Notes and Comment

When push comes to pull: Impressions of visual direction

DAVID L. MILLER, ROBERT K. MOORE,
and BILL R. WOOTEN
*Brown University
Providence, Rhode Island*

In the Notes and Comment section of *Perception & Psychophysics*, Hershberger (1984) presents his case for extraocular afference. He offers his observations as "the best, albeit belated, evidence that the extraocular stretch receptors influence the perception of visual direction." As Hershberger himself observes, the previous supporting evidence for this position is thin. His new evidence, then, is a challenge to the orthodox efference models.

Hershberger uses as evidence the well-known (Helmholtz, 1910/1925) phenomenon of apparent movement of a visual target caused by movement of the eye with a finger press. He argues that the direction of apparent motion during eye press is gaze dependent. When the eye is in the physiological position of rest (primary position), a lateral eye press causes a corresponding impression of target motion in the opposite direction. When the eye is deviated approximately 30° temporally, the same correspondence holds. However, Hershberger claims that when the eye is nasally deviated, the same eye press yields the opposite target motion (i.e., in the same direction as the eye press). To verify this unique observation of gaze dependency, Hershberger invites the reader to try it for himself/herself. When the authors of this reply followed Hershberger's suggested method no such effect was produced. This puzzling nonreplication was quickly confirmed in informal observations by 8 of 10 subjects, with only two subjects supporting Hershberger's observations. Clearly, there is more to the gaze deviation experiment than meets the eye.

To investigate the matter further, more controlled eye-press and target motion studies were undertaken. An SRI fourth Purkinje image eyetracker was used to record eye movement during eye press. This eyetracker produces signals that are proportional to eye rotation by recording the relative positions of the first and fourth Purkinje images. An important feature of this technique is that only eye rotation is monitored; linear translations do not confound eye-movement measurements. A description may be found in Cornsweet and Crane (1973). A 13-min/arc target light was observed from three different gaze deviations. The deviations used were 25° nasal, 25° temporal, and 0° (straight ahead). A series of 40 5-sec trials were conducted

for each deviation, during which the subject executed an eye-press. Trials were conducted on the right eye with a leftward eye-press. Following a trial, the subject reported the initial horizontal direction of apparent target movement (left or right) as well as an estimated magnitude. Two subjects were run, one (K.A.M.) who had reported apparent target motion consistent with Hershberger's observations during informal trials and one (B.R.W.) who did not confirm Hershberger's observations. The results are plotted in Figure 1 using the program of Hayes (1981).

Figure 1. Direction and magnitude of apparent target movement as a function of eye movement for (a) Subject B.R.W. and (b) Subject K.A.M.

The authors' mailing address is: Department of Psychology, Brown University, Providence, RI 02912.

The results indicate that a variety of eye movements are produced by "similar" eyepresses. Therefore, a unidirectional eyepress is not necessarily related to a given eye movement. Furthermore, the subject is frequently unaware of the actual eye-movement direction produced by a given eyepress. However, the perceived target motion corresponds well with the actual eye movement: the apparent direction of target movement is almost always opposite to the direction of eye movement.

As can be seen in Figure 1a, Subject B.R.W. was able to produce eye movements to either quadrant with the same eyepress. Subject K.A.M. (Figure 1b) was limited to one quadrant per deviation condition. Artifactual or out of range data were not included. Subject K.A.M. reported only vertical movement in the 0° deviation condition; no eye-movement data were collected.

The cause for the variability in eye movements with the same eyepress is not known, but may be due to the mechanics of gaze deviation (e.g., torque might be applied behind the center of eye rotation). Variability may also be due to subject variables such as eye or orbit morphology or eyepress technique. In any case, actual eye

movement is still the critical parameter in perceived target motion. The underlying assumption upon which Hershberger's argument rests, namely that eyepress direction produces a corresponding eye movement, has not been demonstrated. When actual eye movement is taken into account, there is no reason to reject the traditional efferent models.

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