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METHOD FOR RECORDING AND ANALYZING VISUAL FIXATIONS IN THE UNRESTRAINED MONKEY[1]

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Summary.—Adaptation of the Mackworth wide-angle reflection eye camera for the collection and analysis of visual scanning behavior in the relatively unrestrained rhesus monkey is described. Crucial changes involved the addition of local fibre optic cable incident light, training the animal to view from a port by rewarding short trials, and computer-assisted data analysis for data reduction.

Mackworth (1968) reported the development of a wide-angle reflection eye camera apparatus which provided data on the exact location of visual fixations of human subjects on a 16-mm. film record of the right eye. Advantages over previous methods were (1) indirect photography, eliminating an opening in the display being viewed which was distracting, (2) elimination of a bite bar, allowing accurate records without complete immobilization of the head, and (3) reduction of the light intensity by the use of transparent displays.

The dynamics of eye movements in monkeys have been found by other methods to approximate closely those of humans (Robinson, 1964, 1965; Fuchs, 1967). Cowey (1963), Schrier (1970) and others have reported studies of visual fixations of monkeys but were limited by one or more of the above considerations. This report describes an adaptation of the new wide-angle reflection eye camera for recording visual scanning behavior in monkeys in a relatively unrestrained situation. Its best features are the improvement in ease of animal training and data reduction.

EQUIPMENT

The human camera setup consisting of a display chamber with a top-mounted Beaulieu 16-mm. movie camera was used and an animal chamber (12 × 20 × 24 in.) was built with the long side affixed to the viewer's aperture of the camera box opposite the display (Fig. 1). A fibreglass mask of a monkey face was fashioned using an autopsy specimen as a model. The right eye area was cut out, the mask painted black and mounted flush with the long wall of the animal chamber. *S* could view outside the chamber only by placing his face in the mask (Fig. 2). The corneal surface of the eye was thus restricted to a plane 16¾ in. from the back-lighted display. On the front of the display chamber, between the eye and the display, a half-silvered mirror was mounted at a 45° tilt and the top-mounted movie camera was aimed vertically downward onto this mirror to film the reflected surface of the eye plus the image of the lighted display on the eye. Incident light on the eye was provided by adding fibre optic cables, one each mounted at the lateral and medial edges of the eye opening. Monitoring of the image on the half-silvered mirror by a second experimenter was provided by adding a high-powered monocular viewing lens aimed at a mirror set alongside the camera lens and also aimed at the half-silvered mirror.

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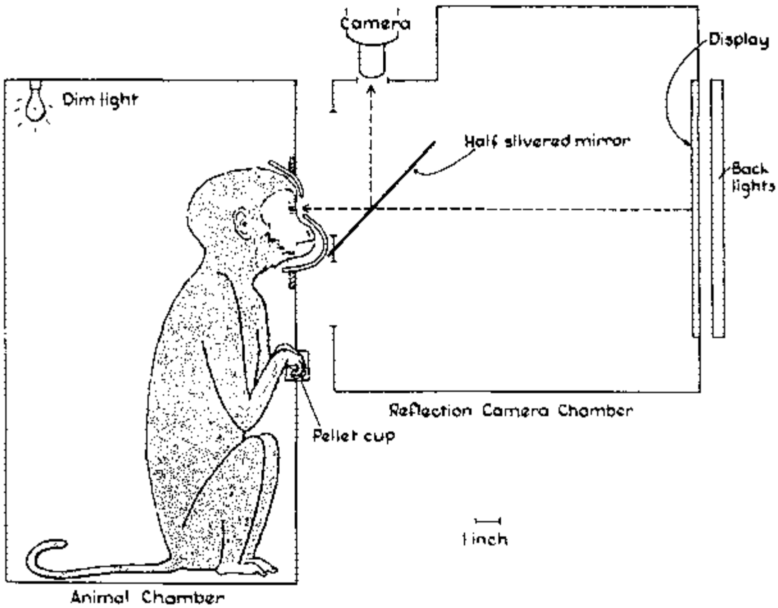

FIG. 1. Side view of the wide angle reflection eye camera with animal chamber. The display reflects through the half-silvered mirror onto the corneal surface. The corneal surface with this image in turn is reflected off the mirror to the top-mounted movie camera.

TRAINING PROCEDURE

A 10- × 10-in. back-lighted transparency of a monkey face was used as a training stimulus. This was made on Kodalith sheet film and mounted over a 10 × 10 opening in a large cardboard carrier resembling an oversized 2 × 2 transparency slide. Trials of 5 sec. were run by a timer which controlled a shut-

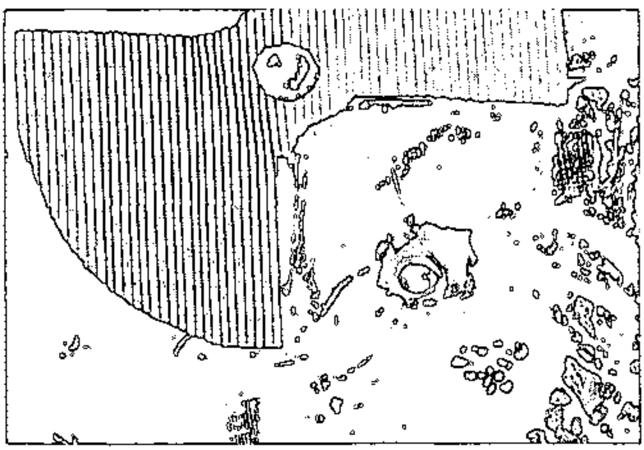

FIG. 2. Photograph of the front view of the animal mask illustrating shutter in the open (trial in) position and the surface lighting of the eye

ter disc mounted in front of the eye cutout of the mask (Fig. 2). At the intertrial position one of the opaque quadrants covered the eyehole. At the start of the trial the shutter turned ¼ turn and the camera automatically started. At the end of 5 sec. the shutter was advanced to the adjacent closed quarter and the filming stopped. A banana pellet was manually dispensed if *S* had viewed during the trial period. As training progressed longer viewing times were required. Six sessions of 20 trials were needed to shape the animals to view consistently for from 3 to 5 sec. on each trial. At this point the pellets were automatically dispensed after 5 sec. Performance after acquisition of the habit was remarkably stable, even after rest periods up to 2 mo.

Data Analysis

The film negative was enlarged by a factor of 32 with a Reichert Visopan microscope. Readings were made on each frame by locating the center of the pupil and the left upper corner of the displayed image wtih one arm of a pantograph. A light sensitive pen was mounted on the other arm of the pantograph and positioned in front of an oscilloscope screen which displayed a computer driven roster display. Upon activation of the light sensitive pen with a foot pedal the coordinates on the roster display were recorded by the laboratory PDP-8 computer. The computer then transformed these into column-row coordinates of the actual display matrix. Preliminary computer analysis of these individual frame readings provided actual and proportional totals of visual fixations for each 2½- $\times$ 2½-in. area of the 10- $\times$ 10-in. display (a 4 $\times$ 4 analysis). Raw data were saved on magnetic tape for more detailed analysis.

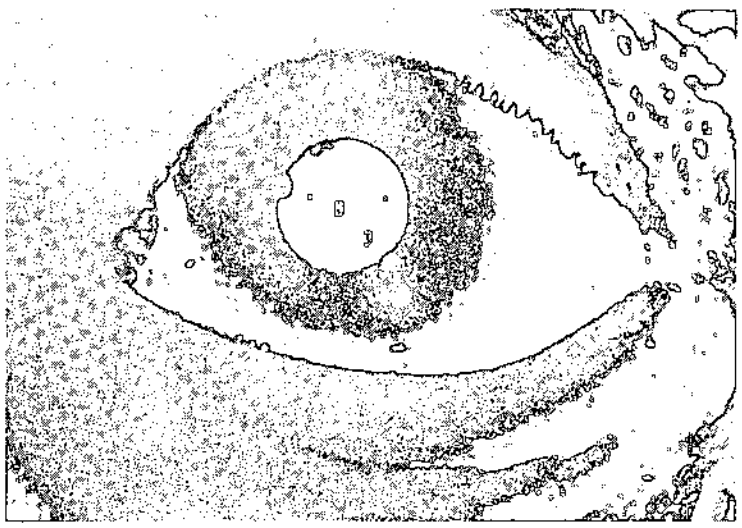

FIG. 3. Single frame (200 msec.) from the film record of a monkey after training to fixate "8" and avoid fixating "3." Note that the pupil encircles the "8."

APPLICATIONS

The method has provided valuable data in two types of experiment, one which examined visual orienting and habituation (spontaneous behavior) and a second wherein differential reinforcement training for discriminative visual fixation was accomplished in only four sessions (Fig. 3).

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