Colour preference model for elder and younger groups

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This study focuses on age difference and colour preference by conducting a psychophysical experiment. Eighty observers took part in the experiment, including 50 observers from 18 to 30 years old and 30 observers from 56 to 84 years old. Each observer was asked to arrange 11 colour patches in order of preference. The colour samples used in the experiment were selected from 11 basic colour schemes (red, orange, yellow, green, blue, brown, purple, pink, white, black, and grey). Each basic colour was produced according to their boundaries in CIELAB space. The results showed the elder group's colour preference differed from that of the younger group. The determinant for colour preference was that the elder group ranked colours according to their chroma, and the younger group ranked them according to their lightness and chroma.

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Introduction

For product appearance, colour is the most direct attribute that customers perceive. Using colour design to fit a particular user group is thus very efficient and useful. This study investigated two age groups' colour preferences. A considerable number of studies over the years has looked into colour preference, with Cohn [1] studying the phenomenon of colour preference in 1894. After more than 100 years, research into colour preferences is still ongoing, as order, oral, and categorical judgments are the most common measures to collect data, as shown in Table 1.

Author	Method of Data collection	Sample display	Colour sample	Age difference
Garth [2] (1922)	No information	Yes	7	No information
Garth [3] (1924)	No information	Yes	7	Children：1000
Dorcus [4] (1926)	Order	Yes	6 (Munsell)	Elder (over 60): 40 Hospital staff : 67 College: 831 10 years old: 68 9 years old: 118 8 years old: 111
Eysenck [21] (1941)	Order	Yes	10	No information
Choungourian [5] (1968)	Oral Order	Yes	8 (Ostwald)	US (Average age20.62) Lebanon (Average age20.6) Iran (Average age22.85) Kuwait (Average age19.6)
Child *et al.* [16] (1968)	Oral Order	Yes	No information	6-18 years old: 1100
Saito [22] (1996)	Order Oral	Yes	77 (Munsell)	15-19 ：193 20-29 ：364 30-39 ：384 40-49 ：367 50-59 ：292 Japan (Average age 21.9) Korea (Average age 22.3) Japan (Average age 19.6) Taiwan (Average age 24.1)
Cooper [6] (1999)	Oral	Yes (assistive devices)	8	63-87 (Average age 76.8)
Lin [9] (2000)	Categorical judgment	Yes	64 (PCCS)	University student
Dittmar [7] (2001)	Oral	No	4	Younger (19-44) Elder (52-90)
Wijk *et al.* [8] (2002)	Order	Yes	7 (NCS)	95 years old:84
Gamgöz *et al.* [10] (2002)	Categorical judgment	Yes	63	20-24 years old
Lee and Luo [11] (2003)	Categorical judgment	Yes	11 (Berlin and Kay's colour terms)	Average age 28
Ou *et al.* [12] (2004)	Categorical judgment	Yes	20 (NCS)	Staff members: 17 PhD student: 8 MSc student: 6
Ou *et al.* [13] (2004)	Categorical judgment	Yes	20 (NCS)	Staff members: 8 PhD student: 7 MSc student: 4
Ou *et al.* [14] (2004)	Categorical judgment	Yes	20 (NCS)	No information
Lee and Luo [15] (2005)	Categorical judgment	Yes	11 (Berlin and Kay's colour terms)	Average age 27

Table 1: The outline of experiments conducted in the colour preference related studies.

Using colour order to collect data is a straightforward method to see the sequence of colour preference. It requires presenting colour samples during the experiment. In some studies the number of colour samples is quite small, i.e., Garth [2-3], Dorcus [4], Choungourian [5], Cooper [6], Dittmar [7], and Wijk [8], while some studies used oral reporting to collect data, i.e., Cooper [6] and Dittmar [7]. This method may result in observers' errors in colour imagination. For instance, each observer's imagined red might not be the same, and they may have difficulty in describing some special colours.

In terms of categorical judgments, 7-step judgments are typically used, i.e., Lin [9], Gamgöz *et al.* [10], Lee and Luo [11], Ou *et al.* [12], Ou *et al.* [13], Ou *et al.* [14], and Lee and Luo [15]. The characteristic of this method is that the observers are required to evaluate one colour at a time. Each judgment involves representing the magnitude of colour preference as a number. However, Lee [15] used the method of categorical judgment to conduct his experiment. His results showed that the variation on preference scale was centralised on neutral attitude when observers did not have ideas about the samples. It was conjectured that if the observers make a judgment on one colour at a time, then the phenomenon of colour preference is discarded. This implies that the method of categorical judgment is not suitable for investigating preferences.

The number of colour samples determines the quality of colour selection. Too many colour samples used can exhibit the details of colour preference, but observers may feel annoyed. A small set of colour samples makes the experiment easy and clear, but some details could be neglected. The challenge for colour preference studies is that if the colour samples cannot be characterised, then the results cannot be compared between different studies, and the colour samples reported in the literature cannot be reproduced precisely. If the results in different studies can indeed be compared, then the results are more useful and helpful.

Previous studies have shown that the participants were relatively young. In fact, issues concerning both elder and younger groups have rarely been discussed except by Dorcus [4], Child *et al.* [16] and Dittmar [7]. For the results of different ages, two studies [4, 16] showed an insignificant difference, whereas another one [7] presented a significant difference.

From our literature review, we understand that changing how the samples are displayed and the way in which the data is collected can influence the results. Age is one of the important issues for colour preference studies. However, only a few attempts have so far been made at determining its effect on colour preference.

The current study hence used the method of order to investigate colour preference. The results were also used to develop colour preference models for different age groups. These models provide a quantitative way to compare preference data in different studies. They also suggest colour guidelines for products designed for different age groups.

Experimental plan

This study's goal was to understand age difference and colour preference by carrying out a psychophysical experiment. The observers were asked to place 11 colour patches from the most favourite colour to the most disliked colour. The eleven colours used were selected from Berlin and Kay's 11 basic colour schemes: red, orange, yellow, green, blue, brown, purple, pink, white, black, and grey [17]. These 11 colours were produced according to Lin et al.'s basic colour boundaries [18-20]. Each colour was applied onto an 8 cm × 8 cm square shape (in Figure 1). The colours were measured by a GretagMacbeth® Eye-One. The CIELAB values were calculated under CIE D65 and 1964 standard colorimetric observers, as shown in Table 2 and Figure 2.

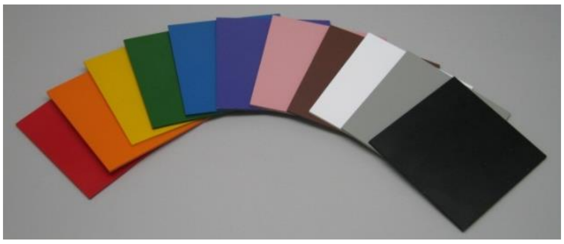
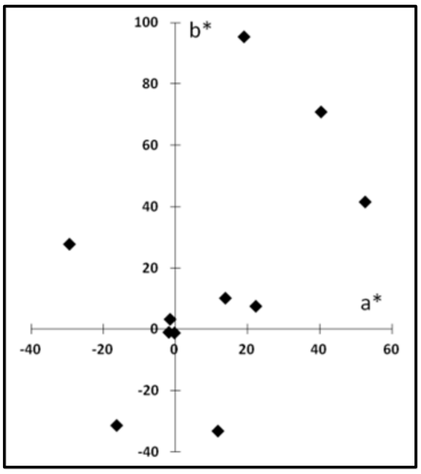


Figure 1: The colour samples used in the experiment.

	L*	a*	b*	C*	hue angle
Red (R)	33	53	41	67	38
Orange (O)	57	40	71	82	60
Yellow (Y)	71	19	95	97	79
Green (G)	34	-29	28	40	137
Blue (Bl)	37	-16	-32	36	243
Brown (Br)	33	14	10	17	36
Purple (P)	31	12	-33	35	289
Pink (Pk)	67	22	7	23	18
White (W)	93	-2	-1	2	212
Black (Bk)	16	0	-1	1	260
Grey (Gy)	61	-2	3	4	116

Table 2: The CIELAB values for the eleven colour samples.



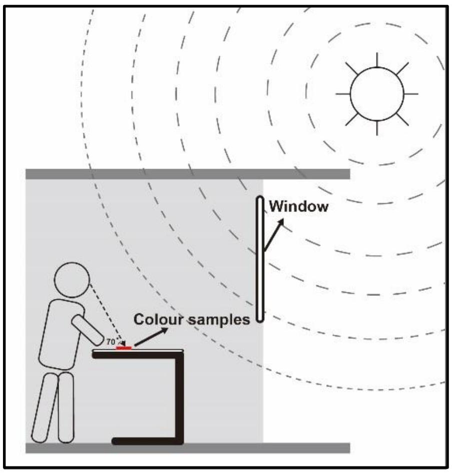


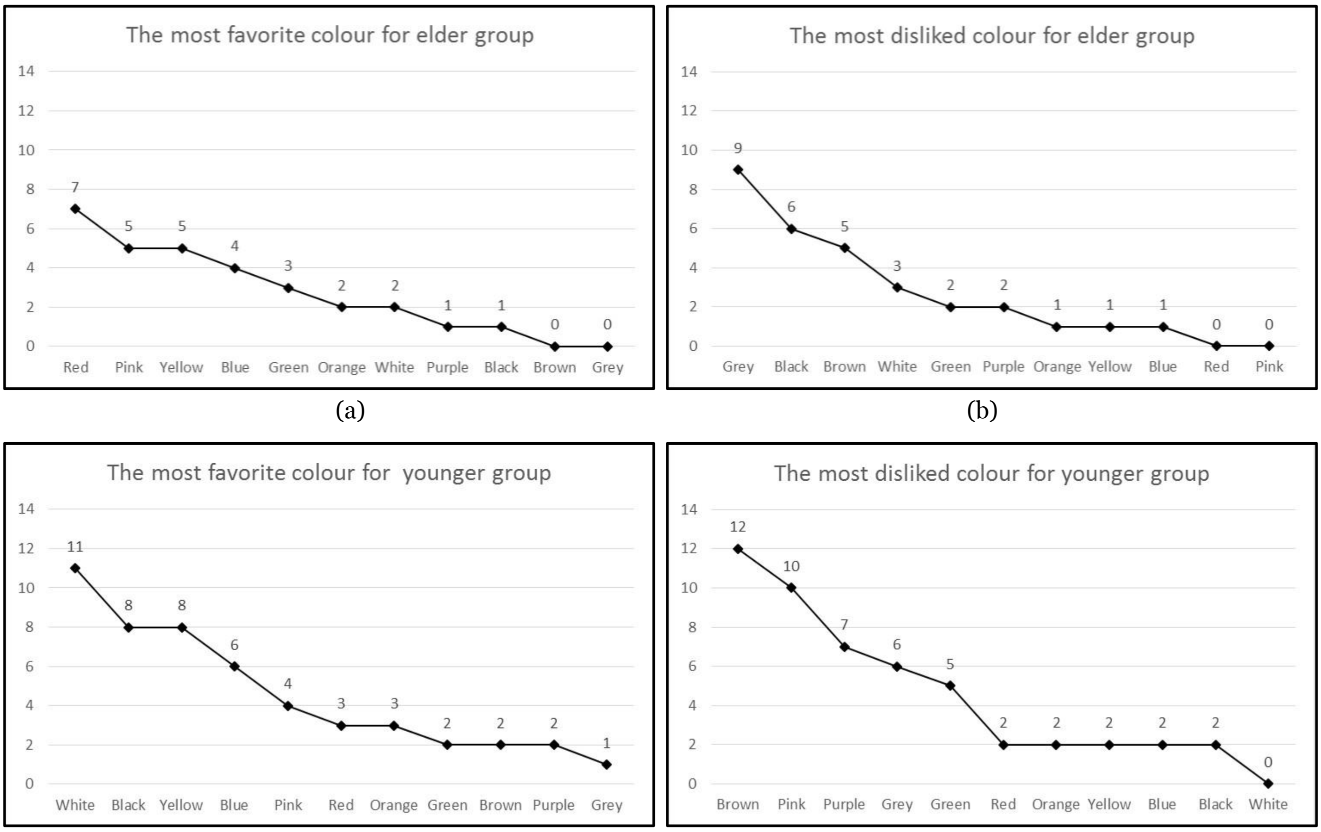
Figure 2 (left): The 11 colours in the CIELAB a-b* diagram.*
Figure 3 (right): Experimental situation.

Eighty observers with normal colour vision, as tested by the Ishihara Colour Test, took part in the experiment. The observers were classified into two groups: elder and younger. The elder group included 30 healthy observers (21 females and 9 males) with an average age of 70 (from 56 to 84). They were selected from Shi-Lin Senior Center, taking educational programs. The younger group included 50 observers (24 females and 26 males) with an average age of 23 (from 18 to 30). They were students in the Department of Industrial Design at Tatung University.

In the experiment, the observers were invited into an office, near to windows, under a daylight illuminate, and from late-morning to mid-afternoon, as shown in Figure 3. The colour temperature was measured before the experiment by a GretagMacbeth® Eye-One. The colour temperature ranged between 5057 and 6430 K.

Colour preference order

In the experiment, the observers were asked to place 11 colour patches from the most favourite colour to the most disliked colour. Figure 4 illustrates the observers' most preferred and most disliked colours. Figures 4(a) and 4(b) indicate the result of the elderly group, while (c) and (d) are the ones of the younger group. According to Figure 4(a), red is the most popular colour for the elderly and was selected by 7 observers, followed by pink and yellow, which were selected by 5 observers. No observers chose grey and brown as the favourite colours. On the contrary, 9 elderly observers selected grey as the most disliked colour and the second most disliked is black, selected by 6 elderly observers, followed by brown, selected by 5 observers, as shown in Figure 4(b). For the younger group, white is the most favourite colour selected for 11 observers, followed by black and yellow, chosen by 8 observers, as shown in Figure 4(c). According to Figure 4(d), brown is the most disliked colour selected for 12 observers. Second is pink, selected by 10 observers, followed by purple, chosen by 7 observers. In addition, the result shows that no observers selected white as the most disliked colour.



(a) (b)

(c) (d)

Figure 4: Frequency with which colours were ranked favourite and most disliked by elder (a and b) and younger (c and d) groups.

The data collected from colour preference order were converted into scores, i.e., the most preferred colour was given 10, followed by 9, 8, 7, etc. until 0. Hence, the data collected from observers can be averaged into mean results, which were used to rank colours in order of colour preference to see if colour preference is affected by age difference.

Figure 5 illustrates the results. For the elder group, pink was the most preferred colour, getting 6.7 points, followed by red (6.6), orange (6.3), yellow (6.3), blue (5.8), and purple (5.2); grey was the most disliked colour at 1.9 points, followed by black (2.6), brown (3.7), green (4.7), and white (4.9). In addition, it also can be see that the disliked interval between grey, black, and brown and the previous colours increases. For the younger group, white was the most preferred colour at 7.7 points, followed by black (6.4), yellow (6.0), red (5.4), blue (5.2), and orange (5.0); brown was the most disliked colour at 2.7 points, followed by purple (3.8), green (4.1), pink (4.1), and grey (4.7). According to the results in Figure 5, it can be seen that the elder group differed from the younger group in colour preference order, especially pink, white and black colour.

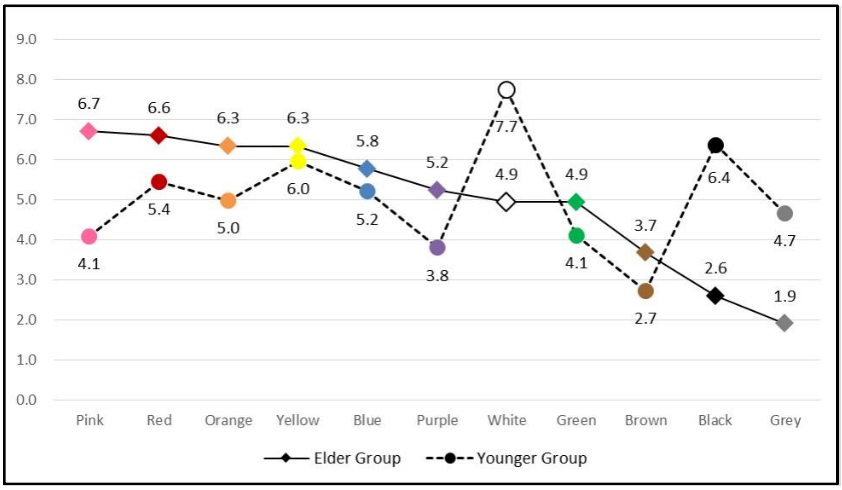


Figure 5: The colour preference order for different age groups.

Colour preference model

To understand how observers judged the colour preference, the bubble chart was used to observe the relationship between colour preference and CIELab colour attributes, as shown in Figure 6. Different size bubbles, which represent the scale of colour preference, were illustrated in CIELab a*-b*, L*-C*, and L*-hue angle diagrams. The dotted bubbles represent “disliked” colours, and solid bubbles represent “preferred” colours. Bubble size represents the magnitude of colour preference. The bigger the dotted bubble is, the more “disliked” the colour; the bigger the solid bubble is, the more “preferred” the colour. In Figure 6, the three diagrams on the left-hand side (a-c) are from the elder group, while the three diagrams on the right-hand side (d-f) are from the younger group.

For the elder group, it can be found that dotted bubbles are located in the central area of the CIELAB a*-b* diagram and the area of lower chroma, as shown in Figures 6(a) and 6(b). They indicated that the colours having lower chroma were the disliked colours, especially achromatic colour. It is also clear from Figure 6(a) that the bigger solid bubbles are located in the first quadrant of the CIELAB a*-b* diagram, thus demonstrating that the elderly group’s colour preference might be influenced by chroma.

To find out the optimum model describing the relationship between colorimetric values and colour preference, the method of least squares was used. Both C* value and a* and b* were used as predictors to seek the best-fit model. The results showed that the optimum model using a* and b* had higher performance (r=0.73) than those that only used C* (r=0.71). Therefore, the colour preference model was developed, as given in Eqn. 1.

This model suggests that the most “disliked” colour was at the coordinates (a*, b*) of (-5, 8). Moreover, the further a colour is from this location, the more preferred it will appear.

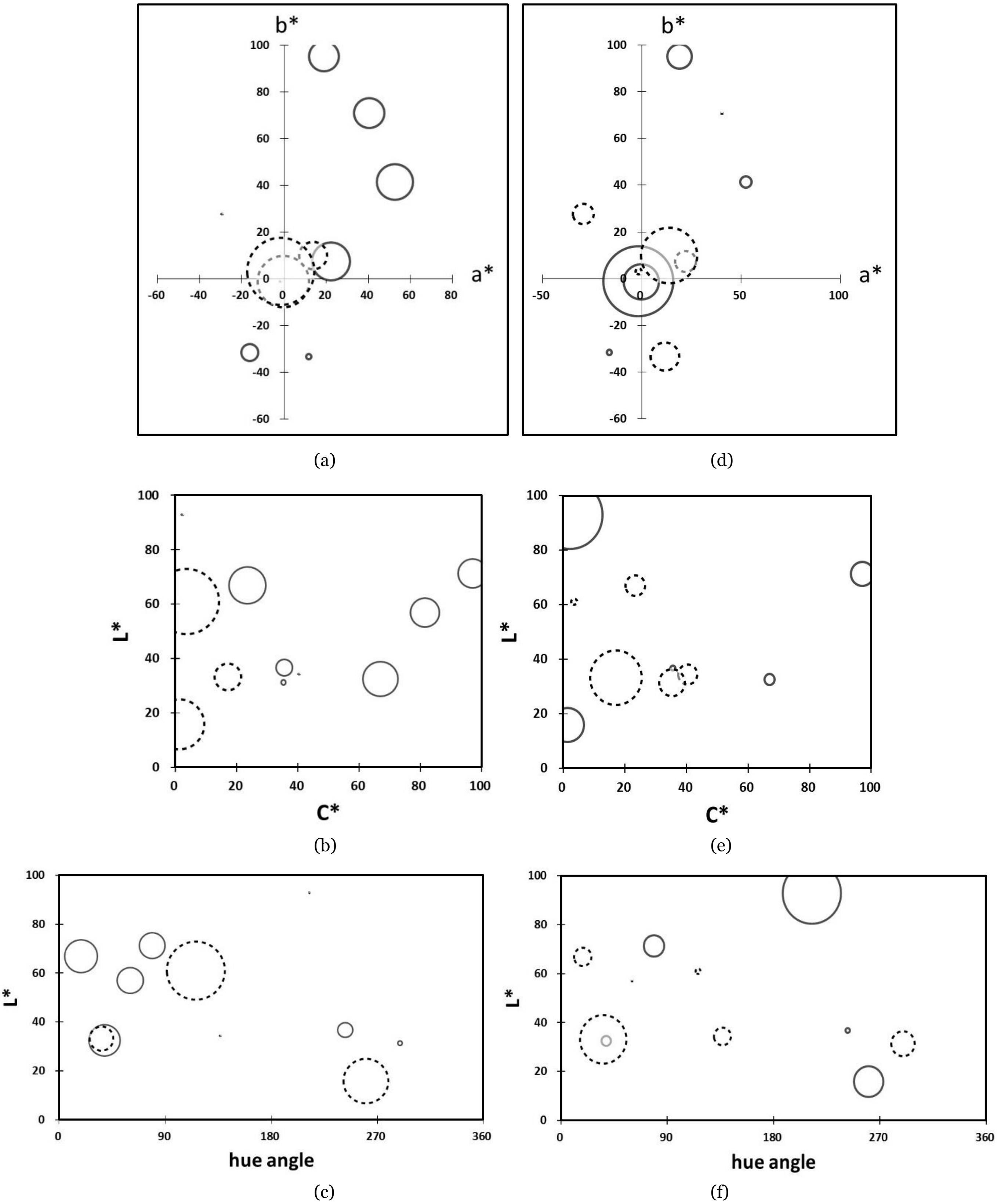


Figure 6: The bubble chart of colour preference. The three diagrams on the left-hand side are obtained from the results of the elder group; the three on the right-hand side are from the younger group.

Colour preference for the elder group

$$3.37 + 0.04\sqrt{(a^* + 5)^2 + (b^* - 8)^2} \qquad r = 0.73 \qquad (1)$$

where a = CIELAB redness-greenness; b* = CIELAB yellowness-blueness*

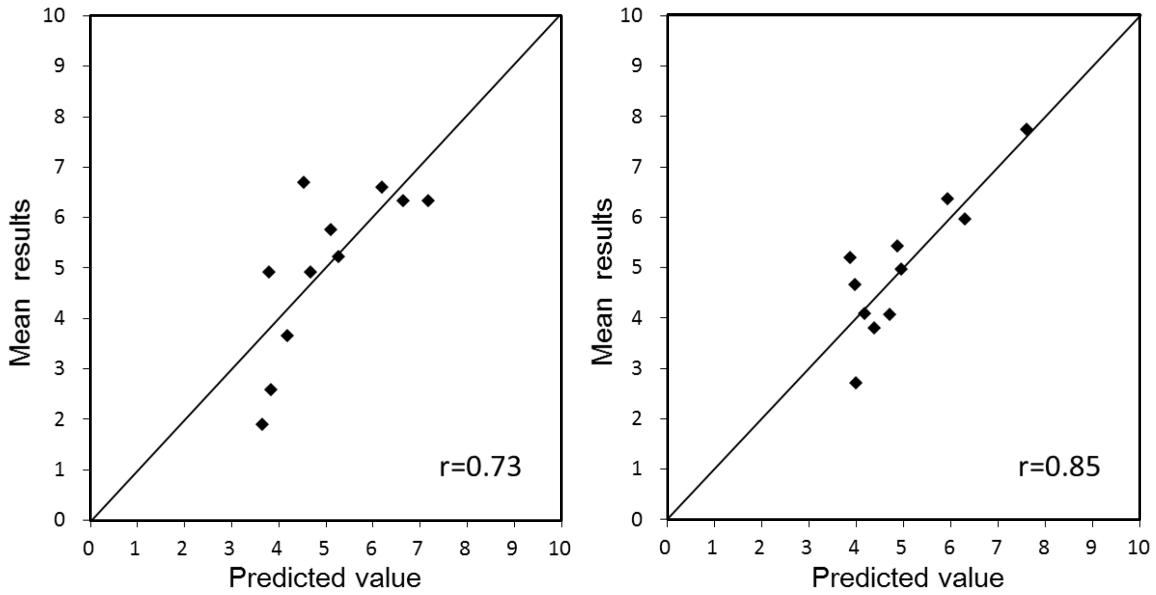
For the younger group, Figure 6(e) shows a clear effect that the dotted bubbles are located in the area of the middle of the lightness and chroma, thus indicating that the colours having middle lightness and middle chroma were disliked. This suggested that the colour preference of the younger observers was likely connected to the chroma and lightness attributes. This result further suggested that lightness and chroma are two likely predictors for modeling the colour preference. The model for younger observers was successfully developed, as given in Eqn. 2. This model suggested that the colours farther away from lightness of 47 and chroma of 5 were the more preferred colours.

Colour preference for the younger group

$$2.36 + 0.03\sqrt{14 \times (L^* - 47)^2 + (C^* - 5)^2} \qquad r = 0.85 \qquad (2)$$

where L = CIELAB lightness; C* = CIELAB chroma*

In order to understand the performance of these models, the correlation coefficient and 45°line are given in Figures 7(a) and 7(b) to see how well the predicted values correlate with the mean results. The results showed that the performance of these models was good. The correlation coefficient was 0.73 for the elder group's colour preference model and 0.85 for that of the younger group.



(a) (b)

Figure 7: The predicted values plotted against the mean results by using Eqn. 1 (a) and Eqn. 2 (b).

The results of the two groups were next used to compare with the previous model developed by Ou, as shown in Eqn. 3. The predicted values obtained from Ou's model [14] were compared with the mean results from this study by using the correlation coefficient.

$$= -0.65 + 0.03\left[(L^* - 50)^2 + \left(\frac{a^* + 8}{2}\right)^2 + \left(\frac{b^* - 30}{1.7}\right)^2\right] \qquad (3)$$

The results showed that the correlation coefficient was fair for the younger group (r=0.67) and poor for the elder group (r=0.36). This indicates the models developed in the current study presented the colour preference more precise than Ou's model, implying the models developed herein are successful. Moreover, there is no age parameter in Ou's model.

Conclusions

The aim of this research is to understand if colour preference is affected by different age levels and to develop colour preference models. To do this, an experiment was carried out. Eighty observers were to ask to arrange 11 colour patches in order of colour preference.

The results showed that colour preference is indeed affected by different age levels. The elder group judged their colour preference by using chroma, while the younger group did so based on lightness and chroma. Moreover, colour preference models for different age groups were developed herein. The model for the elder group suggested that the most disliked colour is at the coordinates (a*, b*) of (-5, 8); and the further a colour is away from this location, the more preferred it will appear. The model for the younger group suggested that the most preferred colour was the colour farthest away from lightness of 47 and chroma of 5.

The difficulty of this research was inviting elderly observers to take part in the experiment. Although the Taipei Shi-Lin Senior Center fully supported the current study, the residents' willingness to participate was critical. Normally, elderly females had a higher willingness to take part than males. Hence, the number of elderly females was greater than that of elderly males in the current study. If future experiments can invite more elderly observers, then the results should be much more useful for product designers who are setting up colour schemes for products that target the elderly.

This study examined how age difference influences colour preferences. There are still other factors that affect colour preference, such as culture, gender, and the observer's perception and personality. These issues thus require more in-depth studies.

This study can be extended to many applications, such as packaging, interior, fashion, cosmetics, etc. If future studies can show the results of such applications, then they would be very interesting.

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