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Metacontrast can be obtained in the fovea: An examination of retinal location and target size

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Metacontrast was assessed as a function of target size, retinal location, and interstimulus interval. Supporting previous findings, there was no effect of retinal location in metacontrast. Various target sizes produced similar results. Monotonic metacontrast functions were obtained in all conditions.

Metacontrast is the phenomenal suppression of one visual stimulus by a second stimulus when the stimuli are nonoverlapping and fall within a critical time period. Metacontrast has been shown to be sensitive to a large number of variables, each of which affects the nature of the results obtained (Lefton, 1973a; Weisstein, 1972). The present study utilized disks as stimuli and rings as masks while examining the effects of target size and retinal location.

Studies of metacontrast which have varied retinal location have shown different results. For example, Alpern (1953) was unable to find metacontrast when the target was in the fovea. Kolers and Rosner (1960) in a detection task found very little metacontrast with foveal fixation relative to the amount obtained when the stimuli were presented in the periphery. Stewart and Purcell (1970) simulated the conditions of the study by Weisstein and Haber (1965) and found that metacontrast was obtained only in the periphery when the task was the indentification of letters. By contrast, Lefton (1970) argued that spatial cuing could account for the results or retinal position. With spatial cuing eliminated, similar functions were obtained in the fovea and in the periphery. Eriksen and Marshall (1969) have also reported foveal metacontrast. The effects of retinal location on metacontrast are, therefore, equivocal with some studies finding foveal metacontrast and others not finding it.

Weisstein (1968) and Kolers (1962) have argued that manipulation of the ratio of stimulus to mask energy determines the nature of the results obtained in metacontrast. This ratio might be in terms of luminance, duration, or size. The size of the surround in studies of metacontrast has, in some cases, proven to be a potent variable since thresholds for any stimulus vary as a function of the size of that stimulus. At the present time, however, there are no systematic studies of metacontrast as a function of target size.

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According to the formulations put forth by Weisstein (1968) and Kolers (1962), the width of a masking ring when stimulus size is held constant should manipulate the nature of metacontrast formation obtained. Mayzner, Blatt, Buchsbaum, Fridel, Goodwin, Kanon, Keleman, and Nilsson (1965) found that amounts of metacontrast decreased with increases in surround width; Matteson (1969) found increases. Weisstein and Growney (1969) found changes in the extent of metacontrast but over a very small range of mask ring widths. With target size held constant, Lefton (1973b) found no effects of mask ring width or of duration.

The present study investigated retinal location and target size when a mask width is held constant to assess possible qualitative and quantitative differences in metacontrast due to these variables. Retinal location is varied over 3.5 deg. Target size is varied from .41 deg to 2.5 deg.

METHOD

Subjects

Six undergraduates at the University of South Carolina served as subjects. All subjects were paid volunteers. Each subject had normal or corrected vision.

Stimuli and Apparatus

Four homogeneous black disks on white cards were used as stimuli. The disks varied in size such that their diameters were .64 cm, 1.27 cm, 2.54 cm, and 3.81 cm. At a distance of 86 cm, the targets subtended a visual angle of .42 deg, .84 deg, 1.69 deg, and 2.53 deg, respectively. The disks were photoprinted on semigloss white photo paper to produce high contrast. There were surround rings used as masks for each of the four stimuli. The inner diameter of each ring corresponded to the diameter of its appropriate target, subtending the same degree of visual angle. There was zero intercontour distance. The width of the mask for all targets remained constant at 1.27 cm (inner to outer border). Thus, the presentation of the .64-cm target with mask covered a field of 2.11 deg of visual angle while the 3.81-cm target and mask subtended 4.2 deg visual angle. Five fixation positions were arranged so that the stimuli appeared either at fixation or 1, 2, 3, or 3.5 deg to the left. The stimuli were presented in a Gerbrands four-channel tachistoscope (Model T-4B).

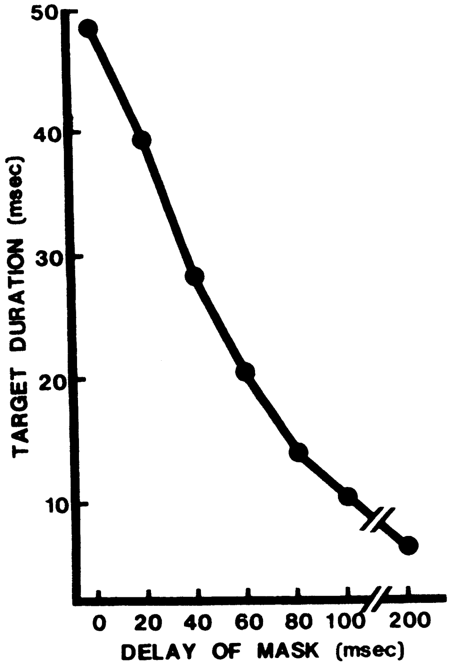

Figure 1. Mean duration threshold is presented as a function of the delay of the mask. (Data are collapsed across target size and retinal location.)

Procedure and Design

Upon introduction to the laboratory, subjects were dark adapted for 5 min to the ambient room illumination. During this time, they helped experimenter align the target and mask so that the target would fall just within the center of the masking ring. The subjects were instructed that within any one experimental session the target size and retinal location would remain constant, though these two variables would change across experimental sessions.

With five retinal locations and four target sizes, there were 20 experimental sessions. Each subject was tested for 22 sessions. The first two sessions were considered practice. The remaining 20 experimental sessions were randomized and counterbalanced across subjects.

Each experimental session consisted of the testing of one retinal location and one stimulus size at seven interstimulus intervals. The ascending method of limits was used. Each interstimulus interval was tested four times within a session. The order of interstimulus interval within a session was randomized and counterbalanced. There were two practice blocks at the beginning of each session. In this within-subject design, each subject was tested on each condition an equal number of times.

The subjects initiated their own trials by pressing a switch. The following sequence of stimulation would then be presented monocularly to the left eye: Fixation, target, interstimulus interval, masking ring, and then fixation. The fixation field was always illuminated except during the time that the target or mask was presented. The luminance of the background was equated at .16 cd/m^2. The dependent variable was the duration at which subjects changed from saying that they did not see the target to saying that they did see the target. With the ascending method of limits, the duration of the stimulus varied on each trial. When the subject responded with a *yes* response, experimenting continued until the subject produced three successive yeses. Interstimulus interval was varied between blocks of trials. The interstimulus intervals tested were 0, 20, 40, 60, 80, 100, or 200 msec. The mask duration was always 200 msec.

The subjects were given strict instructions about fixating and were reminded several times within a session about the importance of fixation.

RESULTS AND DISCUSSION

Each subject provided three durations at which the target became visible for each experimental condition. A mean was computed for each subject for each condition and entered into an anlysis of variance (retinal location by size by interstimulus interval by subjects). There was a dramatic effect of interstimulus interval. As the interstimulus interval increased, the duration threshold decreased monotonically, $F(6,30) = 14.32$, $p < .001$. This result is shown in Figure 1. There were no significant effects of retinal location ($F < 1$) or of target size ($F < 1$). The only significant interaction was of Retinal Location by Size by Interstimulus Interval, $F(72,360) = 1.45$, $p < .01$. The mean duration threshold for each target size for each retinal location for all of the interstimulus intervals is presented in Table 1.

There were no systematic effects of retinal location. In the study by Stewart and Purcell (1970), the task was one of letter identification; Alpern (1953) used a brightness matching technique; both of these studies were unable to find foveal metacontrast. By contrast, Lefton (1970), also using the letter recognition task, was able to find foveal metacontrast; Erikson and Marshall (1969), using a temporal forced choice detection of disks, have reported foveal metacontrast. The present study uses a duration threshold and finds foveal metacontrast. Thus, with the recognition of letters, temporal forced choice detection of disks, and duration thresholds, foveal metacontrast has been obtained.

It's not surprising to find foveal metacontrast. There is no a priori reason to suggest that metacontrast or any other kind of masking function should not be obtained in the fovea. Although the fovea may be sensitive only under photopic conditions, most of the studies that have been conducted to date have been photopic. The present study was conducted at a relatively low luminance; even here, where foveal sensitivity might be reduced, metacontrast was obtained.

There has been no systematic study of target size in metacontrast. It's been argued that when target to mask energy ratios, size, or contrast are manipulated, the nature of metacontrast functions obtained would be different (Kolers, 1962; Weisstein, 1968). Since the studies of mask ring width have produced equivocal results, the present study attempted to hold mask ring width constant and manipulate target size. Target size did not make any systematic difference in relation to the extent of metacontrast. With both relatively small targets (.4 deg) and relatively large ones (2½ deg), there was a small but statistically significant interaction of Retinal Location by Target Size by Interstimulus Interval. As is shown in Table 1, this interaction is probably brought about because of the crossover of points at the longest interstimulus intervals and a large

Table 1
Mean Duration Thresholds

Target Size (Deg)	Retinal Location	Interstimulus Interval 0	20	40	60	80	100	200	Mean
.42	Fovea	56.4	43.9	30.1	23.9	18.2	16.2	11.9	28.6
	1	48.7	37.6	29.7	20.3	15.5	11.2	8.3	24.4
	2	50.2	34.2	26.5	21.3	17.0	10.4	7.0	23.8
	3	38.6	31.9	25.4	16.9	14.2	11.9	9.5	21.2
	3.5	42.4	30.9	22.5	16.8	14.5	12.4	10.0	21.3
	Mean	47.2	35.7	26.8	19.8	15.8	12.4	9.3	23.8
.84	Fovea	38.9	27.3	14.6	9.9	7.6	6.4	4.9	15.6
	1	60.1	44.0	36.4	24.6	17.4	9.4	6.2	28.3
	2	46.5	39.0	29.1	20.3	11.6	9.2	6.4	23.1
	3	43.3	31.8	22.3	18.6	9.4	7.6	4.7	19.6
	3.5	35.8	30.8	18.0	13.9	9.4	8.0	6.2	17.4
	Mean	44.9	34.5	24.0	17.4	11.0	8.1	5.6	20.8
1.69	Fovea	28.4	36.3	19.5	13.4	8.2	6.4	4.1	16.6
	1	32.5	25.4	15.5	11.2	7.7	6.0	4.9	14.7
	2	72.7	54.5	41.0	33.1	23.0	17.8	7.5	35.6
	3	54.4	45.3	32.9	24.3	12.8	8.4	5.1	26.1
	3.5	60.0	50.4	36.3	26.6	17.1	12.9	6.8	30.0
	Mean	49.6	42.3	29.0	21.7	13.7	10.3	5.6	24.6
2.53	Fovea	56.7	53.6	45.0	29.0	21.0	13.7	4.0	31.8
	1	45.9	35.9	24.1	15.8	9.5	6.5	4.1	20.2
	2	34.0	27.8	18.0	10.4	7.6	5.8	4.7	15.4
	3	61.1	55.0	42.8	34.8	23.9	18.6	5.3	34.5
	3.5	60.9	52.6	35.1	25.7	13.4	9.7	5.0	28.9
	Mean	51.7	44.9	33.0	23.1	15.0	10.8	4.6	26.1

Note—All entries are in milliseconds.

number of degrees of freedom (72,360) associated with the small F value.

While surprising, the failure to find an interaction of Target Size by Retinal Location, or of the main effects of these variables, suggests that retinal location and target size are not critical variables in determining the nature and extent of metacontrast. These data should not be seen as a license for metacontrast researchers to manipulate target size and retinal location without due consideration. However, they do suggest that previous designs using dramatically different stimulus configurations are comparable.

When the mask was delayed, metacontrast was shown to be a monotonically decreasing function of interstimulus interval. Previous findings have found both monotonic metacontrast functions and U-shaped functions (Lefton, 1973a). Schurman (1972) has suggested that task differences may create the differences between monotonic vs. U-shaped functions. He suggests that in a recognition or detection task, monotonic functions should be obtained whereas, in a brightness task, U-shaped functions should be obtained. One of the problems in determining the differences between tasks is the criteria that subjects adopt. For example, in a spatial forced choice detection task, the subject's task may be to indicate whether the target appeared in the left or the right ring. However, subjects may not be using a detection criteria but rather one of brightness. Subjects will often report that they are making their discrimination based upon the brightness of the center of the two masking rings. While criterion levels can shift from subject to subject, the change from a criterion of brightness comparisons to one of detection may not be just a shift in the level of criterion, but a totally different dimension.

Monotonic and U-shaped functions have been obtained in a variety of different tasks including letter recognition, detection, and threshold. While possible task differences may account for the results, at present, there is no one model or theory which can account for both monotonic and U-shaped functions as a function of task differences. The present study has shown that stimulus parameters of retinal location or target size do not seem to be critical. Previous studies have shown that the number of internal contours in the target cannot account for monotonic vs. U-shaped functions (Lefton, 1974).

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