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Eye movements place a limit on the processing of visual information because they determine the location and the velocity of the retinal image. Thus, to understand how we see it is necessary to understand how eye movements are controlled. Work this year in my laboratory has concentrated on the roles of expectations and selective attention in the programming of smooth and saccadic eye movements. We have: 1) demonstrated distinct roles for past experience and expecations in the control of smooth eye movement and found that expectation will predominate in the presence of cues about the direction of future motion; 2) found that brisk initial pursuit requires that expectation that target motion will continue; 3) showed that saccadic eye movements are not attracted to visual backgrounds (as had been claimed) unless subjects pay attention to the background. These studies show that central representations of visual scences, containing information about the position, motion and future motion of selected objects, are the natural effective stimulus for human eye movement. Psychomotor Tests, psychology, communication, Eye movement.

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Dr. John F. Tangney	(202) 767-5021	NL

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Abstract

Eye movements place a limit on the processing of visual information because they determine the location and the velocity of the retinal image. Thus, to understand how we see it is necessary to understand how eye movements are controlled. Work this year in my laboratory has concentrated on the roles of expectations and selective attention in the programming of smooth and saccadic eye movements. We have: (1) demonstrated distinct roles for past experience and expectations in the control of smooth eye movement and found that expectations will predominate in the presence of cues about the direction of future motion; (2) found that brisk initial pursuit requires the expectation that target motion will continue; (3) showed that saccadic eye movements are not attracted to visual backgrounds (as had been claimed) unless subjects pay attention to the background. These studies show that central representations of visual scenes, containing information about the position, motion and future motion of selected objects, are the natural effective stimulus for human eye movement.

Papers

Kowler E. (1989) Cognitive expectations, not habits, control anticipatory smooth oculomotor pursuit. Vision Research, in press.

Kowler E. and He P. (1989) The role of location probability in the programming of saccades: Implications for center-of-gravity tendencies. Vision Research, in press.

Talks

Kowler E. (1988) Cognitive expectations determine anticipatory smooth eye movements. Association for Research in Vision and Ophthalmology.

He P., Kowler E. and Leyton M. (1988) Saccadic eye movements to simple forms. Association for Research in Vision and Ophthalmology.

Kowler E., Steinman R.M., He P. and Pizlo Z. (1989a) Smooth pursuit depends on the expected duration of target motion. Association for Research in Vision and Ophthalmology.

Kowler E., Steinman R.M., Collewijn, H., Erkelens C. and Pizlo Z. (1989b) Coordination of head and eyes during natural visual tasks. Second Symposium on Head Movement Control, July, 1989.

Kowler E. The control of smooth pursuit eye movements. Center for Neurobiology and Behavior, Columbia University College of Physicians and Surgeons, January, 1989.

In preparation:

Kowler E. (ed.) Eye Movements and Their Role in Visual and Cognitive Processes (Vol. 4 in Reviews of Oculomotor Research).

Kowler E. The role of visual and cognitive processes in the control of eye movements. (Chapter in above cited volume).

Description

1. Anticipatory pursuit (Kowler, 1989): I found that anticipatory smooth pursuit eye movements are produced by genuine cogntive expectations of future target motion, and are not simply oculomotor habits formed by repeated exposure to the same pattern of target motion. This was done by comparing smooth pursuit of targets moving in cued and uncued paths. When the subject was not given cues about the direction of impending target motion, anticipatory pursuit was determined by the direction of motion on prior trials (sequential dependencies). Sequential dependencies were overridden by cues: anticipatory pursuit was determined by the direction the subject expected the target to move. The results show that representations of expected motion can drive pursuit, just as if they were sensory representation of "real" motion. The representations of real and expected motion may combine at a high level to provide a single input for smooth pursuit.

2. Expected duration (Kowler et al., 1989a): The early portions of smooth pursuit depend on how long a target is expected to remain in motion. Pursuit of brief (200 msec) motions is seldom faster than 2 deg/sec. This means that initial pursuit is not simply evoked by the first sweep of the target across the retina, as is often assumed. The entire pursuit response is adjusted so as to form an appropriate match between the entire trajectory of the motion of the target and the motion of the eye.

3. Location probability (He and Kowler, 1989): The saccades made to target stimuli, presented along with irrelevant background stimuli, are not involuntarily attracted to backgrounds, as has been claimed. Instead, a background location attracts the line of sight only to the extent that the subject expects to find the target there. This implies a 2 stage model (simlar to that already demonstrated for smooth pursuit; Khurana and Kowler, Vision Res., 1987) in which the first stage consists of selection of the target via allocation of spatial attention and the second stage uses the attentionally-weighted position signals to compute the oculomotor command.

4. Saccades to forms (He et al., 1988): Subjects can look at designated locations within outline drawings of simple forms as accurately and precisely as they can look at single points in the same locations, even though the points, in principle, provide a less precise error signal. Saccades directed to the "whole form" land near the center of gravity with spatial precision the same or better than saccades to designated locations. The results support the 2 stage model described above. They show that the first stage selects a spatial window and the second stage computes a saccade to take the eye to the approximate center of the window.

5. Head and eye (Kowler et al., 1989b): We have made the first accurate recordings of eye movements, head movements (rotations and translations) during reading under natural conditions, that is, binocular viewing of text and normal reading distance while the head is free to move. Preliminary analyses shows that reading proceeds by a coordinated pattern of head rotation, head translation and eye rotation.

6. Eye movements and pattern recognition (He and Kowler, in progress): Studies are underway investigating the effects of various scanning sequences on the perceptibility of simple forms and texture patterns. Of greatest interest is whether perception is better when saccades are directed to the border or to the center (symmetric axis) of the form.