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RESEARCH ARTICLE

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Color appearance of afterimages compared to the chromatic adaptation to illumination

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Abstract

The color appearance of negative afterimages was measured by the elementary color naming method, and the results were compared with those obtained by the two-room technique. Twenty adapting stimuli were presented on a display sequentially. Subjects first assessed the color appearance of the stimuli. After looking at the adapting stimulus for 10 seconds, the subjects assessed color of the afterimage. Apparent hue of the afterimage was in general not opponent color to the adapting color. The relation between the adapting stimuli and the afterimages was analyzed by the angle difference $\Delta\theta$, when apparent hues are expressed by the angles of the points on the polar diagram of the opponent color theory. The relation relationship of $\Delta\theta$ to the angle of the adapting color θ_{ing} was quite similar to the results obtained by the two-room technique, implying that the chromatic adaptation shown by the afterimage also occurs in the brain rather than in the retina.

KEYWORDS

chromatic adaptation, complementary color, elementary color naming, opponent colors theory, two-room technique

1 | INTRODUCTION

A state of chromatic adaptation can be shown by the color of a psychophysically achromatic patch under illumination by various colors, which was realized by the two-room technique.[1–3] A subject room is illuminated by a colored light, and a person observes a psychophysically achromatic board placed in a test room illuminated by a white light through a window opened at the separating wall of the two rooms. The board, or rather the window, appears very vividly colored, roughly opposite to the color of the subject room, which cannot be achieved by the simultaneous color contrast experiment. The relationship between the subject room color, which we called the adapting color, and the color at the window, which we called the adapted color, demonstrates how our visual system adapts to the illumination color of the subject room. Chromatic adaptations are also investigated by the color of afterimages. One looks at a colored patch presented on a white field for a few seconds and then looks at a white field. An afterimage (more strictly, a negative afterimage) is observed, with color roughly opposite to the adapting color. The relationship between the adapting color and the afterimage color also demonstrates a state of chromatic adaptation of the visual system. We will compare the relationships obtained by the two-room technique and the afterimage technique in the present article.

The afterimage color was precisely measured by Wilson and Brocklebank[4] by using 120 colored chips to cover possible hues. Afterimages were matched by colored chips, and the correspondence between the adapting color and the afterimage color was shown on the CIE *xy* diagram. In our study, using the two-room technique, the color perception was directly measured for both adapting and adapted colors by employing the elementary color naming method, where colors were expressed by the amounts of chromaticness, whiteness, and blackness and the percentage of four unique hues: red, yellow, green, and blue. Wilson and Brocklebank used words to express the color appearance in addition to the *x* and *y* expression, but only nine words (red, orange, yellow, green, cyan, blue, violet, purple, and magenta) were allotted

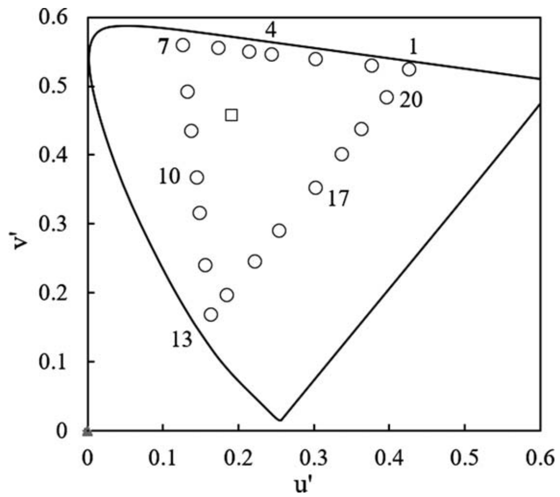

FIGURE 1 Chromaticity points of 20 adapting stimuli shown by open circles and surrounding filed shown by an open square

to the 120 colored chips. We cannot precisely compare their data with our data from the two-room technique. Manzotti[5] investigated afterimage colors, but only four colors (red, green, cyan, and magenta) were used to express the color appearance, as the aim was to show that the afterimage color is the complementary color of the adapting color. Pridmore[6] analyzed data of simultaneous color contrast reported by Wu and Wardman[7] and Luo et al.[8] and strongly asserted that the data can be interpreted better by the complementary color relationship between the adapting and adapted colors than Hiring's opponent colors relation.[9] Fairchild[10] used an ambiguous expression: "Figure 1.12 demonstrates the opponent nature of visual afterimages.... It is worth noting that afterimages can also be easily explained in terms of complementary colors due to the adaptation in a trichromatic system."

In the present article, we express color appearances by the amounts of elementary colors so that the precise correspondence of the adapting color to the afterimage color can be investigated. The data will be analyzed by the opponent colors theory, the complementary concept, and the Munsell color space.

2 | METHOD

A commercially available 24-inch display, EIZO ColorEdge CG246-BK, was used to present sequentially adapting stimuli, which were 20 colors that measured 23 × 16 cm^2 and covered the hue shown by open circles in the CIE $u'v'$ diagram of Figure 1. The stimuli are numbered counterclockwise from 1 to 20 for convenience. The luminance varied from 16 to 205 cd/m^2, depending on stimulus, 53.8, 65.3, 95.1, 143, 193, 205, 175, 186, 127, 70, 47.8, 27.8, 16.0, 20.2, 29.9, 41.5, 68.6, 62.3, 59.0, and 55.9 cd/m^2, for colors #1, #2, and so on. The maximum available luminance was adopted for each adapting stimulus, which resulted in variation in the luminance. Because the chromaticness of the afterimage was assumed to be larger for higher luminance of adapting stimuli, a preliminary experiment, PE, was carried out. The adapting stimulus was surrounded by a white field of 227 cd/m^2, with the chromaticity ($u' = 0.190$, $v' = 0.459$) shown by an open square.

The display unit was placed in a dark test room and binocularly observed by a subject sitting on a stool in a subject room through a 35-cm wide and 19-cm high window W in Figure 2A opened on the separating wall between the test and subject rooms. The window was completely covered by the display so that the inside of the window was entirely the surrounding field except the adapting stimulus as shown in Figure 2B. Figure 2A shows the experimental booth. The display was set upright and placed behind the window at distance 75 cm. The distance to the wall from the subject was 150 cm. There were fluorescent ceiling lamps FL of the daylight type in the subject room, which were switched on and off by a subject when they waited for the next presentation of the adapting stimulus; otherwise the subject room remained dark. The illuminance in the subject room was

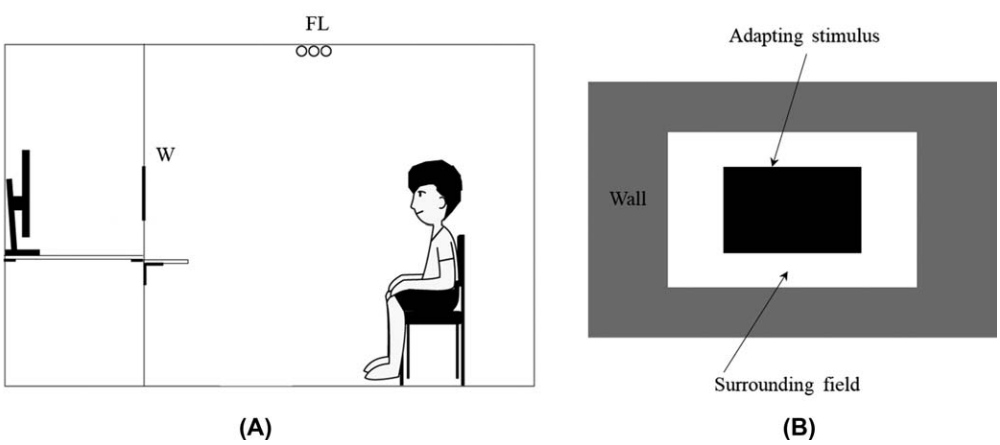

FIGURE 2 A scheme of experimental booth (left) and the visual field (right)

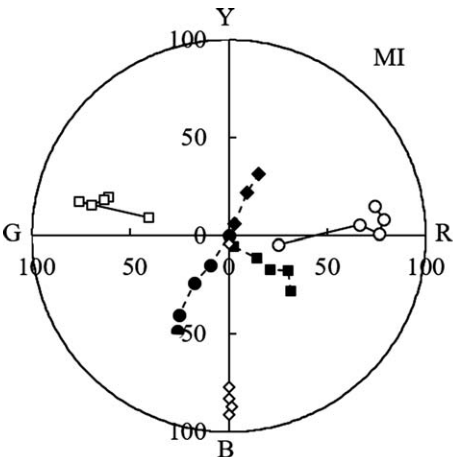

FIGURE 3 The effect of luminance of adapting stimuli of red (circles), green (squares), and blue (diamonds) on the color appearance. Open symbols, adapting stimuli; filled, afterimages. Subject, MI

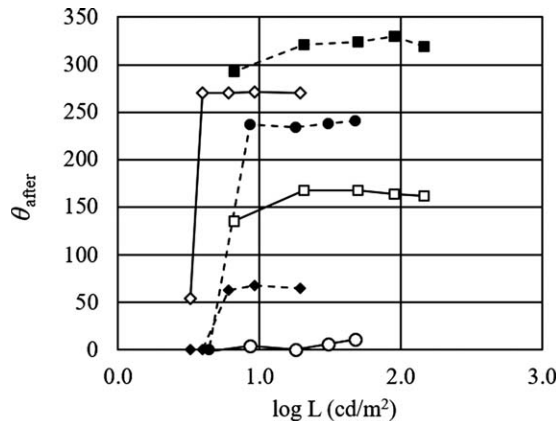

FIGURE 4 Adapting and adapted angle versus adapting angle for luminance of the adapting stimulus for three colors, #1 (circles), #7 (squares), and#13 (diamonds)

350 lx, measured on the subject chair. The viewing distance for the stimulus was 225 cm, which gave a visual angle of adapting stimulus of 6° × 4°, while the visual angle of the surrounding became 13° × 7°.

A preliminary experiment, PE1, was carried out to assess the influence of luminance levels of the adapting stimulus on the amount of chromaticness and hue of the afterimage. Five steps of luminance were adopted for color numbers 1, 7, and 13 from the maximum available luminance to a low luminance, namely, from 48 to 4.4, from 147 to 6.7, and from 20 to 3.2 cd/m^2, for the colors 1, 7, and 13, respectively. The adapting color and the afterimage color were measured by elementary color naming. Two subjects, MI and JM, participated in the experiment, with five repetitions for each condition.

Only one surrounding luminance was employed, namely, 227 cd/m^2. The level of luminance might influence the chromaticness of afterimages. Another preliminary experiment, PE2, was carried out to investigate the influence of the surrounding luminance level on the amount of chromaticness for three adapting colors: color #1, #7, and #13. Eight levels of luminance were adopted; 1.85, 3.37, 5.42, 14.8, 25.3, 56.9, 110, and 227cd/m^2. Four subjects participated in the experiment and the observation was repeated five times.

In the main experiment, ME, stimuli were presented in a random order on the display and a subject judged the color appearance by the elementary color naming method, namely, percentages of chromaticness, whiteness, and blackness and then percentages of unique hues, red, yellow, green, and blue. Then, the subject was asked to fixate their eyes at a black fixation cross presented at the center of the stimulus for 10 seconds, then, the stimulus was removed and replaced by the same white background as the surroundings. The subject was asked again to judge the afterimage color: first, the percentages of chromaticness and whiteness and then the hues. Subjects were not asked to estimate blackness, as they did not see the blackness in most of the afterimages. The afterimage faded away rather quickly in 2 or 3 seconds, and subjects have to respond by memory, particularly for the apparent hue. Subjects were allowed to observe the adapting stimulus again upon request.

Five subjects, CP, MI, JM, BO, and WK, all with normal color vision, as tested by 100 hue tests and the Ishihara test, participated in the primary experiment. Each subject repeated the tests for each condition five times.

3 | RESULTS

3.1 | PE1: Effect of luminance of the adapting stimulus on color appearance

The results of the preliminary experiment PE1 of the subject MI are shown in Figure 3. They are plotted on the polar diagram used in opponent colors theory. The amounts of unique red and green are taken along the horizontal axis, and those of yellow and blue are along the vertical axis. The chromaticness is taken along the radius, 0 at the origin and 100 at the circumference. Open circles are for red adapting stimulus #1, squares represent green adapting stimulus #7, and diamonds represent blue adapting stimulus #13. Filled symbols represent the afterimages of the respective adapting stimuli. Each point is the average of five repetitions. The color of the adapting stimulus is vivid, with large amount of chromaticness, and remains relatively unchanged at four high luminance levels. However, it becomes very desaturated with small amount of chromaticness at the lowest luminance. Alternatively, the color appearance of the afterimage continuously changes to become less saturated with lower luminance of the adapting stimulus. The change of the apparent hue can be more clearly observed by plotting the hue angle, θ, for luminance of the adapting stimulus, as shown in Figure 4.

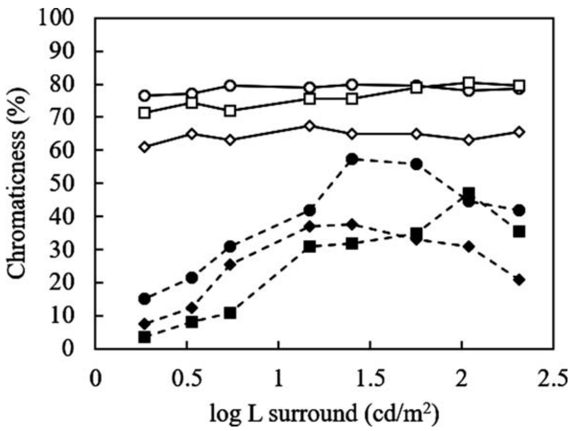

FIGURE 5 Influence of surrounding luminance upon the amount of chromaticness in the afterimage color

The hue angle is that from the red axis to the line connecting the data point to the origin. Along the abscissa the luminance of the adapting stimulus L (cd/m^2) is taken in logarithmic unit and along the ordinate the hue angle of the afterimage color, θ_{after}. The symbols in Figure 4 correspond to symbols in Figure 3: circles represent red adapting stimulus #1, squares represent green #7, and diamonds represent blue #13. The apparent hue remains constant for all luminance levels, except the lowest level (except for the two lowest levels in the afterimage of the blue stimulus). These results suggest that the luminance of the adapting stimulus does not affect the apparent hue of the afterimage.

3.2 | PE2: Influence of the surrounding luminance level to the amount of chromaticness

The results of the preliminary experiment PE2 investigating the influence of luminance of the surrounding field on the amount of chromaticness in afterimage colors are shown in Figure 5, as the average of subjects CP and MI using the same symbols as in Figures 3 and 4. Luminance does not affect the adapting stimuli as shown by the flat curves of open symbols, but there is an effect on the afterimages. Figure 6 shows the individual data of subjects CP and MI, who participated in the main experiment ME, for red

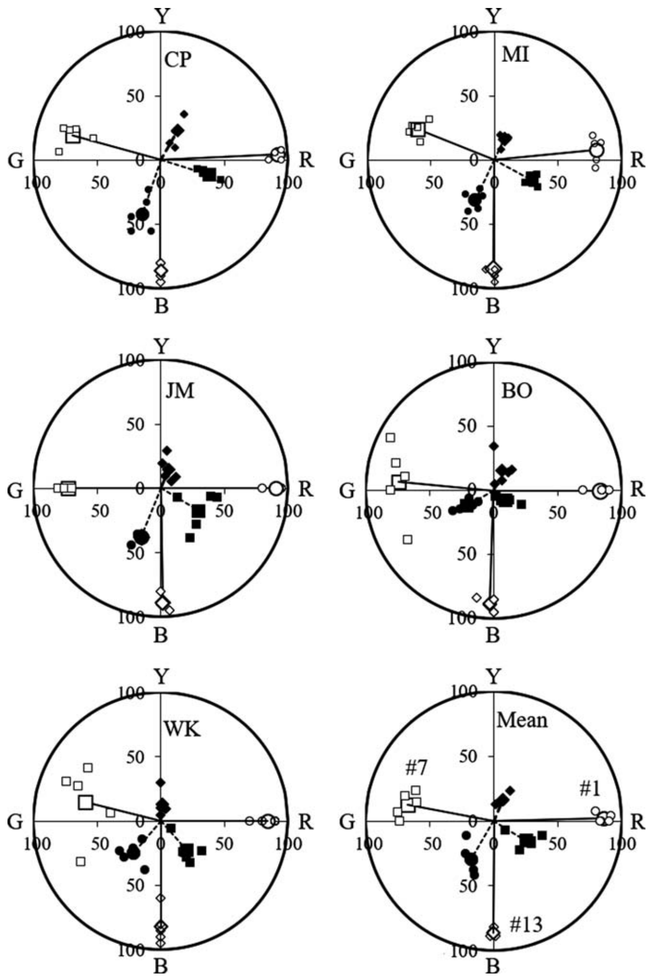

FIGURE 7 Color appearance plotted on the polar diagrams for three adapting stimuli, #1 (circles), #7 (squares), and #13 (diamonds). Small symbols, results of five repetitions; large symbols, the average, Open symbols, adapting stimuli; filled symbols, afterimage. Results of five subjects and the mean

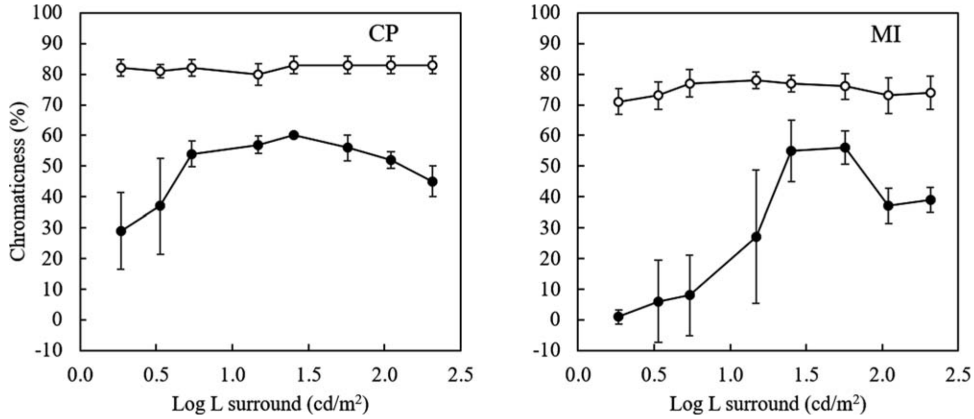

FIGURE 6 Amount of chromaticness plotted for the surrounding luminance for adapting stimulus #1; subjects CP and MI. Short vertical bars indicate the standard deviation of five repetitions of response

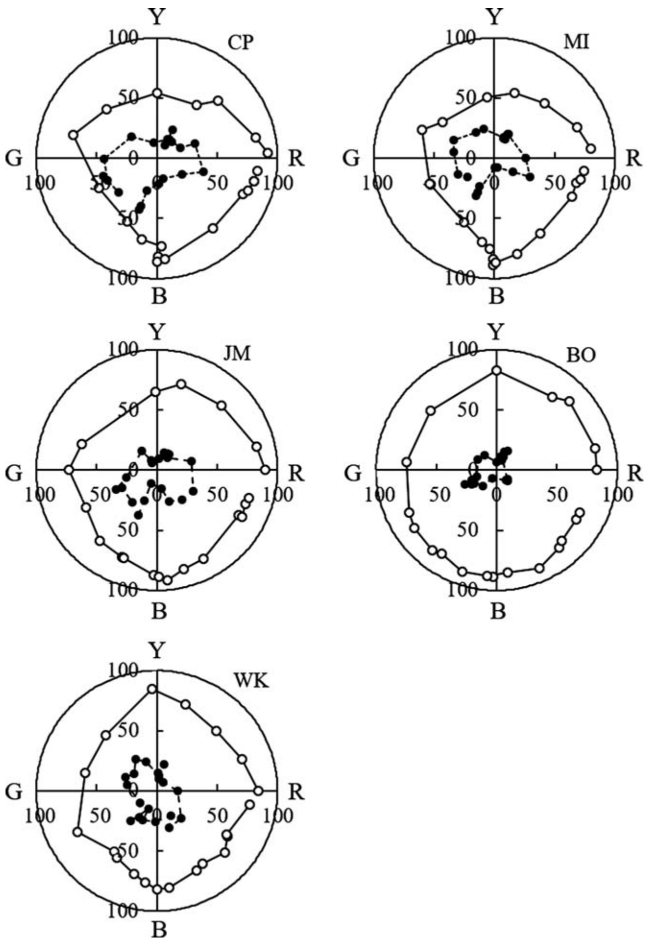

FIGURE 8 Color appearance plotted on the polar diagrams for five subjects. Open circles, adapting stimuli; filled, afterimage

adapting stimulus with the standard deviations of five repetitions. The *SD*s for the adapting stimuli are small but for the afterimage colors they are large particularly at low luminances of the surrounding. From the data points at luminance levels of surrounding beyond 1.4 in log *L*, where *SD*s are small, we can see that the highest amount of chromaticness of afterimage were obtained at the lower luminance of the background than that used in the main experiment, ie, the rightmost point.

3.3 | ME: Main experiment

It was not easy to assess color of afterimages because the image faded out in 2 or 3 seconds. Subjects asked to see the adapting stimulus two or three times to confirm their response. The examples of the main experiment are shown in Figure 7 for three adapting stimuli from all five subjects, with circles for color # 1, squares for #7, and diamonds for #13. The small symbols indicate the results of five repetitions, and the large symbols represent the average. The adapting colors are shown by open symbols, and the afterimage colors are by filled symbols. The average points and the origin are connected by solid lines for the adapting color and by dotted lines for the afterimage color. If the solid line and the corresponding dotted line make one line, the colors are opponent. In the present examples, this is only observed for adapting stimulus #7 with subjects CP and MI. The amount of chromaticness is smaller in the afterimage colors compared to the adapting color, but we observed that the chromaticness in PE2 depended on the luminance level of the surrounding field to some extent. Variance among five repetitions is large for adapting stimulus #7 in subjects BO and WK. Those subjects often commented that the stimulus sometime had yellow element and other time blue element beside green element, which might have caused their variance large. But the average points of this stimulus came pretty close among five subjects.

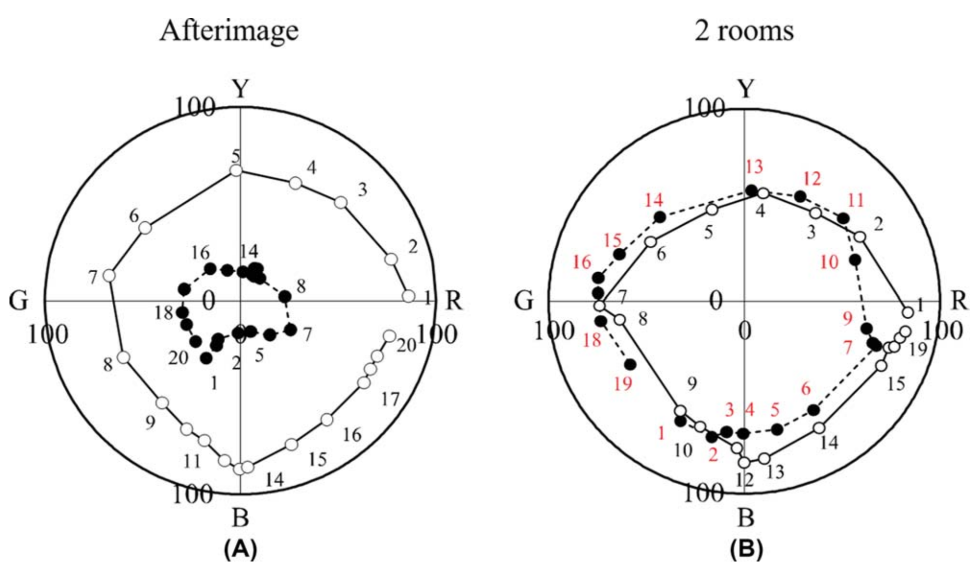

FIGURE 9 A, Adapting and the afterimage color plotted on a polar diagram. B, A similar plot for the adapting and the adapted colors obtained from the two-room technique[13] [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Color appearance expressed by elements for the adapting stimuli and for their afterimages

Color #	Adapting	Afterimage
1	R98Y02	G37B63
2	R82Y18	G34B66
3	R50Y50	G34B66
4	R27Y73	G04B96
5	Y97G03	B85R15
6	Y42G58	B52R48
7	Y12G88	B38R62
8	G71B29	B01R99
9	G39B61	R43Y57
10	G24B76	R28Y72
11	G16B84	R23Y77
12	G06B94	R27Y73
13	B100	R27Y73
14	B97R03	RIOY90
15	B78R22	Y79G21
16	B59R41	Y53G47
17	B37R63	Y15G85
18	B31R69	G87B13
19	B25R75—G71B29	
20	B15R85—G53B47	

Plotting the averages of all 20 points for both adapting stimuli and the afterimages generated the polar diagram in Figure 8, where each graph corresponds to a subject. The results of the three colors shown in Figure 7 appear again in those graphs. Adapting colors are shown by open circles connected by solid lines, and the afterimage colors are represented by solid circles connected by dotted lines. All subjects assessed adapting color #1 as almost unique and vivid red, as shown by the open circles located almost on the red axis. As the color number increases, the open circle moves counterclockwise and ends by approaching the unique red. All subjects assessed the afterimage of adapting color #1 as greenish blue, and the perceived color moved counterclockwise following the adapting color and ended with blue-green. The amounts of chromaticness varied among subjects, particularly the subject BO, who assessed adapting colors very vividly and afterimage colors as very desaturated.

Figure 9A demonstrates the average of the five subjects, with the color number attached at some points. Open circles connected by solid lines show the adapting colors, and filled circles connected by dotted lines the afterimage colors. Figure 9B shows the results obtained with the two-room technique,[3] where open circles indicate the adapting color and solid circles represent the adapted color. Two-room technique is composed of a subject and a test rooms such as shown in Figure 2. If a subject observes a white board placed at the position of the display through a window W while the subject room is illuminated by a colored light, which was called the adapting color, the subject perceives a vivid color at the window filled with the white board, which was called the adapted color. The relationship between the adapting and the adapted colors were investigated in a previous article.[3] The luminance on the front wall varied from 17 to 60 cd/m^2 depending on the color of the subject room. The present experiment employed test stimuli of 16–205 cd/m^2 comparative to the previous two-room technique experiment. In Figure 9A, the contour of the afterimage colors is much smaller than that of the

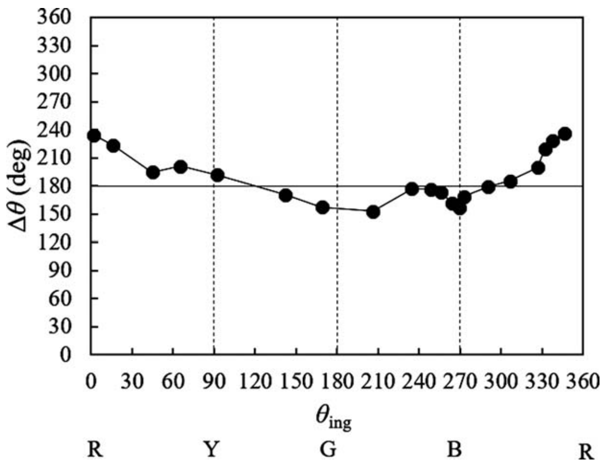

FIGURE 10 Angle difference between the adapting stimuli and the afterimages plotted for the angle of the adapting stimulus. Mean of five subjects

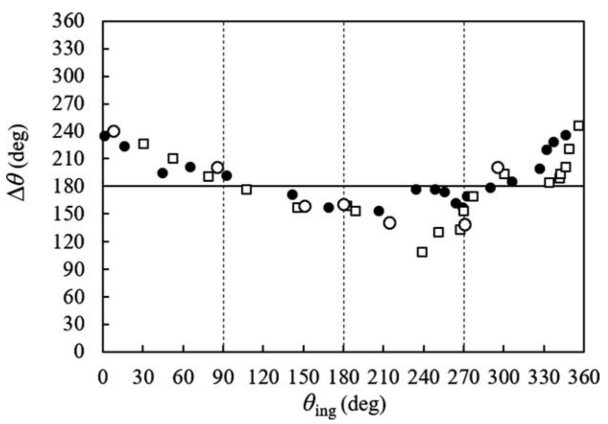

FIGURE 11 Angle difference between the adapting stimuli and the afterimages (filled symbols) and adapted colors obtained by the two rooms technique (open symbols) plotted for the angle of the adapting stimulus[13]

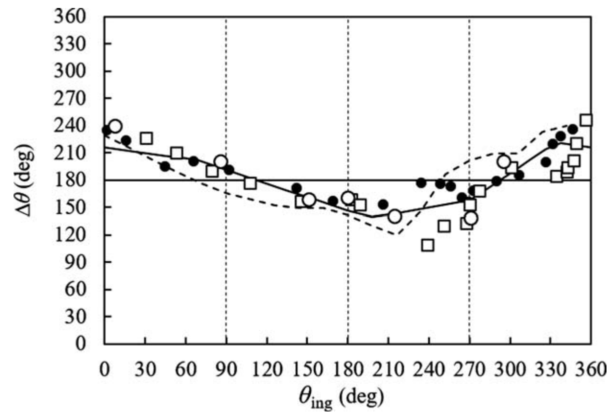

FIGURE 12 Experimental results of afterimage colors (●) and of the adapted colors (○, □) and prediction by the Munsell color space (solid line) and the complementary colors concept (dotted line)

adapting colors; the chromaticness of the afterimage is quite smaller than that of the adapting color.

The distance between the data points shown by open circles and the origin in Figure 9A, B is the amount of chromaticness, which closely resembles the Munsell Chroma, and can be read from the CIE *xy* diagrams showing the loci of constant chroma.[11] The amount of chromaticness also agrees well with data given by Ayama and Ikeda.[12] The correspondence between the adapting color and the afterimage color shown in Figure 9A is given in Table 1. The expression here directly follows the elementary color naming. R, Y, G, and B denote unique red, yellow, green, and blue, and the R98Y02 of color #1, for example, indicates red 98% and yellow 2%.

To observe the relationship between the apparent hues of the adapting stimulus and the afterimage, the difference $\Delta\theta = \theta_{after} - \theta_{ing}$ was calculated based on the angle of the adapting color θ_{ing} and that of the afterimage color θ_{after}, taken counterclockwise from the red axis in Figure 9. When θ_{after} is smaller than θ_{ing}, 360° was added to θ_{after} to make $\Delta\theta$ positive. The result is shown in Figure 10, where the adapting color angle θ_{ing} is taken along the abscissa and the angle difference $\Delta\theta$ along the ordinate. The adapting color angles corresponding to unique hues are indicated by vertical dotted lines. To indicate the relationship between opponent colors, a horizontal line was drawn at $\Delta\theta = 180°$. The curve of $\Delta\theta$ does not follow the 180° line, implying that the adapting and afterimage colors do not obey the opponent colors relation. This finding is similar to that obtained by the two-room technique, where the adaptation was to illumination of LED and fluorescent light.[3] In Figure 11, the present results are plotted together with the previous results by filled and open symbols, respectively. Both results are very close up to approximately 210° of the adapting color angle θ_{ing}, which can be approximated by a line with a slope −0.427. The present result has a regression line of slope −0.387. Both results agree fairly well beyond approximately 270°, but then they are different at adapting color angles between 235° and 256° or color numbers from 9 to 11, that is, cyan.

4 | DISCUSSION

It is clear that the opponent colors theory cannot explain the afterimage color, but is there any other method to explain the color? Pridmore[6] suggested the complementary relation between the adapting and adapted color by analyzing simultaneous contrast results reported by Wu and Wardman[7] and Luo et al.[8] and demonstrated the afterimage color by presenting colored patterns to confirm the suggestion. Manzotti also emphasized the complementary relation[5] and Wilson and Brocklebank[4] used the word complementary in their article. We also analyzed our results by the complementary concept as follows. The color appearance of each adapting stimulus in Figure 1 is given in the first column of Table 1. Then, the color appearance at any point between the neighboring two stimuli on the u′v′ diagram can be obtained by interpolation. We newly selected 20 adapting stimuli with steps of 20 amounts of element; then, their color appearance was obtained by interpolation. The complementary color of each adapting stimulus is located on a line connecting the adapting stimulus and the surrounding white field, which is indicated by an open square in Figure 1 on the opposite side of the adapting stimulus in reference to the surrounding white field.

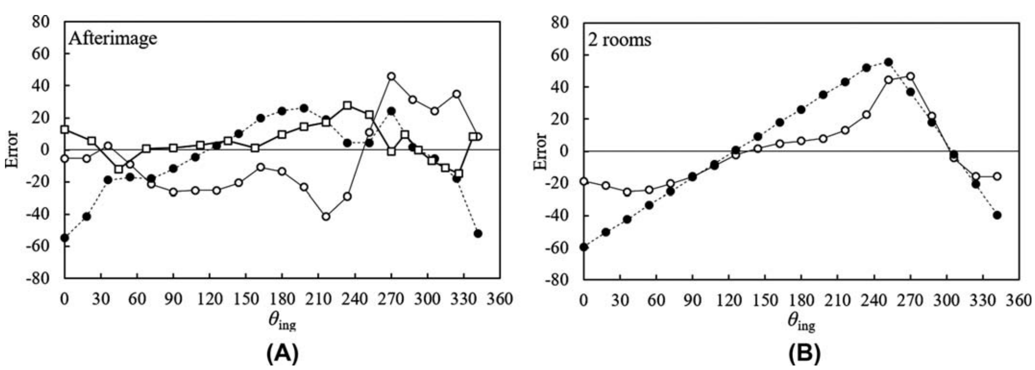

FIGURE 13 Deviation of complementary prediction (○), opponent colors prediction (●), and Munsell prediction (□) from the experimental results. A, The afterimage experiment; B, two rooms experiment

The line crosses another line connecting two adapting stimuli points, generating the color appearance of the complementary color. The results are shown by the dotted curve in Figure 12.

In Figure 12, data from Figures 10 and 11 are replotted by solid circles. The dotted curve demonstrates the predicted $\Delta\theta$ using the complementary colors concept. To evaluate how these predicted colors deviate from the experimental results, the difference of the angle was calculated from the polar diagram. The results are shown in Figure 13A, where the angle of the adapting stimulus is taken along the abscissa and the difference along the ordinate is denoted as error. Open circles indicate the deviation of the color appearance based on the complementary color relationship, while filled circles are the opponent color relation. The shapes of the curves differ, but the root mean square (RMS) is not different: 24 for both data sets. We cannot determine the better method from these data. Figure 13B demonstrates the deviation of the previous experiment, where the two-room technique was employed to investigate the chromatic adaptation to illumination. The color appearance of the adapted color was approximated by two lines to relate the adapting color angle, which was reflected in two lines in Figure 13B. The RMS was 21 for the complementary color relation and 34 for the opponent color relation, showing a slight improvement using the complementary color method.

We can propose another explanation, that is, Munsell color space. When we evaluate the relationship between the adapting color and the afterimage color, we notice good correspondence. Munsell colors 5R, 5Y, 5G, and 10B are unique red, yellow, green, and blue, respectively. Then, the opposite color of 5R is 5GB, and greenish blue agrees with our results. Similarly, the opposite color of 10B is 10YR, yellowish red, again agreeing with our results. Assuming that the opposite colors to any color are the afterimage colors of the adapting colors, we calculated the angle of those hues projected to the polar diagram of the opponent colors theory employed in this article. The angle differences $\Delta\theta$ between the corresponding colors, the adapting color, and the opposite color were then obtained and plotted as the adapting color angle θ_{ing}, which is shown by a solid curve in Figure 12. A dotted curve is predicted by the complementary concept. It is clear that the predicted curve by the Munsell color space is much closer to the experimental data shown by filled circles than that of the complementary color concept. The RMS error based on 20 points of θ_{ing} is 12, which is smaller than 24 from the complementary prediction.

Both the two-room technique and the afterimage technique gave us similar results for the chromatic adaptation, in spite of different techniques. The previous results of the two-room technique emphasized that chromatic adaptation occurs in the brain rather than on the retina.[13] If this interpretation is valid, then the present results suggest that the chromatic adaptation occurring in the afterimage is also a result of brain adaptations, not the retina.

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REFERENCES

[1] Ikeda M, Mizokami Y, Nakane S, Shinoda H. Color appearance of a patch explained by RVSI for the conditions of various colors of room illumination and of various luminance levels of the patch. *Opt Rev*. 2002;*9*:132–139.

[2] Pungrassamee P, Ikeda M, Katemake P, Hansuebsai A. Color appearance determined by recognition of space. *Opt Rev*. 2005; *12*:211–218.

[3] Phuangsuwan C, Ikeda M. Chromatic adaptation to illumination investigated with adapting and adapted color. *Color Res Appl*. 2017;*42*:571–579.

[4] Wilson MH, Brocklebank RW. Complementary hues of afterimages. *J Opt Soc Am*. 1955;*45*:293–299.

[5] Manzotti R. A perception-based model of complementary afterimages. *SE Open*. 2017;*7*:1–10.

[6] Pridmore RW. Chromatic induction: opponent color or complementary color process? *Col Res Appl*. 2008;*33*:77–81.

[7] Wu RC, Wardman RH. Lightness and surface contrast effects in surface fabric colours. *Color Res Appl*. 2007;*32*:55–64.

[8] Luo MR, Gao XW, Scrivener SAR. Quantifying colour appearance. Part V. Simujltaneous contrast. *Color Res Appl*. 1995;*20*:18–28.

[9] Jameson D, Hurvich LM. Opponent chromatic induction: experimental evaluation and theoretical account. *J Opt Soc Am*. 1961; *51*:46–53.

[10] Fairchild MD. Color Appearance Models. 3rd ed. Chichester: Wiley; 2013.

[11] Wyszecki G, Stiles WS. Concepts and Methods, Quantitative Data and Formulae. 2nd ed. New York: Wiley; 1982:855–856.

[12] Ayama M, Ikeda M. Hue and saturation of colored lights in the whole area of the u'v' chromaticity diagram. *J Color Sci Assoc Jpn*. 1994;*18*:186–199. [in Japanese]

[13] Ikeda M, Pungrassamee P, Katemake P, Hansuebsai A. The brain adaptation to the color of illumination and not the retinal adaptation to the color of objects that determines the color appearance of an object in the space. *Opt Rev*. 2006;*13*:388–395.

AUTHOR BIOGRAPHIES

Chanprapha Phuangsuwan received a Ph.D. degree at the Faculty of Science, Chulalongkorn University, Thailand in 2012 and returned to Rajamangala University of Technology Thanyaburi (RMUTT) as a lecturer and became an assistant professor. She is the director of the Color Research Center (CRC) of the university established in 2013. The CRC actively organized the 1st Conference of the Asia Color

Association (ACA) held at RMUTT in 2013 and is organizing the 4th ACA conference to be held at Chiang Mai in December 2018. Her research interest is to investigate the color appearance of objects in relation to the space recognition where the objects are perceived to locate.

Mitsuo Ikeda is a professor emeritus at Tokyo Institute of Technology, a former professor at Kyoto University, Ritsumeikan University in Japan, and at Chulalongkorn University in Thailand. He is presently a professor at Rajamangala University of Technology Thanyaburi, Thailand and works at the Color Research Center of the university. He served the CIE Division 1 director, the president of the International Color Association AIC, and the president of the Color Science Association of Japan. He was awarded the Judd Award from AIC. He currently serves a coordinator of the Asia Color Association ACA and the 4th ACA is coming at the end of this year.

Janjira Mepean graduated from Rajamangala University of Technology Thanyaburi in 2017. She will be entering the master's degree program in June 2018 to continue her research on the afterimage color under supervision of Prof. Ikeda and Dr. Phuangsuwan.

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