Efficacy of a colour conversion filter in colour vision testing

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SUMMARY

C Daylight™ glasses are designed to convert light from domestic incandescent lamps (~Illuminant A) to the Illuminant C phase of daylight. The efficacy of this conversion is quantified here for the Farnsworth D15 test. Spectral transmittance and reflectance data for the filter and D15 caps respectively are used to compute chromaticities of the caps under illuminants C, A and the filtered illuminant fA. The chromaticities of A and fA deviate from C by 13 JNDs and 1.6 JNDs respectively. Similar shifts occur for the 15 caps. After allowing for von Kries adaptation, the chromatic spacing between some adjacent caps approaches 1 JND for Illuminant A but is less than 0.1 JND for fA. It is concluded that the colour conversion is efficient.

INTRODUCTION

Schmidt[1] reported impaired screening efficiency of pseudoisochromatic plates when illuminated inappropriately by an incandescent lamp instead of North Sky Daylight. The importance of illuminating pigment-based tests of colour vision with a standard phase of daylight is now well recognised. The use of Wratten colour filters in the form of spectacles to convert the light from a domestic incandescent lamp to Illuminant C has been described by Pokorny et al[2] and by Higgins et al[3]. *C Daylight*™ glasses* are intended to serve the same purpose and we report spectral transmittance measurements for that filter and calculations related to the performance of the filter for Farnsworth's D15 test.

METHOD

The *Daylight* filter's spectral transmittance was measured on a Perkin-Elmer 550S Spectrophotometer whose wavelength scale was checked against Holmium and Didymium glass standards. Reflectance data for the D15 caps were provided by Prof S Dain. Calculations of chromaticities in the CIE 1976 UCS diagram of the three illuminants, C, A and filtered A (fA), and of the D15 caps under these illuminants both before and after the von Kries adaptation correction were performed using MatLab software.

RESULTS, DISCUSSION AND CONCLUSION

The spectral transmittance of the *Daylight* filter deviates increasingly from the ideal towards the ends of the visible spectrum: being too low below 450 nm and too high above 690 nm (Fig.1).

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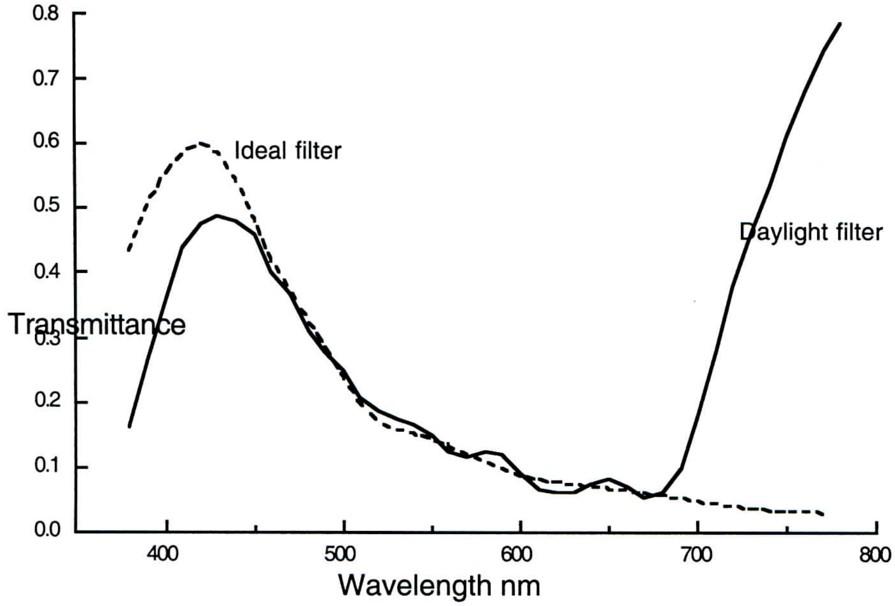

Fig. 1 Comparison of the *C Daylight* filter, measured on a Perkin-Elmer Spectrophotometer, with the *Ideal Filter*, computed as the energy ratio of Illuminant C to Illuminant A (multiplied by an arbitrary constant). The *Daylight* filter deviates increasingly from the *Ideal* towards the ends of the spectrum.

In terms of luminous flux, however, differences between illuminants fA and C seem more significant in the mid-spectral region between 530 and 630 nm (Fig. 2).

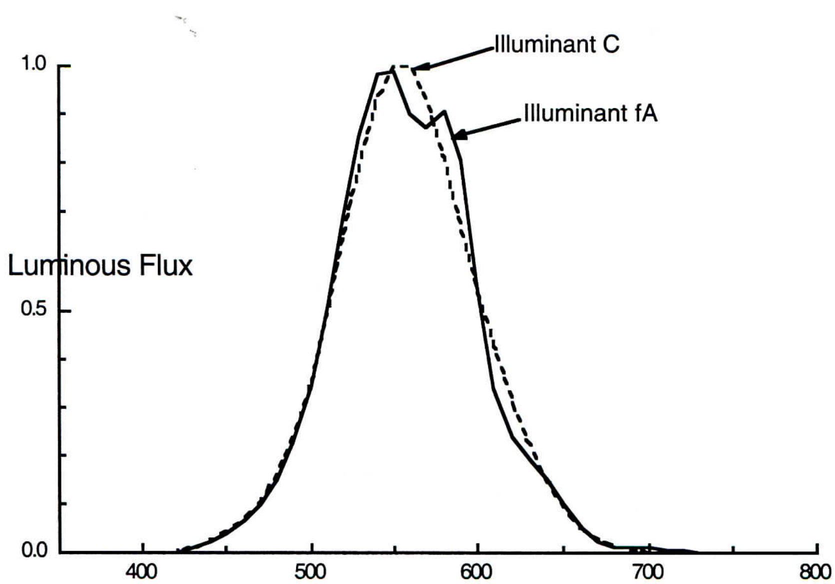

Fig. 2 Comparison of luminous fluxes for illuminant C (broken line: normalised at its peak) and for the filtered illuminant fA (full line: scaled for equal areas under the curves). This plot discounts the spectrum end deviations seen in Fig. 1 and gives greater weight to the mid spectrum deviations.

A more appropriate insight of the filter's efficacy for colour vision testing is obtained by considering chromaticities under C , A and fA in the CIE 1976 UCS diagram. The chromaticity of illuminant A deviates from illuminant C by about 13 JNDs (Fig. 3) while the filtered illuminant fA deviates by only 1.6 JNDs. Chromaticity shifts for the D15 caps are similarly disparate*.

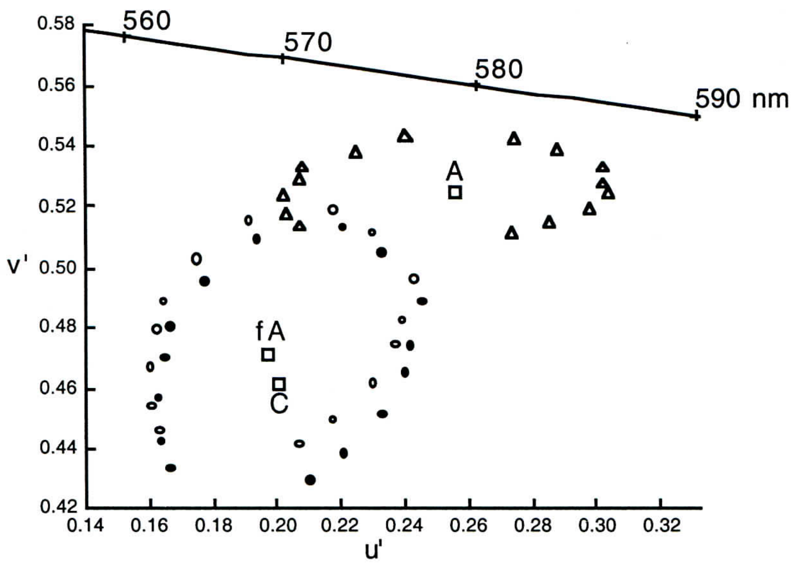

Fig. 3 Chromaticities of the D15 caps under illuminants C, A and filtered A (fA) in the CIE 1976 UCS diagram. Squares - illuminants. Filled circles - D15 under C. Empty circles - D15 under fA. Triangles - D15 under A. Illuminant A is displaced from C by 13 JND towards 583 nm on the spectrum locus and fA deviates by 1.6 JND towards 563 nm.

Taking C as the standard illuminant and allowing for von Kries adaptation to illuminants fA and A, the D15 chromaticity shifts are greatly reduced Those for fA are very small but those remaining for illuminant A are significantly larger and the D15 locus retains a distortion in shape which could help some red-green colour defectives to sort the caps correctly (Fig. 4). This finding supports Schmidt's negative assessment of the use of incandescent lamps in colour vision testing.

The conversion used here (1 UCS unit = 154 JNDs) is based on the average of Wright's[4] 'steps' in the D15 region of the chromaticity chart and adopting his assertion that one 'step' is equivalent to 3 JND.

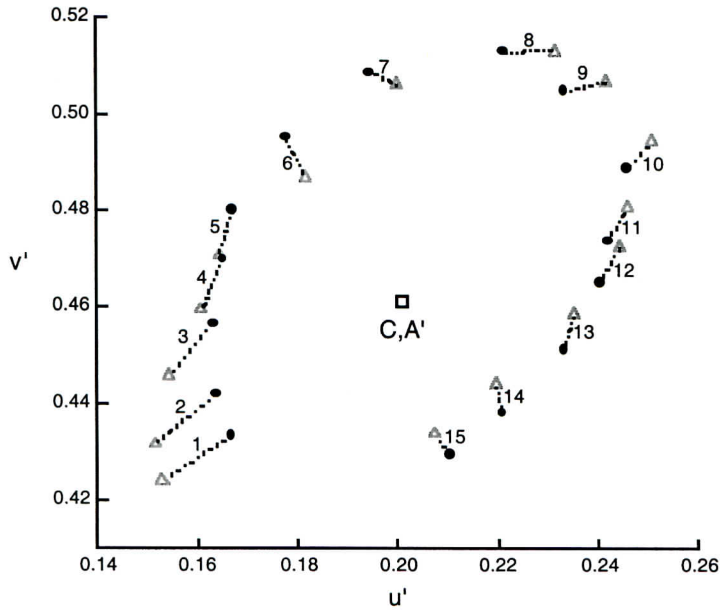

Fig. 4. Chromaticities of the D15 caps under illuminants C and A following correction for von Kries adaptation. Square - illuminants C and A' (the von Kries corrected A). Filled Circles - D15 under C. Empty Triangles - D15 under A'. Distortions in the D15 locus approach 2.5 JND and may help some red-green colour defectives to sort the caps correctly

The chromatic separation of adjacent caps is an important feature in the design of the D15 test (Fig. 5). Chromatic spacing under illuminant fA correlates very well with that under C (r^2 = 0.997) with a maximal deviation of only 0.1 JND. By comparison, the spacing for illuminant A shows deviations approaching 1 JND. None of the deviations of the *Daylight* filter from the ideal are colorimetrically significant for the D15 test and we conclude that the filter conversion from illuminant A to illuminant C is satisfactory.

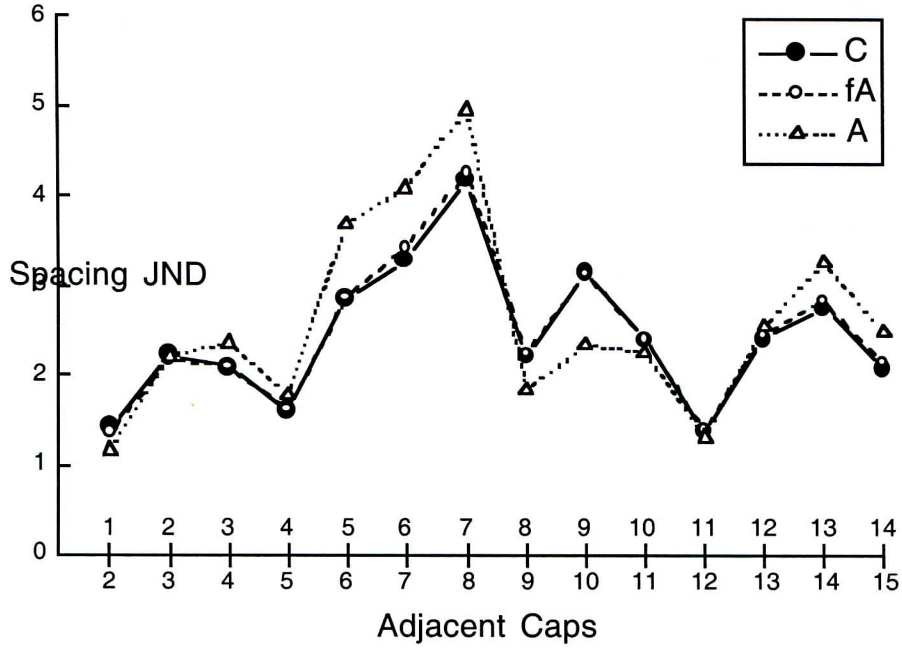

Fig. 5 Chromatic spacing between adjacent D15 caps under illuminants A, fA and C after allowing for von Kries adaptation to the illuminants A and fA. Cap spacing under the filtered illuminant fA correlates very well with that under C ($r^2 = 0.997$) with a maximum deviation of +0.1 JND while that under illuminant A shows large deviations approaching ±1JND

REFERENCES

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