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VISUAL MASKING FUNCTION TO FLICKERING STIMULUS IN "BLANK–FLICK" EXPERIMENT

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Using increment threshold technique, visual masking function to positive ramp saw-tooth flickering stimulus at 2Hz was investigated in "blank-flick" experiment, in which one flick was removed from each 8 flicks in the flickering train. As a result, it was confirmed that smooth threshold elevation at gradual increase and sharp threshold elevation at abrupt decrease in the flickering background luminance were in phase with each flick in the flickering train and regarded as the on- and off-effect, respectively. Also there appeared to be little interaction between on- and off-effect.

Problem

Maruyama and Takahashi (1977) investigated the masking functions to flickering stimuli at 2 and 10Hz with four kinds of temporal wave forms of rectangular, sinusoidal, and negative and positive ramp saw-tooth, and clarified some aspects in the appearance of the on- and off-effects for these flickering stimuli. Then they expressed a view that the appearance of these on- and off-effects coincided temporally with the changes of luminance in the individual flick in the background flickering train. This view was readily inferred from the results of ingenious "blank-flick" experiment by Boynton, Sturr, and Ikeda (1961), in which two flicks have been removed from each 30 of 30Hz chopper wave flickering train. But there is not always confidence in immediate correspondence between each hump in the masking function and the individual flick, e.g., for the masking function to the positive ramp saw-tooth flickering stimulus in Fig. 1, the large sharp hump is the off-effect while the small smooth hump is the on-effect.

Therefore, employing selectively the positive ramp saw-tooth flickering stimulus as background light, we also designed "blank-flick" experiment to test the temporal correspondence between each flick in the flickering train and the masking function to them and to identify the on- and off-effect. At the same time, it is also the purpose of this experiment to explore the manner of the interaction between the on- and off-effect.

Method

Subject: One of the authors, MT.

Apparatus and Procedure: The positive ramp saw-tooth flickering stimulus with blank-flick was produced by the method of "frequency modulation of glow train" that was essentially identical to those in Maruyama and Takahashi (1977). Two beams of

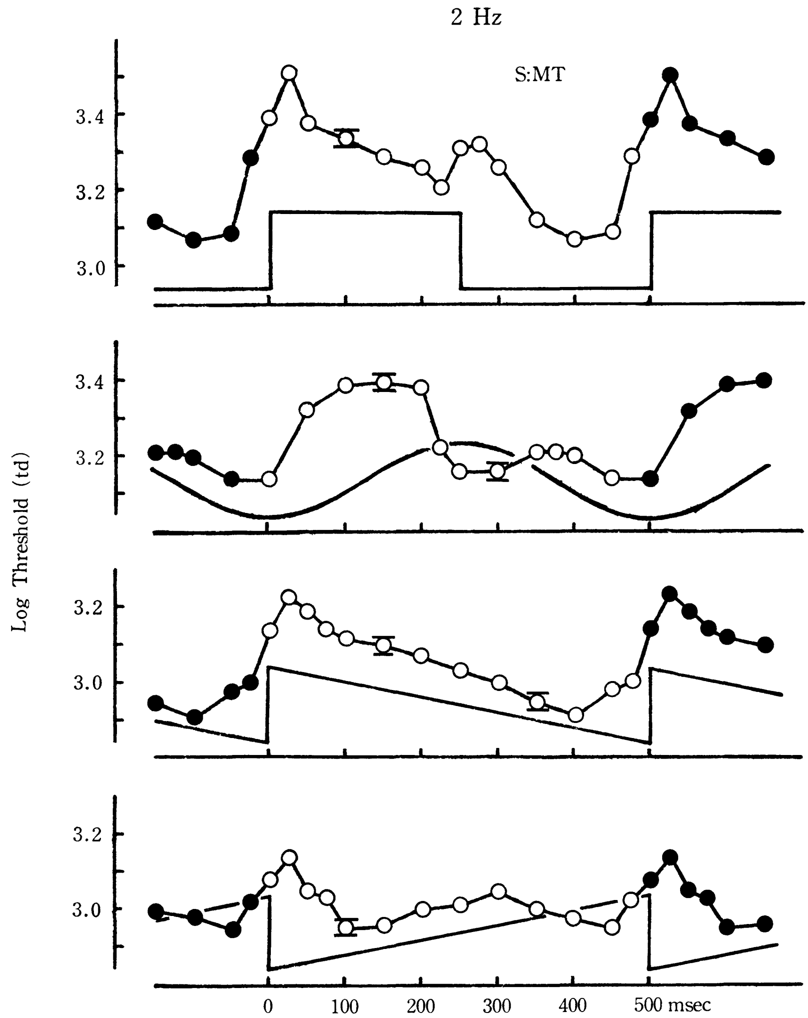

Fig. 1. Masking functions to the flickering stimuli with four kinds of temporal wave forms: rectangular, sinusoidal, and negative and positive ramp saw-tooth (from Maruyama and Takahashi, 1977). Threshold fluctuations (ordinate) are plotted as a function of the temporal relation with background flickering stimulus.

white light were presented centrally to subject's left eye through an artificial pupil of 2mm in diameter, via Maxwellian view system. The larger, circular flickering field with dark surround subtended a visual angle of 1.72° and its modulation ratio was 0.286; the smaller, 0.86°, a test flash of 1msec duration superimposed concentrically on the flickering field. The flickering stimulus has temporal wave form of positive ramp saw-tooth repeated at 2Hz, and a mean retinal illuminance of 31.4 trolands. As the "blank-flick" experiment, one flick was removed from each 8 flicks in the flickering train, giving a repetitive cycle of 7 flicks, one blank, then 7 more flicks, etc. The visual field in blank-flick period was not dark but illuminated with a constant level of 22.4 trolands. The test flashes were presented once every 4sec, and timed to coincide with a fixed phase of the luminance cycle in 3 flicks before or after a blank-flick period.

Following pre-adaptation, increment thresholds for test flashes were determined by the descending method of adjustment, as described in detail elsewhere (Maruyama and Takahashi, 1977). The experiment was divided into 6 sessions, one session a day; since a sufficient number of threshold determinations could not be obtained owing to fatigue for all curves of increment thresholds in a single session. The thresholds in each session were obtained by the method of "round-trip" to counterbalance the order effect; in the first half of a session at least two threshold determinations were made at each temporal phase from earlier phase of flickering cycle to later phase, and then in the latter half they were made likewise in the all reverse order after a few minutes' break. The average of four or more than four thresholds which were determined at a given phase point was plotted to give the masking functions.

Results and Discussion

Fig. 2 summarizes the masking functions obtained from one subject. In this figure, threshold illuminance of test flash in troland is on the ordinate, phase relation in msec between the flickering stimulus with blank-flick period (1500 to 2000msec) and test flash, on the abscissa. A typical standard deviation of thresholds is represented by the vertical bar, as an example in 700msec point. The six masking functions were linked together to give a whole masking function, as seen in Fig. 2, in which the threshold values of the five overlapping points (900, 1300, 1800, 2200 and 2750msec) are much the same, since subject's conditions were arranged carefully to avoid day-to-day variation.

From these results, it should be noted first of all that the masking function to the positive ramp saw-tooth flickering stimulus at 2Hz was quite similar to the results

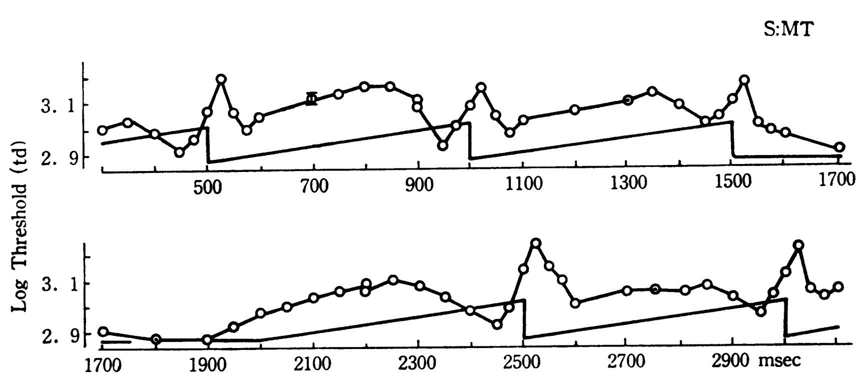

Fig. 2. Masking function to the positive ramp saw-tooth flickering stimulus with blank-flick (1500–2000msec) in which one flick was removed from each 8 flicks in the flickering train at 2Hz.

obtained by Maruyama and Takahashi (1977); a smooth hump at 300 to 350msec points, and then a sharp hump immediately after the abrupt decreasing point in the luminance of the background flickering stimulus, are observed in Fig. 2. These humps, however, disappear in the blank-flick period and there appears to be no marked threshold oscillation. As inferred previously, therefore, it can be concluded that the sharp hump immediately after the starting point of the blank-flick period is the off-effect which depended on the abrupt decrease in the luminance of the background flickering stimulus, and that the first smooth hump after the termination of the blank-flick period is the on-effect. Moreover, these humps are considered to have in-phase relations with each flick in the flickering train.

For the first ramp flick following the blank-flick period, both the on- and off-effect were not only somewhat larger than those to other flicks but also the crest of the on-effect appeared earlier by about 50 to 100msec. This is what would be considerable that the visual system has increased its sensitivity through adaptation to steady light in the blank-flick period and thus should produce a relatively greater effect than to other flicks, as was also stated by Boynton et al. (1961).

No marked difference could be observed between the shape of the off-effect produced by the last flick before the blank-flick period and those by other flicks. Also, there seemed to be only one on-effect to the first flick following the blank-flick period as well as to other flicks. Accordingly, in the masking function to positive ramp saw-tooth flickering stimulus at 2Hz, it is not necessary to take account of any possibility that the on-effect is masked by the off-effect following it. It may safely be stated that only one on-effect appears for each flick in positive ramp saw-tooth flickering stimulus employed in this experiment; that is, between the on- and off-effect there appears to be little interaction worthy of consideration.

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