DTIC FILE COPY

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT
AD-A226 782	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFOSR-TR- 90 0978
Rutgers University / 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: AFOSR
6c. ADDRESS (City, State and ZIP Code): Dept. of Psychology, Rutgers University, New Brunswick, NJ 08903	7b. ADDRESS (City, State and ZIP Code): Building 410, Bolling AFB, DC 20332
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: AFOSR / 8b. OFFICE SYMBOL (If applicable): NL	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: AFOSR-88-0171
8c. ADDRESS (City, State and ZIP Code): Bld 410, Bolling AFB, DC 20332	10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT NO.
61102F	2313	A5	

11. TITLE (Include Security Classification): Eye movements and visual information processing

12. PERSONAL AUTHOR(S): Eileen Kowler

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
interim	FROM 4/89 TO 4/90	Aug 22, 1990	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The research performed extended our understanding of the visual and cognitive process controlling saccadic and smooth eye movements, and the role of these eye movements in visual information acquisition. Experiments showed that: (1) saccades are biased toward likely locations of targets, suggesting that previous reports of 'center-of-gravity' reflexes are actually due to search of attentional strategies; (2) saccades can be directed to spatially-extended targets with an accuracy and precision as good as those found for single point targets; (3) predictive smooth eye movements are caused by cognitive expectations about future path of target motion, not by learned oculomotor habits; (4) slow control is not sensitive to position error; (5) smooth eye movements are sensitive to the expected direction of future target motion; (6) strategies of scanning the boundaries of difficult texture patterns are more effective than strategies of scanning the symmetric axis; (7) normal reading is carried out by a coordinated pattern of eye movements and head movements.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE NUMBER (Include Area Code)	22c. OFFICE SYMBOL
John F Tangney	(202) 767-5021	NL

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

90 ... 27 AUG 1990

Progress report for AFOSR-0171, "Eye movements and visual information processing", April 1, 1989-March 31, 1990. PI: Eileen Kowler

Abstract. The research performed extended our understanding of the visual and cognitive process controlling saccadic and smooth eye movements, and the role of these eye movements in visual information acquisition. Experiments showed that: (1) saccades are biased toward likely locations of targets, suggesting that previous reports of 'center-of-gravity' reflexes are actually due to search or attentional strategies; (2) saccades can be directed to spatially-extended targets with an accuracy and precision as good as those found for single point targets; (3) predictive smooth eye movements are caused by cognitive expectations about future path of target motion, not by learned oculomotor habits; (4) slow control is not sensitive to position error; (5) smooth eye movements are sensitive to the expected direction of future target motion; (6) strategies of scanning the boundaries of difficult texture patterns are more effective than strategies of scanning the symmetric axis; (7) normal reading is carried out by a coordinated pattern of eye movements and head movements.

Summary of progress

1. He and Kowler (1989) demonstrated effects of location probability on saccades. This paper challenges previous ideas that tendencies to make saccades to the center of a stimulus configuration, containing a target as well as irrelevant background stimuli, represent automatic sensorimotor averaging reponses. We found that the so-called "centering" or "averaging" saccades occur only when subjects are uncertain about where the target is located. Centering responses, therefore, represent visual search strategies rather than oculomotor reflexes. We reject models of saccadic control featuring parallel subsystems (one voluntary, another reflexive) in favor of a serial model in which a selection stage is followed by automatic computation of the saccadic command to bring the line of sight into the selected (attended) spatial region. The serial model (unlike the parallel models) guarantees that the line of sight will be directed to regions of interest rather than being drawn to large or intense (but nevertheless unimportant) areas in the visual field.

2. He and Kowler (submitted ms), following up the experiments described above, studied the ability of subjects to direct saccades to designated locations within eccentric forms. Surprisingly, this situation has not been studied before, with investigators preferring unnatural targets, such as points or crosshairs, where the desired endpoint of the saccade is clearly marked. We found that subjects can direct saccades accurately and precisely to locations within forms. Saccades directed to the "whole form" tend to land near the center. The results, which show that the line of sight lands in the center of the selected target region, are consistent with the 2-stage serial model described above.

3. Kowler (1989) showed that anticipatory smooth eye movements are genuine responses to cognitive expectations about the direction of future target motion rather than automatic tendencies to repeat previous pursuit responses. (Most existing models of predictive tracking are based on the latter assumption.) This result implies that central representations of expected target motion are as powerful an input to pursuit as "real" (i.e., sensory) motion signals.

4. Kowler et al. (1990) studied movements of the head and eye during reading and during visual scanning. We found that: (a) during reading subjects make idiosyncratic, coordinated patterns of head and eye movement, including unusual features such as episodes of head and eye moving in opposite directions; (b) eye rotations compensate well for head rotations and translations, leaving residual image velocities comparable to those observered on the biteboard (n.b., image velocities are large enough to move the image at least one

letter space during a reading pause: How do we see in the presence of such smear?); (c) saccade rates are faster with free rather than fixed heads and faster during reading than during visual scanning; (d) subjects have difficulty programming simultaneous head and eye movements with different spatial and temporal patterns. All these results suggest the existence of a common, central programmer for head and eye movements, whose activities are tied to the ongoing visual and cognitive demands of the task, and whose precise characteristics have yet to be determined.

5. Kowler et al. (1989) demonstrated effects of expected duration on smooth pursuit, namely, smooth responses barely get off the ground unless subjects expect the target motion to continue. There was also evidence that velocity and acceleration saturation, usually taken to be characteristics of the sensory mechanisms that launch the pursuit responses, are seen only with randomized target motions, and, therefore, are not true system limitations at all. Further experiments are in progress to nail down this assertion.

6. He (1990) studied the role of saccadic eye movements in texture perception to find out which saccadic pattern, scanning of boundaries or scanning of the symmetric axis, is most effective. He compared the effects of various types of scan patterns, including use of no saccades whatsoever, in both size and shape discrimination tasks. He found that saccades were necessary for detecting the boundary between regions containing different types of texture elements, but were not needed to perceive the size or shape of texture patterns containing easily discriminable elements. Retinal image transients, created by flickering or jumping the display, also helped in finding the boundary, but were not as effective as natural saccades. Scanning along the symmetric axis or scanning randomly chosen locations was ineffective. Boundary-scanning was the most effective pattern, but, surprisingly, perceptual performance was never as good as it was with easily discriminable texture elements. These results imply that saccades helped perceive the size and shape of the texture pattern by facilitating a strategy of searching for and counting elements; they did not serve to provide separate glimpses that would later be integrated into a representation of the pattern as a whole.

7. Kowler et al. (1989) found that slow eye movements keep the line of sight very stable with single point targets at eccentricities out to at least 5 deg. With such targets, in contrast to the discs and various other 2- or 4-point targets studied in the past, it is difficult to choose subjective reference points that might serve as targets for a position-sensitive system. The simplest explanation is that slow control serves to keep images stable, not to bring images to desired locations.

8. In progress is a study to determine the links between saccadic eye movements and visual attention in an attempt to understand the nature of the target selection process that precedes the construction a saccadic programs (see #1 above). In particular, we are interested in whether saccades are automatically drawn to the center of a relative large attended region or whether attention to the precise endpoint of the saccade is required. The first outcome suggests a low-level spatial pooling process computes the saccadic endpoint based on attened information; the second suggests the endpoint is determined by higher-level attentional allocation. We are also interested in whether any independent control of saccadic endpoints is possible without changing the distribution of attention (i.e., separate perceptual and motor "attentions").

9. Also in progress in collaboration with Collewijn and Steinman is work on a book describing a new approach to oculomotor theory organized around 2 (smooth and saccadic) subsystems rather than the traditional notion of 5 or more separate subsystems. The multiple subsystem approach holds that effective oculomotor performance is achieved by a number of independent mechanisms each responding to a single sensory cue. According to the multiple subsystem approach, the outputs of these subsystems are not explicitly integrated.

A-1

Oculomotor performance is determined instead by whichever sensory signal momentarily dominates (e.g., at low frequencies of oscillation of a subject, the visual pursuit subsystem is believed to dominate the vestibular; the domination reverses at high frequencies). Our 2 subsystem approach holds that various sensory cues are integrated at a relatively high level in order to produce a single representation of target position in 3-D space which serves to guide either smooth or saccadic movements of the eye. A contract with Sinauer to write this book has been obtained.

Publications

He, P. and Kowler, E. (1989) The role of location probability in the programming of saccades. Vision Research 29, 1165-1181.

Kowler, E. (1989) Cognitive expectations, not habits, control anticipatory smooth oculomotor pursuit. Vision Research 29, 1049-1057.

Kowler, E., Pizlo, Z., Zhu, G.L., Erkelens, C., Steinman, R. and Collewijn, H. (1990) Coordination of head and eyes during the performance of natural (and unnatural) visual tasks. In The Head-Neck Sensory Motor System. (edited by Berthoz, A., Graf, W. and Vidal, P.P.) Oxford University Press, NY, in press.

Steinman, R.M., Kowler, E. and Collewijn, H. (1990) New directions for oculomotor research. Vision Research. In press.

Kowler, E. (1990) (ed.) Eye Movements and Their Role in Visual and Cognitive Processes (Volume 4 of Reviews of Oculomotor Research). In press.

Kowler, E. (1990) The role of visual and cognitive processes in the control of eye movement. In: Eye Movements and Their Role in Visual and Cognitive Processes (Edited by E. Kowler). Elsevier, Amsterdam. In press.

Kowler, E. (1990) The stability of gaze and its implications for vision. In: Eye Movements (Edited by R. Carpenter) in the series Vision and Visual Dysfunction. Macmillan. In press.

Kowler, E. (1990) Cogito ergo moveo: Cognitive control of eye movement. In: Exploratory Vision: The Active Eye. (Edited by T. E. Weymouth and L.T. Maloney). Springer-Verlag, N.Y. In press.

Talks

Kowler, E. (1989) Cogito ergo moveo: The control of human eye movement. Twenty-fourth Swammerdam Lecture, sponsored by the Netherlands Academy of Sciences, Amsterdam.

Kowler, E., Steinman, R.M., He, P. and Pizlo, Z. (1989) Smooth pursuit depends on the expected duration of target motion. Investigative Ophthalmology and Visual Science Supplement, 30, 182.

Kowler, E., Pizlo, Z., Epelboim, J. and Steinman, R.M. (1990) Slow control is driven by velocity, not position signals. Investigative Ophthalmology and Visual Science Supplement, 31, 532.

He, P. (1990) The role of saccades in texture perception. Investigative Ophthalmology and Visual Science Supplement, 31, 531.