Predicting Perceptions: Proceedings of the 3rd International Conference on Appearance, pp. 160-162, Edinburgh, UK, ISBN 978-1-4716-6869-2, April 2012.

The Psychometry of Colour Quality: a Three-Chamber Viewing Booth Method

P. Bodrogi*, N. Krause*, S. Brückner*, T. Q. Khanh*, H. Winkler**
*Technische Universität Darmstadt: Bodrogi@lichttechnik.tu-darmstadt.de, Krause@ lichttechnik.tu-darmstadt.de, Brueckner@lichttechnik.tu-darmstadt.de, Khanh@lichttechnik.tu-darmstadt.de
**Merck KGaA, Darmstadt: Holger.Winkler@merckgroup.com

ABSTRACT
To alleviate the subject's visual assessment task, a three-chamber viewing booth has been set up with three copies of the same arrangement of multi-coloured test objects. In this experiment, subjects compare the reference appearance in the middle with two test appearances left and right at the same time, allowing for the psychometric method of pair comparisons in addition to interval scaling and ordinal scaling. This new comprehensive method of colour quality assessment is intended to shed light into the relevance and interpersonal variability of each aspect of colour quality and the correlations among them.

General Terms
Measurement, Performance, Human Factors.

Keywords
Psychometry, colour, quality, fidelity, pair comparisons, viewing booth.

1. INTRODUCTION
Today, the development of phosphor-converted white LEDs for general interior lighting is gaining momentum but the perceived colour quality of the indoor environment under these LEDs still has to be increased. To this end, the aspects of colour quality (colour fidelity, chromatic lightness distribution of the illuminated objects, visual clarity, colour harmony, colour preference, colour memory, colour gamut, distinctness of colour categories, small colour differences, presence of fine colour transitions or shadings, colour emotions) have to be co-optimized [1].

To develop a set of usable numeric correlates for these aspects and for a visually meaningful optimization of the relative spectral power distributions of the white LEDs, reliable visual scales have to be established. Firstly, observers should learn to distinguish among the different aspects. Then, they will be able to scale every aspect for every light source uninterruptedly, in a comprehensive psychophysical experiment consisting of unambiguous visual tasks for every aspect. These aspects of colour quality have been assessed generally on interval scales by comparing the colour appearance of coloured objects under a test light source with a reference appearance in a two-chamber experiment [1].

To alleviate the subject's visual assessment task, recently a new three-chamber viewing booth has been set up at the Laboratory of Lighting Technology of the Technische Universität Darmstadt with three copies of the same arrangement of multi-coloured test objects (so-called stilllifes). In this experiment, subjects compare the reference appearance in the middle with two test appearances left and right at the same time, allowing for the psychometric method of pair comparisons [2] in addition to interval scaling [1] and ordinal scaling [3]. This new comprehensive method of colour quality assessment is intended to shed light into the relevance and interpersonal variability of each aspect of colour quality and the correlations among them.

Predicting Perceptions: The 3rd International Conference on Appearance, 17-19 April, 2012, Edinburgh, UK. Conference Proceedings Publication ISBN: 978-1-4716-6869-2, Pages: 160-162

2. EXPERIMENTAL METHOD AND EXPECTED RESULTS
The three-chamber viewing booth is depicted in Figure 1. The same white point is set up in every chamber of Figure 1 at a time. Three colour temperatures are used, 2700 K, 4000 K and 6500K. The illuminance level equals 800 lx at the bottom of every chamber. The reference light source is in the middle (halogen, Solux® and a fluorescent lamp with R_a >90). The two test light sources (A and B) are mounted to the left and to the right. Test light sources (A and B, see Figure 1) include combinations of white phosphor converted LEDs of high and low colour rendering properties to provide a wide range of different relative spectral power distributions. Coloured objects include fruits, flowers, books, household items, toys, textiles and the Macbeth ColorChecker chart. Spectral properties are measured by a high-end spectroradiometer.

Subjects concentrate on specific objects and scale an aspect of colour quality visually. In the present paper, only the results on colour fidelity will be dealt with while the other aspects will be reported later. Subjects scale the similarity of colour appearance of a set of 16 specific objects between the reference light source and one of test light sources (A and then B). Scaling is carried out on an interval scale of similarity (0.00-1.00) and on an ordinal scale of similarity (excellent, very good, good, mediocre, small, bad, very bad).

In addition to the above two visual scales, subjects have to compare the similarity of colour appearance of the objects under test light source A to the reference with the similarity under test light source B to the reference. Thus a Thurstone scale [2] will be established. These visual experiments are currently underway. Results will be presented at the conference. Special attention will be paid to null condition tests including the option of providing the same light source spectral power distributions in the two test chambers and the option of changing the position of the same light source from left to right and vice versa. At least six subjects will take part in the experiment.

The statistical distributions of the two continuous scales and a numeric correlate of colour difference perception (e.g. $\Delta E_{CAM02\text{-}UCS}$) will be analyzed by grouping the values of the continuous variables by the corresponding ordinal scale values. E.g. the question is what average values of a colour difference metric correspond to given ordinal categories, e.g. "excellent" or "good" or "mediocre". This way, a (nonlinear) psychometric relationship

between a colour difference scale and a colour rendering scale [4] can be validated. Such a relationship is essential for the non-expert user to interpret any colour quality metric in terms of categories like "good" or "excellent". Also, to validate a colour difference metric (e.g. $\Delta E_{CAM02\text{-}UCS}$), correlations between the continuous psychometric scales and the numeric colour difference scales (e.g. $\Delta E_{CAM02\text{-}UCS}$) can be computed. The intra- and interpersonal variability of the three psychometric methods can be compared and the possible influence of the type of the colored test object can be investigated.

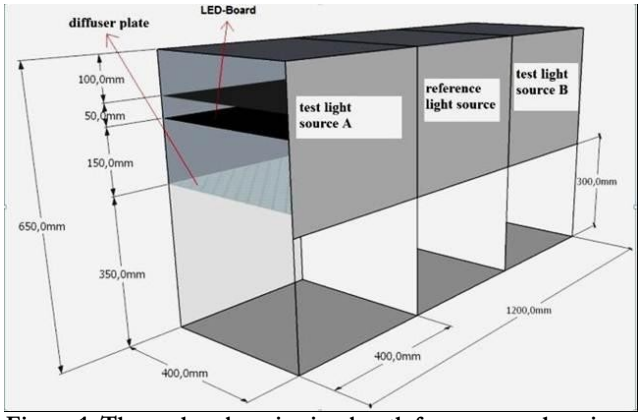

Figure 1. Three-chamber viewing booth for a comprehensive psychometric method to assess the different aspects of colour quality. In reality, all chamber walls are painted white and there is the same stilllife of coloured objects in every chamber

3. REFERENCES

[1] P. Bodrogi, S. Brückner, T. Q. Khanh, H. Winkler, Visual Assessment of Light Source Color Quality, Color Res. Appl., Early View, 2011.

[2] J. P. Guilford, Psychometric methods, New York: McGraw-Hill, 1954.

[3] P. Bodrogi, S. Brückner, T. Q. Khanh, Ordinal scale based description of colour rendering, Color Res. Appl. 36/4, 2011.

[4] P. Bodrogi, N. Krause, S. Brückner, T. Q. Khanh, H. Winkler, Psychological relationship between colour difference scales and colour rendering scales, AIC Midterm Meeting, Interaction of Colour & Light in the Arts and Sciences, Zürich, Switzerland, 2011.