ORIGINAL ARTICLE

Effect of Color Applied to a Character on Its Impression and Gender Difference on Its Perception

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Abstract: This paper clarifies the effect of color on the impression produced by a character, as well as its perception difference between men and women. In our experiments, we selected four letters (B, H, N, O) as we consider they represent the different groups categorized by shape that they belong to. These characters were colored in black, blue, green, red, and yellow to be evaluated through 24 impression word pairs. The results showed a significant impression difference between men and women. It was also shown that the impression produced by the characters can be expressed by three factors: Elegance, Liveliness, and Potency, though the appreciated importance of each factor on character impression varies between gender. In addition, we focus on specific impression word pairs having gender differences. These are “Cheerful-Gloomy,” “Bright-Dark,” “Hard-Soft,” “Optimistic-Pessimistic,” and “Shallow-Deep.” Intensive comparison of the impressions felt by men and women suggest a different perception tendency experimented by each gender.

Keywords: *Color, Character, Impression, Gender difference*

1. INTRODUCTION

We obtain information from the characters on various media such as newspapers and electronic displays, which include characters appearing on the Internet and on smartphones. The color and the shapes of the characters enhance the transfer of information. Color, though, is more easily applied by a computer and smartphone than by paper media. Although the means of communication are varied, what is particularly important is the communication conveyed by the character. A character can express will and feelings accurately, and can transmit any information from concrete to abstract matters. To transmit information quickly and accurately, effective character expressions are considered to be very useful.

Studies on the impression of Japanese characters due to the combination of colors and fonts have been reported [1-3]. In these studies, impression is expressed by four factors, “Elegance,” “Vivacity,” “Stateliness,” and “Neatness.” It has been shown that the influence of color is greater than that of the font. Also, it has been proposed that each *Hiragana* character has a color image, *Irogana*, which is the font including the color as an element [4].

However, there are few studies using alphabet characters rather than Japanese ones. Moreover, gender differences of the influence on the color of a character have not been previously studied.

In this study, we investigated the effect of color on the impression of alphabet characters. Four capital

letters (B, H, N, O) were used as representatives of character groups categorized by shape. The colors used were black, blue, green, red, and yellow. We conducted an evaluation to measure the impression of the color of a character. We especially paid attention to gender differences in our analyses. In addition, we focus on the impression word pairs having gender differences. These are “Cheerful-Gloomy,” “Bright-Dark,” “Hard-Soft,” “Optimistic-Pessimistic,” and “Shallow-Deep.” Intensive comparison of the impressions that men and women feel brings us the gender differences of impression tendency.

The organization of this paper is as follows. Section 2 describes related work on color. Section 3 examines the impression of the characters. In Section 4, a discussion is presented. Finally, Section 5 concludes the paper.

2. RELATED WORK

Studies on colors and characters are extensively conducted. These studies are briefly surveyed.

2.1 The impression of Japanese characters by the combination of color and font

It is thought that the impression of a Japanese character changes according to the combination of both color and font. Honda *et al.* carried out impression evaluation experiments using the Semantic Differential (SD) method to clarify the impression on people by characters of a specific color or font [1].

First, they selected twenty-four impression word pairs to use as an evaluation standard. The word pairs were obtained from the questionnaire results of a preliminary investigation and previous work [2, 3].

The overview of the experiment by Honda *et al.* is as follows.

- The subjects were forty-eight persons (thirty-seven males and eleven females, average age: 26.4 ± 8.45).
- The targets for evaluation were a list of characters: sixty-eight Japanese Hiragana characters and sixty-eight Japanese Katakana characters, including voiced and semi-voiced notation, and ten Arabic numerals. The characters were displayed on a white background.
- Three fonts, MS Mincho, MS Gothic, and HG Gyosho, and four colors, black, red, blue, and green, were used in the evaluation.
- Twenty-four impression word pairs, shown in Table 1, were used.
- The impression of a target was evaluated in seven steps for each impression word pair shown in Table 1.

The impression evaluation experiment clarified that the color of the character influences the impression more than the font does.

An impression was expressed by four factors, Elegance, Vivacity, Stateliness, and Neatness. The Elegance factor tends to be influenced by the font. The Vivacity and Neatness factors tend to be influenced by the color. The factor Stateliness tends to be influenced by both the font and the color. The average factor score, where “score” indicates the level of influence, of Vivacity tends to be high in black and blue, but low in red and green. The average factor score of Neatness tends to be high in red and green, but low in black and blue. In addition, in Gothic, the average factor score of Stateliness tends to be low in black and red, but high in green.

Table 1: Impression word pairs

<i>Impression word pair</i>	<i>Impression word pair</i>
1. Fond-Dislike	13. Heavy-Light
2. Beautiful-Ugly	14. Manly-Womanly
3. Natural-Unnatural	15. Delicious-Unappetizing
4. Dynamic-Static	16. Good-Bad
5. Warm-Cool	17. Optimistic-Pessimistic
6. Showy-Sober	18. Ordered-Disordered
7. Cheerful-Gloomy	19. Elegant-Vulgar
8. Stable-Unstable	20. Shallow-Deep
9. Bright-Dark	21. Clear-Cloudy
10. Strong-Weak	22. Passionate-Intellectual
11. Thick-Thin	23. Gaudy (complicated)-Simple
12. Hard-Soft	24. Mature-Childish

2.2 Irogana: Hiragana font design using colors as a component

The font is designed on the basis of a shape. Kunimoto *et al.* made a font that has shape and color to express essential features. They proposed the new font based on the assumption that “each Hiragana has a color image shared with people” [4].

In their font development, an experiment was carried out to evaluate the color image of the Hiragana character. A total of thirty-nine colors were used. The colors consisted of twelve colors of the Practical Color Coordinate System (PCCS), achromatic color, and three tones. The student subjects (thirty males and twenty females) selected the image color of each Hiragana character. It was clarified that the color image depends on the type of Hiragana.

As we have seen, these works used Japanese characters. There are few studies using alphabet ones. Gender differences of the influence on the color of a character have not been studied. Therefore, we use alphabet characters, and examine the gender differences in this paper.

3. IMPRESSION ON EVALUATION EXPERIMENT OF COLORED CHARACTERS

3.1 Purpose

The purpose of our experiment was to clarify the influence of color on the impression of characters.

3.2 Experimental method

1) Targets:

The targets of the evaluation were characters because the meaning of a word or a sentence can influence the impression of the characters. Here, characters from the English alphabet are used. This is because Japanese characters have specific meanings and may influence the impression.

Evaluating the impression of all twenty-six letters of the alphabet would take a very long time. Under the assumption that the impressions of letters depend on shape, the letters were grouped into four shape categories. The groups are shown in Table 2. The first group includes characters consisting of vertical straight lines and curves. The second group includes characters consisting of

Table 2: Groups of English alphabet letters

<i>Letter</i>	<i>Characteristics of the lines constituting the characters</i>
B, D, P, R	Vertical straight lines and curves
E, F, H, I, L, T	Vertical and horizontal straight lines
A, K, M, N, V, W, X, Y, Z	Vertical, horizontal, and diagonal lines
C, G, J, O, Q, S, U	Curves

vertical and horizontal straight lines. The third group includes characters consisting of vertical, horizontal, and diagonal lines. The fourth group includes characters consisting of curves. The characters B, H, N, and O are decided to be the targets for evaluation because each one significantly represents the characteristics of its group.

A target was displayed against a white background because the brightness of white is high, and the brightness makes it easy to distinguish the characters. We used five colors: four psychological primary colors [5] and the achromatic color black. The RGB values of black, blue, green, red, and yellow were (0,0,0), (0,0,255), (0,176,80), (255,0,0), and (255,255,0), respectively. Therefore, four characters and five colors for a total of twenty colored characters were used for the evaluation.

2) Rating scales:

The SD method was used for the evaluation. The twenty-four impression word pairs shown in Table 1 were used to evaluate the impressions. These impression word pairs were originally used by Honda *et al.* [1]. The rank of evaluation was seven, ranging from -3 to 3. The scores ± 3 , ± 2 , ± 1 , and 0 meant “very,” “rather,” “fairly,” and “neither,” respectively. That is, both positive and negative numbers have the same meaning, respectively.

3) Equipment:

The target characters were displayed on a DELL monitor, E2010H (brightness: 30, contrast: 70).

4) Procedure:

The impression evaluation procedure was as follows:

- After the subject took a seat, the details that required attention during the experiment were orally explained.
- The subject saw the impression evaluation window on the monitor and evaluated the target character in seven steps for the twenty-four impression word pairs. An example of an impression evaluation window is shown in Figure 1. The subject could evaluate the degree of impression by pressing a radio button.
- The twenty target characters were displayed in random order.

Figure 1: Example of the impression evaluation window

5) Subjects:

This experiment was conducted with twenty-five subjects, who are students of the Kyoto Institute of Technology. Their average age was 22.4 (20–29) years old. The average age of the twelve women was 21.8 (20–24) years. The average age of the thirteen men was 23.0 (20–29) years.

3.3 Experimental result

1) Results of variance analysis:

The existence of gender difference was examined by a variance analysis with a significance level of 5% [6].

The impression word pairs that had a significant gender difference are shown in Table 3. The numbers in the “Impression word pairs” column of Table 3 correspond to the number of each word pair in Table 1.

The various impression word pairs have a gender difference for each character and color. But it can be seen that there are some impression word pairs which have a gender difference common to the same colored character. In “black,” 9 (Bright-Dark), 17 (Optimistic-Pessimistic), and 20 (Shallow-Deep) appear. In “green,” 7 (Cheerful-Gloomy), and 9 (Bright-Dark) appear. In “yellow,” 12 (Hard-Soft) appear. We examine these impression word pairs and impressions.

● Impression Word Pair “Cheerful-Gloomy”

First, the impressions of colored characters to the impression word pair “Cheerful-Gloomy” are examined. The average values and the ranges of the evaluation values

Table 3: The impression word pairs and characters having a gender difference

Color	Letter	Impression word pairs
black	B	7,9,13,20,23
black	H	9,17,19,20
black	N	17,20
black	O	6,9,10,14,17
blue	B	4,5,6,7,9,15,16,17,20,21,22,23
blue	H	3,9
blue	N	6,7,17
blue	O	11,13,19
green	B	6,7,9,12,20
green	H	5,6,9,12
green	N	3,7,8,9,17,19,21
green	O	5,7,17
red	B	2,4,5,12,18,20
red	H	20
red	N	17
red	O	7,8
yellow	B	5,9,12
yellow	H	12
yellow	N	3,9,11,12,13,21
yellow	O	4,8,11,12,13,16

of colored characters to the “Cheerful-Gloomy” are shown in Figure 2. Here, gray vertical line in the figure shows the range of the evaluation values. In addition, the vertical axis is the evaluation value, and the positive direction is “Cheerful,” and the negative direction is “Gloomy.” Each number expresses the degree as follows: 0: neither, ± 1 : fairly, ± 2 : rather, and ± 3 : very. There is a gender difference in green B, N, and O.

Only in the color green, the average values of the evaluation values of “Cheerful-Gloomy” of men are opposite to those of women. In the color blue, the absolute values of the evaluation values of men tend to be larger than those of women.

● Impression Word Pair “Bright-Dark”

Next, the impressions of colored characters to the impression word pair “Bright-Dark” are examined. The average values and the ranges of the evaluation values of colored characters to the “Bright-Dark” are shown in Figure 3. The positive direction is “Bright,” and the negative direction is “Dark.” There is a gender difference in green B, H, and N and black B, H, and O. For green characters, majority of the evaluation values of women was 1. In contrast, the range of the men’s evaluation values was wide because most of the men evaluated “dark,” but several men did 2 or 3. In addition, in the color black, the average values of men were smaller, which means darker,

Figure 2: Evaluation for “Cheerful-Gloomy”

Figure 3: Evaluation for “Bright-Dark”

than those of women, and almost all evaluation values of men were -2 or -3. The range for yellow B is wide because one woman evaluated -3.

● *Impression Word Pair “Hard-Soft”*

The averages and the ranges of the evaluation values of colored characters of “Hard-Soft” are shown in Figure 4. The positive direction is “Hard,” and the negative direction is “Soft.” There is a gender difference in all yellow characters. In the color yellow, the average values of men are a little small, which means soft, and those of women are around 0 which means “neither.” However, while there is the woman who evaluated “Hard,” the evaluation values of women had a variation.

Figure 4: Evaluation for “Hard-Soft”

Figure 5: Evaluation for “Optimistic-Pessimistic”

● *Impression Word Pair “Optimistic-Pessimistic”*

The averages and the ranges of the evaluation values of colored characters of “Optimistic-Pessimistic” are shown in Figure 5. The positive direction is “Optimistic,” and the negative direction is “Pessimistic.” There is a gender difference in black H, N, and O. In the color black, while many women evaluated it as -1, many men evaluated it as -2. Therefore, it is thought that men tend to feel black character “Pessimistic.”

● *Impression Word Pair “Shallow-Deep”*

The average of the evaluation values and the range of each color character of “Shallow-Deep” are shown in Figure 6. The positive direction is “Shallow,” and the

Figure 6: Evaluation for “Shallow-Deep”

negative direction is “Deep.” There is a gender difference in black B, H, and N. In the color black, the average values of men are smaller, which means deeper, than those of women. It is indicated that both men and women often feel deep to black characters.

2) Results of Factor Analysis:

A factor analysis based on the main factor method [7,8] was applied to the evaluation results of the women and men. The number of factors was decided based on the following criteria.

- The eigenvalue was more than 1.0.
- The cumulative contribution rate was more than 80%.
- The eigenvalue fell.

The scree plot and the cumulative contribution rate of the women are shown in Figure 7 and Figure 8, respectively. Those of the men are shown in Figure 9 and Figure 10, respectively. Three factors were selected for both men's and women's evaluations according to the criteria described above.

Varimax rotation was applied to the results. The factor burden matrices for women and men are shown in Table 4 and Table 5, respectively. For each impression word pair, the factor that had the largest factor burden is shaded in Table 4 and Table 5.

The three factors are explained. A factor is explained by using impression word pairs with large absolute values. The first factor of women is explained by using the impression word pairs Natural-Unnatural, Beautiful-Ugly, and so on. This factor is called Elegance. The second factor of women is explained by using the impression word pairs Cheerful-Gloomy, Bright-Dark, and so on. This factor is called Liveliness. The third factor of women is

explained by using the impression word pairs Strong-Weak, Heavy-Light, and so on. This factor is called Potency.

The impression word pairs explaining Elegance were the third factor for men and the first factor for women. Similarly, those explaining the first and second factors for men, which are Liveliness and Potency, respectively, were quite similar to those explaining the second and third factors for women.

The average values of factor scores obtained by a factor analysis are spatially shown in Figure 11 for the women and Figure 12 for the men. Each axis expresses one factor. For easy comparison of women and men, the axes of the men are matched with those of the women. The factor scores are colored by the color of the target characters.

For the representative characters, the factor scores of women and men are again shown in Figure 13 and Figure 14, respectively. The axes of the men are also matched with those of the women. Blue, orange, green, and red dots express results of B, H, N, and O, respectively.

The distributions of the factor score of each color in three-dimensional space showed variations between the men and the women. For black and yellow, the Liveliness scores of the women were different when compared with those of the men. For blue, the Elegance scores of the men were different when compared with those of the women. On the other hand, for green, the Elegance scores of the women were different when compared with those of the men.

In the case of the women, Liveliness scores tended to be high in the order of O, H, and N. Elegance scores of O were higher than those of H. In the case of the men, no tendency was found for the letters.

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Figure 7: Scree plot of women

Figure 8: Cumulative contribution rate of women

Figure 9: Scree plot of men

Figure 10: Cumulative contribution rate of men

Table 4: Factor burdens of women

Impression word pair	Factor 1	Factor 2	Factor 3
Natural-Unnatural	0.957	-0.222	0.042
Elegant-Vulgar	0.923	-0.302	-0.001
Beautiful-Ugly	0.904	-0.208	0.027
Fond-Dislike	0.9	-0.248	-0.09
Ordered-Disordered	0.833	-0.373	0.06
Stable-Unstable	0.83	-0.205	0.186
Good-Bad	0.786	0.502	-0.288
Gaudy-Simple	-0.686	0.555	0.388
Warm-Cool	-0.249	0.948	0.113
Optimistic-Pessimistic	-0.349	0.887	-0.127
Delicious-Unappetizing	0.394	0.854	-0.205
Manly-Womanly	0.258	-0.816	0.345
Cheerful-Gloomy	-0.522	0.81	-0.169
Bright-Dark	-0.471	0.8	-0.308
Dynamic-Static	-0.551	0.774	-0.065
Shallow-Deep	-0.518	0.694	-0.392
Mature-Childish	0.652	-0.691	0.257
Showy-Sober	-0.664	0.69	-0.116
Passionate-Intellectual	-0.662	0.687	0.246
Hard-Soft	-0.174	-0.643	0.568
Strong-Weak	-0.136	-0.071	0.939
Thick-Thin	0.363	-0.109	0.856
Heavy-Light	0.317	-0.442	0.801
Clear-Cloudy	0.454	0.035	-0.722
Sum of squares	9.129	8.496	3.994

Table 5: Factor burdens of men

Impression word pair	Factor 1	Factor 2	Factor 3
Warm-Cool	-0.932	-0.044	-0.285
Delicious-Unappetizing	-0.895	0.253	0.162
Optimistic-Pessimistic	-0.891	0.318	-0.221
Cheerful-Gloomy	-0.883	0.127	-0.406
Dynamic-Static	-0.872	0.084	-0.42
Bright-Dark	-0.872	0.304	-0.362
Passionate-Intellectual	-0.864	-0.181	-0.442
Manly-Womanly	0.817	-0.437	0.207
Showy-Sober	-0.786	0.172	-0.542
Mature-Childish	0.648	-0.484	0.537
Strong-Weak	-0.122	-0.947	-0.088
Thick-Thin	0.14	-0.933	0.193
Clear-Cloudy	0.003	0.901	-0.179
Heavy-Light	0.431	-0.831	0.306
Hard-Soft	0.556	-0.723	-0.004
Shallow-Deep	-0.597	0.656	-0.349
Good-Bad	-0.121	0.076	0.913
Beautiful-Ugly	0.248	-0.263	0.818
Natural-Unnatural	0.358	-0.263	0.809
Fond-Dislike	0.524	-0.259	0.769
Elegant-Vulgar	0.621	-0.044	0.721
Ordered-Disordered	0.448	-0.286	0.715
Stable-Unstable	0.386	-0.463	0.666
Gaudy-Simple	-0.581	-0.317	-0.658
Sum of squares	9.653	5.603	6.398

Figure 11: Factor score of women (color)

Figure 12: Factor score of men (color)

Figure 13: Factor score of women (character)

Figure 14: Factor score of men (character)

4. DISCUSSION

4.1 Gender difference of variance analysis

The averages of the evaluation values of “Cheerful-Gloomy” in the color green of men are opposite to those of women. It is regarded as a great characteristic. In summary, for green characters, women tend to have a cheerful impression, while men tend to have a gloomy impression. Also, in the color blue, the degrees of the evaluation values of men tend to be larger than those of women.

For green characters, majority of the evaluation values of “Bright-Dark” of women was 1. In contrast, the range of the men’s evaluation values was wide because most of

the men evaluated “dark,” but several men evaluated 2 or 3. It is thought that women tend to have a fairly bright impression for green characters. In addition, in the color black, the average of the scores of men shows darker than that of women, and almost all evaluation values of men was -2 or -3. In the colors red and yellow, it is considered that both men and women have a bright impression.

In the average of the evaluation values of “Hard-Soft,” there is a gender difference in all yellow characters, the average of scores of men shows a little soft. That of women is near 0 which means “neither.” However, while there is the woman who evaluated “hard,” the evaluation values of women had a variation. In other colors, such tendency was not seen.

In the color black, for the impression word pair “Optimistic-Pessimistic,” while many women evaluated it as -1 (fairly pessimistic), many men evaluated it as -2 (rather pessimistic). Therefore, it is thought that men tend to feel black characters pessimistic. There is similar tendency for blue characters. In addition, it is thought that most people have an optimistic impression for red and yellow characters.

As for the average of the evaluation values for “Shallow-Deep,” in the color black, the average value for men shows deeper than that for women. It is indicated that both men and women often feel deep for black characters. Furthermore, there is a gender difference in B’s evaluation values of all colors except yellow. For this reason, it is considered that the evaluation values of men show deeper than those of women.

4.2 Factor

It was shown that the impression of colored characters can be expressed by three factors: Elegance, Liveliness, and Potency. Although the impression of men and women were expressed by the same three factors, the priority of the factors was different. The first factor of women was Elegance, and its eigenvalue was approximately 13.9. On the other hand, Elegance was the third factor of men, and its eigenvalue was approximately 2.5. In addition, whereas Liveliness was the second factor of women and its eigenvalue was approximately 5.2, it was the first factor of men and its eigenvalue was approximately 15.1. Thus, women first feel Elegance, but men feel Liveliness first. The third factor of women was Potency, and its eigenvalue was approximately 2.5. On the other hand, Potency was the second factor of men and its eigenvalue was approximately 4.0. While the weights of Elegance and Liveliness greatly differed between the men and the women, the eigenvalues of Potency of the men and the women were close. The importance of Potency in an impression was considered to be at the same level in men and women. Therefore, the factor that men first feel is different from the one that women first feel.

In the related work [1], the number of factors was four. It is shown that the impression of colored characters can be expressed by four factors: Elegance, Vivacity, Stateliness, and Neatness. The factors Elegance, Vivacity, and Stateliness correspond to Elegance, Liveliness, and Potency obtained in this work, respectively. Although the targets for evaluation are different, it is thought that the impression of colored characters can be expressed by similar factors.

4.3 Factor score

Since the distribution of the factor scores of colors in three-dimensional space for men resembles that for women, it is considered that a great similarity exists between the impressions of men and women. The Liveliness scores of black and yellow, and the Elegance scores of green for the women were different compared with those of the men. On the other hand, the Elegance scores of blue for the men were different when compared with those of the women.

The influence of the character seems to have a small significance influence. In the case of the women, however, the Liveliness scores tended to be high in the order of O, H, and N. The Elegance score of O was higher than that of H.

5. CONCLUSION

Since communication by characters can transmit any information from concrete matters to abstract matters, characters are considered to be very important. Coloring the characters may bring more effective communication. To clarify the influence of color on impression, an impression evaluation experiment was conducted. Four characters (B, H, N, and O) and five colors (black, blue, green, red, and yellow) were used as targets for evaluation.

We focused on the impression word pairs having gender differences. These were “Cheerful-Gloomy,” “Bright-Dark,” “Hard-Soft,” “Optimistic-Pessimistic,” and “Shallow-Deep.” Intensive comparison of the impressions that men and women feel brought us the gender differences of impression tendency. For the color green, women feel cheerful and fairly bright, while men feel gloomy. For the color black, men feel darker, more pessimistic, and deeper than women. For the colors red and yellow, both women and men feel bright and optimistic.

In addition, it was found that some impression word pairs have different impressions between men and women. By considering this, the factor analysis was separately applied to the evaluation results of the women and those of the men. The impression of a colored letter is similar for men and women, and can be expressed by three factors, Elegance, Liveliness, and Potency. It was also clarified that the influence of color is larger than that of shape. In addition, it is thought that women have various impressions of Liveliness in black and yellow characters and various impressions of Elegance in green. Men have various impressions of Elegance in blue.

The subjects and targets for evaluation were limited. Enlarging the range of subject ages, increasing the number of fonts and colors, and using various background colors are intended as future work.

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