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SPECIAL METAMERISM INDEX: CHANGE IN OBSERVER

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Foreword

The following members of T.C.1-07 (Observer Metamerism) took part in the preparation of this Technical Report. The Committee comes under CIE Division 1 (Vision and Color).

Member

E. Allen	U. S. A.
H. Hemmendinger	U. S. A.
K. McLaren	Great Britain
Y. Nayatani	Japan
N. Ohta (Chairman)	Japan
J. J. Opstelten	The Netherlands
D. Strocka	Germany, Federal Republic
K. Takahama	Japan

Consultant

R. W. G. Hunt	Great Britain
P. K. Kaiser	Canada
G. Wyszecki	Canada

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Special Metamerism Index: Change in Observer

Summary

This report provides a method for evaluating the degree of color mismatch for a metameric color pair (object color or illuminant color) when an actual observer with normal color vision is substituted for the standard colorimetric observer.

The method evaluates both the average values of, and the range of, the color mismatch.

Indice Special de Metamerisme: Changement de l'Observateur

Résumé

Ce rapport fournit une méthode pour évaluer l'écart de couleur d'une paire de couleurs métamères (couleur d'un objet ou d'un illuminant), lorsqu'un observateur réel, ayant une vision normale des couleurs, est substitué à l'observateur de référence colorimétrique.

La méthode permet d'évaluer, à la fois, la valeur moyenne de l'écart de couleur et l'étendue de celui-ci.

Spezieller Metamerie Index: Unterschiede im Beobachter

Zusammenfassung

Dieser Bericht behandelt ein Verfahren zur Bestimmung des Maßes der FarbfehlAbstimmung bei einem bedingt-gleichen Farbenpaar (Körperfarbe oder Farbe einer Lichtquelle), wenn ein tatsächlicher Beobachter mit normalem Farbsehvermögen statt des farbmeßtechnischen Normalbeobachters eingesetzt wird.

Mit dem beschriebenen Verfahren läßt sich sowohl der Durchschnittswert als auch der Gesamtumfang der Farbanpassung bestimmen.

Preface

Two specimens having identical tristimulus values, for a given illuminant and reference observer, are metameric if their spectral radiance factors differ from each other within the visible spectral range. This metameric color match is broken down either by a change of the reference illuminant or the observer.

The degree of color mismatch caused by substituting a test illuminant of different relative spectral composition for the reference illuminant is classified as the Special Metamerism Index : Change in Illuminant (illuminant metamerism).^{1, 1} The method of evaluating illuminant metamerism has already been formulated: the purpose of this report is to formulate a method of evaluating the degree of color mismatch for metameric color pairs (object colors or illuminant colors) caused by substituting a test observer with normal color vision for the reference observer (CIE Standard Colorimetric Observer). This is classified as the Special Metamerism Index : Change in Observer (observer metamerism).

Color mismatch caused by observer metamerism is inevitable for real observers with normal color vision. The evaluation of observer metamerism thus gives a sound basis for establishing color difference tolerances for color matching using various metameric color pairs. It also gives an indication of the degree of illuminant metamerism which can be considered allowable in our everyday lives.

The methods of evaluating observer metamerism are generally grouped into two categories. For a given set of metamers, they are :

- (1) using actual observers with normal color vision to calculate the average of, and the range of, the color mismatches between metamers ;
- (2) selecting a set of color matching functions representing the individual variations among color normal observers, and using them to calculate the average of, and the range of, the color mismatches.

Method 1 is straightforward, and work using this procedure has already been reported using the Davidson-Hemmendinger(D-H) color rule.^{1, 2-4} However, for actual metameric color pairs other than the D-H color rule, method 1 requires subjective evaluation of color mismatches which is difficult and unstable.

Method 2 is therefore preferred. Once the suitable color matching functions are formulated, the calculation of color mismatches is as simple as the calculation of tristimulus values.

In the early stages of formulating method 2, the use of 20 sets of color matching functions for normal color vision was recommended.^{1, 5-6} However, it is rather cumbersome to use 20 sets of color matching functions in evaluating observer metamerism and efforts were made to reduce the number to only one and propose a "Standard Deviate Observer" who has color matching functions which differ from those of the standard observer by amounts equal to the standard deviations among the 20 sets of color matching functions^{1, 7}; these will be referred to as the 20 observers hereafter. The method employed was a statistical analysis of the variances and covariances of the color matching functions of the 20 observers. However, it was found that the Standard Deviate Observer did not give a satisfactory prediction of observer metamerism. An alternative suggestion selected the best combination of two observers from among the 20 observers.^{1, 8} These two observers give highly correlated results with those obtained by the 20 observers.

A further proposal was to use a single Standard Deviate Observer by analyzing the same 20 observers but by use of a different statistical method known as a singular value decomposition.^{1, 9} This Standard Deviate Observer gives a good prediction of the average value of color differences among the 20 observers. A method of evaluating the range of color mismatches was also proposed.^{1, 10} In an attempt to confirm these results a different approach using a nonlinear optimization of the 20 observers and actual metameric samples was performed.^{1, 11} The results turned out to be much the same and the Standard Deviate Observer obtained well represented the original 20 observers.

It was later shown that the age distribution of the 20 observers was rather wide, ranging from about 20 to 60 years old and that apparent differences between the results obtained by method 1 and 2 are simply because of the difference in scaling of color differences.^{1, 12}

The same analysis has been carried out for the color matching functions of 53