Reports

Most naturally occurring human saccades have magnitudes of 15 degrees or less.

A. Terry Bahill, Deborah Adler, and Lawrence Stark.

Normal human saccadic eye movements are seldom larger than 15 degrees. In an outdoor environment, 86 per cent of the saccades of three subjects were 15 degrees or less in magnitude.

Although human saccadic eye movements vary in size from a few minutes of arc to 100 degrees, most naturally occurring human saccades are 15 degrees or less in magnitude. Over 70 years ago, Dodge and Cline[1] noted that saccades invoked during a normal reading task are 12 degrees or less in magnitude. When looking at pictures, normal scanpath patterns are constructed from a sequence of saccades similar in amplitude to reading saccades.[2] Lancaster[3] stated that 99 per cent of all eye movements are within 15 degrees of primary position. Three-fourths of the spontaneous saccades of restrained laboratory monkeys were less than 18 degrees.[4] When the angular direction of gaze is changed by a large amount, it is usually accomplished by using a combination of head and eye movements[5, 6]; thus, the eye movements usually remain less than 15 degrees. The purpose of this experiment was to discern the magnitude distribution of normal, human saccades during naturalistic tasks.

Methods. Electro-oculography (EOG), low-pass filtered at 100 Hz., was used to measure horizontal and vertical components of eye movements. AC-coupled differential amplifiers and an FM tape recorder were mounted on a pack frame and carried by the subject. The subject and experimenter then strolled through the campus at the University of California. The data presented here were derived from three normal male subjects. One subject (TB) wore his glasses during the experiment, while the others had normal vision without corrective lenses.

Results. Fig. 1 shows the relative frequencies of occurrence of 913 various sized saccades. Of these saccades, 86 per cent had magnitudes of 15 degrees or less. Microsaccades were omitted since the noise inherent in the EOG technique made it difficult to measure saccades of one degree or less. We estimate that these small saccades were much more numerous than indicated in Fig. 1. There were no significant differences in the shape of the distribution for horizontal, vertical, and oblique saccades, so the data for these three types have been pooled together in Fig. 1: one-fourth of the saccades were horizontal, one-fourth vertical, and one-half oblique. For the restrained monkey,[4] one-fourth of the saccades were horizontal, 5 per cent were vertical, and the rest were oblique. Our criterion for human data was that if the smaller of the horizontal and vertical components was larger than one-tenth of the large component then the saccade was called oblique; the straight vector length, not the actual travelled path length, was chosen as the amplitude.

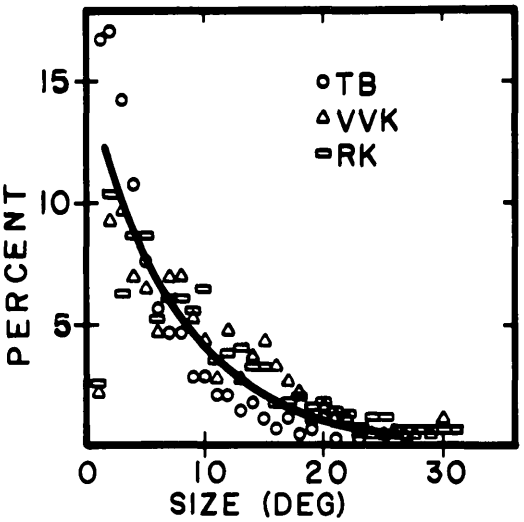

Fig. 1. Frequency of occurrence of various sized saccades for three normal subjects. The solid line representing the equation $Y = 15 \exp(-X/7.6)$, where Y is the per cent occurrence, and X is size of the saccade in degrees, was derived by the method of least squares from all of the data.

Discussion. When reading, looking at pictures, or walking out of doors, most human saccades have magnitudes of 15 degrees or less. This 15 degree saccadic size may be an important physiologic value, for there appears to be a knee in the maximum velocity main sequence curve at 15 degrees. This curve plots the log of the maximum saccadic velocity as a function of the log of the saccadic magnitude and can be approximated in a piece-wise linear fashion with a slope of 0.8 for saccades smaller than 15 degrees and a 0.15 slope for saccades 15 degrees and larger.[7] It is helpful to consider the greatest upper bound of this velocity-amplitude relationship since in this way many factors such as obliquity of the saccade or occurrence of double and overlapping saccades with lower values can be eliminated. Furthermore, at this apparent inflection point the high-frequency burst of motoneuron activity in the

saccadic controller signal undergoes significant changes.

Thus, studies of saccades larger than 15 degrees are helpful in the understanding of the operation of the central nervous system, because they stress the system and demonstrate its operation under difficult conditions. If it is realized that these larger saccades accentuate saccadic abnormalities, then much can be gleaned about the normal operation of the saccadic control system from those studies of both normal and abnormal large saccades. However, if the usual, unstressed operation of the saccadic system is to be studied, then saccades 15 degrees and smaller should be emphasized.

From the Departments of Electrical Engineering and Computer Science and of Physiological Optics, University of California, Berkeley. This research was partially supported by a National Institute of Health grant No. NIH-GM 1418 to T. Bahill. Submitted for publication Jan. 20, 1975. Reprint requests: Terry Bahill, Room 226 Minor Hall, University of California, Berkeley, Calif. 94720.

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The effect of nonspecific immune stimulation on the recurrence rate of herpetic keratitis in rabbits.

H. E. KAUFMAN, STUART MUDD,* EMILY D. VARNELL, AND JOEL ENGELSTEIN.

Cellular immunity is of primary importance in resistance to virus infection. In this study, 75 rabbits were immunized with live BCG, 75 rabbits were immunized with Staphylococcus aureus, and 75 rabbits were injected with saline. Two weeks after immunization the corneal epithelium of both eyes was infected with McKrae strain herpes virus, and five weeks after immunization the rabbits were skin tested with old tuberculin or staphylococcus to ascertain their immune status. The corneas were observed under the slit lamp for recurrent epithelial herpes from day 52 through day 84 after immunization. During the second week of observation the group immunized with BCG had statistically significantly fewer recurrences than the saline-injected control group. The data for the BCG group during the remainder of the observation period, and for the SPL immunized group, were not statistically distinguishable from the control group. These experiments indicate that nonspecific immune stimulation provides little protection against recurrent herpetic infection. It is possible that manipulation of dosage and timing could enhance this effect.

Present evidence suggests that cellular immunity is a primary factor in resistance to virus infection and recovery from such infection. In the case of herpes simplex infection, for example, spleen cells from sensitized mice can be shown to reduce infection in tissue culture and confer protection to challenged animals.[1]

Not only can cellular immunity against specific virus confer protection, but the elicitation and activation of immunocompetent cells against one type of infection can provide resistance against another.[2-4] Utilizing this type of cellular activation, Allan and Mudd showed that the inducement and elicitation of delayed-type hypersensitivity to both mycobacteria and staphylococci seemed to provide protection of mice against vaccinia virus infection.

The present study was designed to induce delayed hypersensitivity to staphylococcus or mycobacteria in animals whose corneas had been infected with herpes simplex virus, and to nonspecifically maximally stimulate their delayed hypersensitivity at the time when recurrences of herpes would be expected.[5] It was hoped that this kind of cellular stimulation might provide a degree of protection against herpes and a reduction in recurrence rate similar to the protection seen against challenge by vaccinia virus, and similar to the protection provided by specific cellular immunity against primary challenge with herpes.

Materials and methods. Seventy-five New Zealand white rabbits were placed in each of the three groups described below and immunized according to one of the following schedules (Table I).

Staphylococcus immunized group. Staphylococcus aureus strain 18Z was grown for 18 hours in