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Smooth Pursuit Eye Movements of Schizophrenics and Normal People Under Stress

By V. BŘEZINOVÁ and R. E. KENDELL

Summary. Eye movements while watching an oscillating pendulum were recorded in 24 chronic schizophrenics and 24 matched normal controls. As others have reported previously, abnormal tracking movements were significantly commoner in the schizophrenics. However, in a series of experiments with normal subjects it was found that conditions designed to distract attention, or to produce declining arousal and attention, produced abnormal tracking movements indistinguishable from those observed in schizophrenics. As chronic schizophrenics are known to perform badly on a variety of psychomotor tasks and there is evidence that this is due to impaired attention or heightened distractibility, it seems likely that these same factors are responsible for their poor eye-tracking performance.

Introduction

Using a simple test of smooth pursuit eye movements Holzman *et al* (1974) reported deviant eye tracking in schizophrenics, and also in a high proportion of their first-degree relatives, and therefore suggested that they might have located a genetic marker for schizophrenia. Shagass *et al* (1974) confirmed that the eye-tracking movements of schizophrenics were less accurate than those of normal controls, but found similar abnormalities in other psychotics as well. Both groups were confident that neuroleptic drugs were not responsible for the abnormalities they observed, though the Chicago workers subsequently showed that quinalbarbitone, but not diazepam or chlorpromazine, did produce disruption of eye tracking for several hours (Holzman *et al*, 1975). The study reported here was designed to find out whether we could confirm these reports of deviant eye-tracking movements in schizophrenics, and whether comparable tracking defects could be produced in normal people by stress, distraction or fatigue.

Methods and Results

All subjects sat with their head against a back rest and watched a small white marker on a pendulum oscillating against a matt black background. The marker was at eye level, 1 m in front of the subject, and the oscillation frequency of the pendulum was 0·4 Hz. The excursion of the marker was 35 cm, corresponding to a 20° visual angle, and the maximum eye movement velocity during accurate tracking was 31·4° per second. Silver electrodes were applied to the outer canthi of both eyes, and the bipolar electro-culogram (EOG) was recorded on an 8-channel Alvar EEG apparatus with a time constant of 2·5 seconds. The amplification was varied to produce a trace with a standard amplitude of 1 cm/10° visual angle whatever the voltage, and the paper speed was 15 mm/second. In most experiments the subject watched the pendulum, and his eye movements were recorded for 60 seconds at a time.

Scoring of the EOG was based on 20 or 40 second epochs, i.e. 8 or 16 cycles. These were scored blind by two (experiments 2, 3, 4) or three (experiment 1) raters, and all comparisons were based on the mean of these ratings. The following variables were scored: (a) Overall irregularity of the tracking curve (The Overall Rating), (b) Frequency of blinking, (c) Frequency of saccadic movements, (d) Frequency of episodes of non tracking, (e) Intermittent irregularities superimposed on the tracking curve, either rhythmical or arhythmical, and (f) Superimposed EMG activity.

The overall rating (a) was made on a five-point scale similar to that of Shagass *et al* (1974) (see Fig. 3 for examples). Close agreement was obtained between raters in all four experiments. For experiment 1 the interrater correlation (Spearman's rho) was 0·91 and in experiments 2, 3 and 4 it was 0·96, 0·82 and 0·99 respectively, with $P<0·01$ in each case. Non-parametric two-tailed significance tests were used throughout (Siegel, 1956).

Experiment 1. Comparison of schizophrenics and normals

The eye-tracking movements of 24 chronic schizophrenics (16 males and 8 females, mean age 42·6±11·8 yr) were compared with those of age and sex matched normal volunteers (mean age 41·4±11·0 yr). Chronic patients were chosen because Holzman *et al* (1974) had reported a much higher incidence of deviant eye tracking in chronic than in acute illnesses. Their mean duration of illness (dated from first hospital admission) ranged from 3 to 38 years with a mean of 18·5, and the majority had been ill more or less continuously throughout that time. No one was included whose initial symptomatology or subsequent course raised the possibility of other diagnoses. All were receiving phenothiazines, and some other drugs as well, at the time of testing. In both groups eye movements were recorded for two 60-second periods separated by an interval of 30 seconds. Half way through the first period the subject was realerted by being told 'Keep your eyes on the white dot—all the time'.

Irregular tracking curves were significantly more frequent in the schizophrenic group than in the normal controls (see Fig 1; Mann-Whitney $U = 137$, z corrected for ties $= 3·14$, $P<0·002$). There was no significant difference between the 13 schizophrenics who had definitely had Schneiderian first-rank symptoms at some time in the past and the 11 who might not have done so. There was a tendency for schizophrenics to blink more than controls ($U = 201$, $z = 1·86$, $P<0·06$), but no difference between the two in the frequency of saccadic movements or non-tracking episodes. After the realerting stimulus, the tracking curve became temporarily more regular in 14 (58 per cent) of the schizophrenics but in only 6 (25 per cent) of the controls; This difference is statistically significant ($\chi^2 = 4·2$ and $P<0·05$ with Yates' correction).

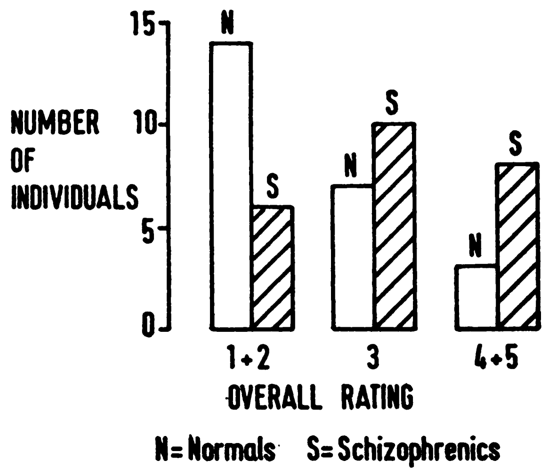

Fig 1.—Distribution of EOG ratings in schizophrenics and matched normal controls.

Experiment 2. The effect of increased anxiety in normals

Ten normal subjects (3 men and 7 women, mean age 28·4±5·0 yr) were tested on two occasions, on one of which their anxiety level was raised by telling them that at some time during the 60-second recording period they stood a 50 : 50 chance of receiving an electric shock from a pair of electrodes strapped to one arm. The serial order of the two was balanced, and anxiety was measured both subjectively (by asking subjects to record their anxiety level on a simple 10 cm analogue

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scale immediately after each recording) and objectively (by measuring heart rate from an ECG during each recording).

All ten subjects rated themselves as more anxious under 'threat of shock' conditions (Wilcoxon's T = O, N = 10, P <0·01), and their mean anxiety rating rose from 34±10 under baseline conditions to 64±12 under threat of shock. Heart rate rose under 'threat of shock' in 7 and remained unchanged in 3 (T = O, N = 7, P <0·02) and the mean rose from 86±16 beats/min under baseline conditions to 98±18 beats/min under threat of shock. However, there were no significant differences in the EOG ratings under the two conditions, either in the overall five point ratings or in the separate ratings of blinking, saccadic movements and non-tracking episodes.

Experiment 3. The effect of distraction in normals

Ten normal subjects (3 men and 7 women, mean age 34·6±9·2 yr) were asked to watch the pendulum as carefully and constantly as possible while performing the following potentially distracting tasks:

1. Writing, on a note pad balanced on one knee, the numbers one to ten as fast and as often as possible.

2. Listening to a prose passage read aloud by the examiner, and counting the number of words beginning with B.

3. Subtracting 7 from 100 serially and writing down each number in the series.

4. Tapping a stylus, on a board balanced on one knee, at alternate one and two second intervals.

5. As 3, but subtracting 13 from 200.

These tasks were designed to require, in varying combinations, attention to other sensory stimuli, co-ordinated motor responses and problem-solving activities of varying difficulty. They were presented in the same order throughout and separated by rest periods of about a minute. Each lasted for 60 seconds, and the series was preceded and followed by 60 second baseline recordings under 'no distraction' conditions. Heart rate was monitored throughout.

Most subjects found tasks 3 and 5 the most difficult, and these were accompanied by a significant rise in pulse rate. Mean heart rate in beats/min was 76±14 for the two baseline periods, 83±14 for tasks 1, 2 and 4 combined, and 92±19 for tasks 3 and 5 combined (χ^2_r = 18·2, df = 2, P <0·001). Tasks 3 and 5 were also accompanied by a significant increase in blinking (χ^2_r = 11·4, df = 2, P <0·01). The mean overall rating was higher for the more difficult tasks than for the baseline recordings and so was the frequency of saccadic movements, superimposed EMG activity and non-tracking episodes, but in no case was the change large enough to be statistically significant.

Experiment 4. The effect of fatigue or boredom in normals

Ten normal subjects (5 men and 5 women, mean age 30·0±7·5 yr) were asked to watch the pendulum continously for 60 minutes with distracting stimuli reduced to a minimum. The amplitude of oscillation had to be restored every five minutes, but was done as unobtrusively as possible. The EOG was recorded for the first 60 seconds of this hour and for a further 60 seconds every five minutes thereafter, giving thirteen 60-second recordings altogether. A bipolar electroencephalogram (EEG) was also recorded on each occasion from the electrodes $C_z - P_z$.

In nine of the ten subjects the overall EOG rating was higher (i.e. the EOG was more irregular) in at least one of the twelve subsequent recording periods than it had been in the first. In six subjects it increased by one or two points on the five-point scale, and in three by three or four points. Deterioration tended to be maximal in the middle of the 60-minute period (see Fig 2) and the mean overall rating was significantly worse for the two recordings taken between 25 and 35 minutes than for the initial recording (T = O, N = 9, P <0·01). Eight of the subjects complained of tiredness, diplopia or difficulty in sustaining attention during the course of the hour. The alpha rhythm tended to become more prominent as time went on, but no definite EEG signs of drowsiness were observed.

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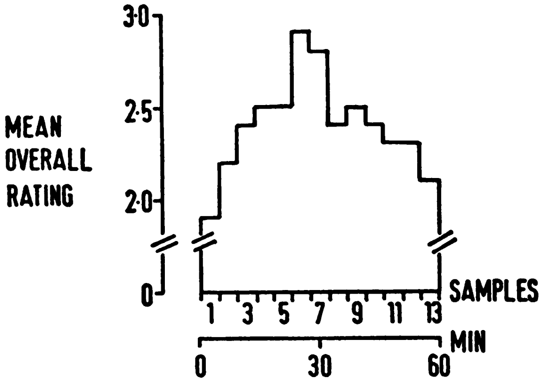


Fig 2.—EOG ratings of normal subjects during continuous eye tracking for 60 minutes.

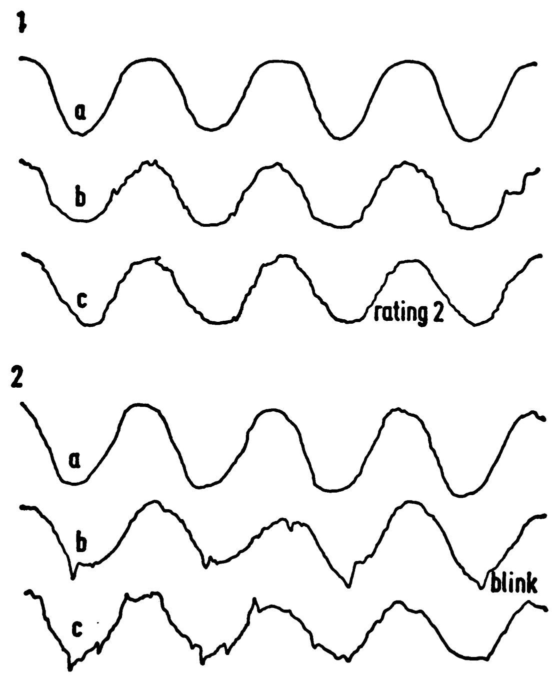
No significant change occurred in the frequency of blinking, saccadic movements, non-tracking episodes or intermittent irregularities.

It was found in Experiment 1 that the overall EOG rating was significantly higher (i.e. worse) in chronic schizophrenics than in age and sex matched controls. The EOG ratings of these schizophrenics were also compared with those of the normal subjects of Experiments 2, 3 and 4. The two were matched for age, but not for sex, in all comparisons. The mean overall rating of the schizophrenics was higher than that of the normal subjects of the other experiments when they were not distracted or fatigued, i.e. the subjects of Experiment 2 under base-line and 'threat of shock' conditions (Mann-Whitney $U = 16$, $N = 10$, $P < 0{\cdot}02$); the subjects of Experiment 3 under 'no distraction' conditions ($U = 25$, $P < 0{\cdot}1$); and the initial 60 second recording of the subjects of Experiment 4 ($U = 9{\cdot}5$, $P < 0{\cdot}002$). However, there was no significant difference between the scores of the schizophrenics and the subjects of Experiment 3 while distracted by task 5 (serial subtraction), or the subjects of Experiment 4 half way through the hour. Examples of the EOG in schizophrenics with defective eye tracking and normal individuals under 'abnormal' conditions are shown in Fig 3.

Discussion

The finding of a higher incidence of deviant eye-tracking responses in chronic schizophrenics than in normal controls confirms the previous reports by Holzman *et al* (1974) and Shagass *et al* (1974). However, as Fig 1 shows, there is considerable overlap between the two. This overlap, and the fact that Shagass *et al* (1974) have already reported similar deviant responses in other psychotics, makes it unlikely that any specific schizophrenic disability is involved.

As Fig 3 shows, abnormal tracking patterns indistinguishable from those observed in schizophrenics can be produced in normal people by distracting them, or allowing their attention to wane through boredom or fatigue. There was no significant difference between the overall EOG ratings of our schizophrenics and those of normal subjects distracted by a serial subtraction task (Experiment 3, Task 5) or whose attention was impaired by prolonged eye tracking (Experiment 4), although there had been significant differences between them under ordinary (baseline) conditions. Increased anxiety (Experiment 2) did not have this effect, however. These results suggest that, of the various mechanisms proposed by Holzman *et al* (1974) to explain abnormal eye tracking,



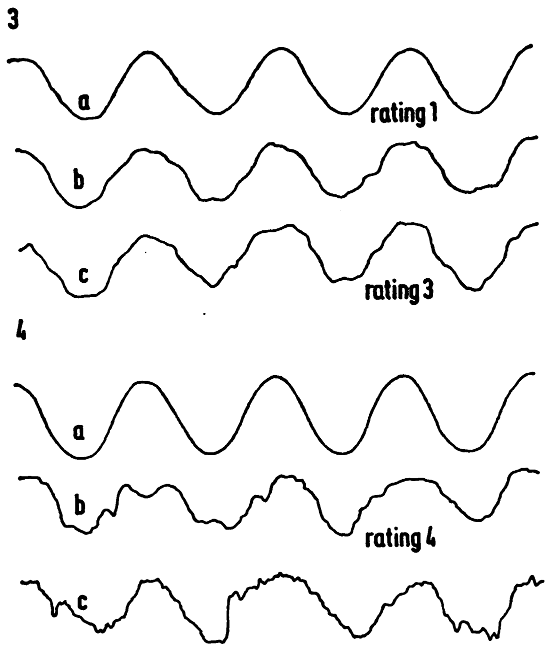


FIG 3.—Examples of the EOG (a) in normal subjects, (b) in the same subjects under 'abnormal' conditions, and (c) in schizophrenics. 1b, 3b, 4b show the effect of prolonged eye tracking (Expt 4) and 2b the effect of distraction (Expt 3, Task 5). The overall ratings of four of these EOG samples are indicated for illustration.

attention is of major importance in normal subjects.

The same may be true in schizophrenics. Chronic schizophrenics are known to perform less well than normals on a wide range of perceptual and psychomotor tasks, and there is evidence that this is due at least in part to impaired attention and heightened distractibility (Silverman, 1964; McGhie *et al*, 1965). Shagass *et al* (1976) have reported that eye-tracking performance is markedly improved, in both patients and normals, by replacing the fixation dot on the pendulum by a changing sequence of numbers in order to maintain attention and aid focusing. In the present study, a realerting stimulus half way through the recording period produced a temporary improvement in the EOG of chronic schizophrenics. It may be, therefore, that the deviant eye tracking observed in many schizophrenics is simply a reflection of their decreased ability to focus and attend in a consistent manner, and so of no greater aetiological significance than their other psychomotor deficits. Whether the abnormal eye tracking and inattention are related to decreased arousal in some schizophrenics (Gruzelier and Venables, 1975) and to increased distractibility in others is a question for further investigation.

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