Eur Arch Psychiatr Neurol Sci (1989) 239:49–57

European Archives of Psychiatry and Neurological Sciences

Visual Search, EEG, and Psychopathology in Schizophrenic Patients

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Summary. Twenty acutely admitted schizophrenic inpatients diagnosed according to RDC and 8 normal controls were instructed to search for a randomly located target letter (Z) in ten lists of 284 distractor letters of either rounded or angular shape projected on a screen (23° × 15°). Eye movements were recorded using infrared corneal reflection-pupil centre measurement. Search performance was defined as the search time in seconds from onset of the display until localization of the target. The EEG was recorded simultaneously in schizophrenics, in whom assessment took place shortly after admission and before discharge. The psychopathological status was assessed at the same time with the Brief Psychiatric Rating Scale and the Scale for the Assessment of Negative Symptoms. Search performance was not significantly different in schizophrenics and normal controls, but was heavily affected by target/distractor similarity in both groups. Moreover, search performance in schizophrenics was not significantly affected by illness severity. However, search performance was differently related to negative and positive symptoms. Schizophrenics and normal controls differed with respect to the relationship between search performance and visuomotor microbehaviour. Additionally, two relatively time-stable eye movement patterns in schizophrenics could be distinguished, which were differently related to psychopathology, performance measures and EEG.

Key words: Schizophrenia – Visual Search – Psychopathology – EEG

Introduction

Measurement of behavioural signs of psychiatric disorders can improve diagnostic precision and understanding of underlying brain mechanisms (Alpert 1985). In biologically oriented schizophrenia research, the assessment of oculomotor dysfunctions as possible markers for the liability to the illness has become increasingly more important (Siever and Coursey 1985; Erlenmeyer-Kimling 1987). Generally, eye movements can be differentiated by means of different function and anatomic organization (Leigh and Zee 1983). However, disrupted smooth pursuit eye movements (Lipton et al. 1983; Holzman 1987) as well as fixation instability and saccade dysmetria (Levin et al. 1981; Mialet and Pichot 1981; Schmidt-Burgk 1984) probably do not characterize an oculomotor dysfunction per se, but refer to a higher-order visuomotor deficit in the broader sense of attentional and information processing dysfunction (Mather and Putchat 1982/83; Nuechterlein and Dawson 1984). This perspective, however, has not yet been strictly applied to the analysis of oculomotor behaviour in schizophrenia.

In visual exploration, eye movements guide the perceptual process, and vice versa. Thus, both eye movements and fixations, which combine to form a scanpath (Noton and Stark 1971), are the elements of visuomotor behaviour. Their interaction, their modification by local stimulus characteristics and their relationship with attentional performance can best be studied by visual search paradigms. Starting from previous eye movement studies in schizophrenia (Gaebel et al. 1986, 1987), the present study tries to elucidate some of the relationships between elementary visuomotor behaviour, search performance, EEG and psychopathology.

Material and Methods

Twenty acutely admitted schizophrenic inpatients (mean age 33.5 ± 11.3 years, 50% men), diagnosed according to RDC (Spitzer et al. 1982), and 8 normal controls (mean age 33.3 years, 6 men) were instructed to search for a randomly located

This article was presented in part at the Symposium on Eye Movements and Psychopathology, Berlin, 23–24 June 1988

target letter (Z) in ten lists of 284 capital distractor letters, each projected on a screen (23° × 15°) for a maximum of 60 s. Half of the lists contained distractor letters of rounded (R) or angular shape (A) respectively, presented in random order.

Both paradigms thus differed with respect to similarity and dissimilarity of formal characteristics of target and distractor letters. While the dissimilarity paradigm ostensibly activates more automatic attentional processes, the similarity paradigm activates more focal attentional processes (Neisser 1974). Both paradigms were chosen, to answer the question as to which of the processes are disturbed in schizophrenia (Nuechterlein and Dawson 1984).

Search performance was defined as the search time (ST) in seconds from onset of the display until localization of the target marked by button press (and verified by the experimenter).

All subjects had normal vision. Eye movements were recorded using infrared corneal reflection-pupil centre measurement (Young and Sheena 1975; Gaebel et al. 1986). Fixations were determined by calculating a running mean for eye position (Kliegl and Olson 1981). A single fixation was defined as representing at least ten consecutive gaze positions (≥ 200 ms) within a predetermined window. From this, the following parameters were extracted: Total number of fixations (TNF), mean duration (ms) of a single fixation (MDF), total scanpath (TSP), and mean scanpath (distance in pixels) between successive fixations (MSP). As a measure of lateral gaze preference, the weighted horizontal mean coordinate XM of all fixations during search (gaze focus) was calculated according to the formula:

$$XM = \frac{\sum [(x_1, x_2, x_3, \ldots x_i) \times (FD_1, FD_2, FD_3, \ldots FD_i)]}{TDF}$$

(x_1, x_2, x_3, ... x_i = horizontal coordinates; FD_1, FD_2, FD_3, ... FD_i = corresponding duration of single fixations: TDF = total duration of fixations). Additionally, the mean diameter of the pupil (MDP) and its individual standard deviation (SDP) as well as its coefficient of variation (VDP) were recorded as indices of arousal and task-evoked processing load respectively (Beatty 1982).

During search, the EEG as a measure of related brain activity was recorded (only in patients). Using fast Fourier transform (FFT) the absolute alpha-power (7.5–13 Hz) was calculated for each individual record as the mean of all 2-s epochs during ST for the four leads F_3/A_1-F_4/A_2- O_1/A_1-O_2/A_2 (AF_3-AF_4-AO_1-AO_2). In order to assess possible changes of topographical relationships, two lateralization quotients [LQP (posterior) = $AO_1/AO_1 + AO_2$. LQA (anterior) = $AF_3/AF_3 + AF_4$] and two anteriorization quotients [AQL (left) = $AF_3/AF_3 + AO_1$. AQR (right) = $AF_4/AF_4 + AO_2$] were calculated. Moreover, the percentage of absolute alpha-power of each individual lead relative to the sum of absolute alpha-power of all four leads (relative alpha-power) was calculated (PF_3, PF_4, PO_1, PO_2).

In schizophrenics, assessment took place shortly after admission (T_1) and before discharge (T_2), while normal controls were assessed only once. At T_1 a drug washout phase of a minimum of 3 days was required. At T_2 all patients were on neuroleptic drugs. The psychopathological status of the schizophrenic patients was assessed with the Brief Psychiatric Rating Scale (BPRS, Overall and Gorham 1962) at T_1 and T_2. From the 18 items of this scale, 5 factors were calculated (HOST = hostile suspiciousness; ACTV = activation; THOT = thought disturbance; ANER = anergia; ANDP = anxiety/depression). The first 3 factors represent positive symptoms, while ANER represents negative symptoms, which were additionally assessed in more detail with the Scale for the Assessment of Negative Symptoms (SANS, Andreasen 1982). In order to assess the relationship with prognostically relevant items, the prognostic scale of Strauss and Carpenter (Kokes et al. 1977) was used.

The explorative data analysis was performed by means of the computer programme SAS.

Results

Search Performance

Figure 1 gives the mean ST in schizophrenics for both paradigms at T_1 and T_2.

Results of a two-way ANOVA with repeated measurement revealed a highly significant main effect for paradigm (ST/A > ST/R, $F_{1,19} = 15.57$; $P = 0.001$), but no significant dependency on illness severity and neuroleptic treatment. An influence on ST of the position of the randomly located target letter (left/right, centre/periphery) was also ruled out. ST in normal controls was also significantly dependent on task condition, but was not different from that in schizophrenics. Accordingly, since the psychopathological status (including negative symptoms) improved significantly from T_1 to T_2, visual target-distractor discrimination in schizophrenics seemed to be neither state- nor disease-(trait-) specifically impaired. However, true dif-

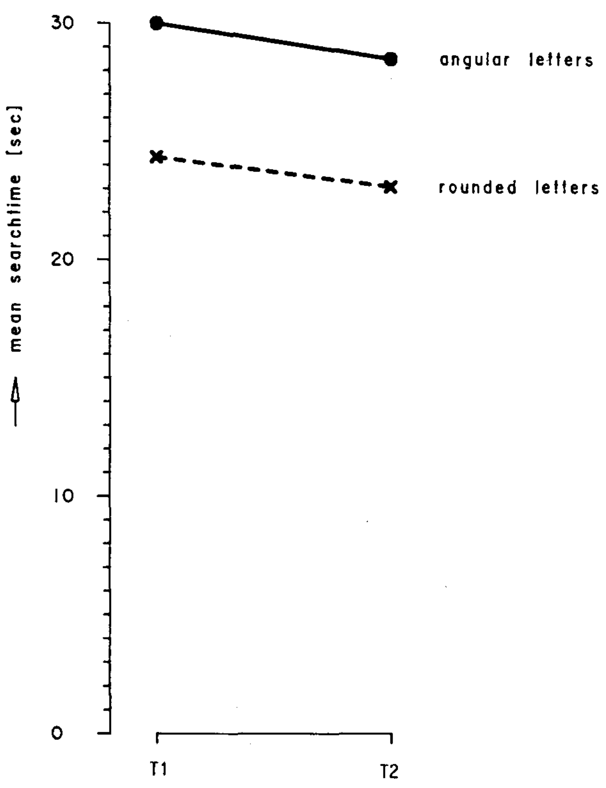

Fig. 1. Search performance (ST) under two task conditions (angular and rounded distractor letters) in schizophrenics at T_1 and T_2

ferences might be obscured by group statistics, in so far as subgroups of schizophrenics may deviate from normal controls in opposite directions. Indirect evidence for this argument comes from the finding that the longitudinal stability (Pearson correlations) of search performance in schizophrenics is only weak (ST/R, T_1/T_2: $r = 0.52$, $P < 0.05$; ST/A, T_1/T_2: $r = 0.52$, $P < 0.05$), pointing to opposite developments of search performance in certain schizophrenic individuals over time, leaving the mean performance unaffected.

Visuomotor Behaviour

There was also no difference between schizophrenics and normal controls in eye-movement-related (TSP, MSP) and eye-fixation-related parameters (TNF, TDF, MDF), neither at T_1 nor at T_2. Thus, schizophrenics in acute and remitted states resemble normals in visuomotor performance and behaviour. However, schizophrenics differed from normals by higher pupil variability (VDP for pooled paradigms: $T = 1.95$, $P = 0.062$) at T_1, but not at T_2, because of a significant decrease in variability over time ($T = 2.38$, $P < 0.05$). This might be an indication that task load in acute schizophrenics is higher than in normals, but normalizes with remission. On the other hand, at T_2 MDP (pooled paradigms) tends to be smaller in schizophrenics than in normals ($T = 1.99$, $P = 0.078$), possibly pointing to hypoarousal in remitted schizophrenics under neuroleptic medication. Finally, at T_2 XM (pooled paradigms) is relatively displaced to the right compared with normals ($T = 2.06$, $P = 0.05$), possibly due to left hemisphere functional overactivation in remitted schizophrenics.

In normals and in schizophrenics at T_1 and T_2 a very similar correlational pattern emerged between ST and visuomotor behaviour for both paradigms (Table 1). Longer ST is highly significantly related to more global scanpath characteristics (macropattern), such as higher TNF, longer TDF and TSP. With regard to elementary characteristics (micropattern), however, longer MDF and shorter MSP are related to longer ST only in schizophrenics. Accordingly, poorer search performance in some schizophrenics is not only the result of a prolonged search process, but is also related to a deviant micropattern, characterized by longer computation time and decreased saccade size. This in

Table 1. Pearson correlations between ST (R/A) and EM parameters (macro-/micropattern) in normals (N) and schizophrenics (S) at T1 and T2

		Macro			Micro	
		TNF	TSP	TDF	MDF	MSP
S						
T1	ST/R	0.97****	0.84****	0.95****	0.63**	−0.66**
	ST/A	0.89****	0.76****	0.86****	0.30	−0.26
T2	ST/R	0.94****	0.89****	0.95****	0.44*	−0.53*
	ST/A	0.90****	0.76****	0.89****	0.45*	−0.46*
N	ST/R	0.92***	0.77**	0.84**	−0.20	0.01
	ST/A	0.97***	0.89***	0.97***	0.02	−0.51

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; **** $P < 0.0001$

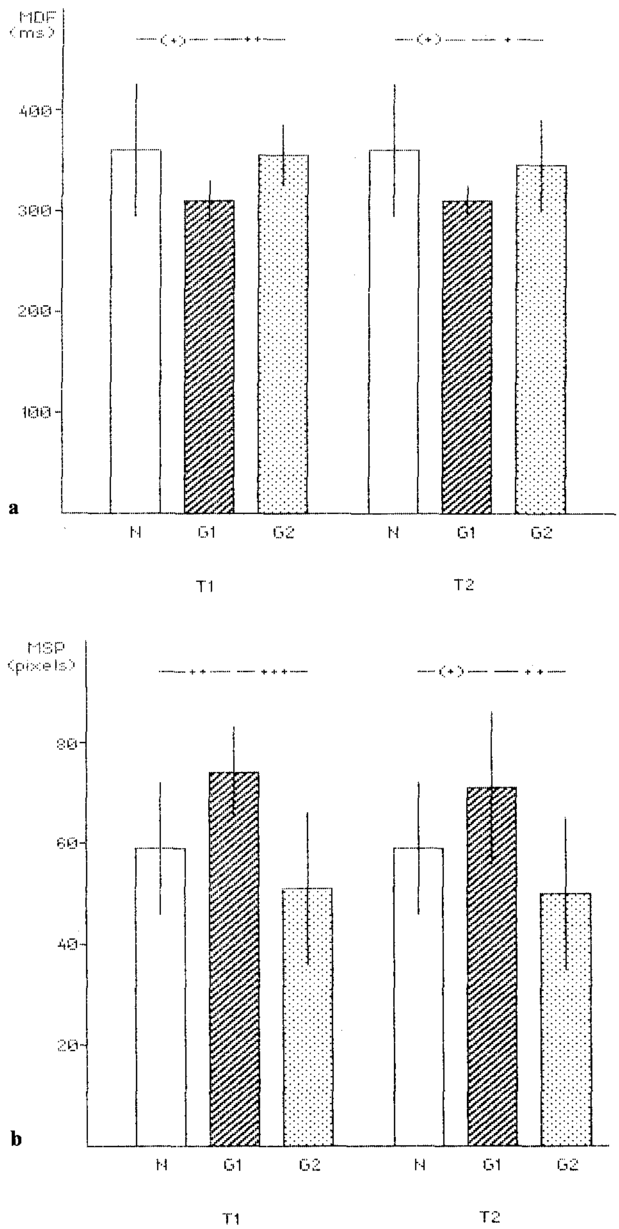

Fig. 2. a Mean duration of fixations *(MDF)* in normals *(N)* and two schizophrenic subgroups (G_1, G_2) at T_1 and T_2. (+) $P < 0.10$; + $P < 0.05$; ++ $P < 0.01$ (*t*-test, two-tailed). **b** Mean scanpath *(MSP)* in normals *(N)* and two schizophrenic subgroups (G_1, G_2) at T_1 and T_2. (+) $P < 0.10$; + $P < 0.05$; ++ $P < 0.01$; +++ $P < 0.001$ (*t*-test, two-tailed)

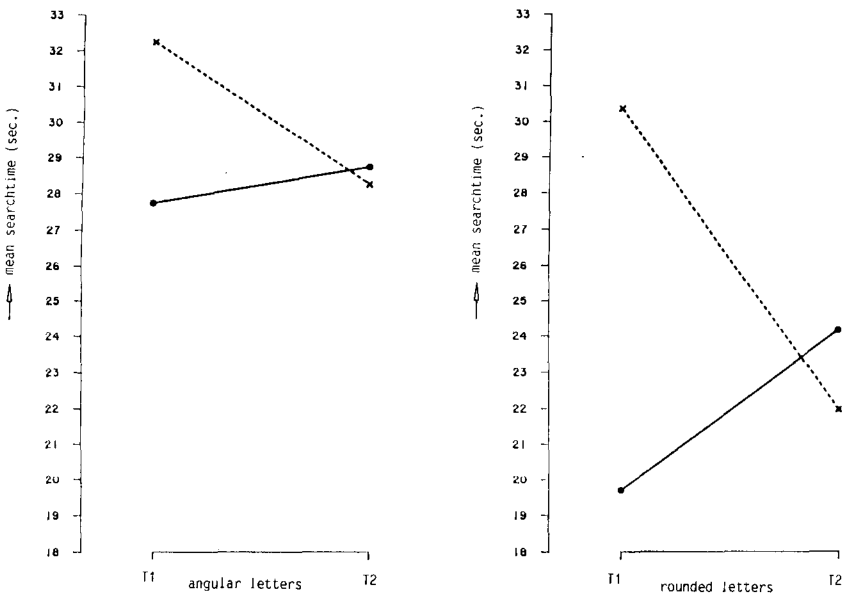

Fig. 3. Search performance (ST) under two task conditions (angular and rounded distractor letters) in two schizophrenic subgroups (G_1 ●—●, G_2 ×—×) at T_1 and T_2

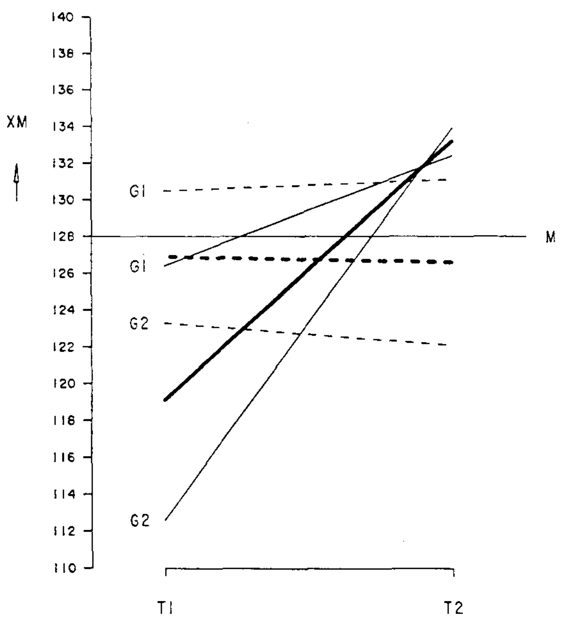

Fig. 4. Horizontal gaze focus *(XM)* under two task conditions (angular ---, and rounded —— distractor letters) in schizophrenics and two subgroups (G_1, G_2) at T_1 and T_2. *M* Theoretical centre coordinate of the display, <128 = left, >128 = right

turn may be related to a decrease in the visual span or width of the functional visual field (narrowed attention), leading to a more focal search process at the expense of a more automatic search process. This concept is indirectly supported by the finding that MDF and MSP were significantly negatively correlated for both paradigms at T_1 and T_2 (T_1: R, $r = -0.74$, $P < 0.001$; A, $r = -0.61$, $P < 0.01$; T2: R, $r = -0.52$, $P < 0.05$; A, $r = -0.60$, $P < 0.01$).

Since in normals MDF and MSP were also marginally negatively correlated for both paradigms (R: $r = -0.58$, A: $r = -0.49$), this relationship between elements of the micropattern points to a basic principle in visual search being unaffected in schizophrenics. However, in order to assess the clinical correlates of different microbehaviour the schizophrenic group was split according to opposite micropatterns (pooled paradigms) at T_1: 10 individuals (G_1) fell below the grand mean of MDF (331.4 ± 34.9 ms) and above the grand mean of MSP (62.3 ± 17.1), and 10 individuals behaved vice versa (G_2).

The difference between the micropattern of G_1 (termed "extensive scanning") and G_2 (termed "minimal scanning") was stable over time, pointing to trait-like visuomotor characteristics of two schizophrenic subgroups (Fig. 2a, b). However, only the micropattern of G_1 differed slightly to significantly from normal controls. The difference in MDF can especially be traced back to shorter fixation durations of G_1 under dissimilar target/distractor conditions.

With regard to ST, there was no difference between G_1 and G_2 under similar target/distractor conditions. However, for the dissimilarity paradigm an interaction effect emerged between time point and group ($F_{1,19} = 6.16$, $P < 0.05$). Accordingly, ST improved with remission, particularly in G_2 (Fig. 3). However, at T_1 ST under dissimilar target/distractor conditions was only slightly longer in G_2 compared with G_1 ($T = 1.91$, $P < 0.10$) and normals ($T = 1.88$, $P < 0.10$).

With regard to lateral asymmetries of the gaze focus during search (XM), for the total group of schizophrenics there was a significant interaction between paradigm and time point ($F_{1,19} = 5.06$, $P < 0.05$), according to a significant rightward shift of the gaze focus from T_1 to T_2 under dissimilar target/distractor conditions ($P = 0.01$). This effect, however, could be attributed especially to G_2 (Fig. 4), while the abovementioned difference in XM between schizophrenics and normals relates to G_1 under similar target/distractor conditions.

Similarly, G_1 is responsible for the above-mentioned difference in MDP between schizophrenics and normals at T_2.

EEG

First of all, there was no significant change in absolute alpha-power from T_1 to T_2. However, the four quotients increased slightly to significantly (LQA: $T = 2.64$, $P < 0.05$; LQP, AQL, AQR: $T = 2.02$–2.03, $0.6 > P < 0.05$), pointing to an increasing left lateralization and anteriorization of alpha-power under activating conditions with psychopathological remission. For the relative alpha-power for each individual lead, there was a highly significant increase in PF_3 ($T = 4.23$, $P = 0.0005$) and a decrease in PO_2 over time ($T = 2.45$, $P < 0.05$). This finding is of special interest, since in acute schizophrenics response-related changes in the topographical distribution of absolute alpha-power under resting conditions (Ulrich et al. 1986) displayed the opposite interhemispheric pattern (increase in PF_4, decrease in PO_1).

These particular EEG variables were also of importance in relation to search performance. While at T_1 PF_3 was significantly negatively related to ST ($r = -0.64$, $P < 0.01$) as well as to parameters of the macropattern of visuomotor behaviour at the 1% level of significance (TNF: $r = -0.61$; TDF: $r = -0.61$; TSP: $r = -0.60$), at T_2 PO_2 was positively related to these variables at the 5% level (ST: $r = 0.47$; TNF: $r = 0.53$; TDF: $r = 0.50$; TSP: $r = 0.53$). For the other EEG variables, a time stable, though only weak relationship to ST evolved only for AQR (see below). Parameters of the micropattern were inconsistently related to EEG variables. With regard to the subgrouping of G_1 and G_2, both groups differed in EEG parameters only at T_1. G_1 displayed less PO_1 ($T = 2.46$, $P < 0.05$) and higher AQL ($T = 2.22$, $P < 0.05$).

Although scalp-recorded EEG from a methodological point of view has to be interpreted cautiously regarding topographic information, which is in any case restricted to cortical activity, several EEG studies have provided evidence for altered functional topography in schizophrenia (Shagass 1987). Relative attenuation of alpha activity, for instance, is generally considered to be an indicator of regional cortical activation (Glass 1984), the topography of which seems to be altered in poor prognosis schizophrenia under resting conditions (Gaebel and Ulrich 1988). Against this background, since neither the absolute alpha-power at one of the four leads nor the lateralization quotients were meaningfully related to search performance and visuomotor behaviour respectively, it has to be concluded that the latter are less related to topographically circumscribed than to extended and interactive electro-physiological processes. These processes might be reflected by the *relative* distribution of alpha-power (PF3, PO2) and seem to involve at least anterior (action-related) and posterior (perception-related) cortical parts of the brain. This would be in accordance with the widely distributed cortical (and subcortical) anatomical and functional organization of visuomotor behaviour (Leigh and Zee 1983). Further studies including EEG in normal controls will reveal whether the present topographic findings are disease-specific or not.

The lateral deviation of the gaze focus XM was exclusively related to the amount of alpha-power over anterior and posterior regions at T_1 and T_2. A higher amount of alpha-power was related to more left-sided deviation of the gaze axis. According to the interpretation of lateral gaze deviation as an indicator of contralateral hemisphere activation (Kinsbourne 1972), the electrophysiologically less activated schizophrenics might be the ones with right hemisphere functional preponderance.

Clinical and Psychopathological Correlates

Univariate analysis of the relationship between search performance and psychopathology did not yield significant results. To examine the complex interrelationship between search performance, psychopathology and

Table 2. Factor pattern^{+} of two separate Principal Component Analyses including ST, EEG ad psychopathology in schizophrenics at T_1 and T_2

	T_1		T_2	
	F_1	F_2	F_1	F_2
ST/A	−0.75	0.50	0.74	−0.35
ST/R	−0.72	0.52	0.75	−0.22
LQA	0.19	−0.26	0.19	0.13
LQP	0.55	0.38	0.13	0.02
AQL	0.43	−0.46	−0.48	0.46
AQR	0.76	0.10	−0.56	0.45
SANS	0.01	0.52	0.71	0.43
ANER	0.21	0.58	0.61	0.38
ANDP	−0.13	0.45	0.55	−0.40
THOT	0.65	0.42	0.48	0.67
ACTV	0.55	0.49	0.02	0.80
HOST	0.14	0.64	0.30	0.74
Explained variance:	35%	31%	37%	31%

F_1, F_2 correspond to the first two of four extracted factors (eigenvalue ≥ 1), which explain 70% of the variance

EEG more adequately, a principal component analysis was applied to the data. Table 2 gives the factorial structure of this analysis at T_1 and T_2.

Taking into account only factor loadings of ≥ 0.50, at T_1 the first factor represents a negative relationship between positive symptoms and ST, while the second factor independently represents a positive relationship between negative symptoms and ST. At T_2, the relative position of these two factors is reversed, but their meaning is similar to T_1. Consequently, positive and negative symptoms retain their opposite relationship to search performance, underscoring the syndrome specificity of search performance.

Only topographical quotients of the EGG were considered in this analysis. AQR retains its specific relationship to search performance, in the sense that higher AQR (anteriorization of alpha-power) has a time-stable relationship to better search performance. While the syndrome-specific context varies with transition from the acute to the remitted state, right hemisphere functions and their involvement in arousal and attentional functions keep their significance for visuomotor functioning.

Concerning G_1 and G_2, there was no difference in age, sex or duration of inpatient treatment. However, at T_1 G_2 scored significantly higher in emotional withdrawal (BPRS: $T = 2.56$, $P < 0.05$) and restricted affect (SANS: $T = 2.20$, $P < 0.05$). However, this difference disappeared at T_2. From these results it may be concluded that emotional withdrawal and poorer search performance in G_2 at T_1 are related phenomena, which are possibly regulated by the same underlying brain mechanisms. Moreover, emotional withdrawal seems not to be a persisting negative symptom (Angrist et al. 1980).

More pronounced leftward gaze deviation (XM) was significantly related to negative symptoms of the SANS either at T_1 or T_2, irrespective of search paradigm (e.g. unchanging facial expression, paucity of gestures, latency of response), as well as to chronicity items of the Strauss/Carpenter prognostic scale (longer duration of symptoms, longer time since illness onset).

Finally, looking for possible outcome predictors, SDP at T_1, especially under dissimilar target/distractor conditions, was negatively related to more pronounced positive symptoms at T_2 at the 5% level of significance (THOT: $r = -0.56$; ACTV: $r = -0.51$; HOST: $r = -0.54$). Higher task load at T_1 thus seems to be a predictor of neuroleptic treatment response.

Discussion

First of all, the results of this exploratory study concerning search performance (ST) demonstrate that schizophrenics' overall ability to extract information from visual displays is neither significantly affected by illness severity and neuroleptic drugs (T_2) nor is it significantly different from the performance of normal controls. The latter result corresponds to previous findings in schizophrenic outpatients (Gaebel et al. 1986). Russell and Knight (1977) and Russell et al. (1980) reported comparable results in process schizophrenics, whose performance was not affected by the paranoid/non-paranoid dichotomy either. From the present findings, however, it is clear, that search performance deteriorates with increasing negative symptoms, and improves with increasing positive symptoms, irrespective of illness phase (acute or remitted). Thus, the results partly confirm the syndrome specificity of attentional deficits, especially in visuomotor performance (Cornblatt et al. 1985; Green and Walker 1985; Gaebel and Ulrich 1987).

If pupil reactivity is taken as a measure of task load upon attentional capacity, as has been proposed by Kahneman (1973) and verified by Beatty (1982), it might be concluded from the findings that in acutely disturbed schizophrenics, the search task imposes a higher load (i.e. requires more controlled attentional capacity) compared with normals. This, however, might indicate that schizophrenics have to compensate for their distractability in order to obtain adequate search performance. Moreover, the higher their ability to mobilize attentional capacity, the better their clinical outcome. This finding is similar to what has been reported for electrodermal reactivity (Straube et al. 1987). Since pupil variability decreased with remission, this might indicate the restorative effect of neuroleptic treatment on attentional functioning.

With regard to the relationship between search performance and visuomotor macrobehaviour, the present findings in schizophrenics and normal controls are in accordance with results from eye movement research in normals. Search performance (ST) is always related to TNF (Gould and Dill 1969); however, this relationship is strongly affected by task complexity, i.e. target/distractor similarity (Gould and Schaffer 1965a; Gould 1967; Gordon 1969; Gould and Carn 1973). With regard to the relationship between ST and visuomotor microbehaviour (especially MDF), research findings are less clear. No systematic relationship emerged in the present study for normals, which is similar to the findings of Gould and Schaffer (1965a), Gordon (1969) and Luria and Strauss (1975). Gould and Dill (1969), however, reported on shorter MDF in fast scanners. In the present study, a similar positive relationship between ST and MDF resulted for schizophrenics, irrespective of task complexity, especially under remitted illness conditions.

Most of the studies in normals have reported that higher task complexity and visual noise lead to longer fixation duration (Gould 1967, 1973; Gould and Schaffer 1965b; Jacobs 1987), whereas only a few studies did not find a significant relationship (Gordon 1969; Gould and Carn 1973). In the present study, although in the normal range (Gordon 1969), schizophrenics did not exhibit longer MDF with increasing task complexity, either at T_1 or at T_2, whereas normals' MDF increased by 30 ms (not significant). One might conclude that the schizophrenics' micropattern is not modulated by local feature characteristics, leaving their visuomotor behaviour partly unadapted to the visual environment. In other words, automatic and focal attentional processes are not well-tuned to task demands.

If fixation duration is conceptualized with regard to the computation-to-acquisition ratio of a task, i.e. the relationship between computional demands and ongoing information intake, the need for anticipation strategies based on peripheral perception is greatest when the ratio is low, i.e. when the computation time per stimulus is relatively brief and a continual input of new information is necessary, as in visual search (Russo 1978). The "useful field of view", however, constricts with increasing visual noise (Mackworth 1965). Moreover, peripheral vision seems to be reduced in chronic schizophrenics compared with acute schizophrenics and normals (Cegalis et al. 1977). Thus, task-related and illness-related factors both may act on the useful field of view, affecting the visuomotor micropattern in visual search of schizophrenics. However, it has been reported that temporal (MDF) and spatial (MSP) eye movement characteristics are independently controlled (Jacobs 1987). The negative relationship between MDF and MSP in schizophrenics and normals, thus, seems to contradict these findings.

With respect to the visuomotor micropattern, there was evidence of two scanning types in schizophrenics, which were labelled "minimal scanning" and "extensive scanning", respectively (following the terms of Silverman 1964). Both types were differently related to psychopathology and attentional performance. Minimal scanning, characterized by significantly longer fixation durations (prolonged computation time?) and shorter MSP between fixations (restricted functional visual field?), was related to more pronounced negative symptoms (emotional withdrawal), poorer search performance (R-condition) and more frequent vertical scanning. This type of visuomotor behaviour has been described in (chronic) schizophrenia (Kojima et al. 1986; Gaebel et al. 1987), mentally retarded children (Reinert 1983) and patients with lesions of the frontal lobes (Luria et al. 1966). The relationship between staring behaviour, emotional withdrawal and poorer search performance only in the acute illness phase points to a state-specific regulation of negative symptoms and attention in a clinical subgroup, which is characterized by restricted scanning. Because of the stability of this eye movement pattern, attention seems to be regulated by varying the width of the functional visual field. This, however, may be an adaptive strategy for dealing with sensory overload in the acute illness phase.

If the present visuomotor task is considered to be a cerebral activation procedure (Berman 1987), then it follows from the EEG findings that the task-related cortical activation pattern is state-dependent and topographically different from what has been observed under resting conditions. On the other hand, a certain topographical distribution of alpha-power seems to keep its relationship with search performance and parameters of the visuomotor macro-behaviour. Especially less pronounced posterior alpha-power (i.e. alpha-blocking) is related to extensive scanning and better search performance. If it is assumed that visual attention as indicated by alpha-blocking is, operationally, oculomotor change (Mulholland and Peper 1971), then the extensive scanners as the group with more extensive oculomotor change are the group with higher visual attention and better search performance. Accordingly, schizophrenics who are able to mobilize their attentional capacity better are the ones with extensive scanning, more pronounced alpha-blocking, better search performance and more favourable clinical outcome. Further studies on EEG as well as on other measures of brain function during defined visuomotor tasks in schizophrenics and normal controls will clarify the nature of dysfunctional brain-behaviour relationships in psychopathology.

With respect to gaze direction, minimal scanners were characterized by a stronger left-sided deviation of their gaze focus during search. The amount of leftward gaze deviation was significantly related to negative symptoms of the SANS. These findings partly confirm the hypothesis that negative symptoms are related to right hemisphere functional preponderance (Gruzelier 1983; Alpert 1985), if it is assumed that lateral gaze deviation is related to contralateral hemisphere overactivation (Kinsbourne 1972). However, with remission the gaze focus shifts from left to right, especially in minimal scanners under dissimilar target/distractor conditions. Thus, EEG and gaze laterality findings both point to a state-specific dynamic imbalance of interhemisphere functional relationships accompanying visuomotor behaviour. Especially minimal scanners seem to be a group with right hemisphere overactivation, at least under acute illness conditions. This, however, is in accordance with the results of Gruzelier and Manchanda (1982) concerning syndrome specificity of laterality findings in electrodermal reactivity.

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Received October 17, 1988