Effect-coating glint according to binocular and monocular vision

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ABSTRACT

This study investigates the impact of two kinds of viewing conditions in glint perception for physical samples. The first aim is to verify how perceptual glint is influenced by two visual modes of observers: binocular and monocular vision. The second is to identify the difference in glint perception between two kinds of surface finishing: rough and smooth. A psychophysical experiment was conducted using 11 glint samples. They were assessed under four conditions which are the combinations of two visual modes and two physical conditions. The data of experiment results was statistically analysed by interpreting the box plot and verifying the results using sign test. The perceptual glint was assessed highly when a sample has bigger glint flake size on smooth surface by binocular vision rather than on rough on monocular.

KEYWORDS

glint **I** *monocular vision* **I** *binocular vision*

INTRODUCTION

Over the past few decades, the texture of visible pigment particles, known as glint, has been one of the most important features for attracting customers in the automobile industry. Therefore, quantifying the effect of glint has become essential for product development and quality control. Research-led understanding of glint has been expanded gradually. The majority of earlier research has been focused on effect coatings according to only external factors such as the illumination and viewing conditions, (Kirchner *et al.* 2008). There is insufficient information about how glint is influenced by not only viewing conditions but also by the material surface properties itself. This study attempted to verify the effect of glint according the combined conditions with the two viewing modes and different surface types under the same viewing condition.

SAMPLE PREPARATION

A set of 11 plastic panels produced by the «Silberline» manufacturing company which exemplifies the visual appeal of coatings, paints, inks, plastics and textiles. The samples used have different sized particles ranging from 9 to 650 microns, as shown in Table 1. Each sample used in the experiment was specially designed so that half of it is rough and another half is smooth while maintaining the same glint level across the entire surface. They were 7 × 4.5 cm silver panels and a reference sample used a particle size of 70 microns. Figure 1(a) shows the one of plastic panels.

PSYCHOPYSICAL EXPERIMENT

Fifteen observers conducted visual assessment to quantify the perceptual attribute of glint. Participants consisted of six males and nine females aged between 25 and 49. All of them passed the Ishihara colour vision test and near visual acuity test. The panel judged a category on nine-point scale (higher value indicated more glint) through comparison with a reference sample of 70 microns. Visual assessment was carried out separately using both monocular and binocular vision for each sample. Hence, it consisted of four conditions that are the combination of two types of visions and two different finishes for the same sample as shown Figure 1(b). The session was carried out three times to test repeatability. Each session did not exceed 45 minutes and included a five-minute break during the experiment in order to avoid visual fatigue. A total of 990 observations (15 observers × 11 samples × 2 viewing modes × 3 repeats) were performed in the experiment.

Figure 1(c) shows a schematic of viewing conditions used for the psychophysical experiment. It was designed to bring out strong glint appearance. A directional illumination, LED spot light, was employed as the light source which was located closely above the observer's head to minimise the angle between light source and observer. A sample was posited 50 cm away from the eye of observers and 2.4 cm beside from a reference sample. It was displayed through 2cm diameter hole of gray mask. An initial viewing geometry of 15°/0° was provided, but observers were free to rotate the tilting table on which samples were mounted while assessing glint. The initial viewing condition is that recommended by ASTM (2017) as one of several angles for the measurement of interference pigments.

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Size (microns)	9	11	30	33	36	90	95	165	225	330	650

Table 1 Glint flake size

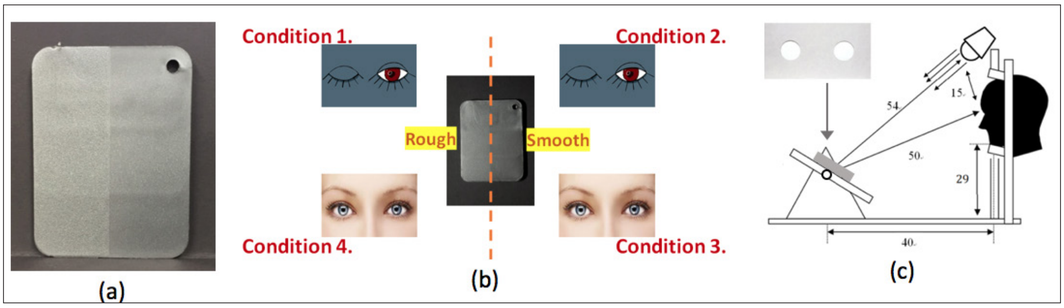

Figure 1 Experiment information: (a) plastic sample, (b) four conditions, (c) schematic of viewing conditions

RESULTS AND DISCUSSION

The reliability of the psychophysical experiments was examined by analysing observer variability. Observer variability of glint was quantified by computinginter-observer (accuracy) and intra-observer agreement (repeatability) respectively. The statistical measures used for data analysis were the coefficient of variation, CV, and coefficient of determination, R2. Table 2 shows two kinds of observer agreement for glint measures in terms of mean, median, max and min from all the samples and from the samples in four conditions. The results show that the coefficient of variation of two kinds of observer agreement, CV, for all the samples was 13.4 and 12.0 on median with a range from 10.1 to 32.5 and 8.9 and 16.5 respectively. Similarly, the coefficient of determination of two kinds of observer agreement, R^2, for all the samples was 0.97 and 0.97 on median with a range from 0.80 to 0.98 and 0.94 to 0.98 respectively. The worst result of inter-observer agreement, 5 kinds of maximum values of CV and 5 kinds of minimum of R^2, came from only one observer. The results of all other observers were close to the means of those results. Therefore, we concluded that the reliability of the visual assessments is acceptable due to the high level of correlations.

		CV					R^2				
		All	Cond. 1	Cond. 2	Cond. 3	Cond. 4	All	Cond. 1	Cond. 2	Cond. 3	Cond. 4
Inter-observer agreement	Mean	14.3	14.9	13.6	11.8	13.8	0.96	0.95	0.97	0.97	0.95
	Median	13.4	12.9	12.4	10.3	12.9	0.97	0.97	0.98	0.98	0.96
	Max	32.5	34.8	35.8	30.3	28.4	0.98	0.99	0.99	1.00	0.99
	Min	10.1	8.6	8.3	6.9	7.4	0.80	0.74	0.83	0.85	0.78
Intra-observer agreement	Mean	12.4	12.8	11.8	10.0	11.0	0.97	0.96	0.98	0.98	0.96
	Median	12.0	12.9	11.4	10.4	10.7	0.97	0.97	0.98	0.99	0.97
	Max	16.5	16.2	15.3	15.0	16.0	0.98	0.99	0.99	1.00	0.99
	Min	8.9	7.2	8.2	5.2	7.8	0.94	0.91	0.95	0.96	0.89

Table 2 A summary of inter- and intra-observer agreement from all conditions and from conditions 1, 2, 3 and 4.

In terms of statistical values for the four conditions, the CV of mean and median for condition 3 and 4 were relatively lower than those values for conditions 2 and 1 respectively regardless of inter- and intra-observer agreement. This indicates that the reliability of binocular vision for condition 3 and 4 is higher than that of monocular vision for conditions 2 and 1. In the same way, the CV of mean and median of inter- and intra-observer agreement for conditions 2 and 3 were relatively lower than those values for conditions 1 and 4 respectively. It signifies that the reliability of glint perception on smooth surface under conditions 2 and 3 is higher than that on matt surface (conditions 1 and 4). For reference, all of R^2 of mean and median of inter- and intra-observer agreement for four conditions were excellent and have two similar trends with CV, which is explained above.

The results of the visual assessment are depicted by the boxplot shown in Figure 2, based on the minimum, maximum, median, and the first and third quartiles. The median was marked as the red line between the first and third quartiles. The blue line through the red lines of 11 samples represents the median of the data set for each sample on each condition assigned by observers. The imaginary line in the center of each box can be regarded as the average for analysis. Here, it can be predicted that the distribution for glint perception is skewed because the imaginary lines of average hardly coincide with the median lines. In comparison between monocular and binocular vision from Figure 2, there is no significant difference between the two upper and bottom graphs. However, compared to the two types of surface, a clear tendency of scaled glint from observers can be seen. The graphs for conditions 2 and 3 show smaller values in low sample numbers than those for conditions 1 and 4, while they have relatively higher values in high sample numbers. This indicates that the results corresponding to smooth surfaces have lower grades for small sample numbers and higher grades for high sample numbers than those corresponding to rough surfaces.

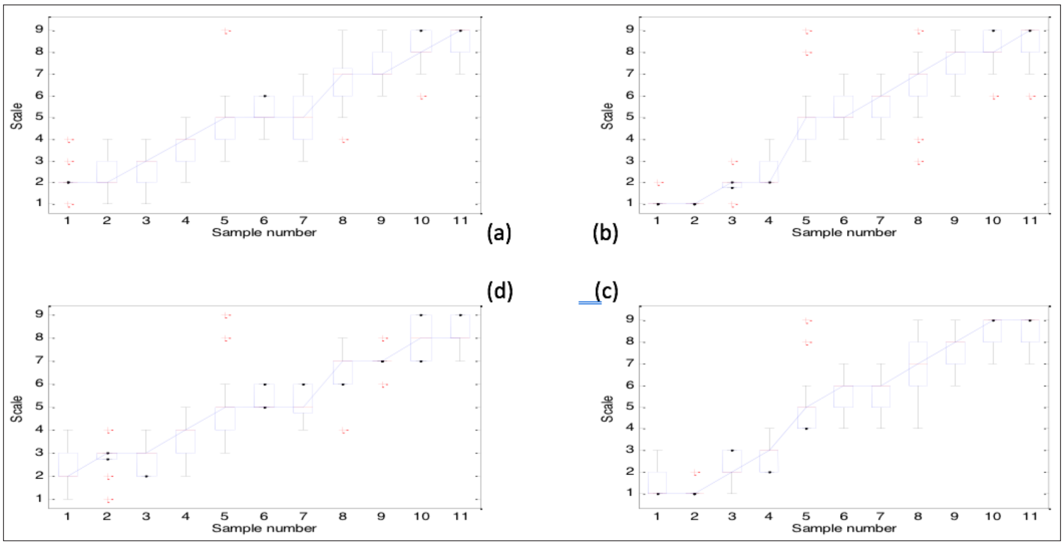

Figure 2 Boxplot and median for four conditions: (a) Condition 1 monocular rough, (b) Condition 2 monocular smooth, (c) Condition 3 binocular smooth, (d) Condition 4 binocular rough.

The sign test was used to testify whether the analysis obtained from boxplot graphs is appropriate for all of the data set. This test was performed twice for each pair of low sample number (sample 1 to 5) and high sample number (sample 6 to 11) group, which is indicated as the green and purple boundaries in Figure 3. For the green data set consisting of 150 samples (15 observers × 5 samples × 2 condition), the hypothesis is explained below.

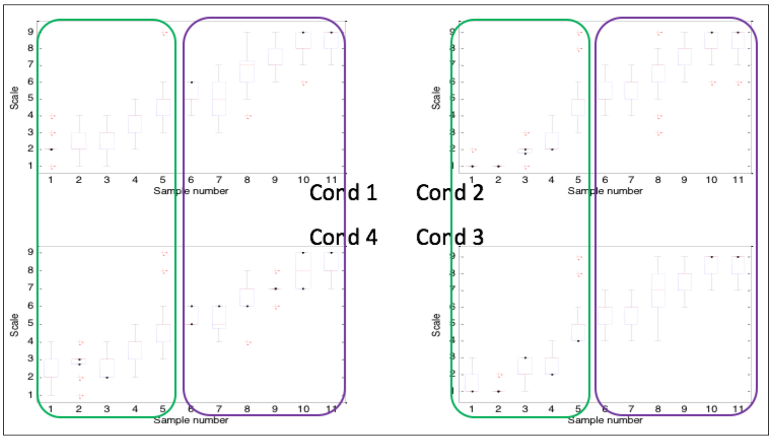

Figure 3 grouping for sign test

	Cond. 1&4 - 2&3 (no. 1-5)	Cond. 2&3 - 1&4 (no. 6-11)
Negative Differences a	6	21
Positive Differences b	100	62
Ties c	44	97
Total	150	180
p-value	0.000	0.000

Table 3 The result of sign test

Figure 2 was plotted on a scale according to sample numbers in which the samples were not ordered using an equal interval of glint flake size. Therefore, it is necessary to examine the effect of flake-size interval on the results from the psychophysical experiment. The results of observation from condition 3 were selected because this condition best represents the typical experience in terms of viewing mode and glint finishing. In addition, its reliability was the highest among the four conditions. In Figure 4, the graph tends to increase regardless of any small interval of glint particle size.

However, two points are close together on the scale 6 which indicates that two samples with 90 and 95 microns of 11 particle sizes were assessed as being the same glint grade. In other words, it can be concluded that the 5 microns interval of glint flake size cannot be distinguished. However, unlike this case, three samples with 3 microns interval (30, 33 and 36 microns) could be clearly distinguished as different glint grades. To find the reason for this, we focused on a 90-microns sample which can be expected to lie on the 5-scale point because of the lowest interval size, 20 microns, with a reference defined as grade 5. In reality, glint samples with 36-microns flakes were assessed as the same grade to a reference even though they have the second lowest interval (34 microns). In same way, the sample with 90-microns flake size must be assigned grade 5, not grade 6.

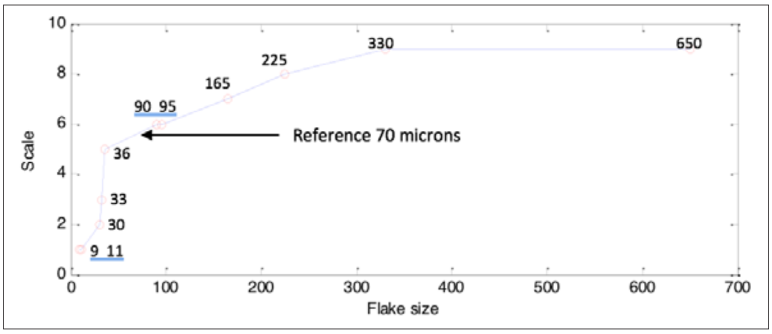

Figure 4 Assessed grade according to 11 glint flake size.

We suggest that this result is partly similar to the crispening effect, Gui (2002). This is a phenomenon whereby the apparent contrast between a pair of stimuli increases when they have similar colour to that of background between them. Similarly, glint increases when the stimuli have similar contrast to that of a reference. For reference, similar tendencies have been found in previous research by Jung (2015) and Kitaguchi (2008). However, since there have not been enough studies to fully explain this phenomenon, more research is needed.

CONCLUSIONS

We observed that the reliability of binocular vision is slightly higher than that for monocular. This means that the performance of glint judgment is improved by binocular vision as this helps to reduce the variance between observers. We also see that the perception of glint is affected by the surface finishing of the sample. The glint on a smooth finishing is perceived to be lower within the sample range of small flake size and higher for large flake size than that on a matt finishing compared to the glint of material with rough surface. It would add that this is probably due to the completion of equivalent effects created by the roughness. The perception of glint can increase when the stimuli have similar contrast to that of a reference.

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