

A Perceptual Study on the Ratios of Areas of Two Adjacent Colors for the Optimal Congruency

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ABSTRACT

Previous studies showed a girl character with yellow hair and violet irises was perceived as cute and pleasant. However, yellow and violet were a pair of complementary colors. It is well known that a pair of complementary colors are perceived as unpleasant. In the present study, two adjacent squares painted in different colors were constructed. The pair of the colors were selected from twelve colors in the Itten's color wheel and 132 pairs of the colors were presented on the display. Twenty participants were requested to shift the boundary of the two colors to be perceived as the most congruent. The results of the experiment showed that a narrow area of yellow was congruent with a wide area of violet. The results were inconsistent with the phenomenon that a girl with yellow hair and violet irises were perceived as cute. The reason why the girl character was perceived as cute may be depending on the cultural effect.

Keywords: Area ratio, Color, Congruency, Adjustment method, Itten's color wheel

INTRODUCTION

In recent years, Japanese video games, anime and manga are called “Cool Japan content” and are actively exported overseas under the leadership of the Japanese Ministry of Economy, Trade and Industry. In the content, attractive characters, who draw viewers into the world of the work, frequently appear. Colors play one of the most important roles to design a character.

Yanagida and Yamada (2016) showed that yellow characters gives a cute impression in the context of Pokémon. Tanaguchi and Yamada (2021) showed that colors of hair and irises determine the impressions of a girl character, largely. They also showed that a character with yellow hair and violet irises was perceived as one of the cutest types of the character. It is well known that a pair of yellow and violet construct complementary colors and generally it is said that a pair of complementary colors gives an unpleasant impression. On the other hand, cuteness includes the meaning of pleasantness. It is a puzzle why an unpleasant combination of colors of yellow and violet constructs a cute character.

It could be hypothesized that the small area the violet irises functioned as an accent color when it was combined with the wide area of

Table 1. The ratios of the brightness for complementary colors Goethe estimated.

Yellow : Violet = 9 : 3 = 3 : 1 = 3/4 : 1/4
Orange : Blue = 8 : 4 = 2 : 1 = 2/3 : 1/3
Red : Green = 6 : 6 = 1 : 1 = 1/2 : 1/2

yellow hair. The accent color of violet may not be perceived as unpleasant with the main color of yellow, rather it could be congruent with the main color and make the design impressive. The hypothesis described above could be supported by the theory of existence of the optimal ratio of areas for a pair of complementary colors to be perceived as congruent.

A Swiss artist, theorist and educator, Johannes Itten (1888-1967) insisted that the brightness and the area ratio of two colors affect the degree of congruency. Itten calculated the optimum ratios of areas of different colors based on a German poet, playwright, novelist and critic, Johann Wolfgang von Goethe (1749-1832). Goethe estimated the ratios of brightness of different colors are “yellow: orange: red: violet: blue: green = 9:8:6:3:4:6.” Table 1 shows the Goethe’s ratios of the brightness for pairs of complementary colors. Itten hypothesized that the optimum area ratio of two colors is reciprocal to the ratio of the brightness and concluded that the optimum area ratio of different colors are “yellow: orange: red: violet: blue: green = 3:4:6:9:8:6.” The ratio “yellow: violet = 3:9” suggested that a narrow area of yellow is congruent with a wide area of violet in the Itten’s theory. Unfortunately, the phenomenon that a girl character with a wide area of yellow hair and a narrow area of violet irises was perceived as cute is inconsistent to the Itten’s theory. In the process where the Itten’s theory was constructed, several intuitive hypotheses and estimation were included. Therefore, a perceptual experiment was directly conducted to determine the area ratios of two different colors for the optimum congruency, in the present study.

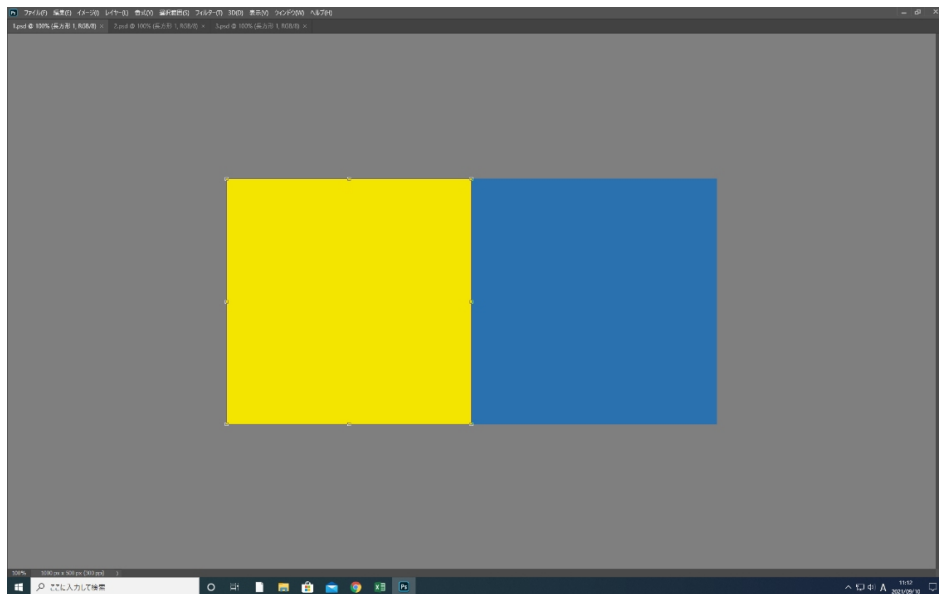
METHODS

In the experiment, twelve colors were selected from Itten’s color wheel and 132 pairs of two different colors were prepared. Table 2 shows the RGB values of the twelve colors. Two adjacent squares were prepared and painted in two different colors, using the software Illustrator (Figure 1).

The experiment was conducted using the adjustment method. The stimuli were presented through a display Flex Scan EV2785W. Twenty participants from the Kanazawa Institute of Technology were requested to adjust the boundary of the two areas to make them most congruent, using the software Photoshop.

Table 2. Twelve colors used in the experiment.

	Color	RGB		
		R	G	B
#1	Yellow	244	229	0
#2	Yellow-Orange	253	198	11
#3	Orange	241	142	28
#4	Red-Orange	234	98	31
#5	Red	227	35	34
#6	Red-Violet	196	3	125
#7	Violet	109	57	139
#8	Blue-Violet	68	78	153
#9	Blue	42	113	176
#10	Blue-Green	6	150	187
#11	Green	0	142	91
#12	Yellow-Green	140	187	38

**Figure 1:** An example of the two adjacent colors used in the experiment.

RESULTS AND DISCUSSION

The values obtained in the experiment were averaged over the participants, and the ratios for the optimum congruency were calculated. The results of the experiment showed that the ratios were approximately “yellow: orange: red: violet: blue: green = 5:6:5:6:7:6.”

The ratio of 5:6 for yellow and violet showed a consistent tendency to the Itten’s theory, although the ratio was smaller than Itten showed.

Then, individual data of the measurement were investigated to estimate the reason of the discrepancy of the values of the ratios between the results of the experiment and the Itten’s theory. Table 3 shows the values of mean,

Table 3. The statistic values of the displacement of the boundary for each participant.

Participant	Average	Max	Min	Variance	SD
1	-27.22	250	-252	11741.29	108.36
2	-18.33	323	-323	41497.09	203.71
3	-3.74	418	-438	29668.93	172.25
4	21.63	427	-426	81491.22	285.47
5	7.38	374	-408	42137.08	205.27
6	11.61	337	-243	13659.46	116.87
7	18.64	300	-288	23584.03	153.57
8	-59.78	334	-343	40642.05	201.60
9	-6.79	382	-416	53696.32	231.72
10	-9.90	391	-439	46176.45	214.89
11	-10.27	310	-328	26293.18	162.15
12	-0.83	291	-320	20389.52	142.79
13	-41.08	444	-449	64623.15	254.21
14	-17.58	290	-330	28823.96	169.78
15	20.70	399	-360	45912.36	214.27
16	-6.94	267	-290	8232.47	90.73
17	-8.40	313	-298	17363.16	131.77
18	-0.08	421	-413	35155.73	187.50
19	13.87	266	-301	12336.10	111.07
20	-4.79	328	-348	24449.24	156.36

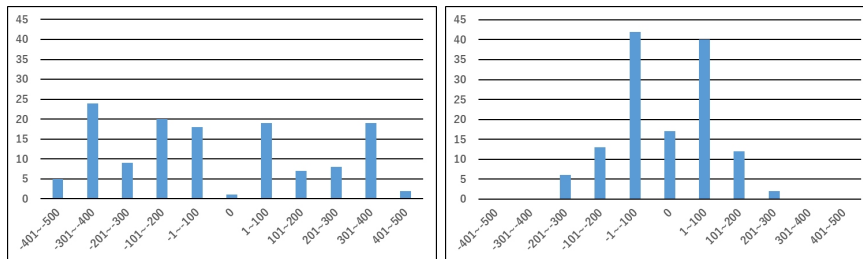


Figure 2: Examples of the distribution of the displacement.

maximum, minimum, variance and standard deviation of the displacement in pixels for each participant. A positive value implies that the boundary was shifted toward right, and a negative value implies toward left. Table 3 shows that the values of the variances and standard deviations are largely different by individuals. Table 3 also shows that the mean values of the displacement are near 0 for all participants. This implies that there is no participant who tend to shift the boundary to right or to left. Figure 2 shows examples of the distributions of the displacement for a participant who shifted the boundary largely and for a participant who shifted in a small area.

These results suggested the possibility that the participants who tended to shift the boundary in a small area made the area ratios smaller. However, there is another possibility that some of the hypotheses and estimation by Goethe or Itten were incorrect. To clarify this, another perceptual experiment using the method of limits or the constant method are needed to conduct.

CONCLUSION

The results of the present study and the Itten's theory both showed that a narrow area of yellow is congruent with a wide area of violet. This is discrepant to the phenomenon that a girl character with a wide area of yellow hair and a narrow area of violet irises was perceived as cute. This implies that the congruent ratio of areas of complementary colors could not interpret the cute girl phenomenon. The reason why the girl with yellow hair and violet irises was perceived as cute may rather depending on the culture where a female with blonde hair and blue eyes like French dolls is recognized as beautiful.

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