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Attentional Scanpath on the Span of Apprehension Task in Paranoid Schizophrenia

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Abstract

The Span of Apprehension task represents a putative cognitive vulnerability marker for schizophrenia. To investigate the nature of the scanning deficits on the Span of Apprehension shown by patients with paranoid schizophrenia a wide visual angle partial report version of the task was administered to 18 paranoid schizophrenics and 18 normal controls. An analysis of scan paths, based upon target detection rates as a function of target location, suggests that patients with paranoid schizophrenia use a similar path and number of covert scan moves in iconic memory as do normal controls. Some evidence was found for an impairment related to the speed of processing information in iconic memory. Paranoid schizophrenics appear to suffer from a delay in the initiation of covert search, but not from an impairment in discrete computational functions (i.e. disengage, move and engage functions). Once search is initiated it seems to be carried out as efficiently as in normal controls (German J Psychiatry 1998; 1: 1-5).

Keywords: schizophrenia; scanpath analysis; span of apprehension task; vulnerability marker; attentional deficit

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Introduction

Reduced perceptual span as measured by the partial report Span of Apprehension (SOA) task (Estes and Taylor 1964) has been suggested to be a cognitive marker of vulnerability to schizophrenia. The partial report SOA task requires individuals to report whether a T or F target letter is among a group of distractor letters flashed briefly in a visual display. Patients with schizophrenia in an acute or remitted symptom state show impairments on the SOA task (Asarnow et al. 1991). Performance on the SOA task seems to reflect the efficiency of the visual search of sensory stores, but it remains unclear which of the multiple cognitive processes tapped by the SOA task are impaired in schizophrenic patients. The SOA task assesses "covert" scanning of iconic (i.e. memory contained) images and has to be distinguished from viewing tasks which measure overt (i.e. eye movements) scanning of actual visual displays (e.g. Gaebel et al. 1987). Stimulus exposure on the SOA task is too short to allow eye movements (<100ms). Different hypotheses have been put forward to account for the pattern of performance of schizophrenic individuals on the SOA task: 1) impairment in one or more of the discrete computational systems (engage, move, disengage functions - Posner and Peterson 1990) involved in visual search, 2) processing of less information within each fixation of the attentional spotlight ("narrower" attentional spotlight), 3) delay in initiating cognitive processes involved in visual search and/ or impaired rate of processing (see Asarnow and Granholm 1990). There is extensive evidence that schizophrenic and normal subjects use a serial scanning process to detect target stimuli in the SOA task because the probability of correctly detecting the target stimulus decreases as the number of letters displayed increases (e.g. Strauss et al. 1984).

Recently, Granholm et al. (1996) conducted a study to test hypotheses regarding which of the cognitive mechanisms tapped by the SOA task may be impaired in schizophrenia. To this end, for the first time scanpaths on the SOA task used by schizophrenics to search for targets were examined. A scanpath is defined as the serial deployment of attention shifts ("scan moves") of the attentional "spotlight" across display information mapped in iconic memory (Posner and Peterson 1990). It has been shown that, on tasks like the SOA task, more than one letter is processed within each scan move (Fisher, 1983). The number and path of scan moves can be inferred by examining detection accuracy as a function of the target's location in the array (e.g. Holmgren 1974). It is decreasingly likely that targets will be detected as time elapses between scan moves and the representation of array information in iconic memory declines. A significant decline in detection accuracy from one target quadrant to another should reflect one general scan move between these two quadrants. Chance level detection accuracy should be observed for those quadrants which were not searched prior to the loss of iconic memory.

One aim of the present study is to investigate the validity of the scanpath findings of Granholm et al. (1996) for paranoid schizophrenics. According to these results, chronic schizophrenics show a similar number and path of covert scan moves to those of normal controls under narrow and wide visual angle conditions. The lowered speed of processing hypothesis should be examined by comparing performance of paranoid schizophrenics and normal controls in quadrant locations. Furthermore, if the SOA deficit is due to a delay in initiating visual search, schizophrenic patients should not finish their search of all array locations within the time limits of iconic memory. An impairment in the discrete computational functions involved in visual search should produce an incremental impairment under conditions that require a greater number of scan moves (i.e. larger array size conditions). If the SOA deficit is due to a narrower attentional spotlight, schizophrenic patients should carry out more scan moves than normal controls, especially in larger array size conditions.

Method

Subjects

The sample consisted of 18 (6 female) schizophrenic inpatients of the Klinik für Psychiatrie of the Medical University of Lübeck fulfilling the criteria for an ICD-10 and DSM-III-R diagnosis of paranoid schizophrenia (World Health Organization 1992; American Psychiatric Association 1987). At the time of testing (three or four weeks after admission) the schizophrenic patients were stabilised (Positive Subscale score on the Positive and Negative Syndrome Scale (PANSS; Kay et al. 1992) 17.8 (SD= 23.0), Negative Subscale score on PANSS 43.2 (SD= 24.3)). All schizophrenics were on neuroleptic treatment, the dosage in equivalence to chlorpromazine was 650 mg (range: 50-2100). The control group consisted of 18 (9 female) normals with no history of mental disorder. Subjects with organic impairments or alcoholism or drug dependence were excluded. For the patient group, mean age was 31.2 years (SD= 7.5), years of education was 13.2 (SD= 2.5), duration of illness was 5.4 (SD= 4.2). The mean age of the normal control group was 32.1 (SD= 7.5), and years of education was 14.4 (SD= 2.1). No significant difference was found between the groups with respect to age and educational level (two-tailed t).

Apparatus and stimuli

A forced choice, partial report version of the span of apprehension task was administered (UCLA test version 3.5 - Asarnow and Nuechterlein 1994). Arrays of 3 or 12 letters were presented for 71ms on the screen (NEC Multi-Sync Monitor 3V) of an IBM-compatible microcomputer with 80486 microprocessor. Subjects were instructed to report via button press on an Advanced Gravis Analog Joystick whether a display contained either the letter "F" or "T" and were told to guess when in doubt. One of the letters was always present, but never both. Before each trial, a dot appeared in the centre of the screen which participants were to focus on with their eyes. The participants were seated 1m from the screen. The version employed a wide visual angle (array: 11.0° x 13.8°, vertical x horizontal; letter: 2.1° x 1.6°). The two conditions of 3 and 12 letters were presented 64 times each in alternating blocks of 16 and 32 presentations. Half of the arrays in each condition contained a T, and half contained an F, and targets appeared equally in the four quadrants of the arrays in each condition.

Procedure

Participants were submitted to a visual acuity check before the computerised test trial. Participants had to be able to faultlessly read print at least as small as in line 5, standing four feet from the miniature Snellen eye chart to have sufficient visual acuity for valid testing. Test sessions were conducted in a quiet room free from auditory and visual distractions. Room lighting was held constant at 6.3 EV at 100 ASA. All participants had a practice trial to ensure that they understood the instructions before data collection began.

Results

On the percentage of correct detections (see Figure 1) a 2 (groups) X 2 (array sizes) X 4 (target quadrant locations) mixed model analysis of variance (ANOVA) was calculated. The ANOVA yielded significant main effects for array size, $F(1, 34) = 193.5$, $p < 0.0001$, and for target location, $F(3, 102) = 7.3$, $p < 0.001$. The main effect for group just failed to reach significance, $F(1, 34) = 3.4$, $p < 0.075$. Significant interactions were found between array size and target location, $F(3, 102) = 5.8$, $p < 0.01$. No other two-way or higher order interaction was statistically significant.

The path and number of scan moves was inferred by comparing detection rates across the four target quadrants at a group level. A significant difference between detection rates in two target quadrants indicates that the quadrant with higher detection accuracy was scanned first. The pattern of performance results and the nonsignificant Group X Target Location interaction from the omnibus ANOVA shows that the pattern of detection rates across quadrants within the 3- and 12-letter arrays did not differ significantly between schizophrenics and controls. The significant Array Size X Target Location interaction from the omnibus ANOVA indicates

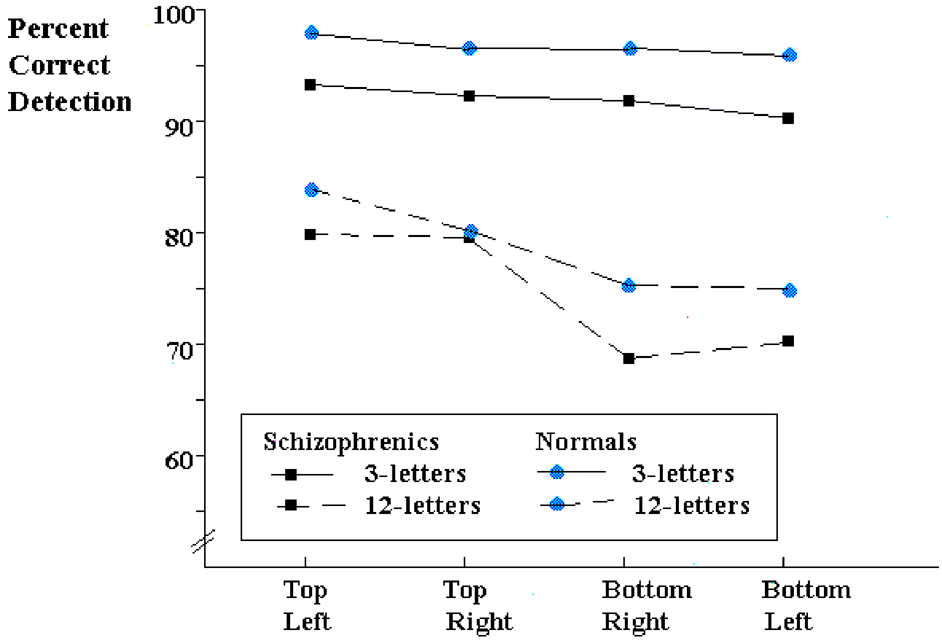

Figure 1. Percentage of correct detections by target quadrant location of 3 and 12 letter span of aprrehension task arrays for each group

that the pattern of detection rates across quadrants (scanpaths) differed significantly between the 3- and 12-letter conditions.

Two-tailed t tests were calculated on overall detection rates (collapsing across groups) for the single target quadrants within each array size to analyse number and directions of scan moves. For 3-letter arrays, detection rates did not differ significantly between target quadrants (see Figure 1). These data suggest that no scan move was carried out. For 12-letter arrays, detection rates were higher in the top-left than in the bottom-left and the bottom-right quadrant (Bonferroni-adjusted p values < .05). No other detection rates were found to differ substantially. These findings are in line with a top (left)-to-bottom scanpath.

Furthermore, the number of participants performing at chance level (less than 66% correct detections) was examined for each target quadrant of the multi-letter condition. Fisher's exact test was used to compare the two groups for each quadrant regarding the number of cases below chance level detection accuracy (see Table 1). The only quadrant where a greater number of schizophrenics than controls

. Percentage and number (in parentheses) of participants in
ɔup with chance level performance for each target quadrant
ɪnted by four cells) of 12-letter arrays on the span of appre-
task.

Schizophrenics		Normal controls	
.2%	5.6%	5.6%	16.7%
(4)	(1)	(1)	(3)
0%	38.9%	27.8%	11.1%
(9)	(7)	(5)	(2)

tended to show chance level detection was the bottom-right, Chi 2 (1, N=36) = 3.7, p = .054. Positive and negative symptom scores (PANSS) were not correlated with test performance.

Discussion

The present data provide evidence that paranoid schizophrenics show a similar number and path of covert scan moves to those of normal controls on the SOA task and are to this extent in line with the findings of Granholm et al. (1996) who examined scan paths in chronic schizophrenics. However, according to our results for 3-letter arrays, no scan move was carried out either by schizophrenics or by controls, and for 12-letter arrays both groups showed a top (left)-to-bottom scanpath. Both findings are in contrast with the results of Granholm et al. who found a top-to-bottom scanpath for 3-letter arrays and a top-left-to-right-half-to-bottom-left scanpath in multi-letter arrays. Insofar as in each study schizophrenics showed the same pattern of scan moves as controls, there is no reason to attribute the discrepancies between studies to differences in schizophrenic samples. As might be expected, patients with paranoid schizophrenia tended to identify a lower number of letters in comparison to normal controls. The failure to detect significant group differences may be due to the moderate power of the test.

This general reduction in scan moves in our study as compared to Granholm et al. (1996) is probably due to our experimental procedure (i.e. the brief display of a point of fixation before array presentation with the instruction to pay attention to the centre of the screen) and offers additional insight into the impaired iconic mechanisms. One cannot ascribe lower difficulty to our span of apprehension protocol, because detection rates were 4 to 5 percent higher for both participant groups in the study of Granholm et al.

Conclusions which are based on the number of scan moves inferred by the present scanpath analyses must be viewed cautiously, because these analyses may underestimate the total number of scan moves made by participants. Several scan moves may have been carried out within each quadrant which could not be detected by measuring overall detection accuracy by quadrant.

The pattern of our results appears to conflict with the view that schizophrenics do not process fewer letters within each scan move (Granholm et al. 1996) because schizophrenics (as controls) performed no scan move at all in the 3-letter array but tended to show lower detection accuracy compared to controls in each quadrant of the 3-letter condition (see Figure 1). This seems to suggest (in terms of a classical neuropsychological computational approach) a smaller attentional spotlight (cf. Asarnow et al. 1991). Previous research suggests that iconic memory does not decay more rapidly in schizophrenics (Schwarz and Winstead 1985). However, slowed speed of search cannot be ruled out as a causal factor especially when taking into account that, in the 12-letter condition, fewer schizophrenics than controls scanned one of the final quadrants (bottom-right) within time limits of iconic memory. Thus, some evidence was found for an impairment related to the speed of processing iconic information. Insofar as performance difference between schizophrenic patients and normal controls did not increase with the number of letters (and scan moves), and schizophrenics scanned poorly one of the final quadrants in the 12-letter condition, it can be hypothesised that paranoid schizophrenics are delayed in the initiation of search. Once schizophrenic patients have started scanning processes they seem to be carried out as efficiently as in normal individuals. Thus, paranoid schizophrenics should not suffer from an impairment in discrete computational functions involved in covert search (i.e. disengage, move, re-engage functions). An impairment in one or more of these functions should have had an additive effect, producing an incremental impairment under conditions that require a greater number of scan moves. However, given the sample size used, the generalisability of our conclusions is limited. Thus, at this moment it is still far from clear what the crucial factors are for a reduced perceptual span in schizophrenia.

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