

Effect of hue, value and chroma on apparent depth in viewing 2-D images

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We conducted experiments to investigate how the arrangement of colors put on a flat surface affects the apparent depth. We combined three quadrangular segments with colors from Munsell color system, so that the quadrangular segments formed a positive hexagon on a white pasteboard. We prepared three conditions in selecting three different colors for each of quadrangular segments in order to examine how hue, value and chroma affect the apparent depth. In the first condition, we combined the advancing colors, the retreating colors and neutral colors. In the second condition, we combined different levels of value and chroma. In the third condition, we combined different levels of value in the achromatic color. We used the method of paired comparisons in order to investigate the apparent depth for a positive hexagon. Our results were the followings: a) the distance of the combined hues has no consistent effect on the apparent depth, b) The effect of value on the apparent depth was larger than those of chroma, c) the combination had no high contrast and neutral gray (N5) had the effect on the apparent depth. We proposed methods to use hue, value and chroma in effectively expressing depth for a object on a flat surface.

Key words: *Arrangement of colors, 3-D objects, Valeur*

Introduction

Painters and visual designer have used the operation of colors to express 3-D objects and space in their 2-D. They expressed 3-D objects and space by the use of shadow with various colors. They used “valeur” that was French language origin as the word to imply the operation of colors. The concept of the “valeur” has been unclear among painters and designers because of the transition in the pictorial expression and of the ambiguity in translation of “valeur” from original French word to the another wards in different languages. Despite of the historical transition of the concept of “valeur”, the relationship between apparent depth and colors has been one of the most important topics in the textbook for visual arts (Fukui, 1978; Kashiwa, 1987). However, there has not been many scientific studies on the relationship between apparent depth and colors. In this study, we are investigating this relationship in order to establish a method to express 3-D objects on a flat surface.

Oyama and Yamamura (1960) reported that the apparent depth from colors depends upon value and hue in accordance with the experimental study in which they

asked observers to evaluate the depth between the observer and the panel with a single color. They found that red is the most advancing color, and orange, yellow and red purple are also advancing while blue, greenish blue and blue purple are receding colors. Green and purple are neutral. The value has little effect on the apparent depth. The effect of hue on the apparent depth increases as the chroma increases.

While, Oyama and Yamamura (1960) examined the apparent depth from the observer to the object with a single color, we examined the apparent depth within an object which consists of arrangement of colors in order to propose effective methods to express 3-D object on a flat surface. We conducted experiments to understand the effects of hue, value and chroma on the apparent depth from the arrangement of three colors on a white board.

Methods

Stimuli and equipment

We presented a positive hexagon that consists of three quadrangular segments with different colors. (Fig.1) We selected several colors from Munsell color system, and combined them so that the three quadrangular segments

formed a positive hexagon at the center of a white pasteboard. We prepared three conditions in selecting three different colors for each of quadrangular segments in order to examine effects of hue, value and chroma.

a) In the first condition (4 patterns), we examined the effects of hue. We combined the advancing color (5R, 5YR and 5RP), the retreating colors (5BG, 5B and 5PB) and neutral colors (5YG, 5G and 5P) (Oyama & Yamamoto, 1960). In those combinations, value and chroma were kept at the same level (Fig.2).

b) In the second condition (8 patterns), we examined the effects of value and chroma. we selected the advancing color (5R), the retreating color (5PB), the neutral color (5G) and the achromatic color. We combined different

levels of chroma and the same levels of value in 5R, 5PB and 5G (Fig.3: a, c, and e). We combined different levels of value and same levels of chroma in 5R, 5PB, and 5G (Fig.3: b, d, and f). We combined different levels of vales in the achromatic color (Fig.3: g and h).

c) In the third condition (8 patterns), we combined different levels of value in the achromatic color in order to examine the effects of value (Fig.4).

The viewing distance from the stimulus to observers was about 30 cm. Each stimulus was illuminated from just above by the daylight simulating fluorescent lamp (D65) (Fig.5).

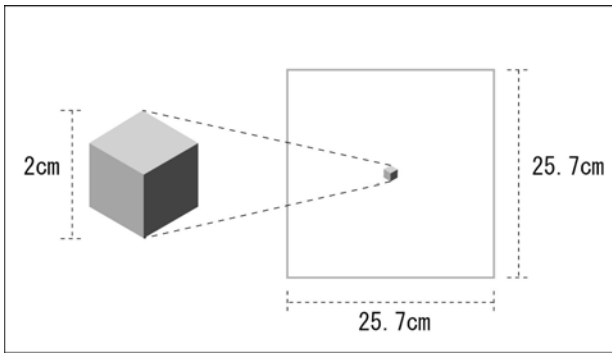


Fig. 1 The form and size of the stimuli

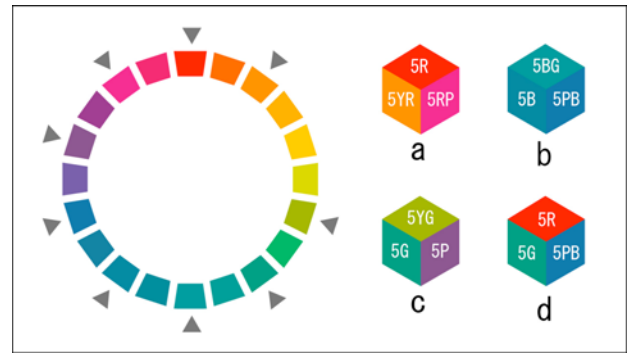


Fig.2 Stimuli used in the first condition; a: advancing colors (5R 6/10, 5YR 6/10, 5RP 6/10 in Munsell notation), b; retreating colors (5BG 4/8, 5B 4/8 5PB 4/8), c: neutral colors (5YG 6/8, 5G 6/8 5P, 6/8), d: composite colors (5R 5/10, 5G 5/10, 5PB 5/10).

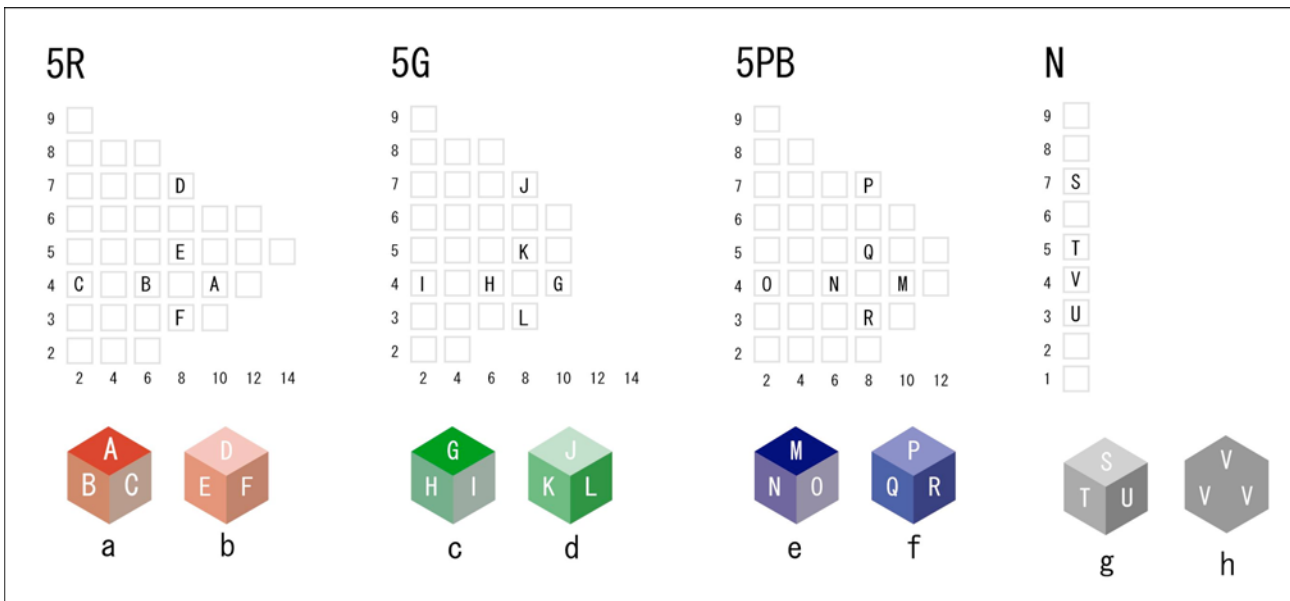


Fig. 3 Stimuli used in the second condition; a: (5R 4/10, 5R 4/6, 5R 4/2 in Munsell notation), b: (5R 7/8, 5R 5/8, 5R 3/8), c: (5G 4/10, 5G 4/6, 5G 4/2), d: (5G 7/8, 5G 5/8, 5G 3/8), e: (5B 4/10, 5B 4/6, 5B 4/2), f: (5B 7/8, 5B 5/8, 5B 3/8), g: (N7, N5, N3), h: (N4, N4, N4).

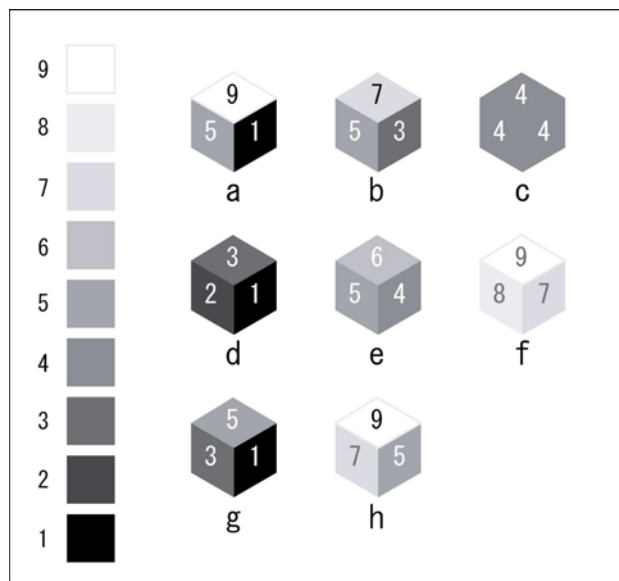


Fig. 4 Stimuli used in third condition; a: (N9, N5, N1 in Munsell notation), b: (N7, N5, N3), c: (N4, N4, N4), d: (N3, N2, N1), e: (N6, N5, N4), f: (N9, N8, N7), g: (N5, N3, N1), h: (N9, N7, N5).

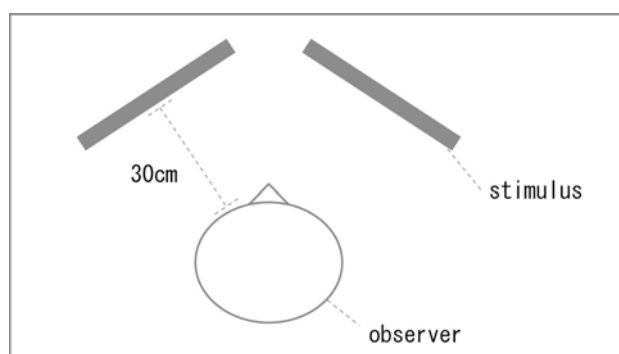


Fig. 5 The situation of the experiment

Procedures

In each of condition a, b, and c observers judged which of the hexagons on the right and left boards they felt larger depth (method of pair comparisons). They had total of 62 trials in three conditions. Each stimulus was presented in random orders for each condition.

Observers

A total of ten observers served (seven females and three males). They were undergraduate and graduate students with normal color vision. Their ages ranged from 21 to 24 years. All of them had normal or corrected to normal visual acuity.

Result & Discussion

a) Effects of hue.

The scores in terms of Thurstone's method showed the degree of the effects of hue on apparent depth (Fig.6). The variance in the apparent depth due to hues of different distance in the hue circle was small (Fig. 2). These results suggested that the effects of hue on apparent depth were minor. The stimuli composed of high levels of chroma might exaggerate apparent depth (Fig.6; a and d).

b) Effects of value and chroma .

The scores in terms of Thurstone's method showed the degree of the effects of value and chroma on the apparent depth (Fig.7). We examined whether the effect on apparent depth of the stimuli was varied with levels of value (Fig.7; b, d and f) or the stimuli was varied with levels of chroma (Fig.7; a, c and e). The result showed that the stimuli with different levels of value more exaggerated than the stimuli with different levels of chroma did. This result showed that the effect of value was much larger than that of chroma on apparent depth. The stimulus with achromatic color (Fig.7; g) was exaggerated the apparent depth more than the stimuli with the chromatic color did (Fig.7; b, d and f). The effect on the apparent depth of chroma varied with hue (Fig.7; a, e and c). Green would exaggerate the apparent depth (Fig.7; c).

c) Effects of levels on value in achromatic color.

The scores showed the degree of the effects of levels on value in the achromatic color on the apparent depth (Fig.8). The stimuli composed of white and black did not exaggerate apparent depth (Fig.8; a). While, the stimuli composed of neutral gray (N5) exaggerated apparent depth (Fig.8; b, e, g and h). The stimulus composed of low values did not exaggerate the apparent depth (Fig.8; d).

In this study, we conducted experiments to examine the effects of value and chroma on hue (5R, 5YR, 5YG, 5G, 5BG, 5B, 5PB, 5P and 5RP) on the apparent depth (Fig.2, Fig.3). However, we did not have the conditions in which different levels of value and chroma were combined. In future study, we should examine the effects of value and chroma on the other hue to get more comprehensive understanding of the effects of hue, value and chroma on apparent depth. If we would examine more comprehensive understanding of the effects, we would be able to make the color system for examination of the effects of hue, value and chroma on apparent depth. The color system would be the useful system when

painter and designer would express apparent depth in their 2-D works by the arrangement of colors.

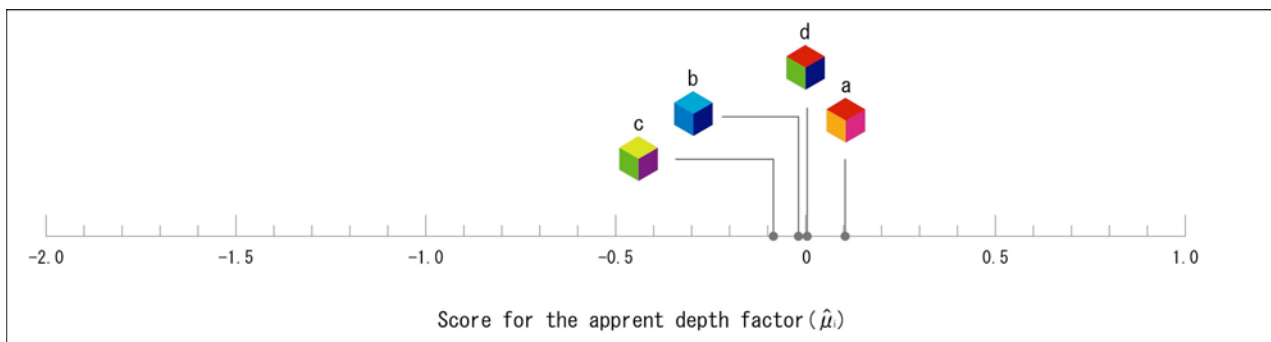


Fig. 6 Score for the apparent depth in the first condition.

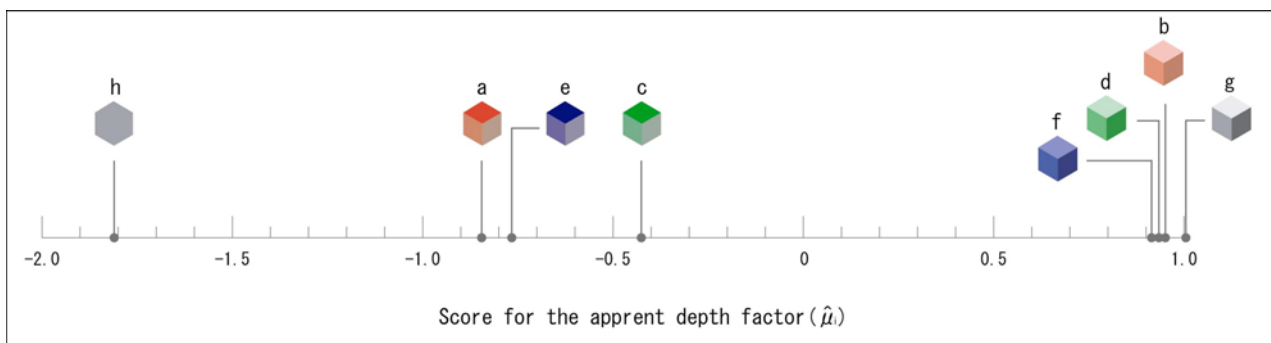


Fig. 7 Score for the apparent depth in the second condition.

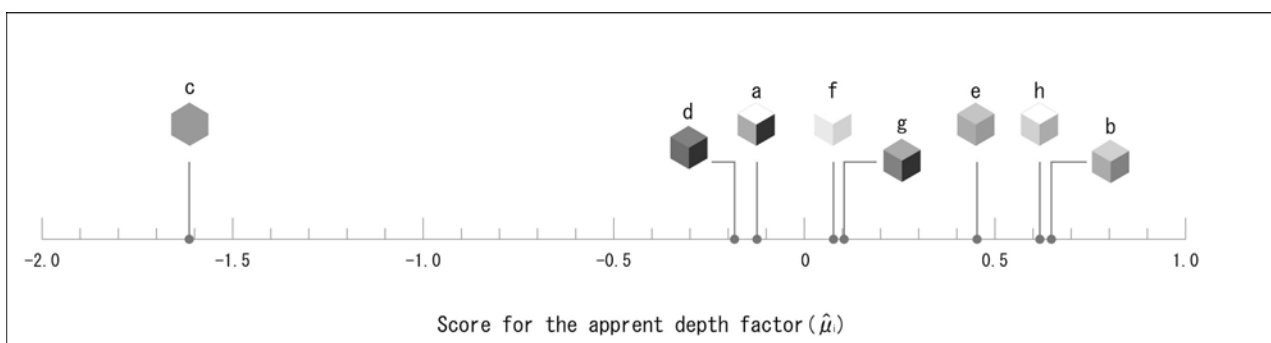


Fig. 8 Score for the apparent depth in the third condition.

Conclusions

We found that the effects of value on the apparent depth are larger than those of chroma and hue. The effects on the apparent depth are different by the levels of value combined. Hue and chroma increase the effect on the apparent depth each other. In order to express 3-D objects effectively on a flat surface, we should use achromatic colors, in particular with moderate contrast around N5 in Munsell notation.

References

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