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Effects of Three Attributes of Color Including Tone on Olfactory Impression

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Abstract: To examine the effect on the olfactory impression by color stimuli from the aspects of the three attributes of color (hue, lightness, and chroma) and tones the seven types of olfactory impression for the color stimuli were measured using the subjective evaluation of five-point scale. The color stimuli were uniformly selected from twelve tones in PCCS and the achromatic colors of N1 to 9 added, the amount of color stimuli was 153 in total. The participants were asked to subjectively evaluate the olfactory impression of seven types (vanilla type, mint type, herb type, floral type, citrus fruit, soap, and putrid odor) for the stimulus presented by the display using the five-point scale. In the results of floral, mint, and citrus fruit smells, the evaluation values increase with the values of lightness and/or chroma of the hues of 6RP, 3G, and 8YR, respectively. Also, in the results of soap and vanilla smells, the evaluation values reach to the peak on 5B and 5Y or 8YR in pale and light greyish tones. Therefore, there is the relationship between the olfactory impression and three attributes of color including the tone as well as the previous studies.

Keywords: *Olfactory impression, Color, Three attributes, Tone, Cross-modal*

1. INTRODUCTION

It is considered that fragrance can be expressed visually by performing effective color expression that can perceive fragrance simply by looking at the product package. Some of the studies have been reported that colors affect the impression of olfaction to humans such as cross-modality effect. Previous studies have already reported that significant color characterizations were found for all 20 tests odors, the strong odors were associated with darker colors and it was suggested the existence of robust correspondences between vision and olfaction [1-2]. And it is reported that the fragrances of positive value were matched for vivid and bright tones while those of negative values were done for dull and dark tones in Practical Color Co-ordinate System (PCCS) developed by Japan Color Enterprise Co., LTD., in terms of harmony of color and fragrance [3-4]. However, it is not clear how the three attributes of color – hue, lightness and chroma have an effect on olfactory impression, from the point of view in the quantitative measurement although the tones of PCCS are combined lightness and chroma to one dimension. Also, it is expected a connection, that colors for use in the perfume package enhance the willingness to buy a product when they are the impression close to actual perfume fragrance, then pass along information to become the criteria of judgment for buying. So, it seems

to be the importance of investigating to the three attributes of color quantitatively. The purpose of this study is to examine the olfactory impression in color stimuli from the aspect of the three attributes including the tones.

2. METHODOLOGY

2.1 Stimuli

Based on the experiment of previous study[4], the twelve tones in PCCS were used in this experiment. These twelve tones were follows: vivid (v), bright (b), strong (s), deep (dp), light (lt), soft (sf), dull (d), dark (dk), pale (p), light grayish (ltg), grayish (g), dark grayish (dkg). Each tone consisted of twelve hues which were 4R, 10R, 8YR, 5Y, 3GY, 3G, 5BG, 5B, 3PB, 9PB, 7P, 6RP of Munsell hue notation on the hue circle of Munsell color system. The values of lightness and chroma in each tone were roughly consistent, respectively, based on the concept of tone in PCCS. In addition, nine achromatic colors were used as following: from N1 to N9 for one by one value. Thus, there were 153 stimuli in total. Table 1 shows the stimuli used in this experiment. The stimuli were presented by 24-inch display (Dell, UP2414Q) placed in front of the observer and the viewing distance was 500 mm. They were displayed into the square at a visual angle of 15 deg in the center of the screen and set N5 as the background color. Referring to the values of tristimulus values (XYZ)

of Munsell color with D₆₅ light source in JIS Z 8721[5], those colors were made. The mean value of ΔE_{ab}^* in all the stimuli (except of N1 to N9) is 3.65.

2.2 Procedure

After three minutes light adaption by the D₆₅ fluorescent lamps in experimental booth, the participants were asked to evaluate the olfactory impression in stimuli presented, to each olfactory impression on a five-point scale (1: feel hardly, 2: feel slightly, 3: feel somewhat, 4: feel, 5: feel very much). As the olfactory impression, the seven types of smell that “vanilla type”, “mint type”, “herb type”, “floral type”, “citrus fruit”, “soap”, and “putrid odor” were evaluated. They are based on the report of Amoores[6] in previous studies. The stimuli were randomly presented and the duration time was left to

Table 1: Color stimuli in this experiment. Each column indicates the tone in PCCS and Munsell hue, Munsell value (lightness), Munsell chroma in Munsell notation, respectively.

Tone	Hue (H)	Lightness (V)	Chroma (C)
vivid (v)	12 hues	3.5 - 8	10 - 14
bright (b)	12 hues	5 - 8.5	8.5 - 12
strong (s)	12 hues	3.5 - 7.5	9 - 12
deep (dp)	12 hues	2.5 - 6	8 - 11.5
light (lt)	12 hues	6.5 - 9	6 - 11.5
soft (sf)	12 hues	5 - 7	5 - 6.5
dull (d)	12 hues	3.5 - 6	5 - 6.5
dark (dk)	12 hues	2 - 4	4.5 - 6
pale (p)	12 hues	8 - 9	2
light grayish (ltg)	12 hues	6.5 - 7.5	2
grayish (g)	12 hues	3.5 - 4.5	2
dark grayish (dkg)	12 hues	1.5 - 2.5	1.5
N	-	1 - 9	-

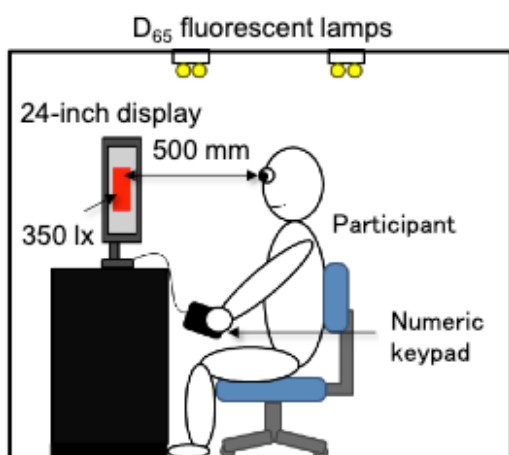


Figure 1: Apparatus in this experiment.

participant’s discretion. The gray image of N5 was displayed as the inter-stimulus stimulus to remove the effect of the previous stimulus. In one session, the participants performed the evaluation of 153 times and three sessions were carried out for one participant. It was 459 times in total. Prior to the experiment, the participants had an enough time to practice for the evaluation.

2.3 Apparatus

Figure 1 shows the apparatus in this experiment. The experimental booth was covered with a black curtain. It was illuminated by the D₆₅ fluorescent lamps and the illumination of screen in the display was around 350 lx. The display was placed in front of the participant and the viewing distance was 500 mm. The observers were asked to respond with the numeric keypad when they evaluate the stimulus.

2.4 Participants

Ten participants participated in this experiment. They were five female and five male students. They have the normal color vision.

3. RESULTS AND DISCUSSIONS

In the results, the effects of color attributes and tones on the impressions of floral, mint, citrus, soap, and vanilla are remarkably obtained.

3.1 Effects on the impression of floral smell

Figure 2 (a) – (b) shows the results of the impression of floral smell as a function with the values of lightness and chroma based on all the participants’ responses, respectively. In each figure, the horizontal axes indicate the values of lightness and chroma, the vertical axis is the subjective evaluation value of floral smell, respectively. As the typical results, the average values of 6RP in Munsell hue are plotted (i.e. for Figure 2 (a) 6RP-/10 or 10.5 as the roughly same value of chroma and for Figure 2 (b) 6RP4/- as the same value of lightness in the Munsell notation are plotted). In these figures, the evaluation value increases with an increasing of the values of lightness and chroma in this hue. It means that the values of lightness and chroma in 6RP of purplish color affect the impression of floral smell and it associates the impression of floral smell with bright and vivid purplish colors. This result corresponds to those of previous studies[3-4].

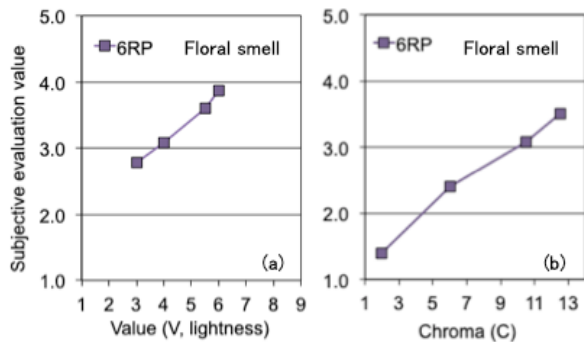


Figure 2: Olfactory impression of floral smell of 6RP while varying the lightness and chroma. (a) Effects of the change in lightness, (b) Effects of the change in chroma.

3.2 Effects on the impression of mint smell

Figure 3 shows the results of the impression of mint smell as a function with the value of chroma based on all the participants' responses. In this figure, the horizontal and vertical axes indicate the value of chroma and the subjective evaluation value of mint smell, respectively. As the typical results, the average values of 3G in Munsell hue are plotted (i.e. for Figure 3 3G4 or 5/- as the roughly same value of lightness in the Munsell notation are plotted). In this figure, the evaluation value increases with an increasing of the value of chroma in this hue. It means that the value of chroma in 3G of greenish color affect the impression of mint smell and it associates the impression of mint smell with vivid greenish colors. This result corresponds to those of previous studies[3-4] as well.

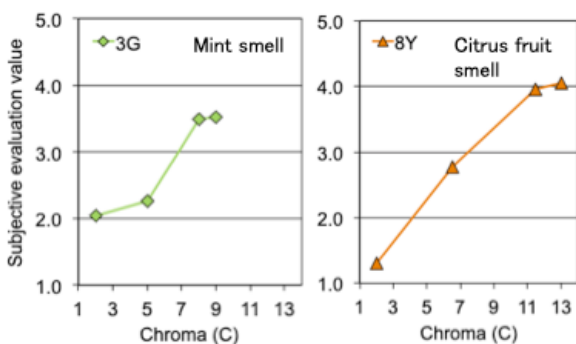


Figure 3: Olfactory impression of mint smell of 3G while varying the chroma.

Figure 4: Olfactory impression of citrus fruit smell of 8YR while varying the chroma.

3.3 Effects on the impression of citrus fruit smell

Figure 4 shows the results of the impression of citrus fruit smell as a function with the value of chroma based on all the participants' responses. In this figure, the horizontal and vertical axes indicate the value of chroma and the subjective evaluation value of citrus fruit smell, respectively. As the typical results, the average values of 8YR in Munsell hue are plotted (i.e. for Figure 4 8YR7 or 7.5/- as the roughly same value of lightness in the Munsell notation are plotted). In this figure, the evaluation value increases with an increasing of the value of chroma in this hue. It means that the value of chroma in 8YR of orange color affect the impression of citrus fruit smell and it associates the impression of citrus fruit smell with vivid orangish colors. This result also corresponds to those of previous studies[3-4].

3.4 Effects on the impression of soap smell

Figure 5 shows the results of the impression of soap smell as a function with hue circle based on all the participants' responses. In this figure, the horizontal and vertical axes indicate the value of hue circle and the subjective evaluation value of soap smell, respectively. As the typical results, the average values of p and Itg of tones in PCCS are plotted (i.e. for Figure 5 the values of lightness vary from 9 to 6.5 (relatively highly lightness) while the values of chroma are consistent of 2 (lower chroma) in those hue circle). In this figure, the evaluation values are over around 2.5 in all the hues in those tones. Especially, for the hue of 5B (aqua color) as the peak, the evaluation value increases. Further in the results of achromatic colors of N1 to 9, the evaluation value rapidly increases with over N6 of lightness. It means that the colors with pale and light grayish tones affect the impression of soap smell and it associates the impression of soap smell with pale (i.e. highly lightness and lower chroma colors).

3.5 Effects on the impression of vanilla smell

Figure 6 shows the results of the impression of vanilla smell as a function with hue circle based on all the participants' responses. In this figure, the horizontal and vertical axes indicate the value of hue circle and the subjective evaluation value of vanilla smell, respectively. As the typical results, the average values of p and Itg of tones in PCCS are plotted (i.e. as the same of Figure 5). In this figure, the evaluation values are over around 2.0 in the hues in those tones except of some hues in Itg tone. Especially, for the hues of 5Y or 8YR as the peak, the evaluation value increases. It means that the yellowish

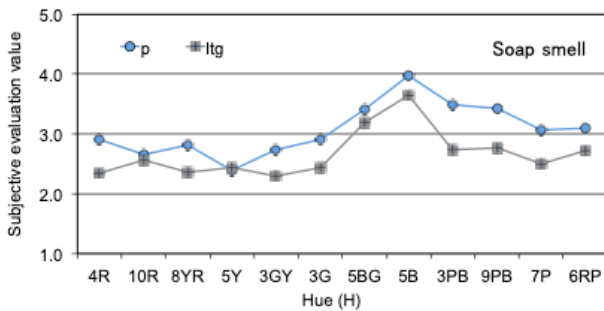


Figure 5: Olfactory impression of soap smell of p and Itg in the tone while varying the hue.

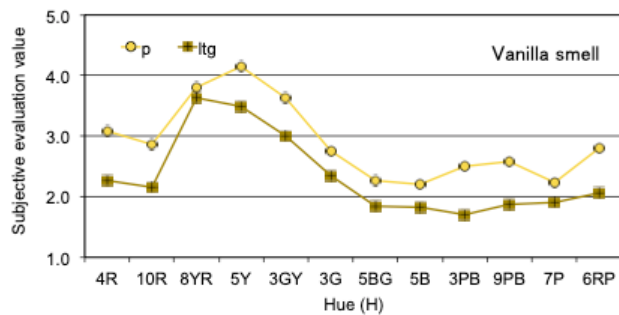


Figure 6: Olfactory impression of vanilla smell of p and Itg in the tone while varying the hue.

colors with pale and light grayish tones affect the impression of vanilla smell and it associates the impression of soap smell with pale yellowish colors.

4. CONCLUSION

To examine the effect on the olfactory impression by color stimuli from the aspects of the three attributes of color (hue, lightness, and chroma) and tones the seven types of olfactory impression for the color stimuli were measured using the subjective evaluation of five-point scale. The color stimuli were uniformly selected from twelve tones in PCCS. They included twelve hues in each tone and the values of lightness and chroma in each tone were roughly consistent, respectively, based on the concept of tone in PCCS. The value of lightness and chroma ranged from 1.5 to 9 and from 1.5 to 14 in all the tones in this experiment. In addition, the achromatic colors of N1 to 9 were used. The amounts of stimuli were 153 in total. The participants were asked to subjectively evaluate the olfactory impression of seven types (“vanilla type”, “mint type”, “herb type”, “floral type”, “citrus fruit”, “soap”, and “putrid odor”) for the stimulus presented by the display using the five-point scale. In the results, the effects of color attributes and tones on the impressions of floral, mint, citrus fruit, soap, and vanilla smell are remarkably obtained. In the results of floral, mint, and citrus fruit smells, the evaluation values increase with the values of lightness and/or chroma of the hues of 6RP, 3G, and 8YR, respectively. It means that the vivid colors of purple, green, and orange obtain the impressions of floral, mint, and citrus fruit smells, respectively. Also, in the results of soap and vanilla smells, the evaluation values reach to the peak on 5B and 5Y or 8YR in pale and light greyish tones. It means that the pale colors of aqua and yellow, green obtain the impressions of soap and vanilla smells, respectively.

Therefore, there is the relationship between the olfactory impression and three attributes of color including the tone as well as the previous studies, based on these results, effective color expression can be considered possible by applying it to the design.

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