Reprinted from
14 June 1974, volume 184, pages 1202-1203

SCIENCE

Eye-Tracking Patterns in Schizophrenia

Holzman *et al.* (*1*) contend that schizophrenic patients show patterns of eye-tracking (smooth pursuit) that differ from normals, thereby implicating a primary ocular motor system defect in schizophrenics. We are concerned about major problems in their study with regard to the eye movement recording technique, the selection of control and subject populations, and the interpretation of results.

Only a sketchy account of the electrooculographic recording method is presented in the report, but Holzman kindly provided us with methodological details (*2*). There are many pitfalls in accurate eye movement recording, of which the authors seemingly were unaware. Their instrumentation and methodology were standard and suitable for electronystagmographic studies in a clinical neurootology laboratory, but are inappropriate for quantitative recording of eye movements. The absence of vertical electrodes, essential for detection of blink artifact, was unfortunate. Whereas horizontal electrodes might detect complete eye lid closure during a blink, there are many incomplete blinks without full closure of the lid. These partial blinks are indistinguishable from actual eye movements when monitored with horizontal electrodes and can only be recognized with vertical electrodes. Thus, blink artifact had to be a problem in this study.

Another serious methodological omission was the absence of head restraints. There is a compelling urge to move the head during slow tracking tasks. The simple instruction to keep the head still, even monitored with careful observation by the experimenter, is inadequate for quantitative recording of eye movement. A small head movement in the direction of the pendulum could cancel the eye position and appear to produce a zero eye velocity.

We duplicated the instrumentation of Holzman *et al.* by using the standard Beckman components described, with both the position and the velocity channel switches in the "slow" setting. The bandwidth of the "slow" position channel is 5.5 hertz, which greatly distorts the response to fast eye movements. The "slow" differentiator mode has a bandwidth of 4 hertz and response time of 75 msec, which also precluded a true record of velocity (*3*). Thus, Holzman *et al.* were analyzing distorted and inaccurate eye movement analogs. The authors defined a "positive saccade" as a fast eye movement exceeding the maximum velocity (31.4° per second) of the target by 33⅓ percent (41.9° per second). With the restricted bandwidth recording system employed in their study, the true velocity of eye movements, which they interpreted as just greater than 41.9° per second, was in fact much higher. We compared the velocities derived from such a restricted recording system with those from d-c–coupled electrooculography with a position channel bandwidth of 100 hertz and a differentiator response time of 4 msec. We determined that saccades of less than 2° in amplitude would not meet the authors' own criteria for the identification of "positive saccades." To record peak velocities of small saccades (less than 5°), the bandwidth of this system should be 100 hertz and the response time of the differentiator less than 10 msec (*4*). By merely switching to the "fast" modes, without any system modifications, the authors could have used the existing bandwidth of 25 hertz and significantly improved the technical quality of their analogs.

Faithful analogs are necessary to eliminate artifact and to detect any small corrective saccades that may occur when a normal subject tracks a slowly moving target (½ hertz). The

bandwidth deficiency prevented proper differentiation between real eye movement and artifact, and thus confused the data. For this reason it is impossible to evaluate the reported increase in "positive saccades" greater than 2°.

The major conclusions were primarily based on a newly defined ocular motor phenomenon present in the distorted velocity analog: "evlocity arrest," a time when the eyes had no velocity relative to the head as determined by the return of velocity analog to the baseline. Obligate velocity arrests must occur at the end of the pendulum swing, which gives 2 arrests per cycle. The authors stated that normals make 4.5 velocity arrests (2 are expected, leaving 2.5 unexpected arrests) and 0.5 saccade per cycle. Similar values were given in their figure 2 for schizophrenics. This is impossible. People not only do not do this, they cannot. Any real velocity arrest occurring during tracking would cause the eyes to fall behind the target, necessitating a corrective saccade. Therefore, a true velocity arrest could not be independent from a saccade as implied by the authors. The independence of the two phenomena ("velocity arrests" and "positive saccades"), which is essential to their conclusions, remains dubious. We have not observed frequent velocity arrests during tracking in normal subjects and must conclude that those described by Holzman *et al.* in their control population are primarily artifacts. Head movement, as previously mentioned, might be interpreted as a velocity arrest, as could blink artifact. Since a partial blink can cause the velocity tracing to cross the baseline twice, their occurrence every few seconds could be responsible for the abnormally high number of "velocity arrests."

Criticism must be made of the selection of patients who were taking a variety of drugs. Drugs—including barbiturates, minor tranquilizers, and phenothiazines—alter the ability of subjects to pursue targets, causing "saccadic" or "cogwheel" pursuit. The fact that the authors claimed in a separate study that no alterations occurred after withdrawal of phenothiazines, raises questions as to the actual ocular motor function that was being monitored. No other information regarding drug intake by either subjects or controls was given. Drug-induced saccades during slow tracking tasks may be less than 2° in amplitude. These movements would be ignored by the authors and not counted as "positive saccades." This is the only reasonable explanation for the observation that drugs did not alter the tracking performances.

In the control group, two of the four subjects with abnormal patterns were later found to have spontaneous nystagmus. The fact that such an obvious sign as nystagmus was detected only after data analysis indicates that the authors did not clinically examine their controls or schizophrenics for eye movement disturbances. We wonder how many of the schizophrenics had similar problems. While one might justify, on a purely statistical basis, the division of the whole population into those with and without schizophrenia and also the elimination of screening of both patients and controls, the inclusion of two "normals" with nystagmus could only confuse the issue. A nystagmus oscillation of 3 hertz would introduce 6 to 12 velocity arrests per cycle of pendulum swing which would be totally unrelated to tracking ability. Screening all subjects for unrelated eye movement abnormalities would result in more meaningful data. Any such abnormality should be cause for exclusion from the study.

In summary, we believe that Holzman *et al.* have not documented an eye-tracking abnormality in schizophrenics.

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References and Notes

1. P. S. Holzman, L. R. Proctor, D. W. Hughes, *Science* **181**, 179 (1973).
2. Standard Beckman components were utilized for a-c–coupled electrooculography with a time-constant of 3 seconds. Both the nystagmus (position) and velocity couplers were in the "slow" mode. The filter switches on the power amplifiers were in the No. 3 position. The velocity couplers were calibrated in the manner advised in the Beckman instruction manual. Target position analogs were not written out on the paper. Vertical electrodes were not used to detect blink artifacts. Heads were not restrained.
3. D. A. Robinson [*J. Physiol.* (*Lond.*) **174**, 245 (1964)] has criticized electrooculographic eye movement recording systems employing bandwidths as high as 85 hertz used to derive accurate quantitative information.
4. For a discussion of frequency characteristics of saccadic eye movements see B. L. Zuber, J. L. Semmlow, L. Stark, *Biophys. J.* **8**, 1288 (1968).

17 August 1973