BLACK HUES MATCHING PROBLEM IN CLOTHES DESIGNING

Glogar, M. I.[1], **Parac-Osterman, Đ.**[1]
[1] *University of Zagreb, Faculty of Textile Technology*
martinia.glogar@ttf.hr

ABSTRACT

In practice the colour matching, in general, is performed based on objective instrumental evaluation of colour parameters and their differences using CIELAB colorimetric system, according to tolerances set by ISO standard. In most cases, the method of instrumental evaluation uses the interval scale in accordance to visual perception of colour and their differences, but in the area of deep dark hues, in this case black hues, the objective evaluation cannot obtained the difference values in accordance to psychological experience of colour. The black hues are characterized with low lightness value on which level the visual perception of colour parameters differ from the measuring results. It is often the case that the instrumental control confirm the colour difference among samples in the range of tolerances set by the ISO standards, while observer perceive certain differences and doesn't accepts the sample. In this paper the analyze of psychological experience and instrumental evaluation of colour parameters and their differences is performed on group of black textile samples, glossy and matt, with colour coordinates values a* +/-1; b* = +/-1, with lightness parameter L*< 16. The psychological perception was set based on visual evaluation by 10 observers.

Keywords: *black hues matching, dE_{ab}, dL*.*

1. INTRODUCTION

In processes of designing with black hues, the requests on colour parameter matching are very high. Much of textile production involves reproductions that should ideally be of exactly the same colour as the original one, predicting the minimum of discrepancies. In practice the colour matching, in general, is performed based on objective instrumental evaluation of colour parameters and their differences using CIELAB colorimetric system, according to tolerances set by ISO standard. In most cases, the method of instrumental evaluation uses the interval scale in accordance to visual perception of colour and their differences, but in the area of deep dark hues, in this case black hues, the objective evaluation cannot obtained the difference values in accordance to psychological experience of colour. The black hues are characterized with low lightness value on which level the visual perception of colour parameters differ from the measuring results. It is often the case that the instrumental control confirm the colour difference among samples in the range of tolerances set by the ISO standards, while observer perceive certain differences and doesn't accepts the sample [1, 2, 3].

In this paper the analyze of psychological experience and instrumental evaluation of colour parameters and their differences is performed on group of black textile samples, glossy and matt, with colour coordinates values a* +/-1; b* = +/-1, with lightness parameter L*< 16. The psychological perception was set based on visual evaluation by 10 observers. Achromatic hues, in general, are not characterized by the dominant hue parameter, but the dominating parameter is the lightness, L*. The results obtained based on instrumental measuring and mathematical evaluation of colour and colour parameter differences as well as total colour difference, dE, showed that some pairs of samples that were set within the established tolerances accepted by the standards, during the visual assessment were rejected due to certain differences perceived by the observers. The glossy samples were perceived lighter in compare to matt regardless the measured lightness value. It was confirmed that the lightness parameter are the most responsible for visual perception in achromatic area. It was also confirmed that the spectrophotometric evaluation of colour differences in the area of lightness lower that value 16 is not reliable and differ significantly from the visual perception. Results obtained confirmed that for matching of black hues in clothes designing, some different criteria and tolerances must be set.

1.1. Short chronology of lightness parameter and its difference calculation transformations

Based on its natural characteristics, lightness is one of the most important parameter of colour in the achromatic area. If the short chronology of transformations and modifications of mathematical models for colour and colour difference evaluations is observed, it can be seen that some major modifications have been made considering the lightness parameter and its difference calculations. One of the major differences between the formulae developed and used in practice concerns lightness differences exactly [4].

Standardised system for colour and colour difference evaluation are all based on CIE tristimulus values X, Y, Z. “Y” tristimulus value (1) uniquely define lightness of one coloured surface[1].

$$Y = k\int_{380}^{700} E_\lambda \bar{y}_\lambda R_\lambda d\lambda \quad (1)$$

In CIELAB system Y value as a definition of lightness, has been replaced with a modified cube-root function of relative luminance (Y) defined as L* value (2), [1].

$L^* = 116\left(\frac{Y}{Y_n}\right)^{\frac{1}{3}} - 16$ for $Y/Y_n \geq 0{,}008856$ (2) or $L^* = 903{,}3\left(\frac{Y}{Y_n}\right)$ for $Y/Y_n \leq 0{,}008856$ (3)

Eventually, it was showed that CIELAB L* scale gives too small dL* values for dark samples and too large dL* values for light samples [1]. So CMC(l:c) mathematical model have been derived by modification of CIELAB formula employing the chroma (*c*) and lightness (*l*) variables that quantifying the tolerances for lightness and chroma differences respectively relative to hue differences. First, the lightness versus chroma tolerance was set as the 1:1 relationship, but later lightness tolerance was multiplied by factor of two. Based on the literature data, in this form, CMC formula gives better performance than all previous formula [5], [6].

$$\Delta E_{CMC(l:c)} = \left[\left(\frac{\Delta L^*}{lS_L}\right)^2 + \left(\frac{\Delta C^*}{cS_C}\right)^2 + \left(\frac{\Delta H^*}{S_H}\right)^2\right]^{\frac{1}{2}} \quad (6)$$

$$S_L = \frac{0{,}04975 L^*_1}{1 + 0{,}01765 L^*_1} \text{ unless } L^*_1 < 16 \text{ when } S_L = 0{,}511 \quad (7)$$

Further modifications concerning lightness and lightness difference evaluation was established in developing the CIEDE2000 colour difference calculation formula. [5], [6].

Based on this chronology of transformations and modifications of mathematical models for colour and colour difference evaluations there is a still many questions and problems to solve considering samples of very low lightness value, L*≤16.

In this paper the analysis of black dyed samples with L* value under 16 were carried out with difference calculations according to standard CIELAB and CMC(l:c) colour difference formula.

2. EXPERIMENTAL PART

For the analyze a group of 13 specific black textile samples were chosen. In this group the 6 samples were matt and the 7 samples were glossy. The chosen samples were measured spectrophotometricaly by means of remission spectrophotometer *DataColor®* type SF600+CT, with constant instrument aperture (apertures “L”=2.6), using d/8° geometry, in order to obtain the characteristics of lightness parameter and "a/b" co-ordinates. The results of a measured values, (L*,a* b*), is shown in the Table 1.

Table 1: Measured colour parameters values for tested group of samples

	L	**a**	**b**	**C**	**h**	**Gloss G/ Matt M**
Standard Sample 1	*13.96*	*0.08*	*-1.00*	*1.00*	*274.57*	*M*
Sample 2	12.06	0.08	-1.00	1.00	274.57	*M*
Sample 3	14.80	-0.08	-1.00	1.00	265.42	*M*
Sample 4	14.90	0.40	-0.50	0.64	308.66	G
Sample 5	13.80	0.80	-0.10	0.81	352.87	G
Sample 6	15.00	0.50	-0.60	0.78	309.81	M
Sample 7	16.00	0.20	-1.00	1.02	281.31	M
Sample 8	16.00	0.10	0.30	0.32	71.57	G
Sample 9	14.50	-0.40	0.60	0.72	123.69	G
Sample 10	13.10	-0.80	0.90	1.20	131.63	G
Sample 11	12.90	0.10	-0.20	0.22	296.56	M
Sample 12	15.50	0.30	0.70	0.76	66.80	G
Sample 13	13.30	0.05	-0.08	0.09	302.01	G

Values of a* and b* co-ordinates are presented in the form of a*/b* diagram and shown on Figure 1.

Further analyze was performed by calculating the total colour difference value (dE) and colour parameter differences values (dL*, da*, db*) employing two colour difference formula: CIELAB and CMC(l:c). Sample 1 was chosen as the standard in calculating the colour difference parameters. The results obtained in colour difference calculations are shown in Table 2.

Also the psychological perception was set based on visual evaluation by 10 normal colour vision observers. The observers had to sort the tested samples by the lightness observed in compare to a standard. The results of visual evaluation are shown on Figure 2.

3. RESULTS AND DISCUSSION

In the area of lightness value lower than value 16 (L<16), some visual selectivity problem would be expected due to a certain sloth of the human eye for colours of very low lightness. The parameters of hue and chroma have no significant influence in the area of achromatic hues, while the lightness is the only parameter that enables the observer to distinguish the blacks from whites and greys.

It can be seen, (Figure 1), that the samples measured are placed in all four quadrant of a*/b* space in are of a*/b* values of ±1 (narrow achromatic area). It can be expected that due to a different hue value (shift in a* and b* values), some higher differences in comparison to a standard will occur, meaning certain problems in black colour matching in designing can be expected.

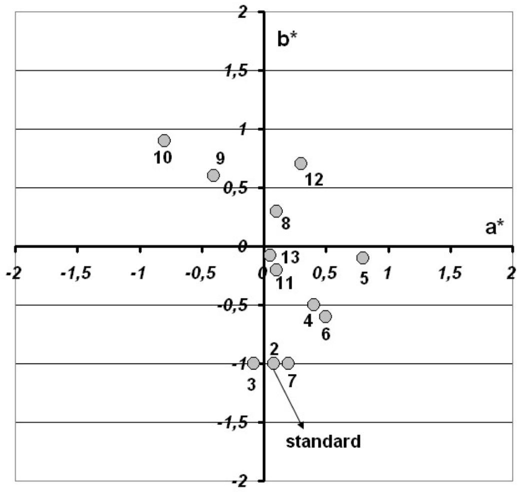

Figure 1: a*/b* diagram of a tested samples

In the further analyse the total colour difference value (dE) and colour parameter differences values, employing two colour difference formula, CIELAB and CMC(l:c), were calculated in compare to a chosen standard.

Table 2: Colour difference values obtained employing CIELAB and CMC(l:c) difference formula

dE CIELAB							dE CMC(l:c)				
	dL	da	db	dC	dh	dE		dL/Sl	dC/Sc	dh/Sh	dE
Sample 2	-1.90	0.00	0.00	0.00	0.00	**1.90**	**Sample 2**	-1.86	0.00	0.00	**1.86**
Sample 3	0.84	-0.16	0.00	0.00	-0.16	**0.86**	**Sample 3**	0.82	0.00	-0.23	**0.85**
Sample 4	0.94	0.32	0.50	-0.36	0.47	**1.11**	**Sample 4**	0.92	-0.52	0.68	**1.25**
Sample 5	-0.16	0.72	0.90	-0.20	1.14	**1.16**	**Sample 5**	-0.16	-0.28	1.64	**1.67**
Sample 6	1.04	0.42	0.40	-0.22	0.54	**1.19**	**Sample 6**	1.02	-0.32	0.77	**1.32**
Sample 7	2.04	0.12	0.00	0.02	0.12	**2.04**	**Sample 7**	2.00	0.02	0.17	**2.00**
Sample 8	2.04	0.02	1.30	-0.69	1.10	**2.42**	**Sample 8**	2.00	-0.98	1.59	**2.73**
Sample 9	0.54	-0.48	1.60	-0.28	-1.65	**1.76**	**Sample 9**	0.53	-0.40	-2.37	**2.46**
Sample 10	-0.86	-0.88	1.90	0.20	-2.08	**2.26**	**Sample 10**	-0.84	0.29	-3.00	**3.13**
Sample 11	-1.06	0.02	0.80	-0.78	0.18	**1.33**	**Sample 11**	-1.04	-1.11	0.26	**1.54**
Sample 12	1.54	0.22	1.70	-0.24	1.70	**2.30**	**Sample 12**	1.51	-0.34	2.44	**2.89**
Sample 13	-0.66	-0.03	0.92	-0.91	0.15	**1.13**	**Sample 13**	-0.65	-1.30	0.21	**1.46**

Regarding the modification of lightness tolerance in CMC(l:c) equation, some slight difference can be observed in lightness difference value (dL*), but since the S_L factor was set as constant for L<16 the lightness differences obtained for both formula are approximately equal. Also the values dE provided by CIELAB formula are followed by the results obtained for CMC(l:c) formula, with no significance difference. So, regardless on the literature data which define that, in this form, CMC formula gives better performance than all previous formula, there is a still many questions and problems to solve considering samples of very low lightness value, L*≤16.

The samples 7, 8, 9, 10 and 12 should be pointed out. For samples 9,10 and 12, significant difference of hue parameter (dh) obtained which caused the dE values out of tolerance. For samples 7 and 8 dE values obtained out of tolerance is caused by significant lightness parameter difference (dL*) (Table 2).

While performing the visual assessment, the observer had to sort the tested samples according to lightness value in compare to a standard. Value 1 was assigned to a standard, while the samples observed lighter than standard was assigned the numerical values up to 2 and the samples observed darker than standard was assigned the numerical values less than 1. Regarding this, the observers were evaluated the tested samples as it is shown on a Figure 2.

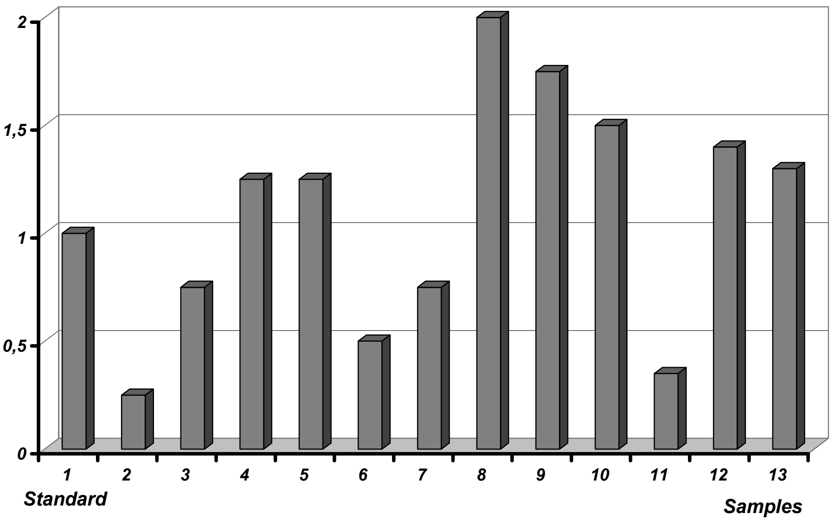

Figure 2: Subjective evaluation of samples by comparison based on perceived lightness difference in compare to standard.

The visual assessment significantly differ from the measured values of difference. It can be seen that observers experienced glossy samples lighter in compare to standard, while matt samples were experienced darker.
Also, the observers evaluated all tested samples as black with no perceived difference in hue parameter. During instrumental assessment, the samples which had a*/b* co-ordinates in different quadrant in compare to standard, obtained hue difference value out of tolerance (dh>0,6), although all samples are from narrow achromatic area. It is confirmed that, although the lightness is considered to be the dominant parameter for achromatic hues, not only the change on lightness scale but also the changes of position in a*/b* colour space would cause significant colour differences, which can cause problems in black colour matching and designing.

4. CONCLUSION

Knowledge of colour influence on observer′s perception, of their energetic relations is essential in artistic creation of an designer. In processes of designing with black hues, the requests on colour matching are very high. Although in the achromatic area visual selectivity problem exist due to a sloth of the human eye for colours of very low lightness, some differences in visual experience of "blackness" can occur.

It was confirmed that the matching of black hues cannot be estimated based on total colour difference value (dE), but some different criteria must be set. Based on the analyze of a*/b* plot of tested samples, it can be defined that the samples should be positioned in the same quadrant and same lightness (L*) level. Also, the criteria of a*/b* values within values ±1 must be set.

Lightness difference value must be set on tolerance of dL*< 0,9, while a* and b* difference values must be set on tolerances of da* < 0,4 and db* < 0,4.

Regardless the modification of lightness tolerance in CMC(l:c) equation, there was no significantly improved performance for the achromatic samples with low lightness value, in compare to CIELAB formula.

5. REFERENCES

1. McDonald, R.: *Colour Physic for Industry*, Society of Dyers and Colourists, ISBN 0 901956 45 7, Bradford, (1987)
2. Chou, W.; Lin, H.; Westland, S.; Rigg, B.; Nobbs, J.: Performance of Lightness Difference Formulae, *Coloration Technology*, **Vol. 117** (2000), pp. 19 – 29.
3. Jordan, D., M.; DyStar, L., P.; Charlotte, N., C.: Color Tolerances in Textile Manufacture, *AATCC Review*, **Vol. 1** (2007.)10, str. 76 – 80, ISSN 1532 – 8813
4. Ikeda, M.; Shinoda, H; Mizokami, Y: Phenomena of Apparent Lightness Interpreted by the Recognized Visual Space of Illumination, *Optical Review*, **Vol. 5,** (1998) No.6, pp. 380 – 386.
5. McDonald, R.; J. & P. Coats Ltd.: Acceptability and Perceptibility Decisions Using the CMC Color Difference Formula, *Journal of AATCC,* **Vol. 20** (1988.) No.6, pp. 31 - 37
6. Heggie, D.; Wardman, R. H.; Luo, M. R.: A Comparison of the Colour Differences Computed using the CIE94, CMC(l:c) and BFD(l:c) Formulae, *Journal of Society of Dyers and Colourists,* **Vol. 112** (1996) No.10, pp. 264 - 269