Investigation of Colour Size Effect for Colour Appearance Assessment

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Abstract: Three psychophysical experiments were conducted to investigate the colour appearance changes between different sizes under various media or viewing conditions. The results are highly consistent that when increase stimulus size, the colour will appear to be lighter and more colourful with little change in hue. © 2010 Wiley Periodicals, Inc. Col Res Appl, 36, 201–209, 2011; Published online 17 June 2010 in Wiley Online Library (wileyonlinelibrary.com). DOI 10.1002/col.20610

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INTRODUCTION

The colour size effect is a colour appearance phenomenon,[1] in which the colour appearance is changed according to different sizes of the same colour stimulus. The common explanation for this effect is that because of the distribution of photoreceptors (cones and rods) is nonuniform across the human retina, colour vision in the peripheral retina is therefore different from colour vision in the fovea.[1] Substantive psychophysical experiments were conducted by vision scientist to investigate the cognitive visual mechanism of each individual location in the viewing field across the retina.[1–4] It has been well acknowledged that when a stimulus size is enlarged, the viewing field is moved away from the central region of the retina so that peripheral colour vision deviates significantly from foveal and parafoveal colour vision. The deviations generally increase with the distance of the viewing field from the center of the retina. Earlier research showed that colour stimuli became desaturated and even achromatic with increase of retina eccentricity.[1] However, many recent psychophysical studies[2–4] strongly suggest that colour vision in the peripheral retina is similar to that in the fovea if stimulus size is sufficiently increased and the effect of macular pigmentation and the contribution of rod signals are taken into account.

The colour size effect has been also studied by colour scientists[5–8] for accurate colour reproduction across dissimilar sizes of colours. Although CIE has recommended two CIE standard colorimetric observers to represent the normal colour vision viewed by the central region of retina covering the fovea when the field has an angular subtense not exceeding 4°, and including the parafoveal region for fields of 10°,[9] there is still no standard colorimetric observer to represent human peripheral vision for large size colour stimuli. Moreover, there is no transformation can be used to estimate the change of colour appearance for the same colour in different sizes. As a consequence, a large size colour cannot be accurately predicted using colour appearance model and is not possible to be accurately reproduced by the normal size of colour at present. A typical problem that has long been experienced in the paint industry is that the paints purchased in stores usually do not appear the same after they are applied to the walls in a real room. This causes great difficulties for homeowners, interior designers and architects when they select colour ranges. Recently, the display size tends to be larger and larger, size effect has also been of great interest to display manufacturers to reproduce precisely and even enhance the source images on difference sizes of colour displays. To meet these requirements, the research is focused on how the colour appearance is affected by physical size of colours.

The authors' recent work[5] was carried out to accumulate experimental data for describing colour appearance in

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TABLE I. Experimental groups for dissimilar sizes of colours.

Group	Size (°)	No. of colours	Reference white	Illuminant	Background	Media
1	2, 8, 19	25	Cabinet source	D65	Mid-gray	Reflection paint
2	22, 44	15	Ceiling light	D65	Mid-gray	Reflection paint
3	8, 50	12	TV	D93	Black	LCD TV

a real room subtending 50° to the observers' eyes. The results were used to develop models to predict the appearance between 10° and 50°. This was confirmed by other studies.[6–8] The general understanding is that the size does indeed have a significant impact on colour appearance, and that psychophysical experiments are the only way to reveal the colour size effect. However, there is no common understanding how colour size effect impacts on the colour appearance. This is caused by the different viewing conditions including media and the experimental techniques applied in different studies. Moreover, in the previous studies, size effect was always studied based on two stimulus sizes only. Obviously, there is a strong demand to acquire reliable colour appearance data for more dissimilar sizes under different viewing conditions and different media. This is the main objective of this study.

This article describes a number of psychophysical experiments for investigating the colour appearance shift due to colour size effect. Different viewing conditions or media were applied in the experiment to identify the possible dependency for the size effect. The approach applied in this study is to assess the colour appearance of dissimilar sizes of the same colours by colour matching[10] using one fixed standard size of colours (10°) that can be predicted by basic colourimetry and colour appearance model.[11] The asymmetric colour matching technique[12] was applied in this study to investigate the changes of colour appearance due to dissimilar of sizes by representing results on CRT displays. The dissimilar sizes of colours refer as the test colours, while the fixed size of colours refers as the reference colours throughout this article. Note that in the authors' earlier study,[5] three psychophysical methods, magnitude estimation, colour matching in a viewing cabinet and colour matching using a CRT were used. It was found that the latter method gave the most reliable results. Hence, it was used in this study.

EXPERIMENTS

In this study, the colour appearance of test stimuli covering from 2 to 50° field sizes based on two different media were assessed by psychophysical experiment that was divided into three groups. Each group applying one particular set of viewing conditions in which two or three sizes of test stimuli were assessed. Table I summarizes the experimental conditions used including number of colour samples, media, light sources and backgrounds.

Software for colour matching on CRT colours was developed to generate a 10° size of colour patch on the center of display against a black background. The colour patch can be adjusted by three controls based on CIELAB: lightness (L^*), chroma (C^*_{ab}) and hue (h_{ab})[9] within the CRT colour gamut. During the experiment, each observer was asked to match visually each size of test colours under particular viewing condition by adjusting the reference colour patch (80 × 80 mm) displayed on a CRT. Ten observers aged from 22 to 40, who all passed the Ishihara vision test,[13] participated in the experiments. There was no time limit for each matching task. In general, it took about 1 minute for each observer to complete a matching task. The experimental details for each group is described in the following sections.

Group 1 Experiment

In Group 1 experiment, 25 colours were selected from the popular shade range of ICI paints selection. Figures 1(a) and 1(b) show the sample distribution in CIELAB a^*b^* and L^*C^* diagrams, respectively. The lightness values of all selected colours are above 60 indicating that all colours have relatively high lightness values. There is a lack of darker shades in the experiment due to the ICI range, i.e., dark is not popular for interior usage. However, the selected colours covered well in the hue and chroma directions. The 25 colours were painted onto small paper cards in the three sizes (2, 8, and 19°). They were assessed in a VeriVide viewing cabinet against a mid-gray background with an $\sim L^*$ of 50. A D65 simulator source in the viewing cabinet was used in this experimental group. It was measured by a Minolta CS1000 tele-spectroradiometer (TSR) against a $BaSO_4$ diffuser. Table II gives the measurement results for different experimental conditions.

A 21″ Hewlett-Packard P1100 CRT display was adopted for experimental groups 1 and 2. The CRT has a white point nearly equal to D65 and was driven by a 24 bit S3 128 graphic card with 16 MB of S-DRAM graphic memory in a Hewlett-Packard computer. Before each group of experiments, CRT was well calibrated. The characterization was also performed to control precisely the reference colour patch based on CIELAB colour appearance attributes.

Figure 4(a) illustrates the experimental condition in Group 1 Experiment, for which the viewing cabinet and CRT were placed side by side in a dark room. During the experiment, each of the three sizes of the test colours was randomly presented in the viewing cabinet under the D65 simulator and was visually matched by adjusting the reference colour on the CRT display. In total, 750 colour assessments (25 colours × 3 sizes × 10 observers) were made.

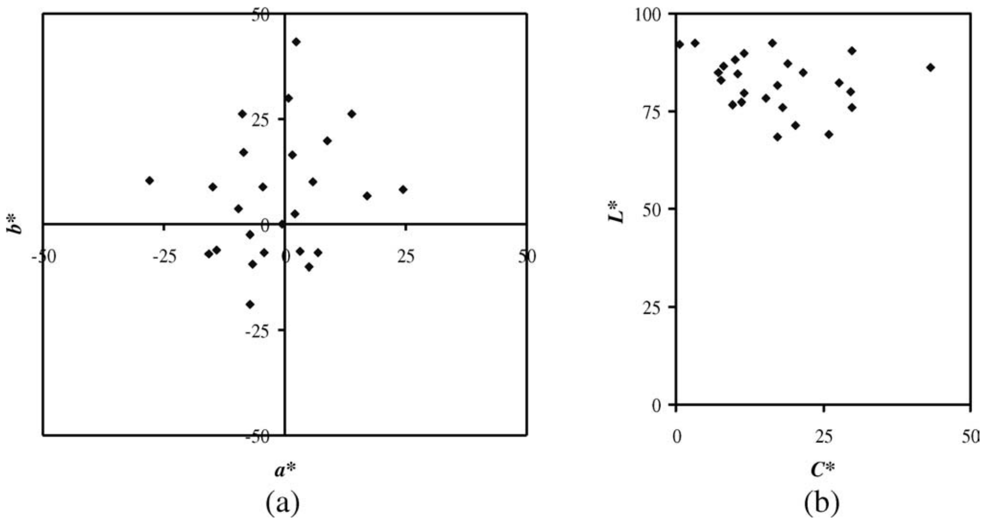

FIG. 1. Colour selections for experiment group 1: (a) a^* vs. b^*; (b) L^* vs. C^*_{ab}.

Group 2 Experiment

In the Group 2 experiments, 15 colours painted on two sizes of cardboard (22° and 44°) were employed to be test colours. The colours are plotted in Fig. 2 using CIELAB uniform colour space. The 12 colours used in Group 1 Experiment were employed with the addition of three darker colours which cover L^* ranged from 40 to 60. Again, the intention was to give a reasonable uniform coverage in colour space. In this group, the samples were placed onto the one side of wall in the room having the physical size of 3 m long by 4 m width by 3 m high. A D65 simulator was installed on the ceiling and was used to illuminate the samples. The source was measured by the TSR against the diffuser located beneath the source. The measurement results are again given in Table II. All four walls were painted to be mid-gray having L^* of 50, while the ceiling and the floor are a matt-white and a dark gray shade, respectively.

Figure 4(b) illustrates the experimental conditions in Group 2 Experiment. Each observer sat in the middle of the room and viewed the test colour against the wall. The CRT was placed on the right hand side of observer. During the experiment, each test colour was randomly displayed in the middle of the wall and was then visually matched by the reference colour patch on the HP display as that used in Group 1 experiment. In total, 300 colour assessments (15 colours × 2 sizes × 10 observers) were conducted.

Group 3 Experiment

In the Group 3 experiment, a 46″ Sony LCD TV (KDL-46XBR3) controlled by a Samsung PC was used to generate two sizes of test stimuli (8° and 50°). Each size of test stimulus was displayed on the center of TV against a black background. The TV has a nearly D93 white point which was directly measured by the TSR as given in Table II.

A different CRT, a 21″ Samsung SyncMaster 927MB with a D93 peak white, was used in this group of experiment due to different experimental period and locations (2 years apart). Although the two CRTs were used, the visual results were represented by the TSR results. Hence, the difference between them can be ignored. Both the LCD TV and the CRT were characterized and evaluated to present good uniformity and channel independence, i.e., average CIELAB colour differences of 0.8 and 1.6 against the central white colour for CRT and TV respectively. Figure 3 shows twelve colours selected in this experiment. These colours were selected to be within the colour gamuts of the two displays. This resulted in a limited L^* range from 30 to 70. However, there was a good coverage in chroma and hue directions.

The same interface used to generate reference colour for Groups 1 and 2 experiments was also used here to generate reference colour on the CRT in this experimental group. Consequently, the viewing conditions for the reference colour in this group are similar to those in Groups 1 and 2 experiments.

As illustrate in Fig. 4(c), the LCD TV and the CRT were placed side by side in a dark room. Group 3 experiment was further divided into two sections. In "Introduction" section, each observer assessed the test colour patches with the 50° field size, whereas the observer assessed the 8° test colour patches in "Experimental" section. For both experimental sections, the test colour patch was displayed randomly and assessed in a dark room.

TABLE II. The colour specification of the cabinet or display for each experimental group.

Groups	L (cd/m^2)	x	y	u'	v'	CCT
1	459	0.3134	0.3298	0.1981	0.4688	6458
2	156	0.3143	0.3312	0.2001	0.4721	6427
3	257	0.2813	0.2843	0.1923	0.4374	9356

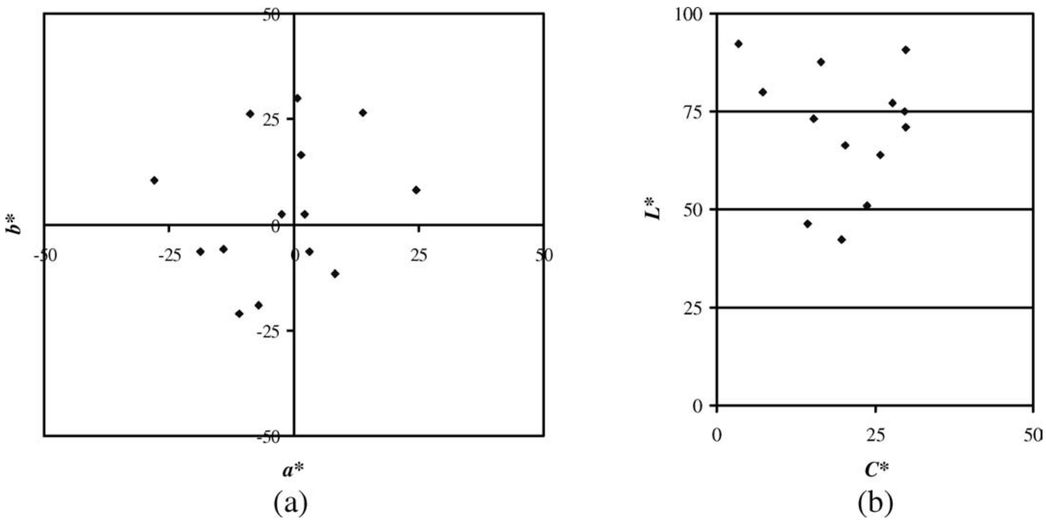

FIG. 2. Colour selections for Experiment Group 2: (a) a^* vs. b^*; (b) L^* vs. C^*_{ab}.

Totally, 240 colour assessments (12 colours × 2 sizes × 10 observers) were conducted in this group of experiment.

RESULTS AND ANALYSIS

After the experiments, the reference colours on display to match each dissimilar size of test colours were measured using the TSR in term of the absolute CIE XYZ tristimulus values in the unit of cd/m^2 with the CIE 1964 standard colorimetric observer. Note that the TSR was placed in the same position as the observer when they conducted visual assessments. Subsequently, the visual results from all observers were averaged to represent the panel results. Then, colour size effect can be investigated by comparing colour difference or colour appearance shift between each two different sizes in each individual experimental group. Note that the comparison for two colour sizes across different experimental groups can not be made directly because of large viewing condition or media differences between the three groups of experiments.

OBSERVER VARIATION

Observer variation analysis was carried out first. It is a measure used to indicate the extent to which individual observer agrees with the majority decision of the group. It is of significant importance for verifying the reliability of colour appearance data and provides the basic level of accuracy required for colour appearance models. In this study, observer variation for the corresponding colour data for dissimilar sizes was represented by CIELAB colour difference unit. For a particular test colour, each observer's variation (ΔE^*_{ab}) was calculated by the difference between his/her own judgement and the mean of the whole group. Individual deviations from the overall mean values were then averaged for the test colours applied for difference experimental group, representing the mean colour difference

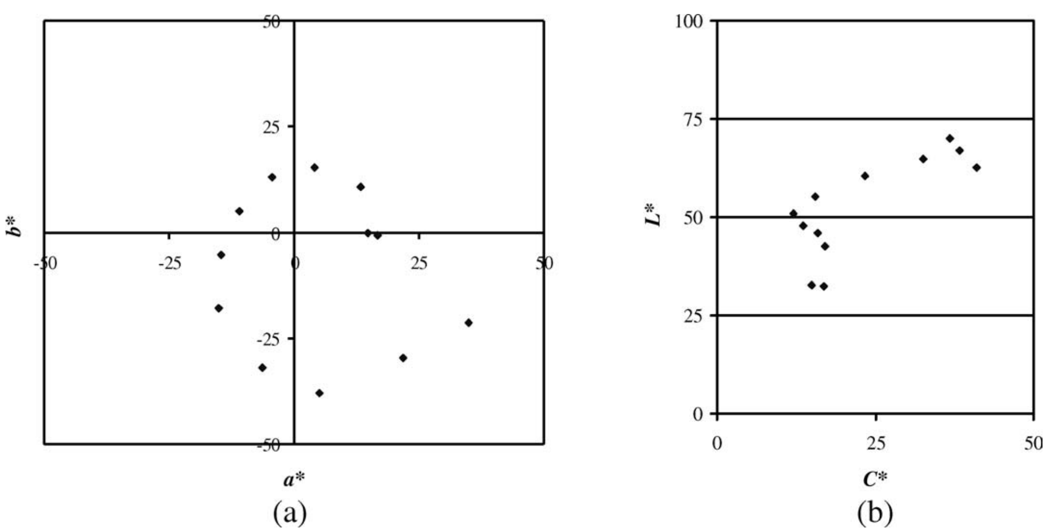

FIG. 3. Colour selections for Experiment Group 3: (a) a^* vs. b^*; (b) L^* vs. C^*_{ab}.

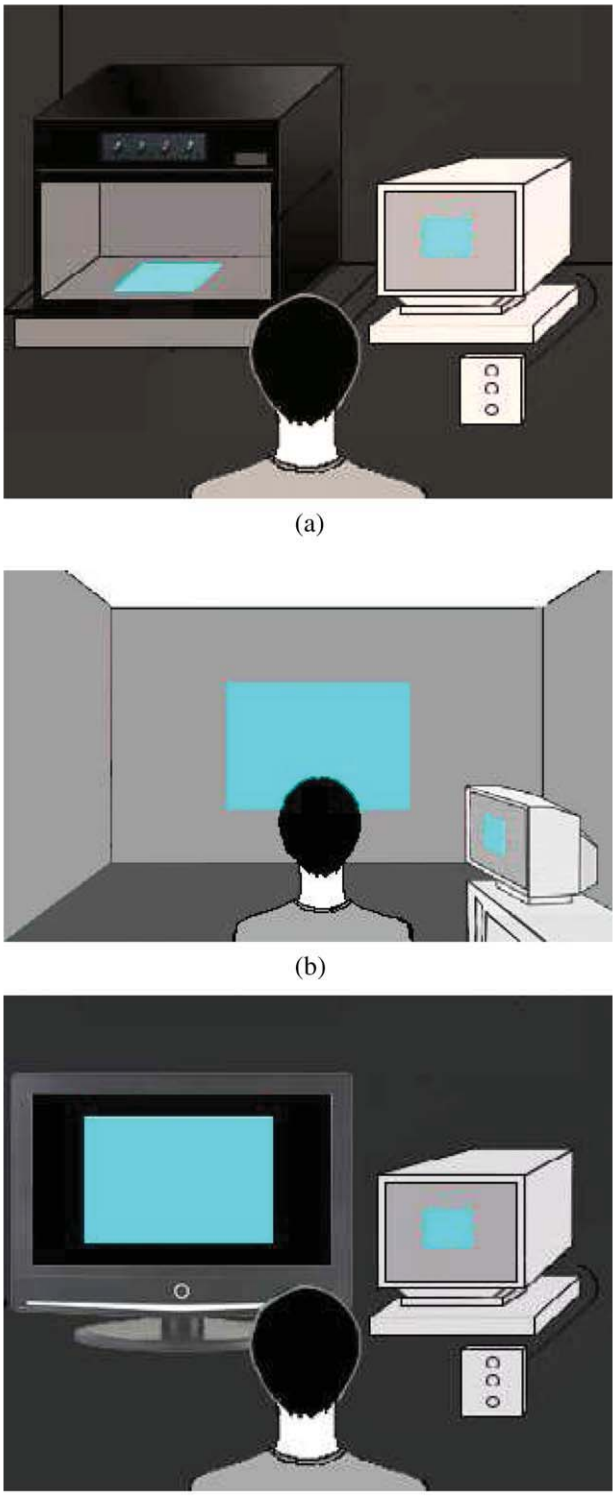

FIG. 4. Experimental set up. (a) Experimental Group 1, (b) Experimental Group 2, (c) Experimental Group 3.

from the mean (MCDM).[14] Table III summarizes the observer variation performance for each group.

The results indicate that the observer variations were 6.6, 7.1 and 6.8 for each group with a total mean of 6.8 ΔE^*_{ab} units. This performance is considered to be reasonable comparing with the colour appearance data from the authors' earlier study,[5] i.e., a MCDM of 9 ΔE^*_{ab} units. There is also no clear difference for observer variation between different groups of experiments.

TABLE III. Observer variations for the three experimental groups.

Observe variation (MSDM)	Group 1			Group 2		Group 3	
	2°	8°	19°	22°	44°	8°	50°
ΔE^*_{ab}	7.7	6.3	5.9	6.8	7.3	6.5	7.0

Size Effect

In this study, CIELAB colour difference formula was employed to predict the colour difference between dissimilar sizes of colour stimuli for each experimental group. Table IV lists the mean, maximum and standard deviation of colour difference results for each group.

As shown in Table IV, the average colour difference between the three sizes in Group 1 is between 5 and 7 ΔE^*_{ab}, units while the ~8 ΔE^*_{ab} units between two sizes of colours in either Group 2 or Group 3. These large magnitudes indicate a very large colour shift between dissimilar sizes of colours. A consistent trend of colour appearance shift between different sizes was found that colour difference increases as the size difference between the two sample sizes compared increases.

Colour Appearance Shift

As mentioned earlier, the mean XYZ values were used to represent the panel visual results. These were then used to calculate CIECAM02 lightness (J), chroma (C) and hue composition (H).[15] Table V summarizes the viewing parameters used for calculation CIECAM02 attributes. The CIECAM02 model rather than CIELAB is used here because the former take into accounts the distinct viewing conditions applied in different groups.

The size effect can be revealed by comparing the predicted J, C, and H between different stimulus sizes. Figures 5(a1) to 5(c5) are plotted to reveal the colour shift between two field sizes. The alphabets (a, b, c) given in the descriptor of each diagram in Fig. 5 represent the lightness, chroma and hue attributes, respectively. The numbers of 1–5 included in the descriptor of each diagram in Fig. 5 designate the compared pairs of stimulus

TABLE IV. Colour difference between each of dissimilar sizes in term of ΔE^*_{ab}.

Size difference	Mean	Maximum	Standard deviation
8° vs. 2° (Group 1)	4.86	8.87	2.06
19° vs. 2° (Group 1)	6.72	12.10	2.79
19° vs. 8° (Group 1)	4.55	9.28	2.08
44° vs. 22° (Group 2)	8.31	13.62	2.44
50° vs. 8° (Group 3)	7.96	19.12	4.59

TABLE V. Viewing parameters of CIECAM02 for different groups of experiments.

Parameters	L (cd/m^2)	x	y	Y_b	Surrounding
Group1	97.6	0.2968	0.3279	0.16	Dark
Group2	102.9	0.2972	0.3283	2.34	Average
Group3	85.3	0.2824	0.2856	1.81	Dim

sizes: 2° vs. 8°, 8° vs. 19°, 2° vs. 19°; 22° vs. 44°, and 8° vs. 50°, respectively. In each diagram of Fig. 5, a 45° line representing equal appearance value is drawn to reveal the trend of changes between the results from two sizes. Note that in each of the diagram of Fig. 5, the attribute values in the horizontal axis always correspond to the smaller size. To investigate the hue dependency of size effect in the lightness and chroma attributes, the data points are plotted according to different hue regions using red, yellow, green, blue colours correspond to CIECAM02 H (hue composition) of 0–100, 100–200, 200–300, and 300–400, respectively. Finally, for each individual data point in Fig. 5 diagrams, an error bar representing one standard deviation of observer variation is also plotted in Fig. 5 for Groups 1 and 2 data. For Group 3 data, the raw data were not available for calculating the error bars. The error bars were plotted originally for both x and y data sets. However, the legibility was poor and the error bars were similar in magnitude. Hence, only error bar in Y direction for each data point was plotted.

Figure 5(a) diagram show that most of the data points for comparing lightness results (diagrams labelled with 'a') are located above the line of equal appearance value. This implies that colours appear lighter with the increase of stimulus size. The same trend is found for all Fig. 5(b) diagrams comparing chroma results, except Fig. 5(b1), in which 2° and 8° sizes show hardly any chroma difference due to too small size difference. Comparing the trends between lightness and chroma diagrams, it can be seen that the shift in chroma is smaller than that in lightness. This indicates that a lightness increase is larger than a chroma increase, when the field size of stimulus is enlarged. Furthermore, many error bars overlap with the line of equal appearance except for the darker shades [see Fig. 5(a) diagrams] and higher chroma shades [see Fig. 5(b) diagrams].

All Fig. 5(c) diagrams show an excellent agreement between the pairs of stimulus sizes compared. Almost all data points lie on the line of equal appearance value. There is also no obvious evidence to show the hue dependency affected by the lightness shift or chroma shift, since the points in different hue regions are well mixed together.

The quantitative colour appearance shift between each of two sizes was also calculated for each experimental group. They were achieved by subtracting visual attribute of larger field from that of smaller field. Table VI shows the average results of the colour attribute differences for each of two sizes of samples.

Table VI shows the overall trends of colour appearance shift between different stimulus sizes in each perceptual attribute. It can be seen that the direction of shift (sign) between attributes could be different. To investigate the statistical significance of the shift, the Student's t test was used. Table VII gives the t and p values for each comparison between different sizes. If there is a significant difference between a pair, the *t or p* values are underlined in Table VII.

It can be seen in Table VII that t values for all lightness and chroma are all underlined except the chroma results between 2° and 8° sizes. However, there is no significant difference for hue. Therefore, it can be concluded from the present results that with an increase of the field size, colours appear to be lighter and more colourful except between 2° and 8° which had no significant chroma effect [see Fig. 5(b1)]. For the hue attribute, there is no significant change at all due to change of sizes. It also can be found that the overall lightness shift is more significant than chroma shift, especially for Groups 2 and 3 experimental results.

Investigating Size Effect

The present results showed a consistent pattern of colour appearance shift due to various stimulus size. The mathematical equation was derived to express the relationship between the sizes and each colour appearance attribute by minimizing the sum of the squares of the differences between each of two sizes of colours with a linear equation for each individual experimental group.

For lightness equation, a function forced to pass through the point (100,100) were developed. This is justified because observers were adapted to a reference white set in each size of experiment. While for chroma equation, a function was also forced to pass the point (0, 0) because the assumption has been made that a zero chroma corresponds to neutral colours. There is no need to derive hue equation because hue attribute is not changed with the change of sizes. Eqs (1) and (2) were developed for lightness and chroma respectively.

$$J_P = 100 + K_J \times (J - 100) \qquad (1)$$

$$C_p = K_C \times C \qquad (2)$$

where the K_J and K_C coefficients represent the colour shift for each pair of sizes are given in Table VIII together with. The root mean square (RMS) values calculated between the equation and experimental data.

From those data, the magnitude of colour appearance shift for lightness and chroma attributes is clear. Note that, the smaller K_J value in lightness attribute represents the larger difference between two colour sizes. It can be seen that the lightness shift between 2° and 19° in Group 1 is the largest, while the largest chroma shift was found in Group 3 between 8° and 50°. It also can be seen that the lightness shift between 8° and 19° for Group 1 is similar to that between 8° and 50° for Group 3. Based on this

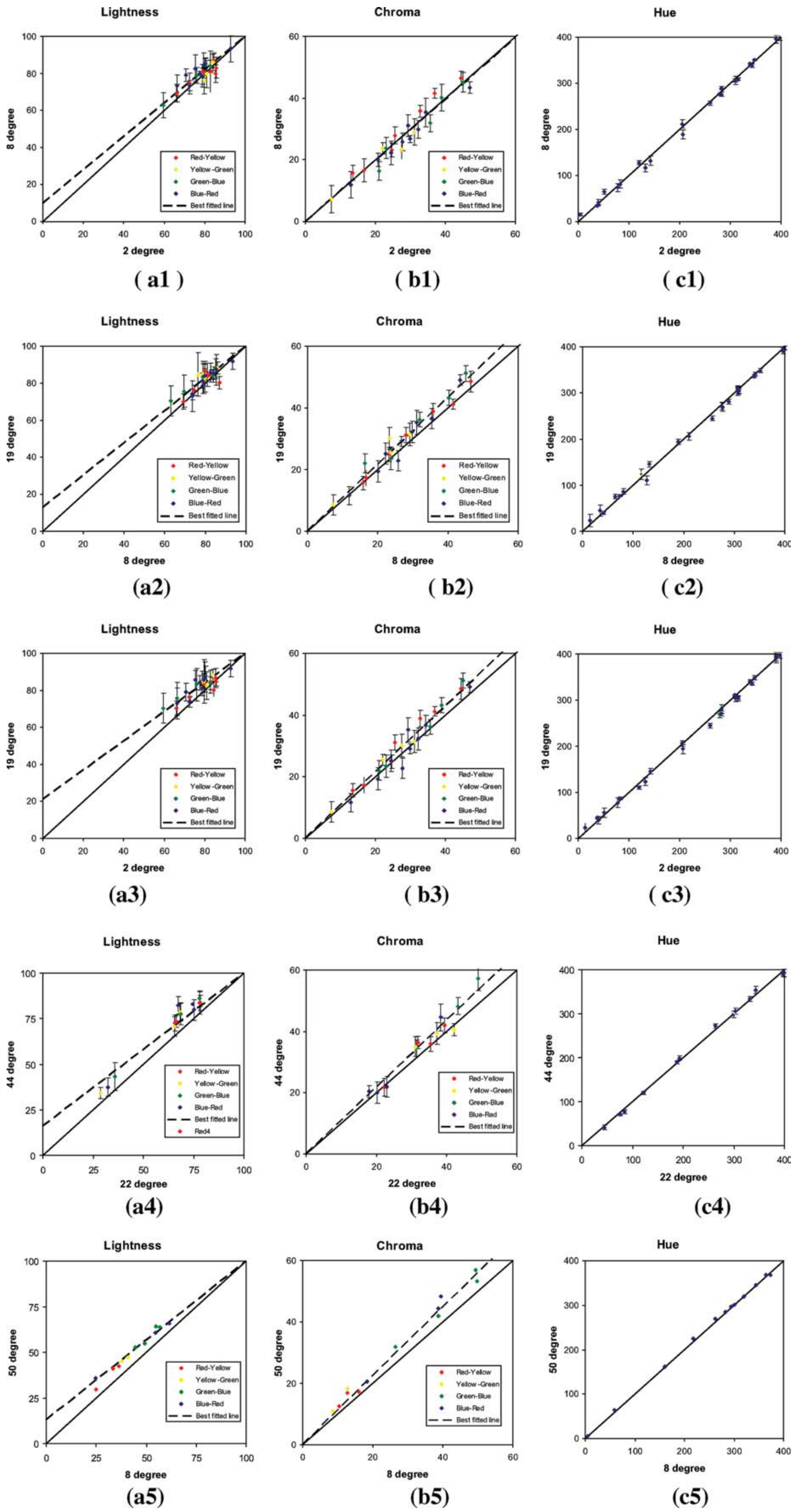

FIG. 5. Relationships of colour appearance attributes between dissimilar sizes.

TABLE VI. Colour appearance shift between each of dissimilar sizes.

Appearance shift	ΔJ	ΔC	ΔH
8° vs. 2° (Group 1)	1.90	−0.45	−0.74
19° vs. 2° (Group 1)	4.39	1.77	−1.24
19° vs. 8° (Group 1)	2.48	2.22	−0.51
44° vs. 22° (Group 2)	7.25	2.77	0.45
50° vs. 8° (Group 3)	5.55	3.55	0.75

TABLE VIII. Coefficients for lightness and chroma shift between the three sizes.

Coefficients	K_J	RMS (J)	K_C	RMS (C)
2° vs. 8° (Group 1)	0.90	3.0	0.99	2.7
8° vs. 19° (Group 1)	0.87	2.8	1.08	2.5
2° vs. 19° (Group 1)	0.79	2.9	1.07	2.7
22° vs. 44° (Group2)	0.83	3.9	1.09	2.4
8° vs. 50° (Group3)	0.87	2.1	1.12	1.6

method, the colour appearance from one size can be transformed to that of another size. The method was originally employed by the authors for specifying room colour appearance.[5]

DISCUSSIONS

The present study investigated the impact of stimulus size on perceived colour appearance. Although the experiments were conducted applying cross-media colour matching conditions, the visual results were always presented by the TSR measurement results of the CRT colours. Thus, the size effect can be evaluated directly compared using the same set of viewing conditions. For instance, in Group 1, the colour patches displayed on the CRT in a dark room were used to represent the colour appearance for all three sizes presented in the viewing cabinet. Therefore, the colour shift genuinely reflects the effect caused by dissimilar sizes. It is different from the studies by Kutas *et al*.[6] and the authors' earlier work,[5] where the larger size of colours are in immersive environments either displayed in a cabinet illuminated by a large TV display or painted in a room. For those studies, the large size colour was represented by a fixed size of CRT colour, whereas the small size colour is achieved by the direct TSR measurement for the large size stimuli in the immersive environments. Hence, the difference between the two sizes of colours in the previous studies was affected by not only size effect but also viewing conditions of the two media used. This results in the lightness shifts between dissimilar sizes in their studies being larger than those of the present study, i.e. their K_J value of about 0.70 comparing with that of 0.85 in the present study (see Table VIII). However, the K_C value in our earlier study was 1.45 comparing with an average of 1.10 in the current study, where as no difference was found in Kutas's study.

Based on the present experimental data, the results showed clear trends that colour size impacts upon colour appearance significantly. The effect is more obvious when the size difference is larger between the two sizes compared. When colour size increases, colours would appear lighter and more colourful, whereas hue does not change. This trend is fairly consistent based on the three groups of experiment data implying the trend of colour appearance shift between different sizes can be independent to the viewing condition or media applied. The trends on lightness and chroma shifts found in this study agreed well with the authors' pervious study for room colour appearance specification.[5] However, in Kutas *et al*.'s study, the chroma shift is dependent on hue, although the lightness and hue shift between dissimilar sizes is same to that found in the present study.

During the colour assessments in Group 3, observers were commonly aware that the magnitude of colour appearance shift between the two sizes (50° vs. 10°) can be changed with the time spent for judging each colour. For instance, when observers concentrated on the large size of test colour patch (50°) for a while and then viewed the corresponded 10° reference colour patch, they always realized a significant colour shift between the two colours in the beginning. However, the shift tends to be reduced when they become more adapted in the mixed viewing conditions between two fields. This implies that a kind of adaptation took place, named size adaptation here (Adaptation is the ability of an organism to change its sensitivity to a stimulus in response to change in the condition of stimulation[10]). Size adaptation might indicate the changes visual sensitivity with the changes of stimulus size. When the eyes concentrate on one particular size, it can be fully adapted. Nevertheless, if our eyes move between two sizes, there could be an adaptation to reduce the perceived colour shift between the two sizes of colours. However, this phenomenon was unclear for Groups 1 and 2 experiments

TABLE VII. The *t* value of the Student's *t*-test to represent the significance of colour appearances shift due to size effect.

t (*P*) value	ΔJ	ΔC	ΔH
8° vs. 2° (Group 1)	2.84 (*P* = 0.009)	−0.91 (*P* = 0.372)	−0.48 (*P* = 0.318)
19° vs. 2° (Group 1)	5.81 (*P* = 2.72e–06)	3.27 (*P* = 0.0032)	−0.66 (*P* = 0.258)
19° vs. 8° (Group 1)	3.88 (*P* = 0.000358)	4.71 (*P* = 8.78e–05)	−0.35 (*P* = 0.366)
44° vs. 22° (Group 2)	10.48 (*P* = 5.16e–08)	14.25 (*P* = 0.0024)	0.40 (*P* = 0.381)
50° vs. 8° (Group 3)	9.42 (5.19e–8)	5.46 (*P* = 5.29e–05)	0.44 (*P* = 0.332)

which were conducted using physical samples rather than self-luminous stimuli. As also shown in Table III, the overall colour difference in LCD TV between 8° and 50° is similar to that between 22° and 44° for physical colours, which seems to indicate a smaller size effect for self-luminous colours than physical colours. This could be due to the fact that colour patches on display are more difficult to adapt by human eyes comparing with physical colour samples.

In terms of size effect, Eqs. (1) and (2) developed here is to transform colours from one size to another based on CIECAM02 colour appearance attributes. The relationship between the size and colour appearance attribute is simple and easy to understand. Other methods can also be adopted such as the one derived by the authors[16] based on cone fundamentals. However, the main contribution in the current study is to provide the experimental data for modeling the size effect. The data could be useful for the new CIE Technical Committee aimed to derive a comprehensive CIECAM02 including the prediction of colour appearance for dissimilar sizes. This should be a valuable tool for the industries such as paint (interior), display and TV manufacturers.

CONCLUSIONS

In this article, the colour size effect was carefully investigated in term of colour difference and colour appearance shift between dissimilar sizes. The six dissimilar sizes colours covering viewing field from 2° to 50° under various viewing conditions were assessed in three groups of experiments. The significant colour difference and the consistent colour appearance shift for each perceptual attributes were identified. The relationship of the changes of colour appearance between different sizes was revealed, i.e., a colour appears lighter and more colourful with an increase in stimulus size. The factors which could affect the colour size effect were also discussed.

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