Helping Reading with Colour

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INTRODUCTION

Until recently there was little convincing evidence that colour could help with reading, but such evidence is emerging and slowly acquiring the scientific respectability it has hitherto lacked.

THE IRLEN INSTITUTE

Helen Irlen, a psychologist from California, has established Irlen Centres in many western countries. She aims to treat a syndrome that she has variously named 'Scotopic Sensitivity Syndrome' or 'Irlen syndrome'. According to Irlen, this is a syndrome in which reading is hampered by distortions of print. The distortions abate when the text has a particular colour, different for each individual[1]. The Irlen Centres diagnose the required colour and issue individually dyed coloured lenses.

The first detailed description of the syndrome that I have been able to find is by an astute teacher from New Zealand, Olive Meares[2]. She describes the difficulty certain children have with glare from the page and the way in which this glare can be reduced by coloured filters placed over the page.

PERCEPTUAL DISTORTIONS

It is interesting to listen to children who benefit from coloured filters giving a description of what they see when they look at a page of text. Many describe quite florid distortions which their vocabulary is often inadequate to convey to a sceptical adult. They may, for example, say "the text fizzes" or "the letters jumble" or "fall off the edge of the page", or "the white page comes up and hits my eyes". Sometimes the children suppose that these distortions are normal and do not mention them until prompted by questions such as "Do the letters and words do anything different, after you have been reading for a while?"

SCIENTIFIC KNOWLEDGE

These distortions of spatial perception are poorly understood and there is no scientific rationale for supposing they might be reduced with colour. Indeed there is little scientific rationale for supposing that colour might affect spatial perception in any way. Current knowledge suggests that the image captured by the eye is processed in modules that keep certain aspects of spatial information at least partially independent of information concerning colour. Not only has the study of colour perception and spatial perception proceeded along separate lines, the notion that there are differences in visual processing between different observers has usually been ignored for the sake of simplicity.

Claims that colour could reduce spatial distortions in text, and that each individual benefited from a different colour are therefore quite free from any basis in established knowledge and run counter to the little that has been established. Given the absence of any scientific rationale, scepticism was understandable. It was fuelled by Irlen's use of the term 'Scotopic Sensitivity Syndrome' because the word scotopic is normally used to refer to the activity of the rods, receptors that are active in twilight.

The lack of scientific rationale for a treatment does not, of course, mean that the treatment does not work! Many successful medical treatments are empirical and without a well established scientific rationale. As we will see, Irlen's claims have been borne out in recent scientific investigations and, in recognition of her contribution and that of Meares, it would seem appropriate to give the name 'Meares-Irlen syndrome' to a cluster of symptoms of perceptual distortion and visual discomfort with which readir.g is sometimes associated.

RECENT SCIENTIFIC EVIDENCE

We began our investigation of the effects of colour on reading in 1989 by examining 20 clients who had received Irlen's coloured lenses and who found them beneficial. We gave the clients a wide range of tests: those that an optometrist would conventionally use and less conventional tests designed to assess perceptual function and reading. These tests revealed surprisingly little, although the Irlen lenses appeared to reduce perceptual distortion and to improve the speed of visual search by a small amount[3]. Nevertheless the clinical histories the clients gave were convincing and consistent; most reported improvements in reading and a reduction in headaches. Sixteen of the 20 individuals had migraine in the family. We had earlier studied relationships between migraine and susceptibility to perceptual distortions[4], and so we thought the issue deserved further investigation.

INTUITIVE COLORIMETER SYSTEM

To study the effects of colour we needed an instrument that would allow colours to be sampled in a simple way. Clients

needed to be able to obtain any subtle shade systematically, so that if indeed there was a colour that reduced distortions, they would be able to find it. We invented a device which has subsequently become known as the Intuitive Colorimeter[5]. It is simply a box with an aperture through which can be seen a page of text lit uniformly with light of a particular colour. One control on the side of the instrument changes the colour (hue), one changes the depth of that colour (saturation), and a third control changes the brightness. Using this device it was simple to demonstrate that individuals who reported distortions of text were often able to find a colour where those distortions disappeared and the text appeared stable and comfortable to view. The range of colours over which this improvement occurred was often quite small, and the optimum colour varied from one individual to another. Settings made using this instrument have proved to be reliable[6], notwithstanding early claims to the contrary[7].

Many of the children we saw could not afford to obtain Irlen lenses, so we tried to help them by selecting colours from the cosmetic tints then available. The intention was to provide glasses that under conventional lighting would produce the colour the child had selected in the Colorimeter. Sometimes these would be successful, but often the child would say "these are good but not as good as the colourbox". We tried dyeing our own lenses, dipping CR39 resin lenses into hot dye until the required depth of colour was obtained. This improved matters, but it was clear that the dyes we had available did not sample colours adequately or systematically, particularly greens. At this point we were visited by a firm who manufactured cosmetic dyes. They were interested in the Colorimeter and offered to help produce a range of trial lenses that would sample colours systematically and thoroughly. Before long we had a range of trial lenses that could reproduce any colour very simply and with a very high degree of precision. It was a simple matter to dye spectacle lenses to match a chosen combination of trial lenses.

Preliminary observations and open trials

In preliminary trials[8] there were remarkable clinical results in a few cases. One client springs to mind. She could not correctly read the words was and saw. In a list in which these words occurred at random her performance was similarly random. She was unaware of her errors but reported that the **s** and **w** moved around. With a particular yellow hue this illusory movement ceased and she was then able to read the words quite correctly even though she was still unaware as to whether or not her performance was correct. Changing the hue slightly resulted in a return to the previous random performance.

Following publicity, we saw 50 individuals, mainly children, who reported perceptual distortions when reading. These volunteers were offered coloured overlays and if the overlays were helpful, the volunteers were assessed with the Colorimeter and offered lenses of the selected hue free of charge. We interviewed these individuals after they had been in possession of the lenses for more than ten months. A surprisingly high proportion (82%) reported they were still using the glasses[9]. This provided the motivation for a double-masked trial.

Double-blind study

A double-blind or double-masked trial is one in which none of the participants, neither investigators or subjects, knows which is the experimental treatment and which is a sham treatment against which the experimental treatment is being compared. Such trials are invariably used to assess a new drug before it is released on the market. The sham (placebo) must be indistinguishable from the active drug in terms of its appearance. It is only in this way that the effectiveness of a drug can be assessed independently of a person's belief in it. Many people thought it was impossible to undertake a double-masked study of tinted lenses because participants would know which colour they had selected and this would be the one they believed in. Fortunately the Colorimeter circumvented this difficulty.

Using the Colorimeter it was possible to determine the colour that subjects found beneficial for perception without them knowing the shade of the lenses that provide the colour under conventional lighting. This was because when subjects observe text in the Colorimeter they adapt to the coloured light and are eventually unaware quite how strong a colour is illuminating the page. When the appropriate lenses are provided they appear far more strongly coloured than expected.

The children who took part in the study selected their optimal colour in the Colorimeter. The hue wheel was then turned until the child reported the distortions starting to reappear and this setting provided a placebo control. Spectacle lenses were made to match each setting and one pair, active or placebo, selected at random, was glazed into frames and sent to the child. The child kept the glasses for a four-week period during which a headache diary was completed and then the spectacles were returned.

After a four week interval while the frames were reglazed (active lenses being replaced by placebo and vice versa) the spectacles were returned for a second period of four weeks during which the headache diary was completed. Two optometrists, Dr. Bruce Evans and Jenny Brown helped us conduct the study.

Despite the small sample of children (only 31 completed

headache diaries systematically), there was a clear reduction in headaches when the active lenses were worn, as compared with the placebo[10]. In seven of the children the reduction was most unlikely to have occurred by chance. In none of the children was there a significant reduction with the placebo lenses. The likelihood of such a result by chance was less than 0.5 per cent. And this was despite a very small difference in colour between the active and placebo lenses.

The effects on reading were more equivocal. Scores on the Neale Analysis of Reading Ability were better with either lens than with neither, but although the scores with the active lenses were superior to those with the placebo, the difference could well have occurred by chance. As will become clear later, the Neale Analysis is not the most sensitive instrument for investigating the effects of colour on reading.

Earlier studies

The double-masked study lends credence to earlier studies. As others have remarked, "many of these studies have been difficult to interpret due to design problems, such as selection bias, sample size, heterogeneity of subjects, subjectivity of results, financial interest of investigators and failure to consider such factors as placebo effect, controls and ophthalmic status of subjects."[11] It also helps to explain the failure of several well-controlled studies to reveal any beneficial effects of colour. One such study was by Menacker and colleagues[11]. These authors measured reading errors and used a limited choice of coloured lenses. They failed to show any differences between the coloured lenses and grey (neutral density) lenses. Martin and colleagues[12] also measured reading performance but did so with and without Irlen lenses and failed to show improvements in reading. If the effects of coloured lenses have more to do with symptoms of eye-strain and headache than with reading *per se*, as the double-masked study suggests, then these findings are to be expected. As will become clear from the studies described below, the effects of colour depend critically on typography. Colour has its greatest benefit with text that is small and closely spaced. With more conventional text, the effects on reading speed take time to appear and do so only when the reader is beginning to tire.

Overlays

Overlays are sheets of coloured plastic that can be placed upon a page so as to colour the text beneath without interfering with its clarity. There are several studies that have used coloured overlays rather than lenses. Some of these studies have shown improvements in reading, at least in selected clients[13,14]. As Solan[15] has remarked, the studies that have shown beneficial effects have generally been conducted by investigators associated with the Irlen Centres; independent investigators have usually failed to show any effects.

Tyrell and colleagues[16] measured the speed with which a child read a passage photocopied from a book chosen by the child. On separate days and in random order the reading was undertaken with or without an overlay the child had selected as optimal. About half the children chose a clear overlay, included as a control, and the remainder chose one of the coloured Irlen overlays. The reading continued for 15 minutes and initially there was no difference in speed between the two conditions. Differences emerged only after the children had been reading for ten minutes and had begun to tire. The children who had chosen a coloured overlay slowed up when they were reading without it and reported symptoms of eye-strain; the children who had chosen a clear overlay reported fewer symptoms, did not slow up and showed no benefit from use of the overlay. The children who took part in the above study were selected from the entry year of a secondary school and a surprisingly high proportion reported improvements in the appearance of text using an overlay, a greater proportion among the children with reading difficulty than among the good readers.

In two subsequent studies, as yet unpublished, we examined all the children aged 7 - 11 in two primary schools, using the Intuitive Overlays[17]. These differ from other overlays on the market in that they sample a wide range of colours systematically and efficiently. As in the study by Tyrrell and colleagues, abut 50 per cent of children reported improvements in the perception of text with one of the overlays. These children were given their preferred overlay free of charge to use as and when they wished. After ten months about half the children were, of their own volition, still using the overlay.

In these recent studies reading speed was assessed using a test we devised called the 'Rate of Reading Test'. This test consists simply of a passage of words that subject is required to read aloud as rapidly and as accurately as possible. The words are all of very high frequency and are therefore familiar to most children, even those whose reading is very poor. The words are arranged in random order to minimise contextual cues. The text is printed in small, closely spaced lettering so that any visual difficulty is maximised and affects reading speed after only a short period of reading.

The rate of reading measured using this test is highly reliable from one examination to the next, but differs considerably from one child to another. The difference in a child's rate of reading with and without a chosen overlay predicts whether the child will continue to use the overlay. Children who will subsequently persist in using their overlay average an increase in speed of 15 per cent when reading with the overlay. In some children the increase can be as great as 50 per cent[18, 19].

The increase in reading speed cannot readily be attributed to motivation because:

1. clear or grey filters usually have little effect;
2. the increase in speed occurs only when the text is visually stressful;
3. as mentioned above, children persist in using the overlay for many months without prompting.

The increase occurs in children who have been carefully screened for refractive errors and anomalies of binocular vision[18].

We obviously need to know why such a large proportion of children in British schools seem to be demonstrating a visual component of reading difficulty. What proportion of children receive adequate visual screening and what proportion of children continue to use their overlay once they have received adequate optometric and orthoptic treatment?

These are questions that we are now trying to answer.

Physiological basis

The physiological basis for the beneficial effects of colour remains uncertain and contentious. The effects can no longer be dismissed as placebo effects and some physiological explanation is called for. In a recent book, Visual Stress[20], I draw attention to the similarities between the physiological mechanisms that induce seizures in patients with photosensitive epilepsy and those responsible for photophobia in migraine. The children who find colour helpful usually have migraine in the family and migraine is now known to have subtle effects on vision. The argument is spelled out in detail in the book, with supporting evidence that cannot be given here. In essence, the perceptual distortions are attributed to a hyperexcitability within the visual system, neurones firing inappropriately as a result of a spread of excitation. Coloured spectacles are thought to reduce the excitability by redistributing the excitation within the neural network of the cortex so as to avoid localised areas of hyperexcitability. This is only one viewpoint among several but it brings together a great many very disparate pieces of evidence. Scientific theories are only as good as the predictions they make and this theory predicts that coloured glasses will prove of benefit in photosensitive epilepsy and certain forms of migraine. There are initial indications that this may indeed be the case. ❖

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References

1 Irlen, H. (1991) *Reading by the Colors.* New York. Avery Publishing Group Inc.

2 Meares, O. (1980) Figure/background, brightness/contrast and reading disabilities. *Visible Language*, 14, 13-29

3 Wilkins, A.J. and Neary, C. (1991) Some visual, optometric and perceptual effects of coloured glasses. *Ophthalmic and Physiological Optics,* 11, 163-171

4 Wilkins, A.J., Nimmo-Smith, I, Tait, A., McManus, C., Della Sala, S., Tilley, A., Arnold, K., Barrie, M and Scott, S (1984). A neurological basis for visual discomfort. *Brain*, 107, 989 -1017

5 Wilkins, A.J., Nimmo-Smith, I. and Jansons, J. (1992b). A colorimeter for the intuitive manipulation of hue and saturation and its role in the study of perceptual distortion. *Ophthalmic and Physiological Optics*, 12, 381-385

6 Wilkins, A.J. (1996) A system of precision ophthalmic tinting and its role in the treatment of visual stress. In Dickinson et al (ed) *Proceedings of the Dalton Conference*, Manchester

7 Mason, A.J.S., Fowler, M.S. and Stein, J.F. (1994). Evaluation of the Intuitative Colorimeter, *Investigative Ophthalmology and Visual Science*, 35(4), 1754

8 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. (1992a). Preliminary observations concerning treatment of visual discomfort and associated perceptual distortion. *Ophthalmic and Physiological Optics*, 12, 257-263

9 Maclachlan, A., Yale, S. and Wilkins, A.J. (1993). Open trial of subjective precision tinting: follow-up of 55 patients. *Ophthalmic and Physiological Optics*, 13. 175-178

10 Wilkins, A.J., Evans, B.J.W., Brown, J.A., Busby, A.E., Wingfield, A.E., Jeanes, R.J. and Bald, J. (1994). Double-masked placebo-controlled trial of precision spectral filters in children who use coloured overlays. *Ophthalmic and Physiological Optics*, 14(4), 365-370

11 Menacker, S.J., Breton, M.E., Breton, M.L ., Radcliffe, J. and Gole, G.A. (1993) Do tinted lenses improve the reading performance of dyslexic children? *Archives of Ophthalmology*, 111, 213-218

12 Martin, F., Mackenzie, B., Lovegrove, W. and McNicol, D. (1993) Irlen lenses in the treatment of specific reading disability: an evaluation of outcomes. *Australian Journal of Psychology*, 45(3), 141-150

13 Kyd, L.J.C., Sutherland, G.F.M. and McGettrick, P.M. (1992) A preliminary appraisal of the Irlen screening process for scotopic sensitivity syndrome and the effect of Irlen coloured overlays on reading. *British Orthoptic Journal,* 49, 25-30

14 Robinson, G.L. (1994) Coloured lenses and reading: a review of research into reading achievement, reading strategies and causal mechanism. *Australasian Journal of Special Education*, 18(1), 3-14

15 Solan, H.A. (1990) An appraisal of the Irlen technique of correcting reading disorders using tinted overlays and tinted lenses. *Journal of Learning Disabilities*, 23(10), 621-623

16 Tyrrell, R., Holland, K., Dennis, D. and Wilkins, A.J. (1995) Coloured overlays, visual discomfort, visual search and classroom reading. *Journal of Research in Reading*, 18(1), 10-23

17 Wilkins, A.J. (1994) Overlays for classroom and optometric use. *Ophthalmic and Physiological Optics*, 14, 97-99

18 work in progress

19. Wilkins, A.J., Geanes, R.J., Pumfrey, P.D., Laskier, M. (1996) Rate of reading test: reliability and its validity in the assessment of the effects of coloured overlays. *Ophthalmic and Physiological Optics.* In Press.

20. Wilkins, A.J. (1995) *Visual Stress.* Oxford University Press