Notes and Comment

A single-transient masking paradigm

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Visual masking, as typically studied in the two-transient paradigm (Matin, 1975), involves suppression of the visibility of one brief stimulus, the target, by another (spatio-)temporally contiguous brief stimulus, the mask. Recent neurophysiologically based theories of visual masking rely on the existence, in the higher mammalian visual system, of short-latency, fast transient channels which inhibit longer latency, slower sustained channels (for review, see Breitmeyer & Ganz, 1976). In particular, recent theoretical approaches to visual masking, namely, those of Breitmeyer & Ganz (1976) and Weisstein, Ozog, and Szoc (1975), make use of this two-channel, transient-sustained distinction. Both approaches share the assumption that the typical U-shaped or type B metacontrast function (Kolers, 1962) is a consequence of the inhibition of the slow, target-activated sustained channels by the faster mask-activated transient channels in the target-mask sequence. The two models are similar in the specification of conditions required to activate the transient channels. For Breitmeyer and Ganz's (1976) and Weisstein et al.'s (1975) model, it is sufficient that the mask activate fast transient channels, although both models acknowledge that either target or mask can and does activate both transient and sustained channels. The activation of transient channels by the target is not regarded as a necessary condition for obtaining metacontrast masking.

However, Matin (1975) proposed a model in which activation of spatiotemporal sequence detectors, termed target-mask, or T-M, neurons, are required to produce type B metacontrast functions. In other words, Matin suggests that transient neurons may be a substrate for the T-M sequence detectors and that, in addition to the activation of mask transient neurons (Breitmeyer & Ganz, 1976; Weisstein et al., 1975), activation of *target* transient neurons is also necessary for producing metacontrast. The present experiment demonstrates that Matin (1975) may have been misled in her theorizing by the prevailing *methodological* rather than *physiological* facts.

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Rationale and Method

The typical and prevailing method for studying visual masking is to employ the two-transient paradigm in which both the target and the preceding or following mask stimulus are presented briefly and abruptly. The present method may be called a single-transient masking paradigm. In it, the target is presented continuously for 10 sec. Thus, during target presentation, except for its onset and offset, only sustained channels ought to be activated. A brief, transient 50-msec mask is presented 2 sec after the target onset. The mask activates both transient and sustained channels. First, since its transient activity occurs 2 sec after the onset and 8 sec prior to the offset of the target, it is almost impossible that a spatiotemporal sequence analyzer, as envisaged by Matin (1975), is activated.¹ Moreover, if visibility of the target is temporarily reduced by the mask, it is most likely, as will be shown, that it is a consequence of the inhibition of target-sustained activity by mask-transient activity.

The target consisted of a $.33 \times 1.33$ deg vertical black bar drawn with India ink on a white 10×15 cm index card. The contrast of the black-on-white target was .92. The mask consisted of two middle-gray (contrast = .46), $.25 \times 2.00$ deg vertical bars, each of which symmetrically flanked the target, left or right, at one of four possible spatial separations: .3, .6, 1.2, and 2.4 deg. The target and mask stimuli were presented above fixation at viewing eccentricities of 1.7, 6.0, or 10.3 deg. The rationale for this procedure was to exploit the fact (see Breitmeyer & Valberg, 1979, Footnote 18) that the ratio of transient-to-sustained activity increases as one increases retinal eccentricity of stimulation. Therefore, according to theory (see Breitmeyer & Ganz, 1976), one ought to obtain increasing masking effects as eccentricity increases.

The stimuli were presented on a Gerbrands G1135, Model T-4A, four-field Harvard tachistoscope, with front-illumination at 31.0 cd/m². Field 1 contained the target, Field 2, the fixation point, Field 3, the mask, and Field 4, a blank. The 10-sec stimulus sequence on any trial was as follows: Fields 2+4 (fixation point), followed by Fields 1+2 (target+fixation point) for 2 sec, followed by Fields 1+3 (target+mask) for 50 msec, followed by Fields 1+2 (target+fixation point) for 7.95 sec to complete the 10-sec trial sequence. All viewing was binocular at a distance of 80 cm. One of the authors, B.B., a 33-year-old male, and M.K., a 24-year-old male, both with normal vision, served as observers.

The procedure was as follows: Whenever the visibility of the target was suppressed by the mask, the observer pressed a micro-switch with his right thumb at the onset of the suppression and held it pressed down until the target reappeared, at which point he released the switch. The pressing of the microswitch at the onset of the suppression of target visibility initiated a Gerbrands G1271 Digital millisecond clock, which was stopped when the observer released the microswitch. Thus, the dependent measure was the duration of suppression of the target visibility by the flanking mask. At a given, randomly chosen target-mask spatial separation, 24 trials were run, in blocks of 8 trials at each of one of the three randomly chosen viewing eccentricities. Since there were four spatial separations, $4 \times 24 = 96$ trials were run per observer. The mean value of the eight observations at each spatial separation-eccentricity combination served as an index of masking magnitude.

Results and Discussion

The results for both observers are displayed in Figure 1. Despite the fact that there are large overall differences between the results obtained by the two observers, both sets of data share some important

Figure 1. The suppression duration, in seconds, of the sustained target as a function of target-mask spatial separation and viewing eccentricities, both in degrees of visual angle. Open symbols show M.K.'s results; closed symbols show B.B.'s results. The duration of target suppression is taken as an index of masking magnitude.

features. For one, the masking magnitude, as indexed by the duration of the suppression of target visibility, increases with retinal eccentricity at all four target-mask spatial separations. In fact, separate analysis of variance of each observer's results showed that the main effect of viewing eccentricity is highly significant [B.B., $F(2,84) = 181.8$; M.K., $F(2,84) = 676.2$; $ps < .001$]. At the smallest eccentricity of 1.7 deg, both observers obtained no masking effect, whereas at increasingly greater eccentricities, both observers yielded increasingly greater masking effects. This monotonic increase in the mask effectiveness as eccentricity increases is consistent with the aforementioned increase in the ratio of transient-to-sustained activity as retinal eccentricity of stimulation increases.

This explanation, of course, assumes that the transient, rather than sustained, activity of the mask is responsible for the masking effect. The assumption is warranted on the basis of the following. In control experiments, both target and mask were presented synchronously and continuously for 6 sec at each combination of target-mask spatial separation and viewing eccentricity. This procedure assured that, except for onset and offset, the mask as well as the target were activating only sustained channels. However, under these conditions, neither of the observers reported any disappearance or decrease in the visi-

bility of the target. Hence, sustained activity of the mask can be effectively ruled out as a source of the suppression of target visibility.

Another feature of the results is that masking magnitude decreases with target-mask separation. For both observers, this main effect was statistically significant at $p < .01$ [B.B., $F(3,84) = 5.9$; M.K., $F(3,84) = 25.0$]. This result is not surprising, since one would expect lateral interactions between target and mask to decrease as spatial separation increased (Alpern, 1953; Kolers & Rosner, 1960; Weisstein & Grownay, 1969). The interaction between target-mask spatial separation and viewing eccentricity was also statistically significant for both observers' results [B.B., $F(6,84) = 6.5$; M.K., $F(6,84) = 7.8$; $ps < .005$]. This very likely may be an artifact of the floor effect obtained at a viewing eccentricity of 1.7 deg at which no fading or suppression of the target was obtained at any of the four target-mask spatial separations.

An additional noteworthy and rather striking feature of the results is that the duration of the disappearance or suppression of the target produced by the mask far exceeds the mask duration of 50 msec. For B.B., the suppression duration hovered around 2 sec at the two greater viewing eccentricities; for M.K., the suppression duration hovered around 4-5 sec. To obtain suppression durations 20 to 50 times the brief duration of the mask is rather unexpected and is irreconcilable with the rather short response persistence of the transient channel's impulse response (Breitmeyer & Ganz, 1977; Cleland, Levick, & Sanderson, 1973; Watson & Nachmias, 1977), which is on the border of 30-70 msec. A highly likely explanation is that the mask effectiveness, becoming stronger in the parafovea and periphery, exploits and amplifies the well-known Troxler effect obtained under semistabilized viewing, which, when initiated, runs its temporal course in proportion to the strength of the mask. The fact that no masking is obtained at or near the fovea supports this contention. The micro-movements of the eye that accompany fixation are very likely too small to destabilize the semistabilized patterns in the periphery; however, they are probably large enough to continually destabilize the foveal and near foveal patterns and thus eliminate the mask's exploitation of the Troxler effect. This explanation predicts that under similar conditions one ought to obtain enhanced foveal and near-foveal suppression of target visibility with optically stabilized retinal images.

The present results show conclusively that one can obtain suppression of target-sustained activity by a single mask transient. Hence, Matin's (1975) theoretical assertion that activation of two transient stimuli, which supposedly in turn activate spatiotemporal sequence analyzers, may certainly be a sufficient, but not a necessary, condition for obtaining target

suppression. As mentioned, her conclusion was based on a confusion of what one may term the "methodologic" and the "physiologic," since the methodology of previous masking studies fortuitously, but rather religiously, adhered to the two-transient paradigm. On the other hand, the present results would not contradict the theoretical formulation of visual masking proposed by Breitmeyer and Ganz (1976) or Weisstein et al. (1975). In fact, Breitmeyer and Ganz (1976) explicitly state that transient channels are involved in signaling either *the* spatial location or the *change* in spatial location (i.e., motion) of a stimulus event. Accordingly, since transient channels are presumably activated in either case, one can claim that the activation of transient channels by the mask is a necessary condition for obtaining the particular variant of visual masking known as metacontrast. However, the activation of some class of spatiotemporal sequence analyzers, whether or not identified with transient channels, is not a necessary condition.

Recently, Breitmeyer and Horman (1980) have come to a similar conclusion on the basis of the results of a different experimental procedure. They, like Weisstein and Growney (1969), showed that at stimulus spatial separations at which one obtains strong stroboscopic motion and, hence, activation of spatiotemporal sequence analyzers in a two-transient paradigm, one can fail to obtain metacontrast brightness suppression. Hence, activation of spatiotemporal sequence analyzers cannot be even a sufficient condition for obtaining metacontrast in the general case, although it may be in restricted cases. Moreover, they demonstrated that when the same, that is, optically superimposable, stimulus configurations serve as both target and mask, one can obtain powerful metacontrast masking of the first stimulus in the two-stimulus temporal sequence, although no spatiotemporal sequence analyzers were activated. These results concur with those of the present experiment, from which one can infer that activation of transient channels *qua* spatiotemporal sequence analyzers is

not a necessary (or a sufficient) requirement for obtaining metacontrast.

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NOTE

1. Metacontrast and stroboscopic motion experiments from which Matin (1975) infers the existence of spatiotemporal sequence analyzers generally indicate that the optimal temporal interval over which one can activate these analyzers is on the order of 150-250 msec, a range of values about one order of magnitude or more smaller than the duration values employed in the present experiment.

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