Blackness: Preference and Perception (Value and Chroma)

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Abstract

This study investigates preference for, and perception of, blackness using psychophysical experiments. A total of 29 black samples (varying in value and chroma) were evaluated for colour perception (which of two black samples observers considered to be closest to a pure black) and colour preference (which of two black samples observers preferred). For colour perception there was no statistical difference between UK and Chinese observers nor between male and female observers. However, for colour preference there were effects of culture; Chinese observers preferred darker samples and UK observers preferred lighter samples.

Introduction

Black is a multi-dimensional and important colour in our daily life. It is particularly important as an ink in printing systems and many black inks include a number of dyes or pigments. Therefore, black inks exhibit slight differences in colour. Which hues appear most black? And do observers have a preference for some hues over others in terms of blackness? This study aims to explore blackness preference (observers were asked to indicate which of two black samples they preferred) and blackness perception (observers were asked to indicate which of two black samples they considered to be closest to a pure black) for observers from different cultures (defined in this study by gender and nationality).

There are three dimensions of colour: hue, value and chroma and this study is focused on value and chroma. An earlier study considered blackness perception and preference with particular emphasis on the effect of hue [1]. In that study neither nationality nor gender had a high impact on blackness perception. However, the results showed clearly that colour preference of blackness was influenced by nationality particularly (and by gender to a smaller extent). Interestingly there was also a difference between blackness perception and blackness preference. Though most observers perceived the darkest and least chromatic samples to be the most black, these samples were not judged to be the most preferred blacks. Most observers expressed a strong preference for bluish blacks and a lesser preference for yellowish blacks. The aim of this research is to further explore the difference between perception and preference for black and to seek to validate the effects of nationality and gender that were found in the earlier work [1]. In this study the samples varied predominantly in value and chroma.

Experimental

Methods

The set of colour samples was 29 colours (Figure 1) taken from the Munsell system. For each of ten Munsell hues (R YR Y GY G BG B PB P RP) three samples were selected (Munsell V/C = 1/2, V/C = 1/4 and V/C = 2/2). The exception was for the hue Y where only two samples were available (see Table 1). RGB values were obtained for each of the 29 samples and these were used to display the colours on a computer display. The RGB values were obtained from the 2006 WallkillColour Table of Munsell Conversion Program (WallkillColour Munsell Conversion Software).

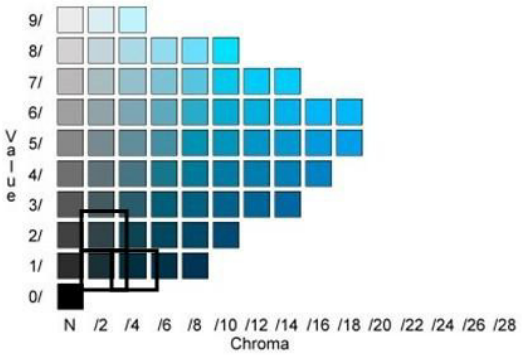

Figure 1. *Colour samples from the Munsell system.*

Table 1: RGB values of the colour samples.

Hue	V/C = 1/2	V/C = 1/4	V/C = 2/2
5B	[19 36 43]	[0 38 52]	[39 55 61]
5BG	[20 36 37]	[0 39 41]	[39 55 55]
5G	[24 36 31]	[0 39 27]	[42 55 49]
5GY	[31 35 24]	[23 28 0]	[49 54 42]
5P	[41 30 45]	[45 26 52]	[58 49 63]
5PB	[28 34 46]	[21 34 56]	[47 52 65]
5R	[48 28 32]	[57 22 32]	[67 47 49]
5RP	[45 28 40]	[52 23 44]	[65 47 56]
5Y	[40 33 16]	-	[58 52 37]
5YR	[47 30 23]	[57 24 5]	[65 49 41]

An alternative approach would be to specify the Munsell samples with CIE coordinates and then use monitor characterization to determine the appropriate RGB values to display those colours. However, note that colour management is imperfect and the actual colours displayed would be likely to differ from those that were intended. Our approach was to use the RGB values as a guide for obtaining approximately the correct colours on screen and then to measure the CIE values of the actual colours that were displayed. The CIE tristimulus values of each colour on-screen were carefully measured using a Minolta CS100 colorimeter. The white of the display was used in subsequent calculations of CIELAB values for the samples. Table 2 shows the CIE values of all colour samples as measured experimentally.

The colour samples were presented to the observers in pairs as shown in Figure 2 (such that the samples in each pair had the same hue) on a computer screen GUI (written in MATLAB) with neutral grey (R=G=B=133) background. The samples were each 8 cm × 8 cm and viewed from approximately 90 cm.

Table 2: Measured CIELAB values.

Hue	V/C = 1/2	V/C = 1/4	V/C = 2/2
	L*	a*	b*
5B	32.73	-4.43	-4.66
5BG	31.91	-7.93	0.00
5G	32.51	-10.36	5.62
5GY	32.13	-6.62	11.46
5P	32.65	8.04	-6.22
5PB	32.83	-0.99	-6.32
5R	31.83	8.92	3.56
5RP	32.02	10.61	-2.98
5Y	32.24	-4.62	18.69
5YR	30.70	3.64	12.22
Hue	**V/C = 1/2**	**V/C = 1/4**	**V/C = 2/2**
	L*	**a***	**b***
5B	30.23	-10.84	-10.90
5BG	30.64	-17.14	-2.99
5G	30.08	-20.72	7.11
5GY	30.41	-18.65	31.83
5P	30.84	14.50	-12.76
5PB	31.53	1.14	-14.11
5R	30.05	19.10	2.08
5RP	29.93	19.50	-8.30
5Y	-	-	-
5YR	29.48	9.30	30.23
Hue	**V/C = 1/2**	**V/C = 1/4**	**V/C = 2/2**
	L*	**a***	**b***
5B	32.73	-4.43	-4.66
5BG	31.91	-7.93	0.00
5G	32.51	-10.36	5.62
5GY	32.13	-6.62	11.46
5P	32.65	8.04	-6.22
5PB	32.83	-0.99	-6.32
5R	31.83	8.92	3.56
5RP	32.02	10.61	-2.98
5Y	32.24	-4.62	18.69
5YR	30.70	3.64	12.22

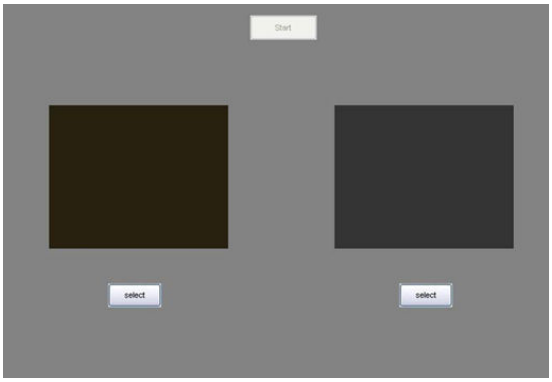

Figure 2. *The GUI used in the experiment.*

The experiment was carried out in two phases. First, the observers were asked to choose which colour (of a pair) they prefer (blackness preference); second, they were asked to choose which colour was the closest to a pure black (blackness perception). All observers were tested in the same environment (CRT monitor at a distance of 90 cm, a visual field size of 15°, and using the same computer in a dark room). Observers were asked to indicate their choice by pressing the button below the colour samples (see Figure 2) after which the next pair of colour samples would be displayed. In this study 25 observers took part; 13 Chinese people and 12 UK people. All of these observers passed the Ishihara Test for colour blindness before participating in the experiment and were therefore assumed to have normal colour vision. The test for colour blindness was carried out in the darkened room during the period (approximately 20 minutes) in which the observers adapted to the environment.

Data Analysis

In this study a pair-wise comparison procedure was used (Thurstone, 1927; Morrissey, 1955). That is, the colour samples were presented in pairs in each hue group and the observer was forced to choose one of a pair over the other according to some criterion – phase 1 (blackness preference) or phase 2 (blackness perception). The total number of observations was 1400 (28 pairs × 25 observers × 2 phases).

Results

Blackness Preference

The experiment was divided into two phases: blackness preference and blackness perception. In this section the results of the blackness preference phase are analysed. Recall that observers were asked to indicate which of a pair of samples they preferred.

Figure 3 shows the scale values for colour preference of nationality in each colour group. Chinese observers preferred V1C2, but V2C2 has a high preference score for UK observers. In addition, they have the lowest score in other nationality group respectively (V1C2 = -0.06, V2C2 = 0.10 for UK and V1C2 = 0.10, V2C2 = -0.08 for Chinese). That means Chinese observers like the darkest samples and British observers like the lightest ones. Table 3 displays the scale values of colours according to nationality.

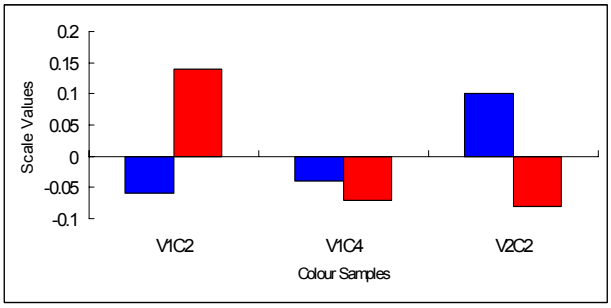

Figure 3. *Scale values for colour preference scaling for UK (blue bars) and Chinese (red bars) observers.*

Figure 4 indicates the general order of preference of colour samples in different nationality groups. The all colours are divided into ten groups according by hue, and there are three sections in each hue. As indicated in Figure 4, 5G, 5GY and 5PB have similar range in both groups. Almost all people in these two groups preferred V2C2 and disliked V1C4. But there was very big difference in 5BG, 5R and 5RP. Figure 4 shows, in 5BG Chinese preferred V1C4 but disliked V2C2, but the results for UK observers were contrary to Chinese (V1C4 is lowest one and V2C2 is highest one). Same as that, in 5R V1C2 (0.18) has highest scores and V1C4 (-0.08) has lowest score in the Chinese group. But V1C4 (0.55) of 5R was clearly the favorite colour

and V1C2 (-0.32) was dislike colour for UK observers. Similarly, UK observers dislike V2C2 (-0.15) in 5RP, but Chinese have strongly agreed that V1C4 (-0.92) is the least favorite colour in 5RP colour groups.

Table 3: Scale values for colour preference according to nationality.

Hue	V1C2	
	UK	Chinese
5B	-0.37	-0.07
5BG	0.00	-0.10
5G	0.00	0.37
5GY	0.24	0.32
5P	-0.32	0.00
5PB	0.00	0.29
5R	-0.32	0.18
5RP	0.15	1.49
5Y	0.11	0.14
5YR	-0.14	0.39
All	**-0.06**	**0.14**
Hue	**V1C4**	
	UK	**Chinese**
5B	0.29	0.69
5BG	-0.55	0.55
5G	-0.55	-0.53
5GY	-0.92	-0.45
5P	0.60	0.55
5PB	-0.14	-0.32
5R	0.55	-0.08
5RP	0.00	-0.92
5Y	-	-
5YR	0.21	0.29
All	**-0.04**	**-0.07**
Hue	**V2C2**	
	UK	**Chinese**
5B	0.08	-0.32
5BG	0.55	-0.37
5G	0.55	0.39
5GY	0.69	0.39
5P	-0.29	-0.29
5PB	0.14	0.32
5R	-0.22	0.15
5RP	-0.15	0.71
5Y	0.00	-0.07
5YR	-0.07	-0.39
All	**0.10**	**-0.08**

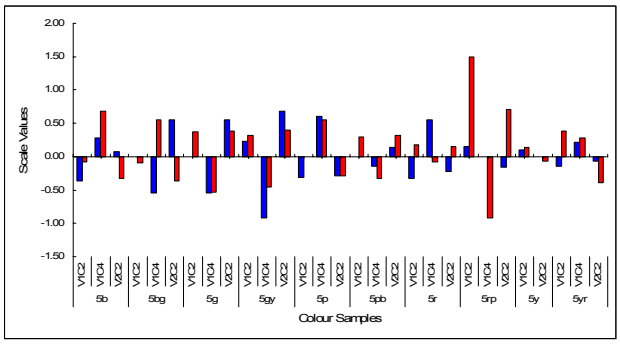

Figure 4. *Scale values for colour preference scaling for UK (blue bars) and Chinese (red bars) observers in each hue.*

Table 4 shows the scale values for male and female groups pooled over all nationalities. As Figure 5 indicated females gave the similar scores to all colour section. V1C2, V1C4 and V2C2 have very close scores (V1C2 = -0.01, V1C4 = -0.02 and V2C2 = 0.02). V2C2 is a little high than others and V1C4 is a little bit lower. But there have a quite difference for males. Males preferred V1C2 (0.13) and disliked V1C4 (-0.08). As Figure 5 shows, both females and males do not like V1C4. The V1C4 colour samples always have lowest scores of three sections.

Table 4: Scale values for colour preference according to nationality.

Hue	V1C2	
	UK	Chinese
5B	-0.26	-0.23
5BG	0.08	-0.18
5G	0.34	0.06
5GY	1.34	0.06
5P	-0.25	-0.14
5PB	0.43	-0.06
5R	-0.08	-0.11
5RP	0.56	0.36
5Y	0.84	-0.08
5YR	-0.11	0.17
All	**0.13**	**-0.01**
Hue	**V1C4**	
	UK	**Chinese**
5B	0.46	0.36
5BG	-0.17	0.17
5G	-0.85	-0.40
5GY	-2.84	-0.42
5P	0.60	0.42
5PB	-0.85	0.06
5R	0.17	0.17
5RP	-0.71	-0.23
5Y	-	-
5YR	0.46	-0.06
All	**-0.08**	**-0.02**
Hue	**V2C2**	
	UK	**Chinese**
5B	-0.20	-0.14
5BG	0.08	-0.11
5G	0.51	0.31
5GY	1.51	0.35
5P	-0.35	-0.29
5PB	0.43	0.00
5R	-0.09	-0.06
5RP	0.15	-0.14
5Y	-0.84	0.08
5YR	-0.35	-0.12
All	**0.08**	**0.02**

Figure 6 shows scaled values for colour preference in each hue according to gender. The results indicated that people have different perspectives between male and female in 5BG and 5PB sections. Females gave the lowest scores to V1C2 (5BG = -0.18 and 5PB = -0.06) and the highest scores to V1C4 (5BG = 0.17and 5PB = 0.06) in both sections, but males preferred V2C2 (5BG = 0.08 and 5PB = 0.43) and disliked V1C4 (5BG = -0.17 and 5PB = -0.85). In 5Y hue selection, the results between male and female are the exact opposite. Male preferred V1C2 and disliked V2C2, but female gave a higher score to V2C2 than V1C2. As the Figure 7 shows, V2C2 has a high score and V1C4 has a low score in 5G and 5GY hue selections both in male and

female group (V2C2 = 0.51 for male, V2C2 = 0.31 for female and V1C4 = -0.85 for male, V1C4 = -0.40 for female in 5G; V2C2 = 1.51 for male, V2C2 = 0.35 for female and V1C4 = -2.84 for male, V1C4 = -0.42 for female in 5GY). It also indicated both male and female liked V1C4 in 5B, 5P and 5R hue selections.

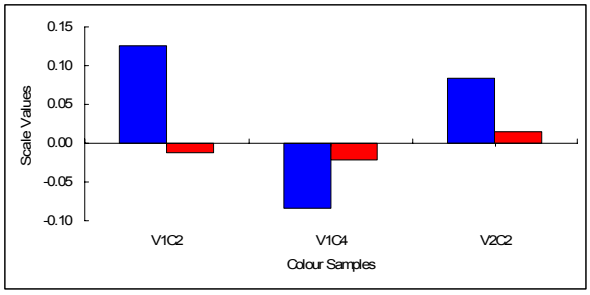

Figure 5. *Scale values for colour preference scaling for Male (blue bars) and Female (red bars).*

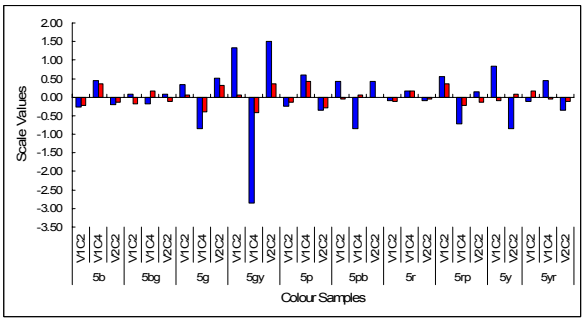

Figure 6. *Scale values for colour preference scaling for Male (blue bars) and Female (red bars) observers in each hue.*

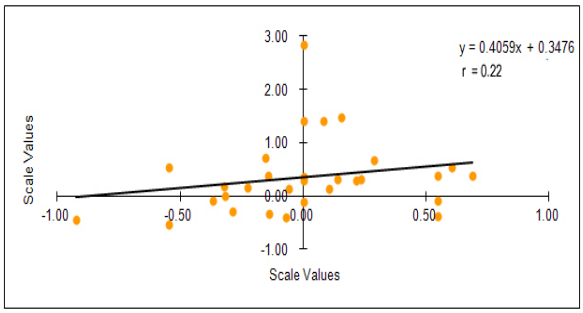

Figure 7. *Scale values for colour preference scaling accordingly to nationality (UK and Chinese).*

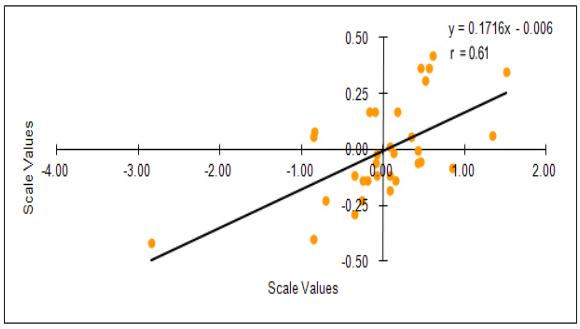

Figure 8. *Scale values for colour preference scaling accordingly to gender (Male and Female).*

Figure 7 and Figure 8 could indicate that culture differences play an important role in colour preferences. The correlation coefficients (r) for nationality and gender are 0.22 and 0.61 respectively. This could indicate that colour preference is influenced by culture, and that nationality has a greater effect on colour preference than gender.

The results indicated when observers were asked about colour preference, the results were very different. The correlation coefficient for the nationality comparison is 0.22 and for gender is 0.61. This could suggest that there are systematic differences between nationality and gender. The results are consistent with previous research which discussed the gender and nationality difference of colour preference according to hue.

Blackness Preference

In this section the results of the blackness perception phase are analysed. Recall that observers were asked which of two black samples they judged to be closest to a pure black.

Table 5: Scale values for colour preference according to nationality (UK and Chinese).

Hue	V1C2	
	UK	Chinese
5B	2.84	2.84
5BG	2.84	2.84
5G	2.84	2.84
5GY	2.84	2.84
5P	2.84	2.84
5PB	2.84	2.84
5R	2.84	2.84
5RP	2.84	2.84
5Y	1.42	1.02
5YR	2.84	2.84
All	**2.84**	**2.14**
Hue	**V1C4**	
	UK	**Chinese**
5B	-1.10	-1.39
5BG	-1.65	-1.76
5G	-2.84	-1.90
5GY	-1.88	-1.90
5P	-1.28	-1.39
5PB	-2.84	-1.76
5R	-2.84	-1.76
5RP	-1.42	-1.45
5Y	-	-
5YR	-2.84	-1.76
All	**-1.64**	**-1.65**
Hue	**V2C2**	
	UK	**Chinese**
5B	-1.74	-1.45
5BG	-1.20	-1.08
5G	0.00	-0.95
5GY	-0.96	-0.95
5P	-1.57	-1.45
5PB	0.00	-1.08
5R	0.00	-1.08
5RP	-1.42	-1.39
5Y	-1.42	-1.02
5YR	0.00	-1.08
All	**-1.21**	**-0.49**

Table 5 shows the scale values of each colour sample those results from different nationality (British and Chinese). The greater and more positive the scale values the more the sample was judged against the criterion of being pure black. Figure 9 illustrates the scale values of colour samples. It shows all scale values are similar in different group that V1C2 has the highest scale value (2.84 for British and 2.14 for Chinese); then V2C2 ranked second place (-1.21 for British and -0.49 for Chinese); at least, V1C4 is the least blackness colour sample that -1.64 for British and -1.65 for Chinese. This result indicates that people considered V1C2 to be the nearest colour to pure black. This is expected, since it is the darkest of all the samples being considered. Then people think V2C2 is blacker than V1C4, which means the more colorful sample, the less blackness.

Figure 10 shows scale values for colour perception according to nationality in details. It indicates that there no difference between the UK and China populations in different hue group. All scale values in different hue groups of Chinese and British are similar. V2C2 have the more positive the scale values in most hue groups, but it shows that there has a difference rank in 5B and 5P hue groups. The result shows that people considered that V1C4 is blacker than V2C2, which means the more colorful, the more blackness in 5B and 5P.

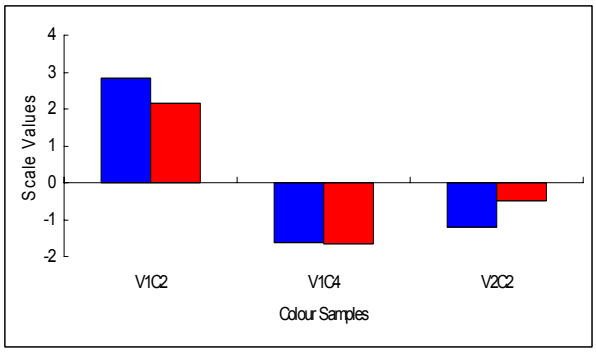

Figure 9. *Scale values for colour perception scaling for UK (blue bars) and Chinese (red bars) observers.*

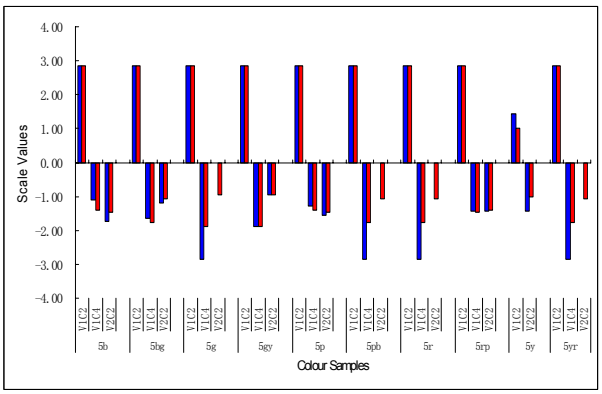

Figure 10. *Scale values for colour perception scaling for UK (blue bars) and Chinese (red bars) observers in each hue.*

Table 6 displays the scores of colour samples according to colour perception of different genders. Figure 11 shows a direct comparison between male and female; it seems that results from female and male observers are similar like nationality. V1C2 is the most blackness and V1C4 is the least blackness colour sample in male and female groups.

Table 6: Scale values for colour preference according to nationality.

Hue	V1C2	
	UK	Chinese
5B	2.84	2.84
5BG	2.84	2.84
5G	2.84	2.84
5GY	2.84	2.84
5P	2.84	2.84
5PB	2.84	2.84
5R	2.84	2.84
5RP	2.84	2.84
5Y	1.42	0.37
5YR	2.84	2.84
All	**2.84**	**2.16**
Hue	**V1C4**	
	UK	**Chinese**
5B	-1.14	-1.34
5BG	-1.60	-1.79
5G	-2.84	-1.92
5GY	-2.84	-1.79
5P	-1.25	-1.39
5PB	-2.84	-1.79
5R	-2.84	-1.79
5RP	-1.51	-1.45
5Y	-	-
5YR	-2.84	-1.79
All	**-1.65**	**-1.64**
Hue	**V2C2**	
	UK	**Chinese**
5B	-1.70	-1.51
5BG	-1.25	-1.05
5G	0.00	-0.92
5GY	0.00	-1.05
5P	-1.60	-1.45
5PB	0.00	-1.05
5R	0.00	-1.05
5RP	-1.34	-1.39
5Y	-1.42	-0.37
5YR	0.00	-1.05
All	**-1.19**	**-0.52**

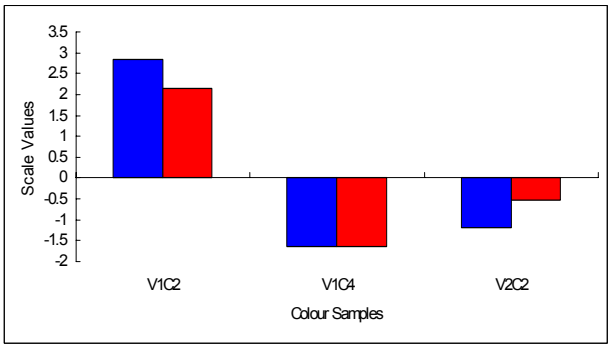

Figure 11. *Scale values for colour perception scaling for gender: Male (blue bars) and Female (red bars).*

Figure 12 indicated the scaled values for colour perception according to gender in each hue, and there are no differences compared to when we considered the effect of nationality. Thus, the result suggests that both male and female observers rate V2C2 is blacker than V1C4 in most hues except 5B and 5P. But in general, same as the results of colour perception according to

nationality, gender does not have a significant influence on blackness perception.

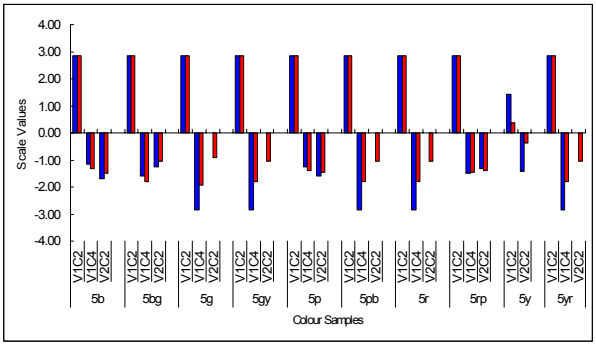

Figure 12. *Scale values for colour perception scaling according to gender: Male (blue bars) and Female (red bars) in each hue.*

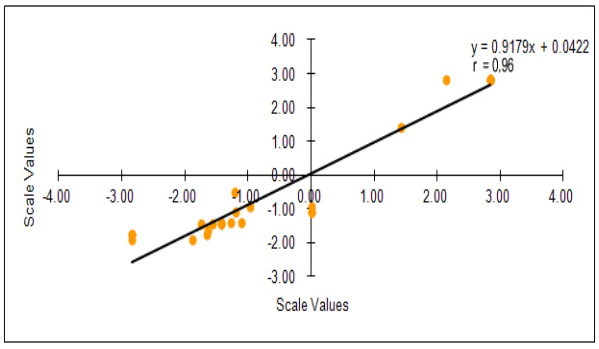

Figure 13. *Scale values for colour perception scaling according to nationality (UK and Chinese).*

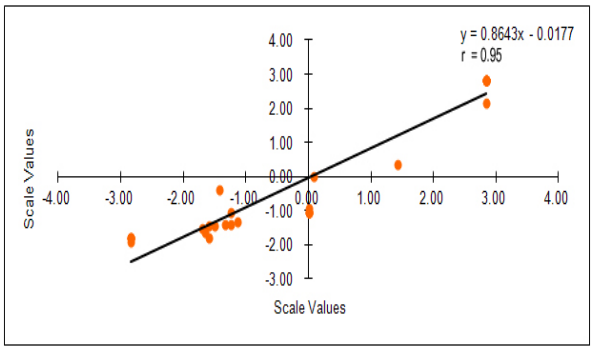

Figure 14. *Scale values for colour perception scaling according to gender (Male and Female).*

According to the results in this phase, Figures 13 and 14 (the correlation coefficient (r) is 0.96 for the nationality and 0.95 for the gender) indicate that neither culture nor gender have a significant influence on blackness perception. Regardless of cultural background, there is a common understanding of what is black.

Conclusions

The main aim of this study was to investigate the relationship between blackness perception and blackness preference and to explore the effects of nationality and gender on this relationship. In this study particular emphasis was placed on value and chroma.

When observers were asked about which black is a pure black neither nationality nor gender differences had a significant impact on results. For example, the scale values derived from observers from Chinese and UK observers were strongly correlated. The correlation coefficients (r) for the nationality and gender comparisons were 0.96 and 0.95 respectively.

When observers were asked about blackness preference, the results were very different. The correlation coefficient for the nationality comparison is 0.22 and for the gender comparison is 0.61. This could suggest that there are systematic differences between nationality and gender groups in this regard.

In an earlier (related) study [1] it was shown that for blacks that vary in hue there was no effect of culture on blackness perception; however, there was evidence (as in this study) that nationality and gender may affect blackness preference.

We note that the effect of the background could have a large effect on performance in the tasks. However, in this study the background was not a parameter that was evaluated; rather, a standard background condition was employed throughout the experiments. The study seems to reveal cultural differences in blackness preference. Further work is required to confirm this tentative finding using more observers and also, possibly, greater control over the observers' other characteristics (such as whether they were experienced in looking at colours). In addition, it would be interesting to collect qualitative feedback from the participants in order to provide a deeper contextual analysis.

References

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