Eur Arch Psychiatry Clin Neurosci (1995) 245 : 125–126

SHORT COMMUNICATION

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Smooth-pursuit eye-movement dysfunction and motor control in schizophrenia: a follow-up study

Received: 13 December 1994 / Accepted: 3 February 1995

Abstract Smooth-pursuit eye-tracking data of 63 schizophrenic patients and 52 normal controls are presented and compared with data collected on the same subjects 2 years earlier. Despite considerable clinical stabilization of the patients the overall eye-tracking performance did not improve. Intrasubject stability over 2 years was moderate. Eye-tracking impairment was significantly correlated with number of psychomotor soft signs and with number of errors in an antisaccade task. The correlations indicate that impairment of smooth-pursuit eye movements is likely to be a consequence of deficient motor control.

Key words Schizophrenia · Eye tracking · Temporal stability · Antisaccades · Psychomotor soft signs

Introduction

In a previous report we presented data on the eye-tracking performance of 81 schizophrenic patients and 54 healthy controls (Schlenker et al. 1994). The performance of the patients was impaired under both attention-enhancing and distracting conditions with a most pronounced difference between groups in the distraction condition. The Root Mean Square Error scores (RMSE) were associated with poor perfromance in the Wisconsin Card Sorting Test (WCST) and with the number of psychomotor neurological soft signs.

Two years later subjects were contacted for a follow-up investigation. In addition to the procedures presented in the previous study, eye tracking was also assessed in a standard condition without additional attention-enhancing or distracting instructions. As a test of motor control, in particular of the inhibition of spontaneous responses, an antisaccade task, reported to be highly sensitive to dysfunctions of the frontal lobes (Guitton et al. 1985; Pierrot-Deseilligny et al. 1991), was included.

This research was supported by the Bundesministerium für Forschung und Technologie, Germany

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Subjects and methods

Of the schizophrenic patients (diagnosed according to DSM-III-R) from the original study (see Schlenker et al. 1994), 73 could be recruited again. Ten patients had to be excluded because of movement artifacts or technical failures, resulting in a sample size of 63 schizophrenic patients (mean age 29.0 years; 43 males and 20 females). A total of 52 normal subjects (mean age 28.9 years; 28 males and 24 females) served as controls. At follow-up, 88% of the patients were considered free of psychotic symptoms on the basis of a clinical interview, only 14% were inpatients in a psychiatric hospital, and 75% were in outpatient treatment. A total of 86% received neuroleptic maintenance therapy. With a Brief Psychiatric Rating Scale (BPRS) total score of MD = 32 (Q3 – Q1 = 13), psychopathology tended to be less severe than 2 years earlier ($P < 0.06$).

Eye-tracking performance was assessed with a sinusoidally moving target stimulus (0.4 Hz; ± 10° visual angle) on a CRT screen while subjects placed their heads in a head-and-chin rest. Three conditions were administered in a fixed order:

1. In the standard condition (STAND) subjects were only instructed to follow the target with their eyes.

2. In the attention-enhancing condition (AEC) the target changed color every 5–8 s requiring the subjects to quickly press a button while following the target with their eyes.

3. In the attention-distraction task (DISTR) the horizontal band on which the target was moving changed its color with the same temporal distribution as in the second task. Again, subjects had to respond to each color change with a fast button press. Eye movements were measured with the horizontal electro-oculogram (EOG), tracking accuracy was determined by RMSE scores (for more details see Schlenker et al. 1994).

In the antisaccade task subjects were asked to look in the opposite direction from a laterally displaced target stimulus appearing 10° randomly either to the left or right of a central fixation point on the screen. Percentage of errors (i.e., saccades toward the visual target) was determined for the 28 trials. Two subscales ("Motor Coordination" and "Sequencing of Complex Motor Acts") of the Neurological Evaluation Scale (NES) by Buchanan and Heinrichs (1988) were administered and scored by a trained neurologist. In addition, the WCST in the version of Nelson (1976) was administered. The

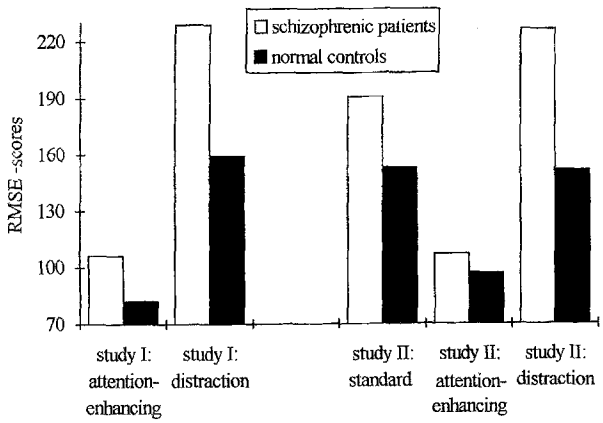

Fig. 1 Average RMSE scores of schizophrenic and normal subjects in the experimental conditions of the two studies

number of perseverative errors (Milner 1963) served as a dependent variable.

Results

A two-way ANOVA of the RMSE scores from the three eye-tracking tasks (see Fig. 1) revealed an interaction "Groups" × "Conditions" ($F(2,113) = 5.89$; $P < 0.05$) and main effects for "Groups" ($F(1,114) = 4.64$; $P < 0.05$) and "Conditions" ($F(2/228) = 49.15$; $P < 0.001$). Although performance of both groups was better in the attention-enhancing than in the standard condition ("AEC vs STAND": $F(1,113) = 56.96$; $P < 0.001$; "AEC/STAND" × "Groups": $F(1,113) = 2.17$; $P = 0.14$), only the performance of the patients worsened in the attention distracting condition ("DISTR vs STAND": $F(1,113) = 4.89$; $P < 0.05$; "DISTR/STAND" × "Groups": $F(1,113) = 5.49$; $P < 0.05$). Group differences were only significant in the distraction condition ($F(1,113) = 7.65$; $P < 0.01$).

In an additional three-way ANOVA we compared performance in the AEC and DISTR conditions with the performance 2 years earlier (study I). There was no significant main effect for "Study", nor any interaction with that factor ($0.00 \leq F(1,102) \leq 1.95$; $P \geq = 0.17$). Significant main effects were found for "Groups" ($F1,102) = 8.01$; $P < 0.01$) and "Conditions" ($F(1.102) = 120.58$; $P < 0.001$), as well as for the interaction "Groups" × "Conditions" ($F(1,102) = 9.84$; $P < 0.01$). In both studies group differences were most pronounced in the distraction condition.

The 2-year retest reliability was $r_{tt} = 0.65$ for the attention-enhancing and $r_{tt} = 0.63$ for the distraction condition across all subjects, and $r_{tt} = 0.62$ and $r_{tt} = 0.43$ for the schizophrenic patients.

Under all three conditions eye-tracking performance was correlated with the percentage of erroneous saccades in schizophrenic patients ($0.40 \leq r \leq 0.61$; $P < 0.01$) with the highest coefficient for the attention-enhancing condition. No association was found between eye-tracking impairment and WCST number of perseveration errors ($r \leq 0.18$; $P > 0.20$). Eye-tracking impairment correlated with both subscales of the NES in all three conditions: "Motor Coordination" $0.27 \leq r \leq 0.43$; "Sequencing of Complex Motor Acts" $0.37 \leq r \leq 0.41$. The highest correlations were again found for the attention-enhancing condition.

Conclusion

Smooth-pursuit eye-tracking performance is of moderate stability across a period of 2 years, somewhat higher for the attention-enhancing than for the distraction condition. The retest reliability is comparable to the figures reported by Iacono and Lykken (1981) for normal subjects (r_{tt} = 0.64 and 0.66), also over a 2-year interval, and by Rea et al. (1989) over a 4-week interval for schizophrenic patients ($r_{tt} = 0.57$). Despite the only moderate within-subject stability and the general improvement of the patients' psychopathology, the overall level of tracking performance did not change over time. Eye-tracking performance was found to be associated reliably with performance in motor-coordination tasks, supporting the notion that impaired eye tracking in schizophrenic patients is probably not the consequence of a specific deficit in the smooth-pursuit system, but rather of a more general deficiency in motor control. This interpretation is strengthened by the association between eye-tracking performance and the ability to suppress reflexive saccades in an antisaccade task. Despite the low correlation with the WCST, the association with errors in the antisaccade task argues strongly for a prefrontal deficit in schizophrenic patients as a critical determinant of their poor eye-tracking performance.

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