

Saccadic Integration of Spatial Patterns as a Function of Spatial Frequency

著者	MOTOYOSHI Isamu, KUBODERA Toshio
journal or publication title	Tohoku psychologica folia
volume	55
page range	39-43
year	1997-07-01
URL	http://hdl.handle.net/10097/56186

SACCADIC INTEGRATION OF SPATIAL PATTERNS AS A FUNCTION OF SPATIAL FREQUENCY

By

MOTOYOSHI ISAMU (本吉 勇)¹ and KUBODERA TOSHIO (久保寺俊朗)¹

(Tohoku University)

Integration of spatial patterns across saccadic eye movements was investigated, using large and small texture patterns with a range of spatial frequencies. Four human subjects were asked to detect an abrupt change of a texture pattern composed of Gabor patches. Detection performance for the change of the pattern degraded when it occurred during or nearby saccades. Degradation was more prominent at high spatial frequencies when the pattern was small and presented at peripheral. Increasing the size of the pattern improved performance only at high spatial frequencies. The results are accounted for by peripheral factors rather than the trans-saccadic memory.

Key words: saccadic integration, saccadic suppression, spatial frequencies, trans-saccadic memory.

INTRODUCTION

We are not aware of any change of a visual scene despite eye movements which cause great changes of the retinal image. This has been thought to reflect some significant mechanisms in the brain for stabilizing the visual world (Irwin, 1991).

The perceptual stability has two aspects. One is the constancy of spatial position and shape of objects despite displacements of their retinal image, which is partially based on the conversion of retinotopic spatial representation into spatiotopic one (Duhamel, Colby, & Goldberg, 1992; Honda, 1993). Another is the continuity of a scene despite saccades during which visual inputs are disrupted (Volkman, 1986). The continuity, however, may depend on indiscriminability between images across saccades rather than integration of them. It has been suggested that saccades impair the perception of motion and flick consequent to the detection of temporal changes of the image (Shioiri & Cavanagh, 1989). However, there are evidences for discrimination between spatial patterns across saccades without perception of motion or flick, indicating pattern integration based on the short-term visual memory which is persistent during saccades but of limited capacity (Irwin, 1991).

The capacity limited nature of the trans-saccadic memory implies the integration of restricted aspects of visual stimuli. However, it is unknown that what aspects of the stimulus mostly correlate with tokens available in the trans-saccadic memory. We here investigate the parameters of the stimulus integrated across saccades.

1. Department of Psychology, Faculty of Arts and Letters, Tohoku University, Kawauchi, Aoba-ku, Sendai, 980-77, Japan. [e-mail: mossi@sal.tohoku.ac.jp]

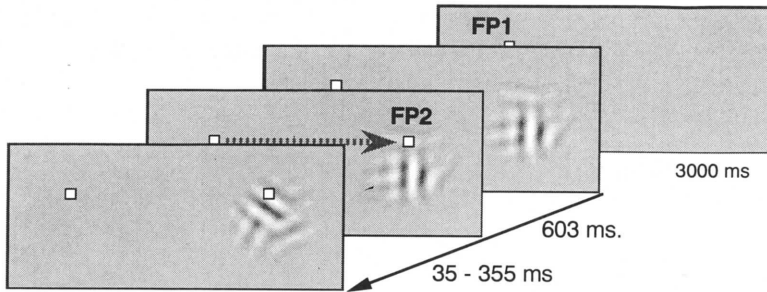


Fig. 1. Stimulus sequence in Experiment 1.

EXPERIMENT 1

METHODS

Stimuli and Apparatus: We used a texture pattern composed of Gabor patches (GPs) within a Gaussian window having a space constant of 1.28 deg, which was presented on a uniform background of 11×22 deg (Fig. 1). Each GP was a cosine grating having a carrier frequency (f) of .4, .8, 1.6, 3.2, or 6 c/deg, modulated with its contrast (.8) by a Gaussian envelope having a space constant of $1/f$ deg. The GPs were randomly oriented and distributed with a separation of $2/f$ deg or larger. The mean luminance of the GP was 10 cd/m^2 as same as the background. The stimuli were generated by a micro-computer (NEC, PC9801BX3) with a 32 bit frame-buffer (Digital Arts, HyperFrame3), and displayed on a 17 inch CRT (IDEK&IDXON, MF8517). The CRT had a 30 pixels/deg spatial resolution and a 56.4 Hz refreshing rate. The visual field outside the display was kept dark. Horizontal EOG was recorded with a frequency of 500 Hz.

Procedure: In each trial, subjects fixated a square (FP1) at 6 deg left and 2 deg above the center of the background. After a blank of 3 sec, the texture pattern was presented 6 deg left from the center of the background. 603 ms after the onset of the pattern, the second square (FP2) to which subjects should saccade was presented at 12 deg right from the FP1. After an 35, 177, 195, or 355 ms, the pattern was replaced by an another one with the probability of 80%, and presented for 400 ms. Subjects were then asked to answer whether the pattern had changed by pressing a button. Trials were run in random order.

Subjects: Four males including one of the authors served as subjects. All had corrected-to-normal vision.

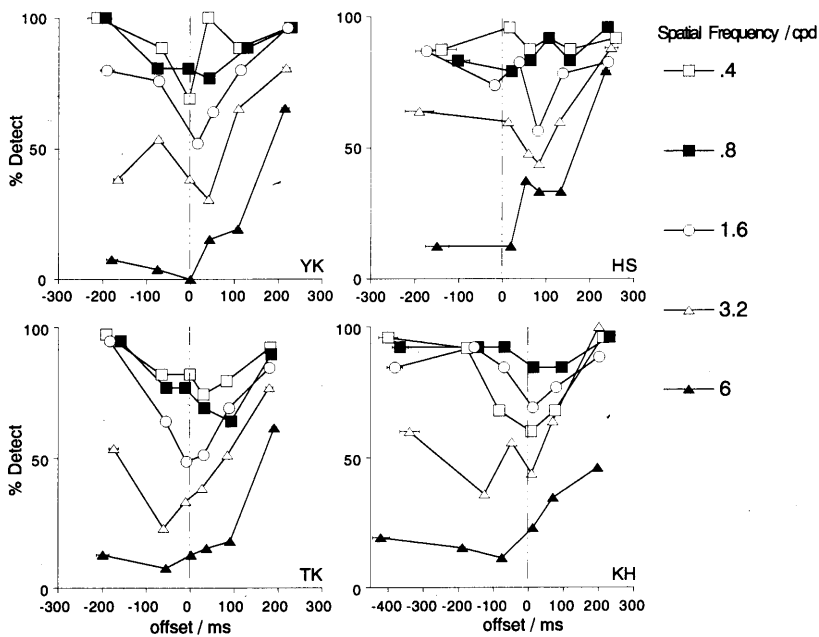


Fig. 2. Proportion correct detection for the change of the pattern as a function of time offset between the change of the pattern and the beginning of a saccade. Each point is based on 36 trials on average for subject TK, and 27 trials for subject MO, YK and HS. The horizontal bar represents a standard error of the saccade latencies.

RESULTS AND DISCUSSION

Figure 2 shows proportion correct detection for the change of the pattern as a function of time offset between the change of the pattern and the beginning of a saccade. In any condition, the detectability decreases at time offset from -200 to 200 ms, indicating saccadic suppression. The detection performance is lower at higher spatial frequencies even before saccades. This is due to low sensitivity of the visual system to high spatial frequency stimuli presented in peripheral vision (Wilson, Levi, Maffei, Rovamo, & DeValois, 1990). Our additional measurements without saccades also support this. Thus, the result has a mixed effect of both saccadic suppression and eccentricity. In the next experiment, we eliminate the effect of eccentricity and evaluate the effect of spatial frequency more precisely.

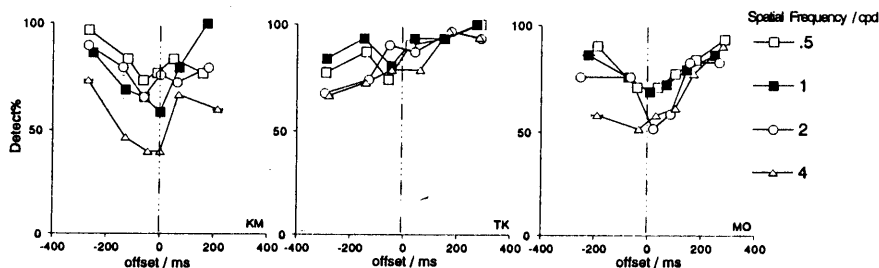


Fig. 3. Proportion correct detection for the change of the pattern as a function of time offset. Each point is based on 27 trials on average.

EXPERIMENT 2

METHODS

In this experiment, we used a texture of Gabor patches (GPs) within a rectangular window subtending 6×20 deg, which was larger than the length of a saccade (12 deg). The carrier frequency (f) of the GP was varied among .5, 1, 2, and 4 c/deg. The pattern was presented in the center of the background. Others were the same as Experiment 1.

RESULTS AND DISCUSSION

Results are shown in Fig. 3. The performance at higher spatial frequencies are still low but better than that in Exp. 1. In addition, the difficulty of the detection for the pre-saccadic change also remains.

GENERAL DISCUSSION

If the trans-saccadic memory is capacity limited, integration of a pattern across saccades would be determined by the number of tokens extracted from the image of the pattern. Furthermore, if such tokens are represented in the early processing level, integration is expected to be easier for the pattern with low spatial frequency and small size. However, our results are inconsistent with these assumptions, and accounted for by the properties of the early spatiotemporal filters. Although it has been suggested that contrast sensitivity at high spatial frequency is enhanced during saccades (Burr, Morrion, & Ross, 1994), the detection of the temporal change of a suprathreshold pattern seems to be easier at low spatial frequencies (Kulikowski, 1971). On the other hand, it remains possible that representations in the trans-saccadic memory is more than the filter's output, and that our procedure is not sufficient for tapping such representations.

REFERENCES

- Burr, D. C., Morrion, M. C., & Ross, J. **1994** Selective suppression of the magnocellular visual pathway during saccadic eye movements. *Nature*, **371**, 511-513.
- Duhamel, J. R., Colby, C. L., & Goldberg, M. E. **1992** The updating of the representation of visual space in parietal cortex by intended eye movements. *Science*, **255**, 90-92.
- Honda, H. **1993** Saccade-contingent displacement of the apparent position of visual stimuli flashed on a dimly illuminated structured background. *Vision Research*, **33**, 709-716.
- Irwin, D. E. **1991** Information integration across saccadic eye movements. *Cognitive Psychology*, **23**, 420-456.
- Kulikowski, J. J. **1971** Some stimulus parameters affecting spatial and temporal resolution of human vision. *Vision Research*, **11**, 83-93.
- Shioiri, S., & Cavanagh, P. **1989** Saccadic suppression of low-level motion. *Vision Research*, **29**, 915-928.
- Volkman, F. C. **1986** Human visual suppression. *Vision Research*, **26**, 1401-1416.
- Wilson, H. R., Levi, D., Maffei, L., Rovamo, J., & DeValois, R. **1990** The perception of form: retina to striate cortex. In L. Spillman & J. S. Werner (Eds.), *Visual perception: the neurophysiological foundations*. New York: Academic Press, pp. 231-272.

(Received December 6, 1996)

(Accepted April 1, 1997)