Eye-Head Coordination in Homonymous Hemianopia


Departments of Neurology and Bioengineering, University of California, Berkeley, and Department of Neuroophthalmology, University of California, San Francisco, USA

Summary. Quantitative studies of latencies and trajectories of eye-head movements during visual search and fixation in patients with occipital hemianopia show that (1) the latency of head movement is bilaterally increased, with significantly greater delays in movements toward the blind side; (2) the compensatory eye movements (CEMs) during head movements toward the blind side have increased velocity; (3) these CEMs entail a non-vestibular anticipatory component; and (4) head movements toward the blind side are comprised of multiple steps similar to staircase eye movements documented in previous studies. Hemianopic patients seemingly simplify search and fixation strategies by minimizing or entirely eliminating head movements and relying on eye movements instead.

Key words: Eye-head coordination – Homonymous hemianopia – Target search strategies

Zusammenfassung. Quantitative Untersuchungen der Augen- und Kopfbewegungen, die von Patienten mit occipitaler Hemianopsie zum Erfassen und Fixieren visueller Ziele verwendet werden, zeigen: (1) beidseits verlängerte Latenzen für Kopfbewegungen, bei einer signifikant zusätzlich verlängerten Latenz für Kopfbewegungen zum blinden Halbfeld; (2) erhöhte Geschwindigkeit der kompensatorischen Augenbewegungen für Kopfbewegungen zum blinden Halbfeld; (3) eine nicht-vestibuläre, antizipatorische Komponente dieser kompensatorischen Augenbewegungen bei Kopfwendungen zum blinden Halbfeld, und (4) multiple treppenförmige Kopfbewegungen, ähnlich den treppenförmigen sakkadischen Augenbewegungen dieser Patienten bei Wendungen zum blinden Halbfeld. Patienten mit homonymer Hemianopsie

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Offprint requests to: Dr. W. H. Zangemeister, Neurological University Clinic (UKE) Hamburg, Martinistr. 52, D-2000 Hamburg 20, Federal Republic of Germany

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vereinfachen und sichern offenbar ihre Strategien zum Aufsuchen und Fixieren visueller Ziele dadurch, daß sie ihre Kopfbewegungen zugunsten von Augenbewegungen eliminieren.

Introduction

In looking to either side, normal persons coordinate eye and head movements in a single act consisting of a rapid saccade to the target followed by a head movement. To keep the gaze fixed on target during the head movement, the eyes are driven in the opposite direction by the vestibular ocular reflex. The quantitative aspects of these movements have been determined in monkeys [7, 11, 21, 26] and normal human beings [4, 5, 13, 17, 35, 42]; and some abnormalities in those movements have been reported in studies of patients [1, 19, 43].

Various clinical studies of eye movements of patients with occipital hemianopia have defined the adaptive ocular motor strategies employed by these patients [14, 23, 29, 30, 32, 36], and the possible role of extrastriate vision in these strategies has been considered [12, 25, 28, 39]. When searching for targets in their blind hemifield, such patients at first employ a safe but slow strategy consisting of a stepwise series of saccades (Fig. 1). Subsequently, they adopt more efficient strategies for particular situations. When the position of the target is predictable, they use a strategy consisting of a single, large saccade that slightly overshoots the target. When fixating targets in their seeing hemifield, they use a saccade that slightly undershoots the target.

This report documents and analyzes the adaptive changes in combined eye-head movements of patients with homonymous hemianopia.

Methods

Eye Movement Recordings

Horizontal eye movements were recorded by means of the infrared reflection method [2, 34]. The recordings were linear within the range of the eye movements examined. The system bandwidth was 0 to 150 Hz, with the upper frequency limit determined by the range of the rectilinear chart recorder. A chart speed of 100 mm/s was used in order to allow measurement of latencies and detailed analysis of trajectories. In addition, all data were stored on an Ampex FR 1300 tape recorder and, as necessary, could be played back at different speeds or further analyzed on a PDP 8 Minicomputer.

To prevent interference from vergence movements, eye movements were recorded monocularly from the eye with the temporal field defect. The other eye was covered with a patch. In patient 1, comparison of recordings from each eye alone and both together showed no differences in movement patterns.

Head Movement Recordings

Rotational head movement in the horizontal plane was measured with an apparatus previously described [41]. Briefly, it consisted of a bicycle helmet, on top of which was mounted an acryl rod flexible enough to act as a universal joint; to the top of the rod was clamped a low-torque, low-backlash potentiometer fixed in a parallelogram linkage frame. The electrical signal from the potentiometer varied directly with torsional movement of the helmet. The apparatus was strapped on the subject’s head and positioned at the center of a horizontal arc perimeter.