Research Note

Open trial of subjective precision tinting: a follow-up of 55 patients

Anne Maclachlan[1], Sheila Yale[2] and Arnold Wilkins[1]

[1]MRC Applied Psychology Unit, 15 Chaucer Road, Cambridge CB2 2EF, and [2]18 Claremont Drive, Ormskirk, Lancashire L39 4SP, UK

(Received 21 August 1992, in revised form 24 December 1992)

We gave glasses, tinted using new techniques, to 55 patients with visual discomfort and a range of associated complaints. The techniques permitted the patients to adjust the colour and saturation of tint for maximum clarity and comfort when viewing text. Benefit was experienced by 45 patients (82%) who were still using them more than 10 months later. Of these, 40 presented with a perceptual distortion of text that the glasses alleviated; 86% reported migraine in the family. An independent series of 74 children with reading difficulty was examined using coloured plastic sheets placed upon a page of text. Of those reporting beneficial effects of colour, 60% had migraine in the family, as compared with 31% of those for whom colour was of no benefit.

Irlen[1] has pioneered the use of spectral filters in the treatment of reading difficulty. She reports that reading can be compromised by perceptual distortions of text, and that usually these distortions are no longer apparent when the text has a particular colour, different for each individual. She has developed proprietary techniques for the provision of tinted lenses that have a spectral transmission guided by the individual's report of distortion. Despite anecdotal reports of success, her treatment remains controversial[2]. We have developed alternative techniques for precision tinting, involving the use of a device that enables an observer to vary the hue and saturation of light incident upon a page of text, without altering its luminance[3]. We reported beneficial effects on reading, eye-strain and headache in a few preliminary case studies[3]. The purpose of this note is to report the results of a long-term follow-up of the first 55 consecutive cases to have been offered precision tinting using the techniques we described. (The remaining cases referred to in the earlier publications[3] are too recent to be included.)

The series is of heterogeneous aetiology, subjects having been referred from a wide range of sources, many in response to publicity. The cases were initially seen by one of us (A.W.) and have been followed up independently (by A.M.) after an intervening period averaging one year.

Method

Selection of subjects

There were 55 subjects referred for precision tinting, of whom 23 came in response to publicity: an article in *Living* magazine (January 1991, p. 13) described perceptual distortion of text in children with reading difficulties. The article reported the work of Helen Irlen and suggested that parents of backward children who suspected that their child suffered perceptual distortion should ask them questions such as the following: What do you see when you look at a page of print? Do the words jump about? Do they change shape? Do they wobble or go wavy? Do colours come and go around the letters? The article did not mention migraine.

Another 16 patients were referred by educationalists (teachers and educational psychologists), 13 by neurologists and psychiatrists, and 3 by optometrists. The referral route and presenting symptoms are summarized in *Table 1*.

All subjects had received a recent optometric examination, and 17 had been prescribed a refractive correction. At the time of examination all 17 were wearing any prescription appropriate for close work.

In 37 cases the symptoms related to difficulties with reading (diagnosed by professionals as specific reading difficulty or dyslexia in all but one). In all of these 37 cases and in a further 5, questioning revealed perceptual distortion of text. In 21 cases there was 'eye-strain' (periocular pain) and in 35 cases, headache. In four cases the headache had been diagnosed as migraine by a neurologist, but in most a formal diagnosis was not available. Five patients had symptoms from the use of visual display terminals, and four from fluorescent lighting. Five had photosensitive epilepsy, and three agoraphobia.

Those patients who reported distortion of text were first offered the use of an overlay selected by the patient from among 10 theatre filters placed in turn upon a page of text: Rose (Rosco 603); Orange (Rosco 09); Yellow (Rosco 96); Green (Lee 244); Turquoise (Rosco 673); Aquamarine (Rosco 66); Blue (Lee 202); Purple (Rosco 642); Lavender (Rosco 38); Neutral grey (Lee 209).

Correspondence to: Dr A. Wilkins, MRC Applied Psychology Unit, 15 Chaucer Road, Cambridge CB2 2EF, UK

© 1993 Butterworth-Heinemann for British College of Optometrists
0275-5408 93 020175-04

Precision tinting was offered if, after a one month trial, the subject had reported benefit from a coloured overlay and was using it regularly. There were 15 subjects who did not return for precision tinting and do not form part of the present series. The series also excludes a further four subjects who did not give consistent chromaticity settings in the intuitive colorimeter[3,4] described below.

Procedure

The procedure for precision tinting has been described elsewhere[3]. It uses an intuitive colorimeter[4] to give subjects the opportunity of adjusting the hue and saturation of light falling upon a page of random letters arranged to resemble text. The adjustments leave luminance unaffected. Subjects were instructed to find a colour that made the text as clear and as comfortable as possible. Once a chromaticity had reliably been obtained in a succession of trials, luminance was adjusted. A combination of tinted trial lenses with chromaticity similar to that chosen by the patient was selected by the examiner. Under conventional lighting of various kinds, the combination was offered to the patient, together with a range of similar alternative tint combinations. When viewing a

Table 1 Characteristics of patients given precision tints. The table shows the sex, age, referral route (educational, medical, optometric or self/publicity) and reason for referral: reading problems (R), headache (H), diagnosed migraine (M), eyestrain (E), photo-sensitive seizures (S), agoraphobia (Ag), or problems with fluorescent lighting (Fl), or visual display units (vdu). The table shows whether a refractive correction had been prescribed, whether specific reading difficulty/dyslexia had been professionally recognized, whether the patient reported perceptual distortion of text, whether the glasses were still in use, and if so, why, and finally, whether there was a known history of migraine in the immediate family

Sex	*Age* (years)	*Referral route*	*Presenting symptoms*	*Refractive correction prescribed?*	*Specific reading difficulty?*	*Perceptual distortion?*	*Glasses still worn?*	*Helped with*	*Family history of migraine*
M	9	educ.	RH	Y	SRD	Y	Y	RH	—
M	9	educ.	R	N	SRD	Y	Y	R	Y
M	9	educ.	R	N	SRD	Y	Y	R	Y
M	9	educ.	R E	Y	SRD	Y	Y	R H E	N
F	10	pub.	R H	N	SRD	Y	Y	R H	Y
M	10	pub.	R H E	Y	SRD	Y	Y	R	Y
M	10	educ.	R	Y	—	Y	Y	R	—
F	10	educ.	R H M	N	RD	Y	Y	R H	Y
M	11	educ.	R H	N	—	Y	Y	R H	Y
M	11	educ.	R	N	SRD	Y	Y	R	Y
M	12	educ.	R H E	N	SRD	Y	Y	R H E	—
M	12	pub.	R H E	N	SRD	Y	Y	R H E	Y
M	12	pub.	R H	Y	SRD	Y	Y	R H E	Y
M	12	educ.	R H	N	SRD	Y	Y	R H	Y
M	12	educ.	R	N	SRD	Y	Y	R	—
F	12	opt.	R H M	N	—	Y	Y	R H	Y
M	12	pub.	R	N	—	Y	Y	R	—
M	13	pub.	R H	N	SRD	Y	Y	R H	Y
F	13	educ.	R H	N	SRD	Y	Y	R H	N
M	13	pub.	R E	N	—	Y	Y	R H E	Y
F	14	med.	R	N	SRD	Y	Y	R	—
M	14	pub.	R H E M	Y	SRD	Y	Y	R H E	Y
M	14	pub.	R	N	—	Y	Y	R	Y
F	15	pub.	R H E	Y	SRD	Y	Y	R H	Y
F	15	educ.	R H E	N	—	Y	Y	R H E	—
M	15	opt.	R	N	SRD	Y	Y	R	—
M	15	pub.	R H E	N	SRD	Y	N	—	—
M	15	pub.	R	Y	—	Y	Y	R	—
M	16	med.	S R H E	Y	—	Y	Y	H	—
M	17	pub.	R H E	N	SRD	Y	Y	R E	—
M	17	educ.	R H E	Y	—	Y	N	—	—
F	17	med.	S	N	—	N	Y	S	—
F	18	pub.	E R	N	SRD	Y	Y	R E	Y
F	19	pub.	R H	N	—	Y	N	—	—
F	19	med.	Ag E H	N	—	N	Y	R H	—
F	22	med.	H	N	—	Y	N	—	Y
F	22	med.	H	N	—	Y	Y	H	N
F	25	—	S	N	SRD	Y	Y	R H	Y
F	32	pub.	S	N	—	Y	Y	—	N
F	33	pub.	H Fl	N	—	N	Y	H Fl	—
F	35	pub.	H	Y	—	N	N	—	—
F	36	pub.	H E vdu	N	—	N	Y	H E vdu	—
F	38	med.	S Ag	N	—	Y	Y	Ag	N
F	38	pub.	R H	N	—	Y	Y	R H	N
F	38	educ.	R H E	N	—	Y	N	—	Y
M	42	pub.	H vdu	Y	—	Y	Y	H vdu	Y
F	42	educ.	E Ag Fl	N	—	Y	Y	—	—
F	43	med.	H E vdu M	N	—	Y	Y	H vdu	—
M	45	med.	Fl	N	—	N	—	—	Y
F	46	med.	E	Y	—	N	N	—	—
F	53	opt.	vdu E H	Y	—	N	N	—	—
F	53	pub.	E H vdu Fl	Y	—	N	N	—	—
F	56	med.	H E	N	—	N	Y	H	—
M	56	med.	R	Y	—	Y	Y	R	—
M	64	med.	H	Y	—	N	N	—	—

normal scene and text, patients were invited to select the combination that best reduced the distortion, with a minimum of effect on colour perception. The choice of trial lenses was used to guide the tinting of spectacle lenses with virtually identical spectral transmission. The patients were provided free of charge with lenses suitable for fitting into frames. The lenses incorporated any refraction that was habitually worn. Patients were instructed that the lenses were experimental, that they should wear the glasses only if it was comfortable to do so and that they should stop wearing them if the eyes watered, reddened or went dry. It was stressed that children should be left free to choose whether or not to wear their glasses.

Results

All patients were contacted in follow-up an average of one year after their first visit (range 10–26 months). They were asked whether or not they were still wearing the glasses, and, if so, whether the glasses were reducing the presenting symptoms. *Table 1* presents a summary of the findings. There were 45 patients (82%) who were still using their glasses; 44 reported improvements in reading, reduction of headaches or other benefits.

Most patients were referred with problems relating to reading, headache, or 'eyestrain' (periocular pain), and many patients had more than one of these complaints, see *Table 1*. Those who were referred with reading problems were more likely than others to report benefit ($\chi^2(2) = 4.9$, $P < 0.03$). Of the 45 patients who were still wearing their glasses, 40 had reported perceptual distortion of text, as compared with only five of the 10 who were no longer wearing them ($\chi^2(2) = 8.4$, $P < 0.02$). The few patients with photosensitive epilepsy will be reported in detail elsewhere.

The chromaticities of the lenses were necessarily similar to those of the colorimeter settings, although patients tended to choose lenses with lower saturation than the colorimeter setting. The mean saturation (CIE 1976 s_{uv}) for colorimeter settings was 1.43 (SD 0.07) and for lenses, 0.78 (SD 0.05); $t(32) = 3.15$, $P < 0.004$. The chromaticity coordinates of the lenses are shown in *Figure 1*. The average phototopic transmission was 54% (range 1–93%). A small positive correlation between u' and v' values ($r_s = 0.29$, $P < 0.045$) indicates the scatter of chromaticities is not random. The scatter resembles that for a large sample of Irlen filters[5], which also show a similar though non-significant correlation ($r_s = 0.17$, $P < 0.06$). In the present study there were significantly more data points with u' coordinates less than those of equal energy white (shown by the intersection of the dotted lines in *Figure 1*). The distribution was more even with respect to v' coordinates. The greatest concentration of points was in the quadrant with both u' and v' coordinates less than those of equal energy white, that is, with blue hues. Fewest points lay in the quadrant representing purple hues. A one-sample χ^2 test indicated that the distribution over the four quadrants differed from that expected by chance ($\chi^2(3) = 6.04$, $P < 0.013$). The mean hue angle (CIE 1976 h_{uv}) was derived from unit vectors independently of saturation[6] and was found to be 163°, indicating a tendency for blue-turquoise hues to be more common, although the mean vector length was 0.15 and a Rayleigh test did not show significant departure from randomness[6] when saturation was separated in this way. The mean saturation (s_{uv}) of glasses that were still worn (0.73) was marginally greater than those that were not (0.34), $t(45) = 1.86$, $P < 0.07$.

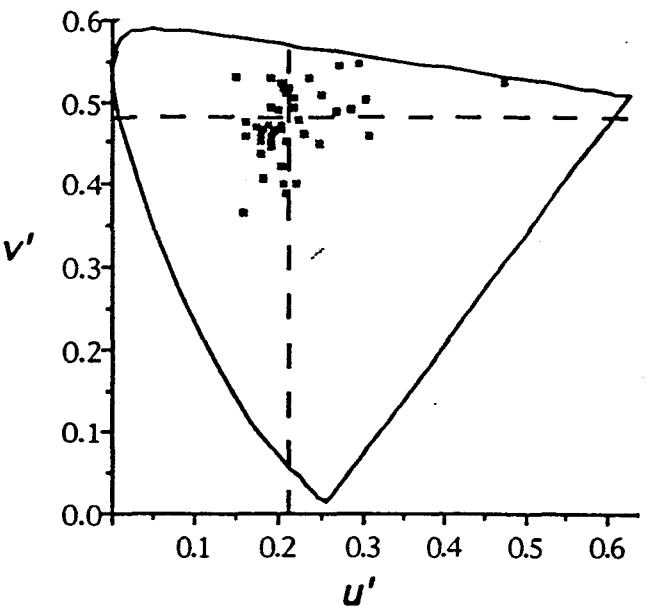

Figure 1 Chromaticity coordinates of lenses. The broken lines intersect at the coordinates of equal-energy white

There were 32 patients reporting a family history of 'migraine' as compared with 8 who did not. Five of the eight were no longer using their glasses. The prevalence of migraine in the general population is only about 10%, although it varies considerably from one study to another, depending partly on definition[7]. The information provided by patients was insufficient to allow a formal classification of the migraine, and without such classification it is uncertain whether the incidence of reports of 'migraine' (as referred to by the subject) is higher than that to be expected. To ascertain whether the family history was exceptional, the present data were complemented by those from a completely independent series described below.

Independent series

One of us (S.Y.) teaches children with reading difficulty and routinely assesses perceptual distortion of text using a range of spectral filters. The records of 74 children seen over the last three years were examined. Of the 74, 35 children found colour of benefit in reducing perceptual distortions of text, and 21 of these (60%) reported familial 'migraine' (parents, siblings or offspring). Of the 39 who did not benefit from colour, 12 (31%) reported familial 'migraine'. The sample reporting benefit from colour had a significantly greater incidence of migin the family ($\chi^2(2) = 6.4$, $P < 0.01$).

Discussion

Given the present ignorance concerning the possible benefits of precision tinting, the heterogeneous aetiology of the present sample is perhaps a strength. Patients referred with reading difficulty were more likely than others to continue wearing the glasses, and this may reflect the referral pattern, patients' expectations, or the nature of the assessment. One investigator provided the

tint and a different investigator liaised with patients concerning its effects. Although patients should therefore have felt able to report adverse effects, the majority reported benefit and 82% of the sample reported continued usage. The tints appeared to be of benefit in reducing (unspecified) headache and eye-strain in certain cases, but particularly when this was associated with reading difficulty. Continued usage was predicted by one presenting symptom more than any other, namely the perceptual distortion of text, more common among children. Notwithstanding the directions that the glasses be worn only if they were beneficial, children may have had less choice than adults in this respect, and this may have contributed to the greater usage amongst children.

A high incidence of a family history of 'migraine' amongst subjects reporting benefits from Irlen filters has previously been noted[8]. The two present series indicate that the incidence is more than would be expected by chance, and is related to the reports of beneficial effects of colour on perceptual distortion. People who suffer migraine are known to be more sensitive than others to patterns, particularly stripes with specific spatial characteristics[9,10]. Text resembles stripes with the appropriate characteristics[11], inducing pattern-glare[12], and distortions[8]. When observing text, subjects with migraine differ from controls in the preferences for coloured illuminants that they exhibit[13]. Contrast sensitivity loss in migraine is related to the duration of disease[14], indicating that migraine may have effects on vision, possibly due to the interference with cerebral blood supply[15]. If so, the blob cells of V1 staining for cytochrome oxidase[16,17] are likely to be preferentially affected since they have a greater metabolic turnover. These cells signal colour opponency[18] and interference with their function may therefore provide one possible explanation of the effects of tinting.

Migraineurs usually find reddish hues aversive[13], and in the present sample there was a tendency to select hues complementary to red. Migraine and dyslexia may be related disorders[19]. The apparent success in treating children with reading difficulties may alternatively reflect the effects of the selective loss of transient visual function recently noted in these subjects[20], although the apparent benefit of colour is not readily explainable in these terms. It has been argued that if the transient system deficits impair the transmission of luminance information over channels similar to those postulated by Buschbaum and Gottschalk[21], then a coloured lens may improve the efficiency of transmission over the damaged pathways[3]. It follows from the mathematics presented by Buschbaum and Gottschalk that a lens with hue complementary to red would reduce the information transmitted on the luminance channel. were transmission optimally efficient.

In any open trial of this nature placebo effects may play an important role. Nevertheless, the association with migraine is difficult to explain solely on the basis of subjects' expectations or motivation. The large proportion of the sample reporting continued use of their tinted lenses justifies the multi-centre double-blind, placebo-controlled study now under way. Although the subjects who participated in the present study were wearing any necessary refractive correction, a full optometric assessment would be necessary to rule out optometric mechanisms that have been advanced[22] as explanations of the effects of tinted glasses. The double-blind study incorporates such assessment.

References

1. Irlen, H. *Reading by the Colors: Overcoming Dyslexia and Other Reading Disabilities through the Irlen Method.* Avery Publishing Group, New York, USA (1991).
2. Evans, B. J. W. and Drasdo, N. Tinted lenses and related therapies for learning difficulties—a review. *Ophthal. Phsyiol. Opt.* **11**, 206–217 (1991).
3. Wilkins, A. J., Milroy, R., Nimmo-Smith, I., Wright, A., Tyrrell, R., Holland, K., Martin, J., Bald, J., Yale, S., Miles, T. and Noakes, T. Preliminary observations concerning treatment of visual discomfort and associated perceptual distortion. *Ophthal. Physiol. Opt.* **12**, 257–263 (1992).
4. Wilkins, A. J., Nimmo-Smith, I. and Jansons, J. A colorimeter for the intuitive manipulation of hue and saturation, and its application in the study of perceptual distortion. *Ophthal. Physiol. Opt.* **12**, 381–385 (1992).
5. Wilkins, A. J., Peck, A. and Jordan, B. Visual discomfort in the classroom. *Child Language Teaching and Therapy* **7**, 326–340 (1992).
6. Chronicle, E. and Nimmo-Smith, I. Application of some statistical methods for comparing samples of hue-angle data. *Color Research and Application* **17**, 375–378 (1992).
7. Blau, J. N. and Drummond, M. F. *Migraine.* Office of Health Economics, London, UK (1991).
8. Wilkins, A. J. and Neary, C. Some visual, optometric and perceptual effects of coloured glasses. *Ophthal. Physiol. Opt.* **11**, 163–171 (1991).
9. Wilkins, A. J., Nimmo-Smith, I., Tait, A., McManus, C., Della Sala, S., Tilley, A., Arnold, K., Barrie, M. and Scott, S. A neurological basis for visual discomfort. *Brain* **107**, 989–1017 (1984).
10. Marcus, D. A. and Soso, M. J. Migraine and stripe-induced visual discomfort. *Arch. Neurol.* **46**, 1129–1132 (1989).
11. Wilkins, A. J. and Nimmo-Smith, I. The clarity and comfort of printed text. *Ergonomics* **30**, 1705–1720 (1987).
12. Wilkins, A. J. and Nimmo-Smith, I. On the reduction of eyestrain when reading. *Ophthal. Physiol. Opt.* **4**, 53–59 (1984).
13. Chronicle, E. P. and Wilkins, A. J. Colour and visual discomfort in migraineurs. *Lancet* **338**, 890 (1991).
14. Khalil, N. Investigations of visual function in migraine by visual evoked potentials and visual psychophysical tests. Unpublished PhD Thesis, University of London, UK (1991).
15. Olesen, J. The ischemic hypotheses of migraine. *Arch. Neurol.* **44**, 321–322 (1987).
16. Horton, J. C. and Hubel, D. H. A regular patchy distribution of cytochrome-oxidase staining in primary visual cortex of the macaque monkey. *Nature* **292**, 762–764 (1981).
17. Humphrey, A. L. and Hendrickson A. E. Background and stimulus-induced patterns of high metabolic activity in the visual cortex (area 17) of the squirrel and macaque monkey. *J. Neurosci.* **3**, 345–358 (1983).
18. Livingstone, M. S. and Hubel, D. H. Psychophysical evidence for separate channels for the perception of form, colour, movement, and depth. *J. Neurosci.* **7**, 3416–3468 (1987).
19. Geschwind, N. Cerebral dominance in biological perspective. *Neuropsychologia* **22**, 675–683 (1984).
20. Lovegrove, W., Martin, F. and Slaghuis, W. A theoretical and experimental case for a visual deficit in specific reading disability. *Cogn. Neuropsychol.* **3**, 225–267 (1986).
21. Buchsbaum, G. and Gottschalk, A. Trichromacy, opponent colour coding and optimum colour information transmission in the retina. *Proc. Roy. Soc. Lond. B* **220**, 89–113 (1983).
22. Schieman, M., Blaskey, P., Gallaway, M., Cincer, E. and Parisi, M. Visual characteristics of adult Irlen filter candidates: case studies. *J. Behav. Optom.* **1**, 174–178 (1990).