Perception & Psychophysics
1973, Vol. 14, No. 2, 298-300

Saccades in Neal's "Square of Three"

JOSEPH J. KUPIN, GENEVIEVE M. HADDAD, and ROBERT M. STEINMAN
University of Maryland, College Park, Maryland 20742

A contact-lens optical lever was used to measure saccades during maintained fixation of an "op art" painting that produces striking perceptual effects. Saccade frequency was not affected, but saccade vector magnitude was slightly, but reliably, larger with the painting than with a control stimulus. The perceptual effects, however, do not depend on saccades because saccades could be suppressed and the perceptual effects remained.

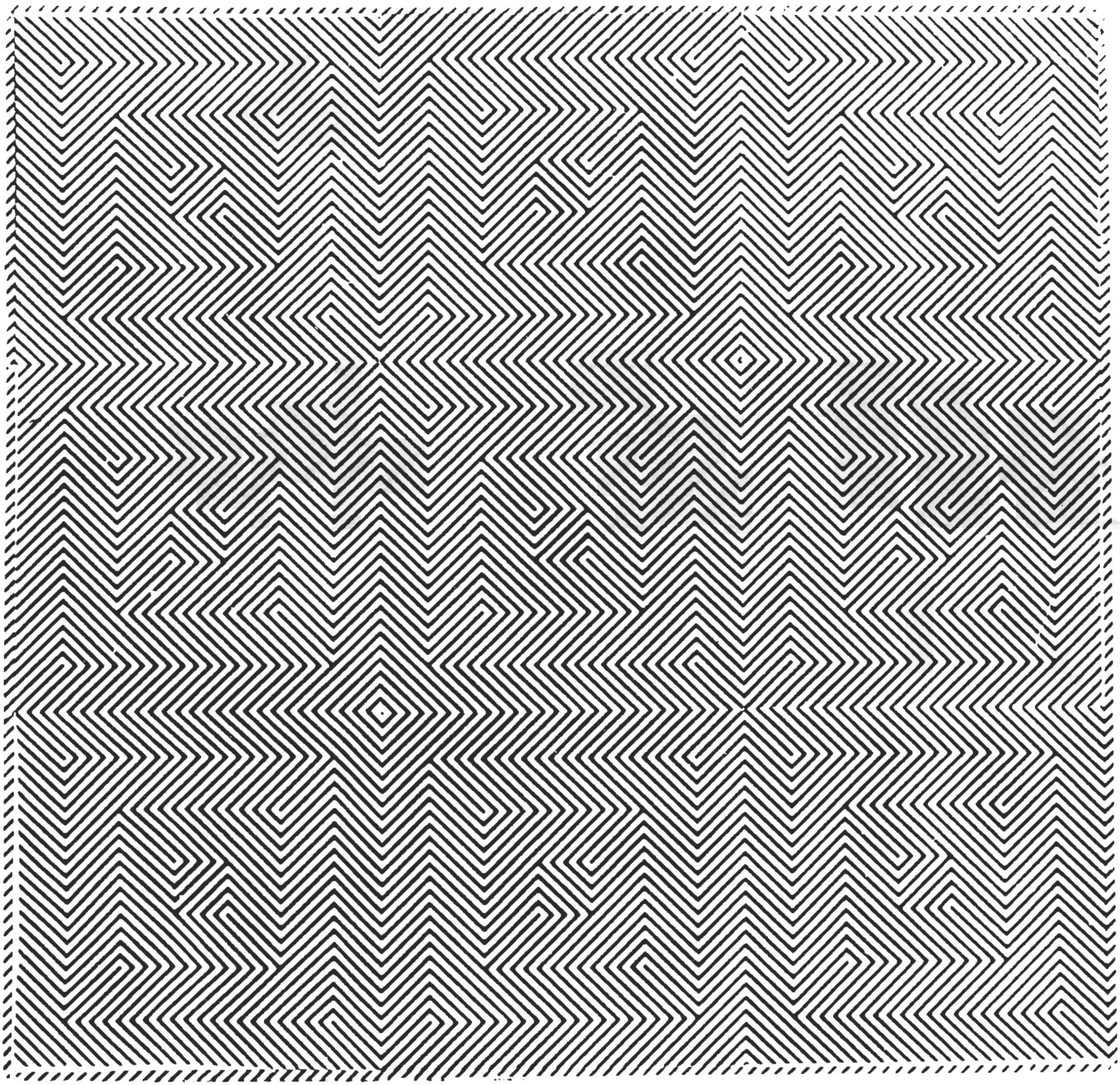

Fig. 1. The black and white reproduction of a painting by Reginald Neal entitled "Square of Three" used as a fixation stimulus.

Table 1
Mean Saccade Vector Magnitude (SVM) in Minutes of Arc for Ss G.H. and R.S. Fixating at the Center of the Perceived Central Square in Neal's "Square of Three" (Three) or at the Same Place in a Control Stimulus (Control)*

	S G.H.			S R.S.		
	SVM	SD	N	SVM	SD	N
Control	6.0	(2.9)	102	3.4	(2.4)	132
Three	8.1	(5.0)	92	3.7	(2.3)	132

**Standard deviations are given in parentheses and the number (N) of saccades made during 10 5-sec trials is also shown.*

fixators (two of us, G.H. and R.S.) had the subjective impression that these visual perturbations were associated with small saccadic eye movements. In this note, we describe what the eye does when this stimulus is viewed.

METHOD

Subjects

The two Ss (G.H. and R.S.), who served in the experiments, have had a great deal of experience in maintaining fixation on a variety of stationary and moving stimuli (see, for example, Steinman, 1965; Steinman, Cunitz, Timberlake, & Herman, 1967; Cunitz & Steinman, 1969; Puckett & Steinman, 1969; Skavenski & Steinman, 1970; Timberlake, Wyman, Skavenski, & Steinman, 1972; Haddad & Steinman, 1973; Sansbury, Skavenski, Haddad, & Steinman, 1973; Steinman, Haddad, Skavenski, & Wyman, 1973; Wyman & Steinman, 1973).

Apparatus

A two-dimensional photoelectric contact-lens optical lever, described elsewhere (Haddad & Steinman, 1973), was used to record horizontal and vertical eye movements. The recording limits with the optical lever length used were 1.0 deg on each meridian, permitting resolution of eye position to 3.6 sec. Records were digitized by a Vidar IDVM and written in analogue and digital form on a Honeywell 1508A Visicorder.

Two kinds of stimuli were fixated: the "op art" figure reproduced above and a control stimulus. The control stimulus was a square of gray cardboard. It was the same size as the op art figure and was placed on top during control trials. A square was cut out at the center of the cardboard, exposing and framing the lines in the region bounded by the subjective central square perceived when Neal's figure is viewed. The square formed by the cutout was the same size as the square perceived in Neal's figure, and the average luminance of both displays was the same (23 mL). The stimuli were located 50 cm from the right eye and illuminated by a "daylight" fluorescent lamp. At this distance, the figures subtended 12 deg 34 min and the subjective central square (and cutout) subtended 38 min at the eye. The left eye was covered and closed.

Procedure

The S was asked to fixate at the center of the central square and start each 5-sec trial when the perceptual effects were well established and vivid. Experimental trials were alternated with control trials, and 10 were run with each of the stimuli. Saccade vector magnitudes were computed from digital samples of eye position before and after each saccade. The experiment was repeated with a different instruction. The second time, the S was instructed to use slow control (suppress saccades) to hold his eyes in place rather than to fixate.

RESULTS AND DISCUSSION

The results of the first experiment are summarized in Table 1.

The frequency of saccades during maintained fixation was not affected by the stimulus display. Both Ss made from 1.8 to 2.6 saccades each second—values typical of their fixation saccade frequency with many other kinds of stimuli. The sizes of saccades, however, were different when each figure was fixated. Saccades were larger while viewing the op art configuration. The differences in mean saccade vector magnitudes, although very small, were statistically reliable [viz, G.H., $t(192) = 7.08$, $p < .001$; R.S., $t(262) = 2.41$, $p < .01$].

The perceptual effects observed with the op art reproduction, however, do not depend on the slightly increased size of the saccades made while this figure is viewed or on the occurrence of saccades, because both Ss were able to suppress saccades in the presence of this stimulus (and the control stimulus as well) without noticing any loss of vividness of the perceptual phenomena, i.e., the appearance and flickering of subjective squares in other parts of the pattern. G. H. made no saccades, whatsoever, in the 50 sec recorded with each of the stimuli. R.S. made nine saccades in 50 sec with the op art figure and seven saccades with the control stimulus.

We now know that the perceptual effects do not require saccades, but we do not know whether the increase in saccade size during fixation requires the op art stimulus, because we have not compared Neal's stimulus with a nonillusory stimulus that contains a similar number of lines. Saccade size during fixation may depend on the amount of detail in the visual field and not on the particular line arrangements that lead to the striking perceptual phenomena observed with this particular array.

REFERENCES

Cunitz, R. J., & Steinman, R. M. Comparison of saccadic eye movements during fixation and reading. Vision Research, 1969, 9, 683-693.

Haddad, G. M., & Steinman, R. M. The smallest voluntary saccade: Implications for fixation. Vision Research, 1973, 13, 1075-1086.

Millodot, M. Influence of accommodation on the viewing of an optical illusion. Quarterly Journal of Experimental Psychology, 1968, 20, 329-335.

Neal, R. "Square of Three." Reproduced in R. G. Carraher and J. B. Thurstone (Eds.), *Optical illusions and the visual arts.* New York: Van Nostrand Reinhold, 1966.

Puckett, J. W., & Steinman, R. M. Tracking eye movements with and without saccadic correction. Vision Research, 1969, 9, 695-703.

Sansbury, R. V., Skavenski, A. A., Haddad, G. M., & Steinman, R. M. Normal fixation of eccentric targets. Journal of the Optical Society of America, 1973, 63, 612-614.

Skavenski, A. A., & Steinman, R. M. Control of eye position in the dark. Vision Research, 1970, 10, 193-203.

Steinman, R. M. Effect of target size, luminance, and color on monocular fixation. Journal of the Optical Society of America, 1965, 55, 1158-1165.

Steinman, R. M., Haddad, G. M., Skavenski, A. A., & Wyman, D. Miniature eye movement. Science, in press.

Steinman, R. M., Cunitz, R. J., Timberlake, G. T., & Herman, M. Voluntary control of micro-saccades during maintained monocular fixation. Science, 1967, 155, 1577-1579.

Timberlake, G. T., Wyman, D., Skavenski, A. A., & Steinman, R. M. The oculomotor error signal in the fovea. Vision Research, 1972, 12, 1059-1064.

Wyman, D., & Steinman, R. M. Small step tracking characteristics: Implications for the oculomotor "dead zone." Vision Research, in press.

NOTE

1. The perceptual phenomena are probably due to fluctuations in accommodation because they were reduced markedly when Neal's "Square of Three" was viewed 50 min after 1 drop of "Cyclogyl" 1% had been placed in both eyes and a spectacle lens provided to focus the stimulus at 50 cm. Similar reductions in a different illusion (perceived motion in stationary concentric rings) have already been shown when fluctuations in accommodation are prevented (Millodot, 1968).

(Received for publication April 24, 1973; accepted April 30, 1973.)