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Perceived size change in a masking paradigm with heightened contrast

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A figural-masking stimulus configuration was presented tachistoscopically for 12 msec with a 120-msec interstimulus interval. Subjects compared the inner diameter of the masking ring with the inner diameter of a comparison ring. In Experiment 1, there were 12 male and 12 female college students who judged stimuli with test-to-inducing-figure contrast ratios of 2:1, 5:6, and 6:5. Illusion magnitude was nonsignificant. In Experiment 2, there were 10 male and 10 female college students who viewed stimuli with a contrast ratio of 150:1. A significant apparent attraction between the (outer) test figure's inner contour and the (inner) inducing figure's outer contour was found. A significant main effect for sex was also found, and an attempt was made to explain it in terms of field dependence. We concluded that figural masking may be in the same class as fixation effects and certain geometric illusions, since in each case parallel contours perceived as being simultaneous appear to displace themselves toward one another.

The study to be described made use of the backward-masking paradigm to produce an illusory size effect. Our purpose was to show a possible linkage between the mechanisms that underlie masking and primary geometric illusions. In order to achieve masking, a disk, the stimulus to be masked, is followed by a circumscribing ring, the masking stimulus, at an optimal interstimulus interval (usually around 40 to 60 msec). Numerous investigations (Cox & Dember, 1971; Cox, Dember, & Sherrick, 1969; Kolers & Rosner, 1960; Streicher & Pollack, 1967) have shown that the disk does not need to be as large as the inner diameter of the ring in order for masking to occur. However, Pollack (1965) demonstrated that considerably greater contrast between the mask and its ground than between the target and its ground is necessary in order to produce masking when there is a spatial separation between the ring and the disk. Cox and Dember (1971) and Kolers (1962) found that greater mask-stimulus contrast levels facilitate masking. Growney (1976) showed that it is the edge luminance of the target and mask that determines the extent of masking. Studies by Werner (1935) and by Pollack (1965) established that masking is greatest when the inner and outer figures' contours are parallel and that angularity of the masked figure inhibits its masking.

The stimulus configuration for both the Delboeuf illusion and the Usnadze effect is the same, except that in the former the concentric circles are presented simultaneously and in the latter the presentation of the circles is separated by an interstimulus interval. Ikeda and Obonai (1955) showed that by gradually delaying the onset of the test circle up to 200 msec, the concentric circles' contour interaction gradually changes from attraction to repulsion—from the Delboeuf to the Usnadze effect.

Along with the orientation of contour, figure-ground contrast of the inducing or inspection figure has been shown by Oyama (1962) to influence the magnitude of the Delboeuf illusion. In all cases, the greater the contrast of the inducing figure, the greater is the illusion, and the greater the contrast of the test figure, the smaller is the illusion (Gibb, Freeman, & Adam, 1966; Oyama, 1962; Oyama & Akatsuka, 1962).

Since the parameters that influence figural masking with a disk-interval-ring paradigm (figure-ground contrast of the inducing or inspection figure and their contour orientations) appear to be the same as those that mediate fixation effects and certain geometric illusions, it seems reasonable to stipulate that these phenomena are the products of similar underlying processes. In light of this conclusion, our study investigated whether, as in the Delboeuf illusion, parallel contours can be shown to attract each other when the figural masking paradigm (i.e., very brief interstimulus intervals, rather than simultaneity) is employed.

Deaton (1973) investigated the possibility of attraction of parallel lines in the figural-masking situation by lengthening the interstimulus interval so that masking of the disk did not occur and its apparent size could be judged. Since there was no separation between the inner edge of the ring and the outer edge of the disk, one would not expect attraction between these contours to have been exhibited in Deaton's study. No significant size change was perceived, which indicates that there was

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no phenomenal contour attraction within either of the two figures.

Our study was an extension of that of Deaton. In our experiment, there was a separation between the inner edge of the ring and the outer edge of the disk in order to determine if this would result in an apparent attraction between the (outer) test figure's inner contour and the (inner) inducing figure's outer contour. The contrast ratio was varied over three levels since a large contrast ratio between the test and inducing figure had been shown to produce significantly greater illusion magnitudes in both the Delboeuf and the Usnadze effect (Gibb et al., 1966; Oyama, 1960, 1962; Oyama & Akatsuka, 1962). We hypothesized that as the contrast ratio between the test and inducing figure increased, the apparent shrinkage of the (outer) test figure's inner diameter would increase.

EXPERIMENT 1

Method

Subjects. Twelve men and 12 women, all college students, served as the subjects. All subjects had visual acuities of 20/25 or better, as measured by Snellen's Distance Vision Test Letters.

Apparatus. The stimuli were viewed in a three-channel electronic tachistoscope (Scientific Prototype Corporation, Model BG). The viewing distance was 1,240 mm. The brightness of Channel 2 and Channel B was 5.2 fL measured at the eyepiece with a photometer. Channel 1, a backlight behind Channel 2, had a brightness of 35.7, 23.4, or 14.6, fL measured at the eyepiece with a Macbeth illuminometer. A Wratten neutral-density filter (Kodak, 0.6) was placed between the stimuli and the light source in Channel 1, thus creating a brightness of 8.9, 5.9, or 3.7 fL, respectively.

The stimuli consisted of black velour paper on which a 1-mm-square fixation dot cut from Munsell paper (light gray, N 7.5) was centered. The fixation dot's brightness was 2.64 fL. In line with and on either side of the fixation dot was a ring whose center was 15.5 mm from the dot. Both rings were cut from Munsell paper (white, N 9.5). The ring's brightness was 4.68 fL. The test ring had an inner diameter of 11 mm and an outer diameter of 21 mm. Centered in the test ring was a circular 7-mm-diam hole that permitted light from the backlight (Channel 1) to pass through the stimulus card placed in Channel 2. This light served as the inducing figure. It permitted exact alignment between the test and inducing figures. The comparison ring, the other ring on the stimulus card, had an outer diameter of 21 mm. Its diameter varied from 6 to 13 mm in 0.5-mm steps. The visual angle subtended by the stimulus configuration did not exceed 3 deg. The stimulus configuration is shown in Figure 1.

Procedure. A convergent method of limits was used. Illusion magnitude was calculated for each subject as the difference between the mean point of subjective equality (PSE) for a baseline series and each of the three experimental series. A PSE was defined as a change to a new response for three consecutive values in ascending and descending order. The subjects were instructed to respond by stating on which side the ring with the larger inner diameter was located. Thus, a response of "right" or "left" was given. All sessions were approximately 1-h long, with a rest period midway. Each of the subjects participated in one session, in which he or she viewed all experimental conditions. The subjects were allowed 3 min at the beginning of the session to adapt to the illumination in the tachistoscope. They viewed a 5.6-fL field with a 1-mm-square fixation dot. Viewing was binocular.

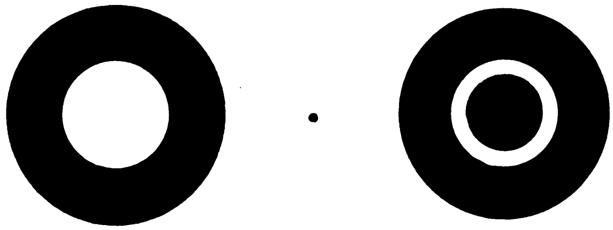

Figure 1. Stimulus configuration for the masking paradigm used in Experiments 1 and 2.

There were three brightness conditions for the inducing figure (8.9, 5.9, and 3.7 fL); these created inducing-figure/test-figure contrast ratios of 2:1, 6:5, and 5:6.

The sequence of presentation for all three conditions was as follows: (1) the inducing figure (a disk created by light shining from the backlight through a circular hole in the stimulus card) presented for 12 msec; (2) an illuminated interstimulus interval (a field with the same brightness as the background figures, 5.6 fL, and with an identical fixation dot, a 1-mm square cut from Munsell paper, light gray, N 7.5) presented for 120 msec; and (3) the test figure and comparison figure (the two rings side by side on a stimulus card) presented for 12 msec. The hole in the test ring was visible only during (1). The subjects viewed a 5.6-fL field with a 1-mm-square fixation dot (Munsell N 7.5) between each presentation sequence while the stimulus card was changed (approximately 5 sec).

There were a total of eight trials for each condition. The order of presentation of the three contrast conditions was random for each subject. The side on which the inducing and test figures appeared (whether they were on the right or left side of the fixation dot) was counterbalanced between subjects.

In addition to the three contrast conditions, there was a baseline condition. Here, only the test figure along with the comparison figure was shown (Channel 2) and the subjects made judgments of the figures' relative sizes without the influence of the inducing figure. The subjects viewed a 5.6-fL field with a 1-mm-square fixation dot (Munsell N 7.5) between each stimulus presentation while the stimulus card was changed (approximately 5 sec). Test sessions began and ended with four baseline-condition trials.

Results

Mean PSEs were determined for all baseline conditions and all trials of the experimental conditions for each subject. The illusion magnitude (IM) for each condition was determined by algebraically subtracting the appropriate baseline PSE from the PSE of each experimental condition. The mean IM for each exposure condition was calculated by taking the average of IMs for all subjects. Means and variances are shown in Table 1.

A 3 x 2 x 2 mixed-model analysis of variance (ANOVA) of IMs for illumination x sex x stimulus position (left or right of the fixation point) was computed. Nonsignificance was found for all conditions. Interaction effects were also nonsignificant.

A Dunnett test was computed to compare the mean PSEs for the three illumination levels with the mean PSEs for the control condition. Nonsignificance was again found for the three illumination levels.

Discussion

The results did not support the hypothesis stated previously.

Table 1
Mean Illusion Magnitudes and Variances in Millimeters for Experiment 1

Variable	Mean	Variance
	Disk Illumination	
3.65 ftL	.260	.174
5.85 ftL	.314	.143
8.93 ftL	.298	.151
	Sex	
Male	.215	.109
Female	.366	.192
	Stimulus Position	
Right	.277	.116
Left	.305	.196

Equal contrast or a slight difference in contrast between the test and inducing figure resulted in very little, if any, illusion magnitude. These results do not indicate that a perceived size change is impossible with a masking paradigm. The growth of the disk and shrinkage of the ring are most likely small, and the conditions used here could be expected to reduce the figural effect—particularly when the contrast level of the inducing figure was less than that of the test figure. Similar reduced Delboeuf illusion magnitudes and Usnadze effects have been found by Gibb et al. (1966), Oyama (1962), and Oyama and Akatsuka (1962) when the difference in brightness between the inducing figure and background was decreased. Therefore, a paradigm that has been shown to increase illusion magnitudes for the concentric circles illusion should be effective here also.

EXPERIMENT 2

The purpose of Experiment 2 was to test the hypothesis that a large contrast ratio between the test and inducing figure (150:1) would result in significant shrinkage of the test figure. For this experiment, those contrast conditions that had been shown to maximize displacement in the concentric circles illusion (Oyama & Akatsuka, 1962) were employed. The inducing figure was considerably brighter than the test figure.

Method

Subjects. Ten men and 10 women, college students who had not previously participated in an experiment for this investigator, served as the subjects. All had visual acuities of 20/25 or better, as measured by Snellen's Distance Vision Test Letters.

Apparatus. The stimulus conditions were identical with those stated in Experiment 1, except for the following changes: (1) brightness for Channel 1 was 198 fL; (2) no filter was used to reduce the illumination in Channel 1; and (3) the test figure (ring) was cut from medium gray Munsell paper (N 5), and its reflected brightness was 1.28 fL. These changes in apparatus resulted in a 150:1 contrast ratio between the inducing figure and the test figure.

Procedure. The sessions lasted .5 h. The procedure was identical to that described in the previous experiment, except that here, since only one illumination level was used, there was only one experimental condition.

Results

Mean PSEs and IMs were calculated in the manner described in Experiment 1. IMs and their variances are presented in Table 2.

A 2 x 2 x 2 mixed-model ANOVA of PSEs for condition x sex x stimulus position was computed. As can be seen in Table 3, significant main effects were found for condition [$F(1,16) = 14.01$, $p < .005$] and for sex [$F(1,16) = 6.55$, $p < .05$]. Main effects for position, as well as all interactions, were nonsignificant.

Discussion

The results supported the hypothesis that in a paradigm resembling masking, it is possible to obtain results that suggest attraction of parallel contours when the inducing figure is considerably brighter than the test figure. The significant main effect for sex was perplexing. The female subjects' larger illusion would be explained by some as due to field dependence. Immergluck (1966a, 1966b, 1968) has shown that subjects classified as field dependent frequently show larger illusions and that females frequently exhibit more field dependence than do males.

In conclusion, it appears that the figural-masking phenomenon may indeed be in the same class as fixation effects and certain geometric illusions. All three seem to behave in a manner that indicates that they depend upon conditions determining the way in which contour is formed and displaced. With proper conditions of figure-ground contrast of the inducing and inspection figures and with parallel contour orientations, all three phenomena behave the same way—parallel contours perceived as being simultaneous appear to displace themselves toward each other.

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Table 2
Mean Illusion Magnitudes and Variances in Millimeters for Experiment 2

Variable	Mean	Variance
Total	.409	.202
	Sex	
Male	.116	.104
Female	.600	.135
	Stimulus Position	
Right	.406	.202
Left	.400	.185

Table 3
ANOVA for Condition, Sex, and Stimulus Position: Experiment 2

Source	SS	df	MS	F
Between	6.094	19		
Sex (S)	1.526	1	1.526	6.55*
Position (P)	.296	1	.296	1.27
S × P	.548	1	.548	2.35
Error Between	3.724	16	.233	
Within	2.945	20		
Condition (C)	1.247	1	1.247	14.01**
S × C	.215	1	.215	2.42
P × C	.028	1	.028	
S × P × C	.037	1	.037	
Error Within	1.418	16	.089	

*$p < .05$. **$p < .005$.

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