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THE EFFECT OF ILLUMINATION LEVEL ON ACHROMATIC TRANSPARENCY

MAMI FUKUDA

The relationships between the impressions of transparency effect and the characteristics of stratification were examined. Kozaki *et al.* (1991) showed that the lightness of each region forming transparent pattern changed with various illumination level. Using a cross pattern, the present experiment tried to clarify whether the illumination level affects the impression of transparency. It has been known that the transparent surface altered, depending on the level of illumination. If there are any similar type in appearances between alternation of transparent surface and the degree of transparency with the change of illumination level, it could be possible to confirm which surface in the pattern is perceived as a transparent by the observers. The result of the present study suggested the relations between the illumination level and the reflectance of region forming the pattern.

Key words: Transparency; Illumination level; perception of surface.

INTRODUCTION

Under appropriate conditions it is possible to produce the impression of a transparency in spite of the absence of physical transparent condition. The conditions under which transparency occured were originally discussed by Helmholtz (1867) and Hering (1888). With the development of Gestalt Psychology, many researchers, e.g., Fuchs (1923a, b), Tudor-Hart (1928), Heider (1933), Koffka (1935), Metzger (1953), Kanizsa (1955) and Metelli (1955) has done further research for the study of phenomenal transparency and other related effects. After precise experimental dxaminations, Metelli (1970) proposed the algebraic model based on Talbot's law of color fusion. According to his model, it is suggested that the index for phenomenal transparency is determined by reflectances of each region. However, it has been known that lightnesses of each region forming transparent pattern changed, depending on various conditions such as illumination level or background reflectances (Kozaki, 1974: Kozaki *et al.* 1991). Thus, if the transparency is determined by the relations in lightness instead of reflectance between each region, it may be expected that the degree of phenomennal transparency changes with varying the lightness of each region of the pattern.

In this article I try to clarity the characteristics of phenomenal transparency in a cross pattern. The common characteristics of the phenomena were analyzed by Mettelli (1985), such as complete transparency, partial transparency, balanced transparency, and unbalanced transparency. Kozaki (1974) argued that the impression of the transparency of the pattern depeded on the lightnesses of the background and of the region where the two figurers intersected, the transparent one and the one seen through the transparent figure. Also, Kozaki *et al.* (1991) found that the impression of transparency varied with whitness (or grayness) of the transparent region of the pattern, but this cross pattern showed some complicated appearance. In their experiments, various conditions in its appearance were included, i.e., the balanced transparency, the unbalanced one, and the partial one as Metelli distinguished (see 1985). Also, it is difficult to confirm the region in which the observers see as transparent figure because these transparent surfaces are often reversed and altered each other.

This experiment was planned to analyze the relationships between the impressions of

transparency, and characteristics of stratification.

METHOD

Two undergraduate students and one teaching staff were participated as the observers in this experiment. They were all naive for the purpose of this study.

APPARATUS

As shown in Fig. 1 the subjects looked at cross patterns composed of four regions on the stimulus disply through an aperture on a black box, 25 cm×30 cm×100 cm. This black box was prepared for observation under the various stimulus conditions The size of the box was decided according to the size of the stimulus display and aperture. Then the stimulus should not be out of focus when the observer watch them through the aperture. The patterns were composed of achromatic Munsell value papers (JCI matt gray paper, Japan). The reflectance of the four regions for each of three patterns used in this experiment are given in Table 1. The reflectances for A, P, and Q remained unchanged. The stimulus displays were illuminated by a xenon slide projector (Hokushin; SLP-1000S). The ND filters (Kodak) were used for varying the illumination level, which were placed in front of the lens of the projector. The illumination level was either 1306 lx, 81.5 lx, or 3.4 lx.

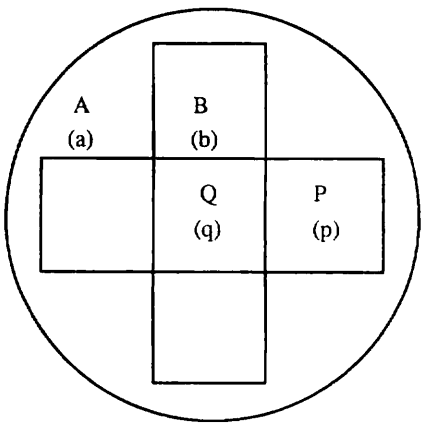

Figure 1. Stimulus pattern used in this experiment. Capital letters (A, P, B, Q) indicate the regions, and small letters (a, p, q, b) indicate the reflectances of each region.

Table 1. Reflectances of each region in the pattern used in this experiment and the alpha values (the degree of transparency calculated by the reflectance of each region) proposed by Metelli.

Stimulus	1	2	3
Bacground (A)			
Munsell Value	5.5 V	6.5 V	9.0 V
Reflectance	25.1%	36.2%	78.66%
Region (B)			
Munsell Value	2.0 V	2.0 V	2.0 V
Reflectance	3.1%	3.1%	3.1%
Region (P)			
Munsell Value	6.0 V	6.0 V	6.0 V
Reflectance	30.5%	30.5%	30.5%
Region (Q)			
Munsell Value	4.0 V	4.0 V	4.0 V
Reflectance	12%	12%	12%
α Value	0.84	0.55	0.24
(Partial transparency)	(1.23)	(0.81)	(0.36)

PROCEDURE

The obsever was sitting on a chair in the small semi-dark booth. After the dark adaptation (approximately 15 minutes), the observer was asked to press one of two small buttons which were near the aperture, depending on which rectangles was seen as a transparent. If the impression of the configuration was reversed, the observer was asked press another button. Each stimulus was exposed for 30 seconds. After the short interval (15 seconds, approximately), the same pattern was displayed in front of the observer. Then he/she was asked to rate the degree (0 or 9) of transparency in both appearances when the gray layer is perceived as transparent and the black layer is perceived as transparent. Each task was done under three illumination levels. The observer was examined on three separate days for each illumination level. The judgments were repeated 6 times for each pattern.

RESULTS

The results for the ratio of the view which gray and black areas were perceived as upper transparent layer is shown in Figure 2. The ratio is presented as a mean of the first 15 seconds and the later 15 seconds. It is clarified that the decrease of ratio of gray area corresponded to the increase of illumination level. The gray layer tends to become upper layer under low illumination level whereas the result reveals that the black layer tends to become upper layer under high illumination level. The result confirmed a similar tendency to those obtained by Kozaki *et al.* (1991). 3×3 analysis of variance (ANOVA) showed that the main effects due to illumination level and background were significant for the both layers. [$F(2,27)=10.02$, $p<.01$, for the black layer, $F(92,27)=0.02$, $P<.01$, for the gray layer].

The results for the rating of the degree of transparency are illustrated in Figure 3. The mean of degree of transparency is showed on the ordinate, and the illumination level is showed on the abscissa. It is clear that the degree of transparency of the gray layer decreased with increasing the illumination level while the black layer increased. 3×3 ANOVA showed that main effects due to the illumination level and the background were significant for both of the layer [$F(2,27)=.12.2$, $p>0.1$, for gray layer and $F(2,27)=10.1$ $P<0.1$ for black layer].

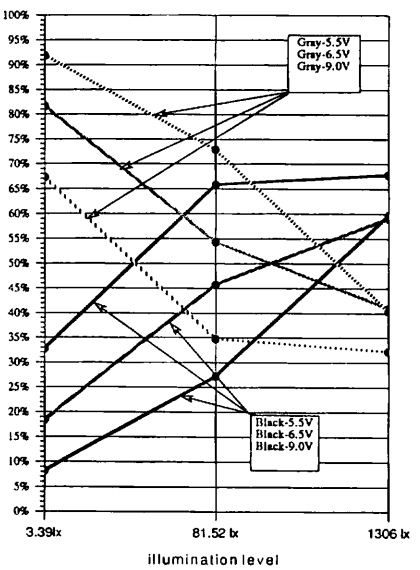

Figure 2. The ratio when the black and the gray area appear as the transparent upper layer. The solid and dotted lines indicate the ratio when the black and the gray area perceived as the transparent upper area, respectively.

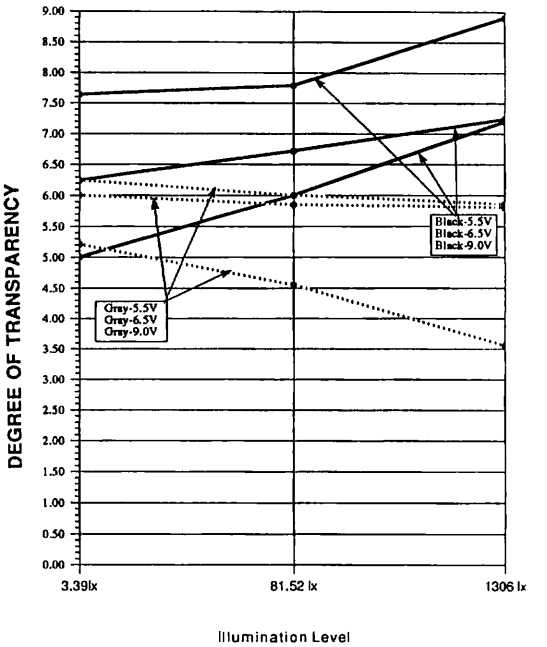

Figure 3. Transparency judgments as a function of illumination level. The solid and dotted lines indicate when the black area and the gray area perceived above, respectively.

DISCUSSION

The data of this report provided a very similar tendency to the result which was obtained by Kozaki *et al.*, (1991). They argued that the since transparency does not depend on physical variables such as reflectances, any ultimate model of transparency should exclusively be expressed in terms of lightness. Under the high illumination condition, black layer tends to become transparent. Kozaki's data support the result because it showed that the black area change their impression of the lightness under high

illumination condition. And under the low illumination condition, gray layer became dominant. Kozaki's data also support this results. As a conclusion, the data of this experiment showed the possibility of the change of the mode of stratification under the strong influence of illumination levels.

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