavior	-0.04	0.01	-0.29	-0.17	0.11	-0.07	0.26	**0.43***
6.no close friends	**-0.56****	**(-0.34)**	**-0.46***	-0.04	**-0.44***	**-0.53****	0.30	**0.39***
7.odd speech	-0.06	-0.04	**(-0.35)**	**-0.38***	-0.05	-0.20	0.19	**(0.36)**
8.constricted affect	-0.14	-0.16	**-0.40***	-0.15	-0.17	**(-0.35)**	0.09	0.30
9.suspiciousness	-0.09	0.06	**(-0.34)**	-0.09	-0.04	-0.11	0.27	**0.52****

Significant r values and trends are presented in bold (**p<0.01, *p<0.05, and numbers in brackets indicate trends, p<0.10). The pattern of performance demonstrated here shows that high schizotypy is associated with decreased reaction times for several SPQ factors, as indicated by negative correlations. This is seen for both reflexive (S, Sg) and voluntary (AS, ASg) tasks. Correlations for errors demonstrate more specific response patterns, where high schizotypy subjects made fewer errors on the saccade tasks (errS, errSg) (as indicated by a negative correlation), and increased errors on the antisaccade task with the gap (errASg) (indicated by a positive correlation).

Examining the patterns of significant effects in Table 1, we note that performance on saccade tasks improves with increasing schizotypy scores. This is true for both response time and accuracy. This effect seems to be particularly prominent for the saccade task with the overlap condition. For the antisaccade tasks, there were several significant positive correlations for the AS gap condition. Indicating that subjects scoring high in schizotypy showed greater errors on the AS gap task. However, mean reaction times for the AS and AS gap condition were reduced in high schizotypals, thus presenting the possibility of a speed accuracy trade off. However, the relationship between speed and accuracy is inconsistent with respect to SPQ factor. Only one factor (SPQ 6) demonstrated a significant correlation between both speed and accuracy on the AS task with the gap, that could represent a speed accuracy trade off. Furthermore, high schizotypals demonstrate a general decrease in saccade latency across all task conditions, including saccade tasks where accuracy is increased in high schizotypals. Finally, the finding that high SPQ scores were associated with increased errors on the AS gap task is consistent with the RISC data previously reported here. In addition to confirming the previous RISC finding of increased AS gap errors, the SPQ correlations showed a significant relationship between performance on the S overlap task and schizotypy, as demonstrated by both an increase in accuracy and a decrease in RT by high schizotypal subjects.

Lateralization. There was no significant main effect of LATERALIZATION in the S and AS tasks for RT, $F(1,22) = 0.70$. However, there was a significant interaction between TASK and LATERALIZATION, $F(3,66) = 5.28$, $p < 0.005$. This was due to subjects demonstrating faster RTs to targets presented in the right visual field in the saccade and saccade gap tasks, whereas mean reaction times were faster to targets

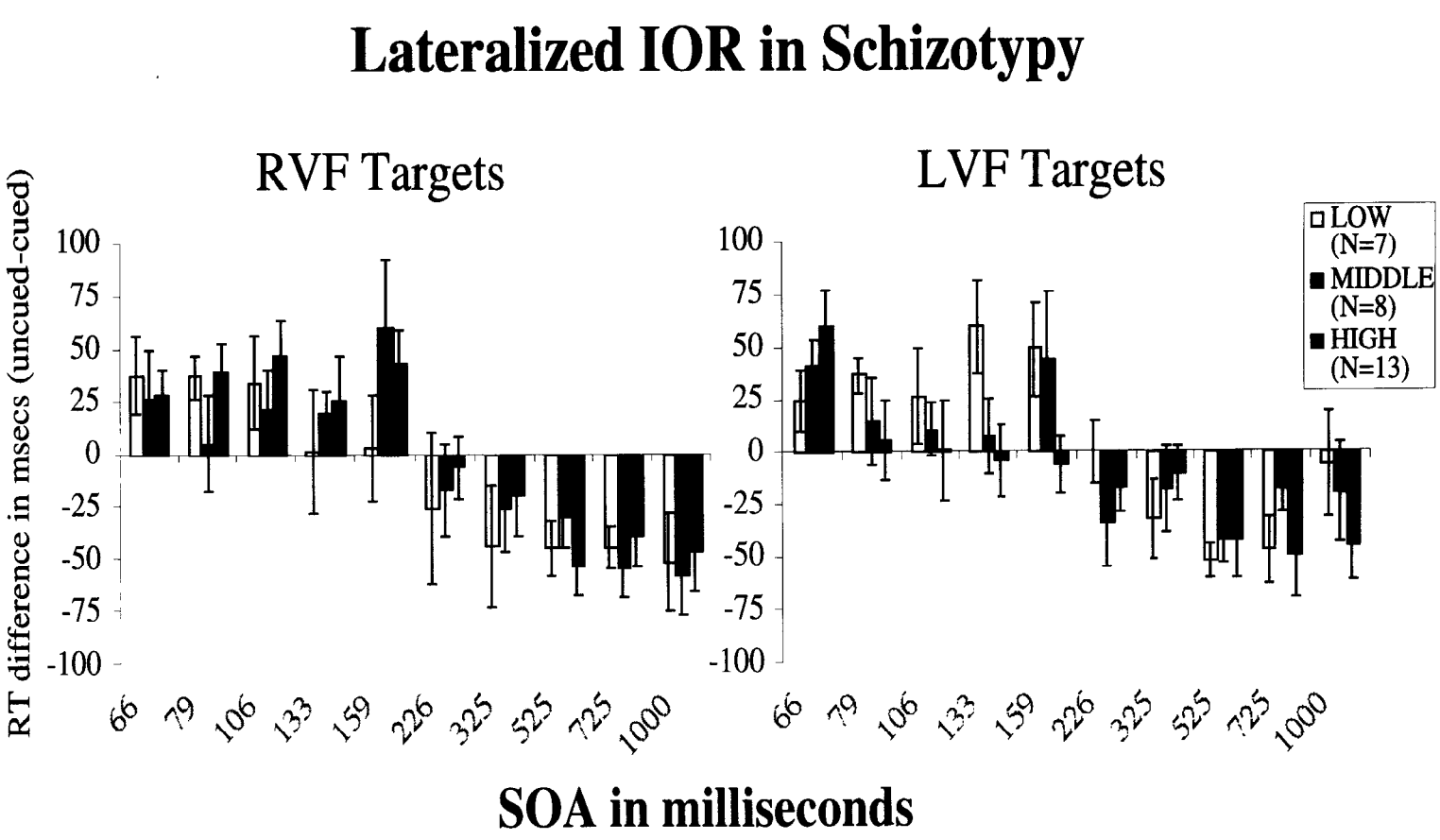

Fig 6. Inhibition of Return in subjects scoring low, middle and high in schizotypy with respect to visual field. There was a significant interaction between visual field and schizotypy. Subjects scoring low in schizotypy showed reduced early cuing effects to targets presented in the right visual field (RVF), whereas high scoring schizotypy subjects showed reduced early cuing effects to left visual field (LVF) targets. Error bars indicate SEM.

presented in the left visual field in both the anti-saccade tasks (Table 2). However, there was no interaction with

Table 2

Mean RTs for the S and AS Tasks with Respect to Location of Target Presentation.

Target Position	S	Sg	AS	ASg
RIGHT	229±4.3	206±5.3	314±5.7	300±7.3
LEFT	242±4.5	212±4.3	311±6.2	294±6.8

A significant interaction between task and target location is demonstrated here. Decreased mean RTs to right visual field targets were seen in the saccade tasks (S and Sg), whereas increased mean RTs to right visual field targets were seen in the anti-saccade tasks (AS and ASg). Thus, for all tasks subjects were faster to respond when the target required a rightward eye movement response.

SCHIZOTYPY, $F(6,99) = .041$, $p = 0.87$. Each schizotypy group showed this pattern of lateralized performance.

For errors, there was no significant main effect of LATERALIZATION, $F(1,22) = 0.17$. In addition, there were no significant interactions for TASK * LATERALIZATION, $F(3,66) = 0.15$, $p = 0.93$, or for TASK * LATERALIZATION * SCHIZOTYPY, $F(6,66) = 0.32$, $p = 0.92$.

Inhibition of Return

Reaction Times. No significant differences were noted for reaction times between the high, middle, and low schizotypy groups either as a main effect, $F(2,26) = 1.37$, $p = 0.27$, or as an interaction between SCHIZOTYPY, SOA and CUING conditions, $F(18,225) = 0.61$, $p = 0.89$.

Difference Scores. No significant differences were noted for difference scores between high, middle and low scoring schizotypy groups either for a main effect, $F(2,26) = 0.01$, $p = 0.99$, or as an interaction between SCHIZOTYPY and SOA, $F(18,225) = 0.61$, $p = 0.89$.

Lateralization. There was no main effect of LATERALIZATION on RT or difference scores, however, there was a significant interaction between LATERALIZATION, CUING and SCHIZOTYPY for RT data $F(2,26) = 3.93$, $p = 0.03$, and for difference scores between LATERALIZATION and SCHIZOTYPY, $F(2,26) = 3.7$, $p = 0.04$ (Fig 6). These effects were due to reduced cuing effects for LVF targets in high schizotypy subjects and reduced cuing effects for RVF targets for low scoring schizotypy subjects. The highest level interaction including LATERALIZATION, SCHIZOTYPY and SOA was not significant for RT or difference score data.

Discussion

Here we demonstrate significant changes in performance on reflexive and voluntary eye movement tasks associated with schizotypal traits. The presence of high schizotypal traits was associated with impaired performance on the antisaccade task, whereas performance on the reflexive saccade task was not impaired. In fact, high schizotypal traits were associated with enhanced performance on the reflexive saccade task, as indicated by both increased accuracy and decreased RT. This pattern of performance, that is impaired voluntary and normal or enhanced reflexive processes, is consistent with previous findings in schizophrenic

subjects (Arolt, et al. 1998; Crawford, et al. 1995; Fukushima, et al. 1988, 1990a, 1990b; Karoumi, et al. 1998; Sereno and Holzman 1995; Thacker, et al. 1989).

It is important to note that significantly greater errors in the voluntary (antisaccade) task were only noted with the inclusion of a gap. The gap is known to increase the difficulty of the AS task, presumably by increasing the ability of the target to produce a reflexive response. It appears that the enhancement of the counterproductive reflexive component of this voluntary task is particularly harmful to a subject who may have hyper-reflexive systems.

For the reflexive saccade task the pattern was the opposite (Table 1). In the saccade task, a significant correlation between schizotypy and performance was most frequently seen in the S task with no gap. That is, differences between subjects scoring high and low on schizotypy were reduced in the saccade gap condition. We believe this might be explained because the gap, or removal of the fixation point, artificially causes the low schizotypal subjects to become more hyper-reflexive like the high schizotypal subjects who are so naturally, hence reducing any differences on this reflexive task.

Performance on the task of covert orienting to an exogenous non-predictive cue demonstrated no overall differences. However, a significant interaction between schizotypy and visual field was revealed. This effect was due to reduced cuing effects to targets presented in the LVF for high scoring schizotypy subjects, and reduced cuing effects for RVF targets in low scoring schizotypy subjects. Although it is not possible to determine the cost/benefits ratios for these differences, as our task did not include neutral cuing conditions, these findings are consistent with reduced effects of RVF invalid cues for high schizotypals, and reduced effects of invalid LVF cues for low schizotypals. The effects for high schizotypals are consistent with other studies of covert orienting suggesting an impairment in processing RVF stimuli in schizophrenia (Posner, et al. 1988; Potkin, et al. 1989; Carter, et al. 1992; Sereno and Holzman 1996).

These findings support the idea that schizotypal subjects share similar eye movement and attentional deficits as seen in schizophrenic patients. One significant difference between ours and others' findings is a lack of overall psychomotor slowing. Increased RTs are consistently reported in medicated and non-medicated schizophrenics (Nuechterlein 1977). In our tasks RT were not significantly different across schizotypy groups. This effect could be due in part to our use of eye movements rather than key presses as response indicators.

The current concept regarding a deficit in voluntary performance in schizophrenia emphasizes the role of cortex, in particular prefrontal cortex, in the control of voluntary attention and eye movements. Frontal dysfunction has been well documented in schizophrenia (Bushsbaum and Haier, 1987), and lesions of the frontal cortex produce similar attentional and eye movement deficits as those seen in schizophrenia, including impaired performance on an antisaccade task (Guitton, et al. 1985). Furthermore, it is proposed that a frontal dysfunction can also account for an increase in reflexive responses in schizophrenia (Levin 1984; Sereno 1992). Sereno (1992) proposed that voluntary processes involving frontal cortex would normally act to inhibit reflexive responses. An impaired frontal function would therefore not only result in reduced voluntary processing, but a disinhibition of reflexive processes. Predictions of this model for schizophrenia would be impaired performance on voluntary tasks and unaffected, or enhanced performance on reflexive tasks. The present findings are consistent with the idea that there is a similar frontal cortical dysfunction in normal subjects with high schizotypal traits.

Conclusions

The authors present data using two tasks of orienting in subjects with varying levels of schizotypal traits. These tasks have previously been used in schizophrenic patients, and the pattern of results we report here are consistent with previous findings in schizophrenics. These findings support the relationship between schizophrenia and persons in the normal population with schizotypal traits. The patterns of attentional performance we report here, namely impaired performance on a voluntary task, and enhanced performance on a reflexive task, are consistent with the findings in schizophrenia patients. This lends support to the idea that persons demonstrating a high number of schizotypal personality traits may have a similar underlying neurobiological dysfunction. The fact that schizophrenic behavior patterns are present in the normal population in subjects with high schizotypal traits indicates the varying degrees to which the symptoms of schizophrenia may be expressed.

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