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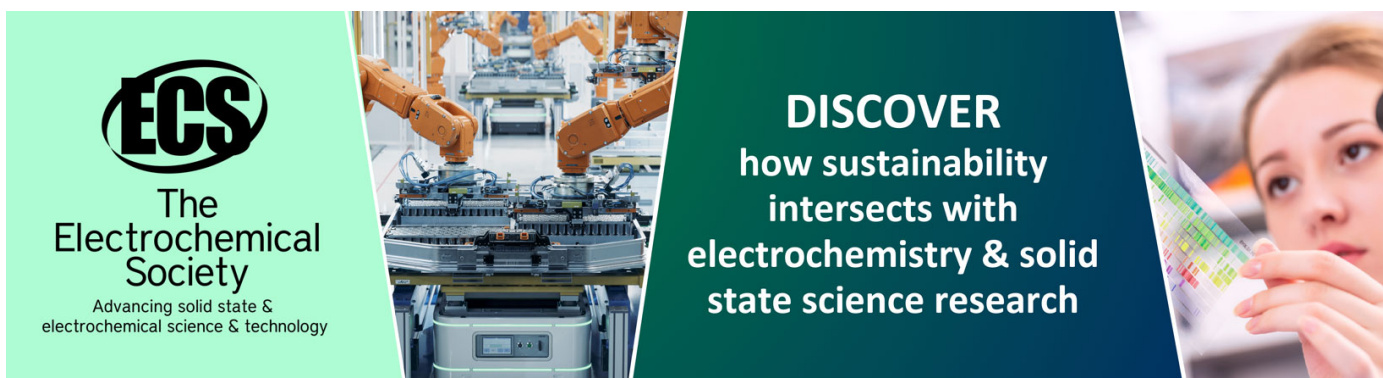
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Visual colour fastness assessments for multi-coloured fabrics

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Abstract. The characteristic of the colour fastness assessment for multi-colours fabrics were investigated. Visual assessments were conducted by experts for assessing colour fastness. The obtained visual results were compared with colour fastness from an instrumental colour fastness rating as a reference value. In addition, the assessment by the experts were compared with that of non-experts obtained in a previous study. As the results, the visual ratings of experts and non-experts were around 1 rating higher than the instrumental ratings. There were some differences in the assessments between the experts and the non-experts, and also among the experts. These results indicates that it is difficult to assess the colour changes of multi-coloured fabrics.

1. Introduction

Colour of textile products is one of the most important qualities for consumers' purchase motivation. Change in colour of textile products often tops the list of consumer complaints. Colour fastness is described as "the resistance of the colour of textiles to the different agents to which these materials may be exposed during manufacture and their subsequent use" [1]. Usually, colour fastness is described with respect to "change in colour" and "staining". Colour fastness particularly "change in colour" is focused in this study. International Organization for Standardization (ISO) [1-3] and Japanese Industrial Standards (JIS) [4,5] introduced the evaluation methods for colour fastness, visually and instrumentally. Instrumental methods are not often used in practice because it is time-consuming to measure colours with an instrument. In addition, fastness formulas to derive the fastness ratings from measured colours are not well established and there is hence room for further consideration [6,7]. Therefore, the fastness evaluation is mostly carried out visually in practice. Experts assess the fastness as a part of quality assessments. It has not been any problem if a fabric is simple. For example, a fabric consists of single colour. Experts are also able to assess fastness even a multi-coloured fabric. However, it is vaguely aware that there could be inconsistency in results of a colour fastness rating of a complicated patterns' fabric assessed by experts. There is no study to indicate the difficulty of the colour-fastness assessment of multi-coloured fabrics. Therefore, in order to understand the characteristics of visual assessment of multi-coloured fabrics, multi-coloured fabrics samples were created and the assessments were carried out by experts of assessing colour fastness. The difference among experts were statistically analysed. Furthermore, the results of experts were compared with the results of non-experts whose data were collected in our previous study [8].



2. A standard method for fastness assessment

In a standard method of assessing colour fastness, a standard grey scale, as shown in Figure 1, is used as a reference for fastness rating [1,2,4]. A grey scale consists of nine pairs of grey coloured chips aligned alongside each other. Each pair has rate which is arranged according to the contrast between each pair. The range of the rate is 5 to 1 with four additional intermediate half rate: 5, 4-5 (4.5), 4, 3-4 (3.5), 3, 2-3 (2.5), 2, 1-2 (1.5) and 1. Regarding the change in colour, the fastness rating is assigned according to visual contrast between a tested sample and an original/standard sample. The rating of 5 is given to the test specimen, if there is no difference between them; otherwise rating of the grey scale which corresponds to the contrast between a tested sample and an original/standard sample is given. When samples are multi-colored fabrics and several colours are change or faded, a rating of the most changed/faded colour is given.



Figure 1. Standard grey scales for assessing change in colour [2-4].

3. Experiment

Visual assessments of colour fastness (change in colour) of multi-colored fabrics were conducted. In the visual assessments, a pair of samples: a standard sample and a test sample, were compared and a colour fastness was rated. An example of a pair of multi-coloured samples is given Figure 2. Each sample consists of four hue coloured fabrics which are Red (R), Yellow (Y), Green (G) and Blue (B). There were three types of sample pairs. One type was that one of four colours in a test sample was faded. The second type was that two of four colours in a test sample were faded. The third type was that all the four colours in a test sample were faded. The total number of the sample pairs was 189 including 20 one faded colour, 164 two faded colour and 5 four faded colour pairs. The fastness ratings of one faded colour sample pairs were either 5, 4.5, 3.5, 3, or 2.5 in each hue. Two faded-colour sample pairs had two different fastness-rating colours; one colour more faded among two were 4, 3.5, 3, 2.5 or 1, less faded colours were 0.5, 1 and 1.5 rating plus to the more faded colours. Sample fabrics were cotton (40s, 148 dtex) and their colours were dyed using direct dyestuffs (manufactured by Nippon Kayaku Co., Ltd.). A colour of the mask of the sample (Figure 2) were back. A plastic sheet was attached at the back of a sample. Thus, the samples could not be bent. Therefore, subjects could not assess the samples side by side. This means there are more than 3cm between a standard sample and a test sample.

All colours of the sample fabrics were instrumentally measured by a spectrophotometer Konica-Minolta CM-3600, and the colour fastness ratings (ICFR) of the faded colours computed using an ISO colour fastness formula [3,9]. The one color faded and two color faded sample pairs were also used in the previous study and assessed by non-experts [8].

Three experts (male) were participated in this study. In the following they are indicated V, W and X. Similar to the previous study, the samples were visually assessed under a D65 lighting condition. In the assessments, the most faded colour among the four in a test sample and its colour fastness rating (VCFR) were assigned for each sample pair.

4. Results

4.1. Comparison between visual and instrumental assessments

The differences (Δ CFR) between the visual ratings (VCFR) and the instrumental ratings (ICFR) were computed. Figure 3 (upper) shows the Δ CFR histogram of the 3 experts. The minimum value was -1.0, the maximum value was 2.5, the average value was 0.98, and the standard deviation was 0.56. The

histogram shifted in the direction of positive, thus the visual ratings were tended to be higher than the instrumental ratings. In order to compare with the non-experts' assessments, the differences (ΔCFR) between visual ratings of the non-experts (10 students, 5 male and 5 female) obtained in the previous study and the instrumental ratings were computed as well. Figure 3 (lower) shows the ΔCFR histogram of the non-experts. In Table 1, statistical values of the experts' and non-experts' results were summarised. The minimum value was -3.5, the maximum value was 3.5, the average value was 0.84, and the standard deviation was 0.76. The histogram shifted in the direction of positive as well as that of the experts, and this again indicated that the visual ratings tended to be higher than the instrumental ratings.

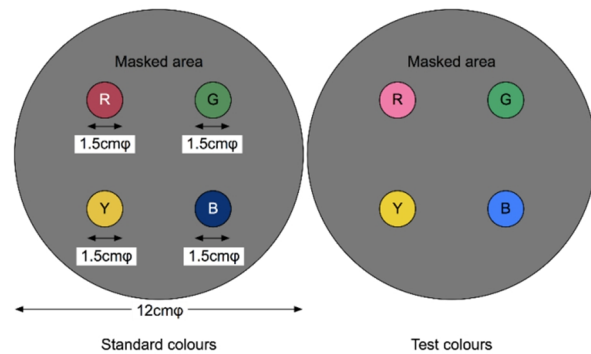


Figure 2. A sample pair of multi-colour fabrics used in this experiment (Two colour changes) (note that the this type of the sample pairs were also used in our previous study [8]).

4.2. Comparison of the assessments among the experts

Figure 5 shows the histogram of ΔCFR of each expert and Table 2 gives the statistical test of ΔCFR among the assessments of the experts. In Table 2, the values at the right upper side are P values by a t-test and those at the left lower side are P values by a F-test. The average of ΔCFR of the expert V had 1% significant difference against those of the experts W and X. The visual ratings of the expert V were around 0.5 rating higher than the instrumental ratings. The visual ratings of the experts W and X were around 1.0 to 1.5 rating higher than the instrumental ratings. However, there was no difference on the variance of ΔCFR among the three experts.

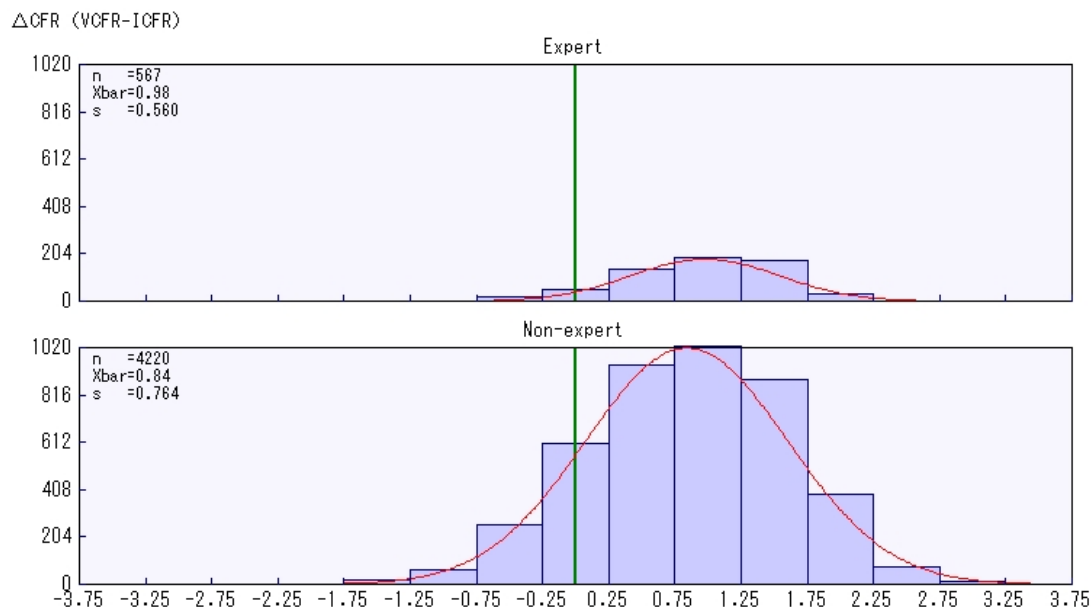


Figure 3. The difference between visual and instrumental assessments. Centre line is $\Delta\text{CFR}=0$. (Upper: Expert, Lower: Non-expert)

Table 1. Statistical values of the assessments by experts and non-experts.

Subject (n)	Number of data	Min.	Max.	Average	Standard Deviation	Skewness	Kurtosis
Expert (3)	567	-1.0	2.5	0.98	0.560	-0.403	-0.057
Non-expert (10)	4220	-3.5	3.5	0.84	0.764	-0.276	0.252

Figure 4 shows the comparison between the assessments of the experts and the non-experts on the box plots of ΔCFR . The visual ratings of the experts and the non-experts were averagely around 1 rating higher than the instrumental ratings. The standard deviation of ΔCFR of the experts was around 0.5 rating smaller than that of the non-experts. In addition, the width of ΔCFR of the experts was also smaller than that of the non-experts, and there were some outliers in ΔCFR of the non-experts.

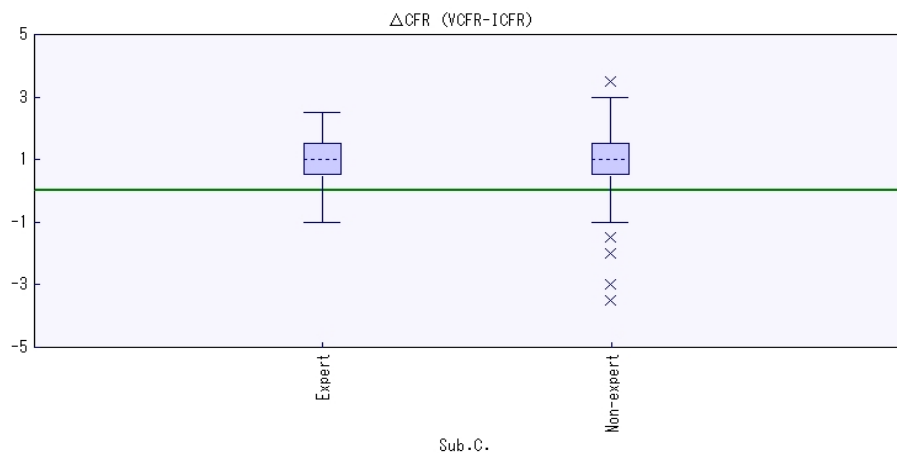
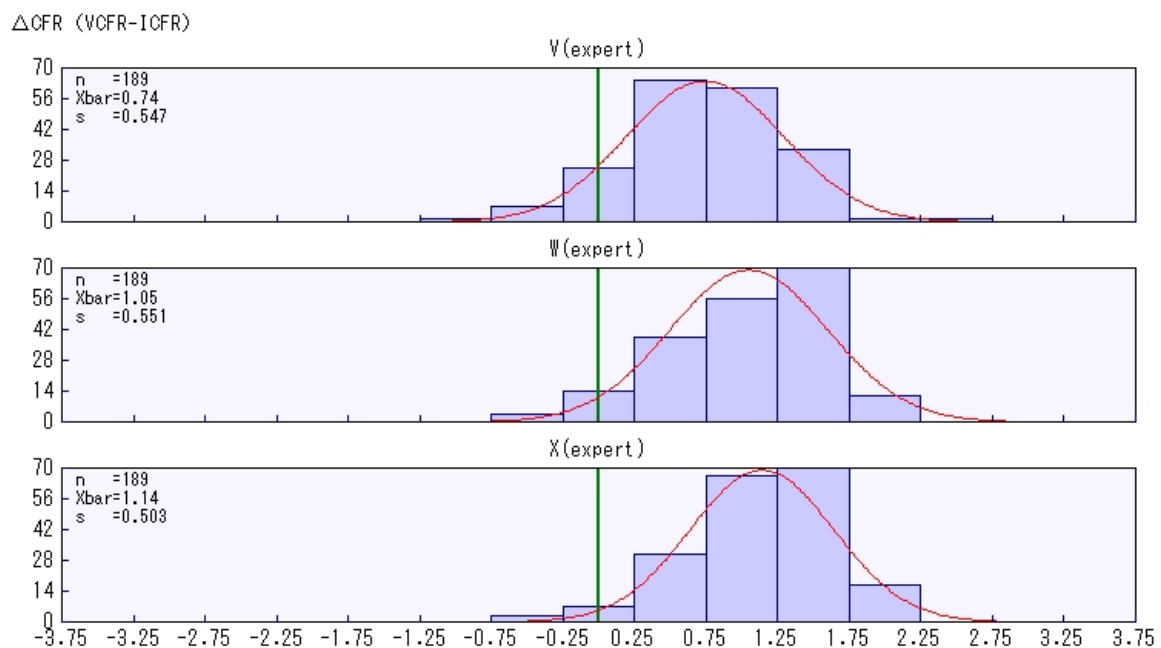
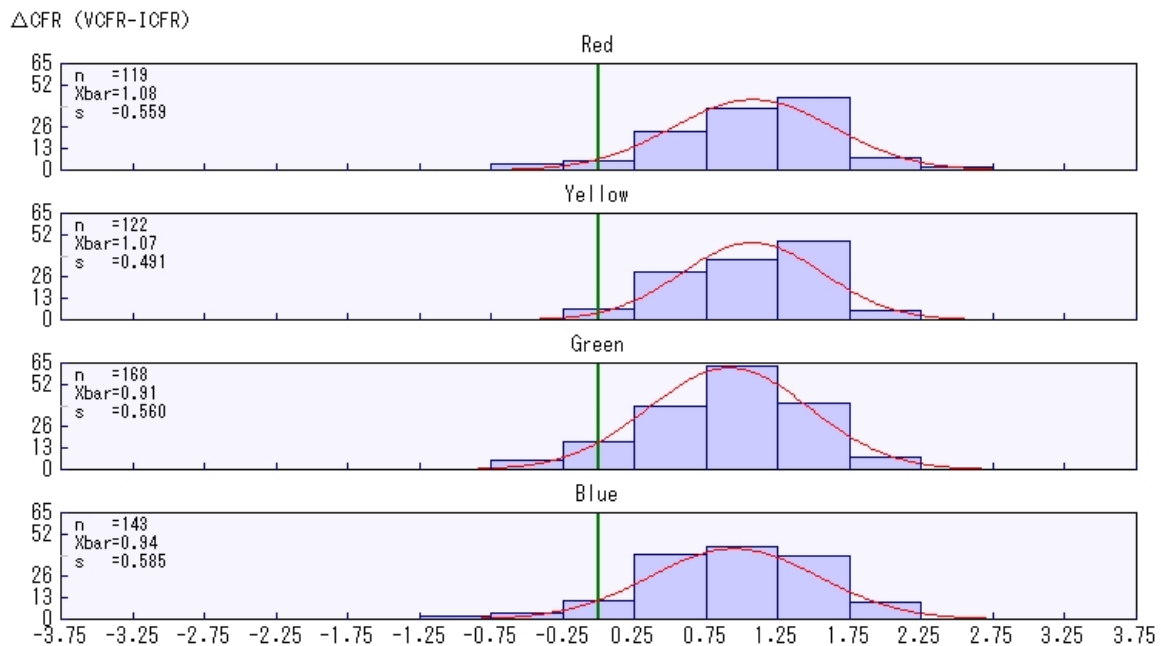
**Figure 4.** Comparison of the assessments between experts and non-experts: Box plot of ΔCFR .**Figure 5.** The difference of the assessments among the experts V, W and X.

Table 2. Statistical test of Δ CFR among the assessments of the experts V, W and X.

Subject	Expert V	Expert W	Expert X
Expert V		0.000** (t-test)	0.000** (t-test)
Expert W	0.926 (F-test)		0.089 (t-test)
Expert X	0.247 (F-test)	0.211 (F-test)	

4.3. Comparison of the assessments on hue

The assessments of the experts were also analysed by the hue selected as the most faded colour. Figure 6 shows the histogram of Δ CFR of each hue and Table 3 gives the statistical test of Δ CFR. In Table 3, the values at the right upper side are P values by a t-test and those at the left lower side are P values by a F-test as well as Table 2. There were 5% significant differences on the average of Δ CFR between the red/yellow and the green, and between the yellow and the blue colours. There was 5% significant difference on the variance of Δ CFR between the yellow and the blue colours. The visual ratings of the red and the yellow were around 1.5 rating higher than the instrumental ratings.

**Figure 6.** The difference of the assessments on hue: Red, yellow, green and blue**Table 3.** Statistical test of Δ CFR on the hue

Hue	Red	Yellow	Green	Blue
Red		0.93 (t-test)	0.013* (t-test)	0.065 (t-test)
Yellow	0.159 (F-test)		0.011* (t-test)	0.058 (t-test)
Green	0.989 (F-test)	0.126 (F-test)		0.577 (t-test)
Blue	0.609 (F-test)	0.048* (F-test)	0.585 (F-test)	

5. Conclusion

In this study, three experts visually assessed colour fastness in terms of the change in colour of multi-coloured fabrics. The obtained results were statistically analysed and also compared with the results of the previous study by the non-experts. The results indicated that the visual ratings of the experts and the non-experts were both around 1 rating higher than the instrumental ratings. This suggests that it is difficult to assess the colour changes of the multi-coloured fabrics not only for the non-expert but also for the expert. Although the number of the participants was small in the assessments with the experts, the standard deviation of ΔCFR of the experts was around 0.5 rating smaller than that of the non-experts and the width of ΔCFR of the experts was smaller than that of the non-experts. These suggest that there are more common understanding among the experts than the non-experts. The results also showed that the experts' visual ratings of red and yellow were slightly higher than those of green and blue. There were only four colours were used in study, but it is interesting to conduct the assessments with various hue of samples in order to carry out the future investigate about the influence of colors on the colour fastness.

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