Technical note

Overlays for classroom and optometric use

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(Received 26 July 1993, in revised form 13 October 1993)

Perceptual distortion of printed text can sometimes be reduced by placing upon the page a sheet of coloured plastic (overlay). The colour that best reduces the distortion differs from one individual to another and may need to be selected with precision. A set of overlays has been developed that samples the CIE UCS diagram systematically. The overlays are robust and have a matt finish. They can be combined in an intuitive way to provide a wide range of chromaticities.

Children with reading difficulty and others who suffer eyestrain when reading sometimes report perceptual distortion of text: for example, the letters may appear to move or to change shape. Helen Irlen[1,2] has pioneered the use of colour to reduce these perceptual distortions. The Irlen Centres she has founded supply seven sheets of differently coloured plastic sheets (overlays). These overlays are used in the classroom to select children who might benefit from the use of coloured lenses.

The overlays are placed in turn over a page of text and pairwise combinations compared side-by-side. The child selects the overlay that best reduces the distortion by a process of successive elimination. Sometimes the chosen overlay appears to allow the child to read more fluently and without discomfort. To date, the literature on the effectiveness of overlays in improving reading is controversial[3,4] and equivocal[5–9]. In one of the few placebo-controlled studies, Tyrrell *et al.*[10] included an untinted transparent overlay with the seven coloured Irlen overlays. They compared the reading and visual search performance of children who selected the clear transparent overlay and those who selected a coloured overlay. Children who selected coloured overlays were more likely to be poor readers. When they read for 15 min with a clear overlay their reading speed decreased slightly but significantly and they reported symptoms of visual discomfort. When, on a different occasion, the same children read using the coloured overlay of their choice, the reading speed was maintained and the symptoms did not occur. Visual search performance was improved. Children who selected the transparent overlay did not show a decline in reading speed and they did not report so many symptoms of discomfort. The transparent overlay had no effect on their reading or visual search. The above findings suggest that the use of coloured overlays may be associated with a reduction in visual discomfort, with possible benefit for reading.

The colour of overlay children find most helpful varies from one individual to another[1,2,10] and sometimes from one occasion to the next. Sometimes a colour formed from a combination of superimposed overlays appears to give the greatest benefit. The fact that some children prefer a combination of overlays might arise because the colour needs to be quite specific to give the optimal result. Wilkins *et al.*[11] provide chromaticity diagrams illustrating just how constrained the gamut of effective chromaticities can be: in one case the range of effective CIE 1976 u', v' hue angles (h_{uv}) was about 10°. Their data were obtained when the chromaticity of the illuminant was varied in a visual field that contained no surface colours. In the case where colour is provided by an overlay, one might expect the gamut of optimal colours to be at least as constrained.

The Irlen overlays are well designed for classroom use: unlike other readily available filters, such as theatre filters, they have a matt coating to reduce specular reflections and they are sufficiently robust to survive the classroom. Unfortunately, the range of available colours does not include a purple, as can be seen from *Figure 1* which shows the chromaticities of the overlays (large points) and of pairs of overlays superimposed (small points).

In summary, there is at present some uncertainty regarding the effectiveness of overlays, and the extent to which

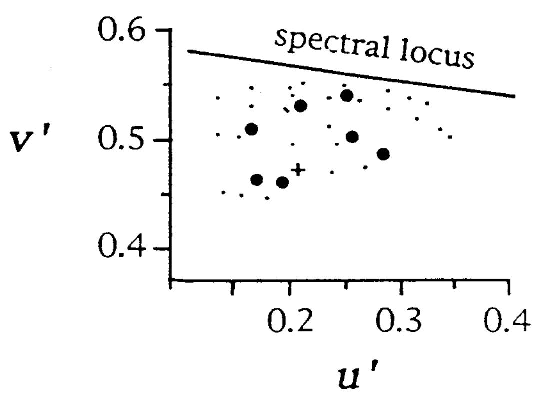

Figure 1 CIE 1976 UCS diagram showing the chromaticity coordinates of the Irlen overlays (●) and of all pair-wise combinations of overlays (·). The coordinate of equal energy white is also shown (+)

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any benefit they may have depends upon the precision with which a colour can be selected. We have therefore developed a set of overlays suitable for classroom or optometric use which have a large range of chromaticities. We did so for three reasons:

1. for research. A wide range of chromaticities was necessary, given the suggestion that the chromaticity may need to be precisely determined;
2. for use in the classroom;
3. for selecting children who might benefit from coloured glasses. Precision tinting is now commercially avail-able using techniques previously described[12]. In an open trial of these techniques[13], more than 80% of participants reported continued use of the tints when followed up one year later. These participants were selected on the basis that they had benefited from the use of overlays prior to entry to the trial. It seems likely that the use of overlays may offer a good way of deciding which children are likely to benefit from precision tinting, although this has yet to be confirmed.

Design criteria

The design criteria for the overlays were as follows:

1. the overlays should be robust;
2. the overlays should have a non-reflective surface, but with minimal interference with the visibility of text beneath, particularly when several overlays are superimposed;
3. as far as possible, the overlays should have an even spectral reflectance function, to reduce metamerism;
4. the set of overlays and combinations of overlays should have an even distribution of chromaticities, preferably with equal CIE 1976 u', v' saturation (s_{uv}) and evenly spaced hue angles (h_{uv});
5. it should be possible to obtain intermediate chromaticities by combining the overlays in an intuitive way.

Methods

Overlays satisfying the above criteria (the "Intuitive Overlays® ") have been manufactured by conventional printing techniques using specially prepared inks (Coates Lorrieux). The central panel of *Figure 2* shows the chromaticities of the overlays. The spectral reflectances are shown in the peripheral panels. There are 10 overlays in all, nine coloured and a grey overlay (not shown). The overlays can be used singly, or in pairs, superimposed. Note that the colour names shown in *Figure 2* are coarse descriptions of the colour signified by the locations in colour space.

Figure 3 shows the chromaticities of the single overlays (small squares) together with the chromaticities of pairs of superimposed overlays, both those pairs formed from two identical overlays (□) and those formed from neighbouring overlays (×). The chromaticity coordinates indicate that colour space has been sampled evenly with respect to hue angle. Note that when overlays having neighbouring chromaticities are combined, the chromaticity is not appreciably affected by which overlays is uppermost. The resulting pair of overlays has a chromaticity mid-way between the chromaticity of the component overlays. This restriction on the combination of overlays to those of neighbouring chromaticity makes the colour mixing intuitive: had other combinations of overlays been used, the resultant colour and transmission would not have been so predictable. For example, if rose and mint-green were combined, the result would have been grey.

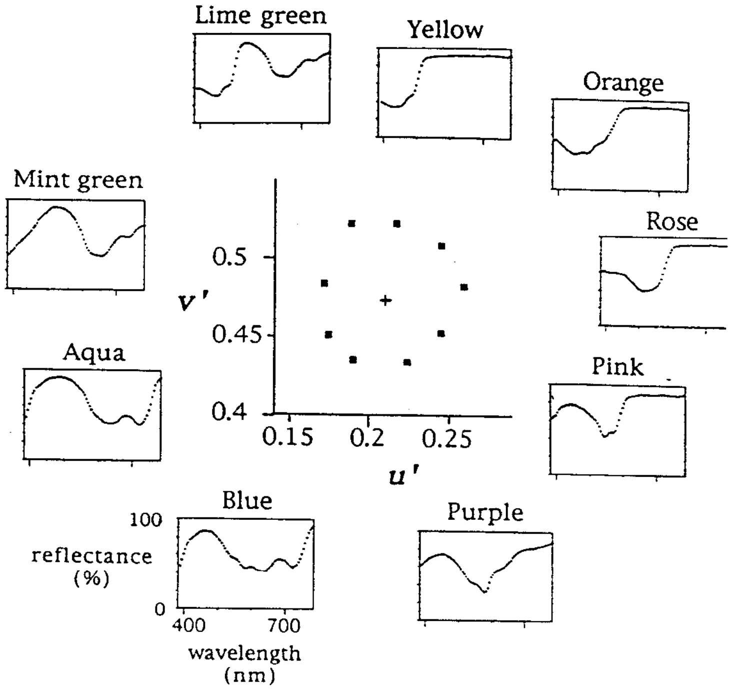

Figure 2 Centre: CIE 1975 UCS (u' v' diagram showing the chromaticity coordinates of the nine coloured overlays (■) and that of equal energy white (+). Perimeter: panels show the reflectance (0–100 %) of each overlay as a function of wavelength (30–780 nm). The panels are disposed in a manner similar to that of the corresponding chromacity coordinate.

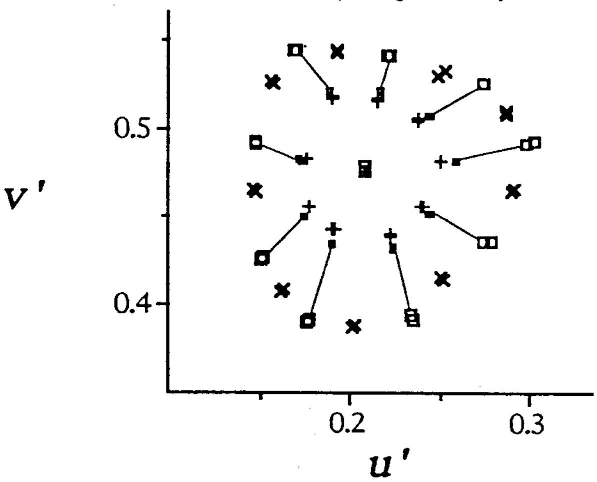

Figure 3 Chromaticities of the single overlays (□) are joined by lines to the chromaticities of two superimposed overlays of the same colour (□). The chromaticities of a single and double grey overlay are shown by the central points. Combinations of a single overlay with a grey overlay (+) and with an overlay of neighbouring chromacity (×) are also shown. In every case data for 45/90 and 90/45 reflectance standards are both plotted, but the chromaticities are so similar that the points are almost superimposed

Figure 3 also shows the chromaticities from combinations of a coloured overlay and a grey overlay. Note that the addition of the grey overlay has only a slight effect on the chromaticity. The reflectances were measured using a Monolight reflectance head, and reflectance standard (Rees Instruments, Surrey, UK). The overlays were placed with the matt side uppermost upon a white surface (halon reflectance standard) with the light incident at 45° to the surface and reflected at 90° i.e. normally (data in *Figures*

1 and 2) and also with light incident normally and reflected at 45° (data in *Figure 3*).

The above measurements were compared with those obtained under more realistic lighting and viewing conditions using a Moonlight telespectroradiometer (Rees Instruments, Surrey, UK). The latter measurements were made in a room lit with diffuse fluorescent lighting, comparing the light reflected at 45° with that reflected from a standard white surface in an identical position. The chromaticities of the filters, discounting the illuminant, were similar to those obtained using the reflectance head.

Suggested use

Following Irlen[1,2], it is suggested that children describe in their own words the perceptual distortions they experience after they have been reading for a time. The examiner may begin with open-ended questions such as, 'After you have been reading for a time, do the letters or words do anything funny?' and end with more structured questions, such as, 'Do the letters wobble, change places, go blurry, etc?' The child's description of the distortion should be noted and used when subsequently referring to the distortion. Two colours should be placed side-by-side on a page of text and the child asked which of the two sides gives the greatest reduction of distortion (using the child's description to refer to the distortion). The colour that gives the greatest comfort or clarity (comfort is more important than clarity) should then be compared with one of the remaining colours until by a process of successive elimination the best colour is chosen. It is suggested that the overlays are initially used singly. The chosen colour should then be compared with other similar colours, i.e. those having neighbouring chromaticities (shown in *Figure 3*). This can be done by superimposing an overlay having neighbouring chromaticity or by superimposing an identical overlay, thus increasing the saturation.

It is evident from a recent study (in preparation) that the colour of a chosen overlay *does not* indicate the appropriate colour for coloured glasses: often the colour of glasses is quite different. This may be because the colour of an overlay is perceived in the context of other differently coloured surfaces, whereas when coloured glasses are worn the entire retinal image is affected. Notwithstanding the different mechanisms involved in the processing of colour from overlays and from lenses, it remains possible that children who benefit from overlays are those who are likely to benefit from coloured glasses. Both groups complain of eye-strain and headache from reading.

Acknowledgements

Edward Chronicle and Rebecca Jeanes kindly assisted with the photometry and artwork.

End notes

Packs of the 20 Intuitive Overlays (A5 size) are available with instructions and suitable samples of text. Dispensing packs of five identical overlays (A4 size) are also available. Both can be obtained from IOO Marketing, Institute of Optometry, London, UK. The Medical Research Council owns the rights. 071 407 1479

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