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The effect of coloured filters on the rate of reading in an adult student population

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Abstract

Meares–Irlen Syndrome is characterised by visual stress (visual discomfort) and visual perceptual distortions that can be alleviated by individually prescribed coloured filters. The benefit from coloured filters can be demonstrated with the Wilkins Rate of Reading Test (WRRT). Previous research using individually prescribed coloured overlays (sheets of plastic placed on a page) found that between one-fifth and one-third of unselected school-children show a significant (> 5%) improvement in their rate of reading with their chosen overlay. This 5% cut-off has good sensitivity and specificity for predicting those children who will continue to voluntarily use their overlay for a sustained period. Previous research has concentrated on children, and we sought to investigate the immediate effect of overlays on rate of reading in an adult population. Subjects were 113 unselected university students who answered a symptom questionnaire and were tested with the Wilkins Intuitive Overlays and WRRT. Some symptoms were common: 73% reported sore or tired eyes when reading and 40% reported four to 12 headaches a year. One hundred of the subjects chose an overlay as improving their immediate perception of text. These subjects were significantly more likely to report perceptual distortions and visual discomfort on viewing text than subjects who did not choose an overlay. The 100 subjects read 3.8% faster with the overlay than without any overlay ($p < 0.00001$), whereas the 13 subjects who did not choose an overlay read 1.7% slower with a placebo overlay than without ($p = 0.37$). Of the subjects who chose an overlay, 38% read more than 5% faster with the overlay and 2% read more than 25% faster. These results are comparable with those obtained for children. We conclude that Meares–Irlen Syndrome is likely to be as common in adults as it is in children.

Keywords: adults, asthenopia, coloured filters, headaches, Meares–Irlen syndrome, reading difficulties, Scotopic Sensitivity Syndrome, visual perceptual distortions

Introduction

Meares–Irlen Syndrome is a condition characterised by symptoms of visual stress (asthenopia) and visual perceptual distortions (VPD) which are alleviated by the use of individually prescribed coloured filters (Evans, 1997a,b). The colour of the optimal filter can be quite specific and varies from one person to another (Wilkins *et al*., 1994). The syndrome is said to be particularly prevalent in people with reading difficulties, such as dyslexia, but can occur in good readers (Irlen, 1991). Controlled research has shown that the benefit from coloured filters cannot be solely attributed to the placebo effect (Wilkins *et al*., 1994; Robinson and Foreman, 1999) and is associated with an improvement in the rate of reading (Wilkins and Lewis, 1999; Wilkins *et al*., 2001; Bouldoukian *et al*., 2002) and in reading accuracy and comprehension (Robinson and Foreman, 1999). The aetiology of Meares–Irlen Syndrome is still not fully understood (Wilkins, 1995; Evans, 2001), but research suggests that the effect of colour is not solely attributable to a contrast reduction with the filters (Jeanes *et al*., 1997), is specific to a certain colour for each individual (Wilkins *et al*., 1994), and is unlikely to be explained by refractive or ocular motor factors

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(Evans *et al*., 1995, 1996; Evans, 2001; Scott *et al*., 2002).

It has been suggested that the benefit from coloured filters might be explained by the finding of a deficit of the magnocellular visual system in many people with dyslexia (Iovino *et al*., 1998). However, there are some inconsistencies in the 'magno deficit' hypothesis (Greatrex and Drasdo, 1995) and it is difficult to see how this hypothesis could account for the idiosyncratic and specific choice of colour that is required in Meares–Irlen syndrome (Evans, 2001). Furthermore, Meares–Irlen syndrome is not synonymous with dyslexia and studies that have directly assessed magno function in Meares–Irlen syndrome have not found it to be abnormal (Evans *et al*., 1995, 1996; Simmers *et al*., 2001). It therefore seems highly unlikely that a magno deficit could directly explain the benefit from precision tinted lenses in Meares–Irlen syndrome. Alternative explanations are discussed in Wilkins (1995) and Evans (2001).

The Wilkins Intuitive Overlays (I.O.O. Marketing Ltd, London, UK) are used to screen for Meares–Irlen syndrome and were used in the present research. They have a range of colours for systematically sampling the gamut of colours (*Figure 1*) that can be discriminated by people with normal colour perception (Wilkins, 1993). Test–retest repeatability is good: when children are tested a second time 68% choose an identical or very similar colour (Wilkins *et al*., 2001).

A problem with diagnosing Meares–Irlen Syndrome is that there is likely to be a continuum ranging from people who experience no help from coloured filters, through those who show a mild benefit, to the more severe cases who may experience one or more of the following benefits when using individually prescribed coloured filters: a marked improvement in symptoms of eyestrain and VPD when reading; reduction in attacks of headaches, migraine (Wilkins *et al*., in press) and photosensitive epilepsy (Wilkins *et al*., 1999). Two diagnostic criteria that have been used for Meares–Irlen syndrome are a sustained benefit from coloured filters or an immediate benefit in terms of improved rate of reading (Evans, 2001).

Conventional reading tests are designed to measure cognitive aspects of reading skills rather than to detect visual problems (Wilkins *et al*., 1996) and therefore tend to use large, well-spaced, text. Wilkins *et al*. (1996)

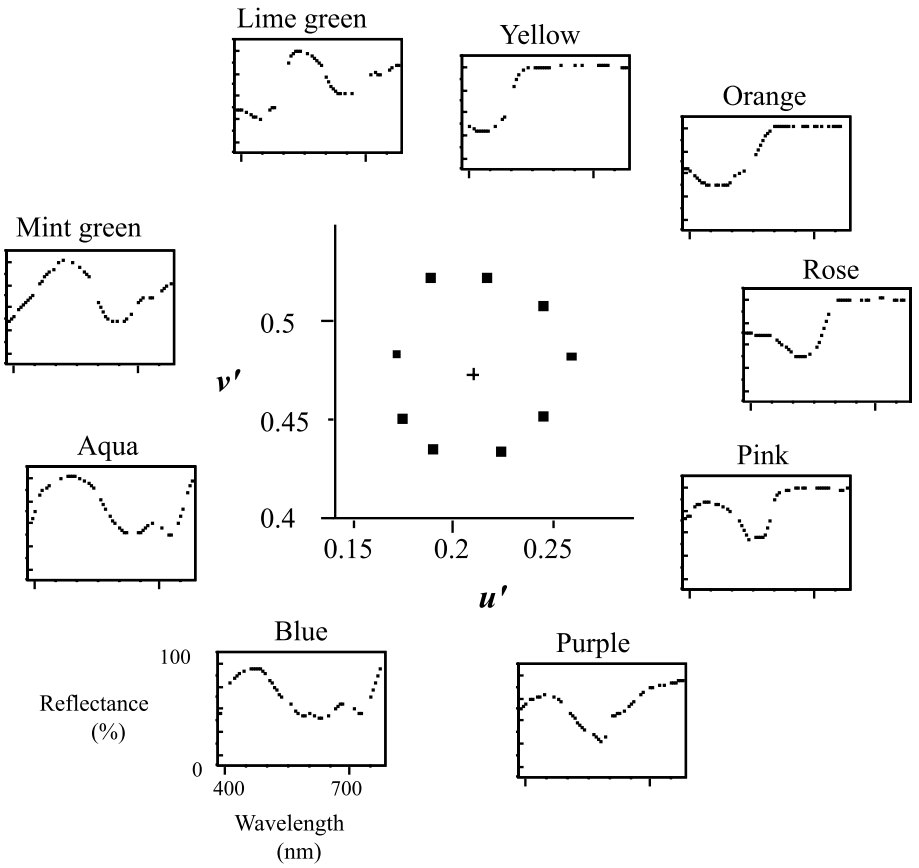

Figure 1. Centre: CIE 1975 UCS (u', v') diagram showing the chromaticity co-ordinates of the nine coloured overlays (■) and that of equal energy white (+). Perimeter: panels show the reflectance (0–100%) of each overlay as a function of wavelength (30–780 nm). The panels are disposed in a manner similar to that of the corresponding chromaticity co-ordinate. Reprinted with permission from Wilkins (1993).

designed a new Rate of Reading Test [Wilkins Rate of Reading Test (WRRT)] which uses commonplace simple words repeated in random order and printed with a small font and closely spaced (*Figure 2*). This test is relatively unaffected by high level reading skills, but is strongly influenced by visual factors. Test–retest reliability (Pearson correlation) was found in two studies to be 0.83 (Jeanes *et al*., 1997) and 0.86 (Wilkins *et al*., 2001).

The WRRT is carried out four times, first with the overlay, then without twice and then with again (an ABBA design to control for practice). The usual criterion that is taken as indicating a clinically significant immediate improvement in performance at the WRRT is an improvement on rate of more than 5%. The data of Wilkins *et al*. (1996, 2001) allow the sensitivity and specificity of this 5% criterion at predicting subjects who would continue to use their overlay on a sustained voluntary basis and this is shown in *Table 1*.

come see the play look up is cat not my and dog for you to
the cat up dog and is play come you see for not to look my
you for the and not see my play come is look dog cat to up
dog to you and play cat up is my not come for the look see
play come see cat not look dog is my up the for to and you
to not cat for look is my and up come play you see the dog
my play see to for you is the look up cat not dog come and
look to for my come play the dog see you not cat up and is
up come look for the not dog cat you to see is and my play
is you dog for not cat my look come and up to play see the

Figure 2. Example of text in WRRT. In the test, there are four samples of text, each similar to that in the figure, with different (random) order of words in each. Reproduced with permission from I.O.O. Marketing Ltd, London, UK.

Three published studies have investigated the prevalence of Meares–Irlen Syndrome in unselected school children (*Table 1*), but no published studies to date have used the Wilkins Intuitive Overlays to investigate Meares–Irlen syndrome in adults. In *Table 1*, Meares–Irlen syndrome is defined on the basis of the benefit from using coloured overlays. Clinically, the presence of symptoms (asthenopia and VPD) that cannot be attributed to binocular or accommodative factors are also taken to be of diagnostic significance. However, there are problems associated with the use of symptoms, which inevitably are highly subjective and may be described by different people in various ways. Additionally, people who have always experienced certain symptoms when reading often seem to accept these as being 'normal' and only realise that they are abnormal once they have been eliminated. The diagnosis of Meares–Irlen syndrome is covered in more detail in the discussion.

All published research on the Wilkins Intuitive Overlays and the WRRT has been carried out on children. Yet, dyslexia, which has a high comorbidity with Meares–Irlen Syndrome (Irlen, 1991; Evans *et al*., 1999), is a life-long condition (Shaywitz, 1996) and it has been alleged that Meares–Irlen Syndrome is also common in adults (Irlen, 1991). One small study suggested a benefit from Irlen filters in adults (Robinson and Conway, 2000). The aims of the present study were to evaluate the suitability of the Wilkins Intuitive Overlays and WRRT for use in adults and to investigate the prevalence of Meares–Irlen Syndrome in an adult population.

Table 1. Prevalence of Meares–Irlen Syndrome in children. The percentage column gives the proportion of the full study population who meet the adjacent criterion. Sensitivity is defined as the percentage of the full study population who chose an overlay and continued to use it – who initially showed an improvement of >5% in the rate of reading. Specificity is defined as the percentage of the full study population who either did not choose an overlay or did not continue to use one – who did not initially show an improvement of >5% in the rate of reading. An alternative method, used by Wilkins *et al*. (2002, Fig. 7) and included here in parentheses, defines specificity as the percentage of participants who chose an overlay but did not continue to use it – who did not initially show an improvement of >5% in the rate of reading

Study	Sample	Criterion	Percentage (%)
Wilkins *et al*. (1996; Fig. 3)	77 Unselected children, aged 8–11 years	Initially selected to use	49
		>5% faster at WRRT	22
		Sustained (8 weeks) voluntary use	20
		Sensitivity of 5% criterion for sustained use	73
		Specificity of 5% criterion for sustained use	90 (74)
Jeanes *et al*. (1997)	152 Unselected children, aged 5–11 years	Initially selected to use	53
		Sustained (3 months) voluntary use	36
		Sustained (10 months) voluntary use	24
Wilkins *et al*. (2001;Table 3 & Fig. 7)	430 Unselected children, aged 6–8 years	Initially selected to use	60
		>5% faster at WRRT	36
		Sustained (8 months) voluntary use	31
		Sensitivity of 5% criterion for sustained use	68
		Specificity of 5% criterion for sustained use	79 (50)

Methods

Subjects

Subjects were university students from the South Bank University in London. This University has approximately 20 000 students on a wide range of courses. Subjects were recruited from several sites: the library, project area, learning resources centre, and a unit providing personal support in terms of counselling, chaplaincy and careers guidance. None of the students seen in the learning resources area was attending for an assessment of learning difficulties.

Procedure

A brief questionnaire was administered individually by the researcher to determine whether there are any symptoms of eyestrain (visual stress) or headaches when reading (Appendix). Volunteers were then tested with the Wilkins Intuitive Overlays (*Figure 1*), as detailed in the test instructions (standard test pack 1999 reprint) (I.O.O. Marketing Ltd, London, UK). In brief, a range of coloured overlays (coloured plastic sheets that are placed over a page of text) are presented sequentially to determine the effect of the filters on the perception of text. The text that is used is crowded and, in the test version used in the research, had randomly ordered letters so that the words cannot be read. The coloured overlay (or combination of overlays), if any, which most improves the perception (clarity and comfort) of text is identified.

The overlays have been described by Wilkins (1993) and the repeatability of the colour choice was evaluated by Jeanes *et al*. (1997). When placed over a page of white paper the reflectance of the paper through the overlays varies little with the angles of incident and reflected light, provided specular reflections are avoided. It is most appropriate to describe the spectral properties of the overlays in terms of the reflectance of white paper through the overlay and this is illustrated in *Figure 1*. The overlays have chromaticities disposed approximately evenly around the circumference of a circle in the CIE 1976 UCS diagram, centred on white (*Figure 1*). The hue angle, h_{uv}, between neighbours averages 40° with a standard deviation of 7.7°; the saturation, s_{uv}, averages 0.52 (S.D. 0.19). The photopic reflectance (when the overlay was placed upon a halon standard) averages 65% (S.D. 13%). The overlays provide nine colours and a grey (reflectance 47%) when used singly. They were also used in pairs, one on top of another. The pairs were either of the same colour or of neighbouring chromaticity and provide a further 19 colours having greater saturation (s_{uv} average 1.1, S.D. 0.13) with a hue angle between neighbours averaging 20° (S.D. 4.8°). The overlays therefore sample colours systematically and comprehensively. They have a matt coating and this reduces the contrast of the text beneath. With diffuse illumination and avoiding specular reflection, which were the conditions during the research, the reduction in contrast is generally less than 5%.

The effect of the overlay on the rate of reading was measured using the WRRT (*Figure 2*). This was used as described in the test instructions (1996 reprint) (I.O.O. Marketing Ltd, London, UK), with one exception: subjects were asked to initially read two lines of the passage in Version D without an overlay to familiarise them with the task. All four parallel versions of the test were used, two were read under condition A (with the intervention) and two under condition B (without any intervention). The order of testing, as recommended in the instructions, was ABBA.

For subjects who did not find any of the overlays to be helpful, a control overlay was used as the intervention. This was an ultra-violet blocking (pale yellow colour) filter (*Figure 3*) (Filter 226; Lee Filters, Andover, UK). The following measures were taken to convince subjects that the control filter was 'special' and to enhance the associated placebo effect: the control filter was mounted in a white cardboard frame; the following text was printed on the frame 'Research Model A16 Anti UV/IR Filter. Made in USA'; and this control filter was falsely described to subjects as a new filter from USA where it was thought to 'reduce glare from the page and improve reading speed'. The control filter was only used with subjects who did not choose a coloured overlay. The WRRT therefore involved either a comparison of overlay vs. no filter, or control vs. no filter.

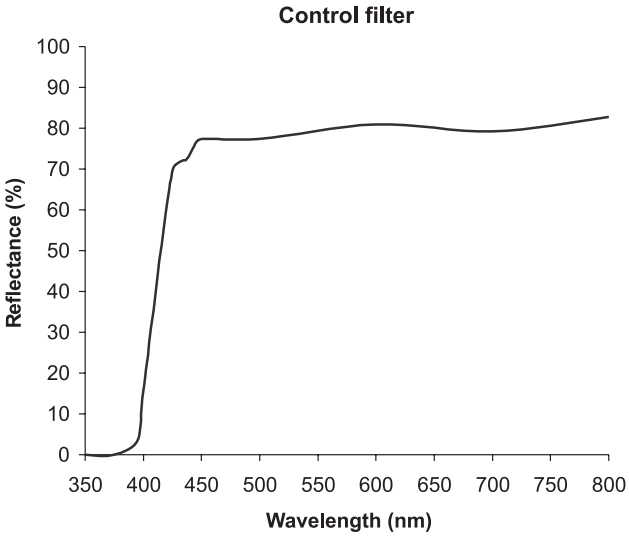

Figure 3. Reflectance of control filter as a function of wavelength. Reproduced by permission of Lee Filters, Andover, UK.

It should be stressed that participants were assigned to the experimental or control groups on the basis of whether or not they found coloured overlays to be helpful. The main purpose of the control group is to compare the characteristics of a group of adults who initially reported coloured overlays to be helpful with a group who did not find them to be helpful. The main purpose of using the control overlay in the control group was to investigate the placebo effect that is associated with use of filters in adults.

Results

Questionnaire

A total of 113 subjects were seen and the data from the questionnaire (Appendix) are given in *Table 2*.

Coloured overlays

The Wilkins Intuitive Overlay test was administered using the standard Record Sheet of the original version of the test (1999 reprint). The first part of this involves asking subjects about their symptoms whilst they view a passage of crowded, meaningless, text. Subjects are asked to report whether or not they experience each of a range of VPD in the text: blurring, doubling, shapes/lines, colours, movement, flicker, wobble and glare. The number of 'yes' responses for these was summed for each subject. Eighty-one percent did not report any VPD, 12% described one VPD, 4% reported two VPD, 2% reported three VPD, 1% reported four VPD, and none more than four VPD. The test also involves asking subjects 'Is the page: very uncomfortable, uncomfortable, comfortable, very comfortable'. Only 1% of subjects found the text 'very uncomfortable', 28% 'uncomfortable', 67% 'comfortable' and 4% 'very comfortable'.

Twelve subjects did not find that any of the overlays improved their perception of text but most (9) of these found that some overlay(s) worsened their perception. All of the other subjects chose overlays as improving perception of text, but one subject reported that all the colours improved his perception equally and was unable to choose a preferred one. Thus, 89% of the subjects reported that a single overlay or pair of overlays had an

Table 2. Responses to questionnaire (see Appendix)

Questionnaire item (see Appendix)	Questionnaire response
Male/female	60% male
University course	Business and Economics: 22% Sciences (including healthcare): 50% Language based (including law): 18% Unknown: 10%
Age	Mean 26 years, S.D. 4 years, range 18–44 years
First language (that usually spoken at home during childhood)	English 64%
History of difficulties at school	Reading: 9%, spelling: 15%, writing: 12%, maths: 18%, other: 8% (other included 2 dyslexia, 3 foreign language)
Last eye examination	40% within last year, 20% never, mean interval for the others 4.7 years
History of eye problems	7% 'turning' eye, 10% eye exercises or patching
Reading 'normally clear'	98%
Prevalence of visual perceptual distortions when reading	Blurring, 24%; jumping, 12%; changing size, 6%; fading or disappearing, 3.5%; doubling, 16%
Frequency of doubling ($n = 18$)	Hardly ever, 39%; rarely, 50%; moderately, 0%; often, 11%
Sore or tired eyes when reading	Never, 27%; hardly ever, 9%; rarely, 47%; moderately, 13%; often, 4%
Holding reading unusually close or far away	4%
Closes or covers one eye	5%
Frequently rubs eyes	20%
Blinks excessively	7%
Skips, re-reads or omits words or lines	35%
Reads slowly	35%
Light sensitive	21%
Prevalence of headaches (based on prevalence in last 3 months multiplied by 4 to give annual prevalence)	None, 28%, 4–12 a year, 40% 13–24 a year, 20%, 25–80 a year, 9% more than 80 a year, 3%
For headache sufferers, association of headache with reading ($n = 81$)	Not associated, 31%, rarely associated, 25% occasionally associated, 24%, quite often associated, 17% very often associated, 3%

immediate positive effect on their visual perception and 88% were able to choose coloured overlays. The proportions of subjects who chose each colour of (single) overlay are illustrated in *Figure 4*.

The subjects' initial symptoms on viewing the text without the overlay were analysed with respect to whether they subsequently chose an overlay. The subjects who found that overlays did not improve their perception did not report any VPD. The most common VPD for the subjects who did find overlays to be helpful were movement (9%) and blurring (7%). The prevalence of these VPD did not differ significantly in the two groups (χ^2 test, $p > 0.6$). Thirty-two percent of subjects who subsequently chose an overlay reported that the text was either 'uncomfortable' or 'very uncomfortable' to view, compared with 8% of the subjects who subsequently did not find overlays to be beneficial. The combined frequency of VPD and visual discomfort was assessed by giving a score of one to each reported VPD (blurring, doubling, shapes/lines, colours, movement, flicker, wobble, glare) and attributing a score of one if the subjects reported the text as being 'uncomfortable' and two for 'very uncomfortable'. This 'combined score' was significantly greater in the subjects who chose an overlay than in those who did not (Mann–Whitney *U*-test, $p = 0.032$). This approach, of combining VPD and visual discomfort (visual stress) scores, has been used in previous research (Wilkins and Nimmo-Smith, 1984; Wilkins and Neary, 1991; Tyrrell *et al.*, 1995; Conlon *et al.*, 1999).

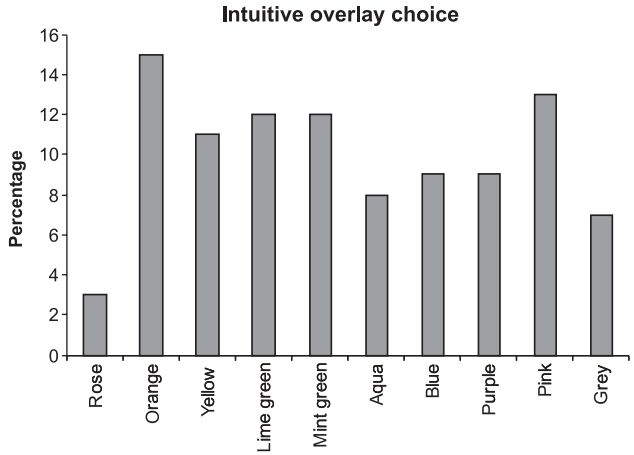

Figure 4. Proportion of subjects who chose each colour of overlay. Only one subjects chose a combination of more than one overlay, which was two purples.

Wilkins Rate of Reading Test

The WRRT results were scored in the usual way as the mean number of words correctly read (wpm) with the intervention (overlay or, if no overlay was preferred, control filter) and without any intervention. These data are shown in *Figure 5* as difference plots showing the change in rate of reading with the overlay vs. the rate of reading. Each point is a subject and points falling above the horizontal line represent an improvement in rate of reading with the filter and those below a decrement in performance.

The 100 subjects who chose a coloured overlay read significantly (paired *t*-test, $p < 0.00001$) faster (3.8%) with their overlay (mean 168.3 wpm, S.D. 35.2) than without (mean 162.1 wpm, S.D. 36.0). On average, the 13 subjects with the control filter read slower (1.7%)

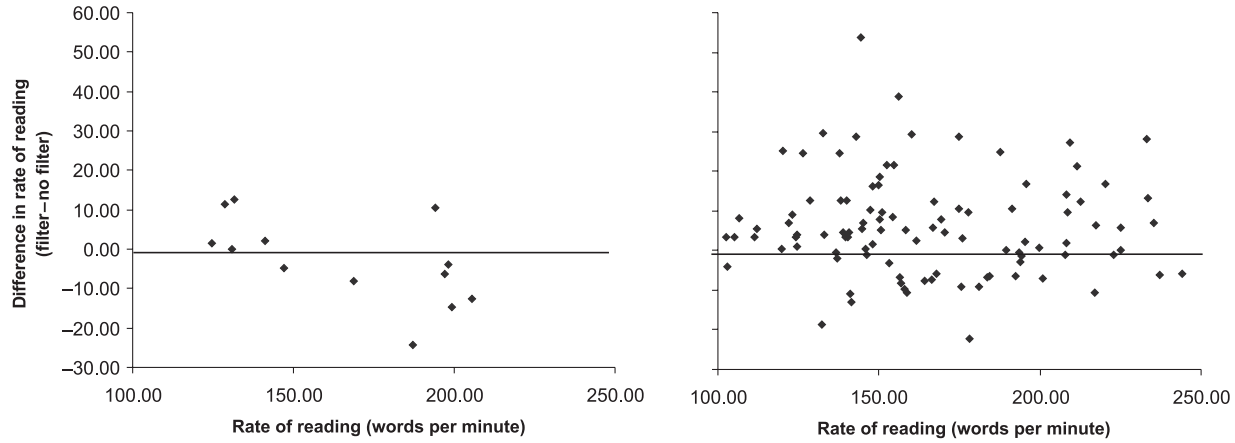

Figure 5. Difference plots showing the effect of filter on rate of reading. Each point is a subject. The vertical axes show the difference in rate of reading (words per minute) obtained by subtracting the rate of reading with no filter from that with the filter (positive values represent faster reading with the filter). The horizontal axes show the rate of reading, calculated as the average of the rate with and without the filter. The left hand graph is for the 13 subjects who did not find a coloured overlay to be helpful and who used the control filter, and the right hand graph is for the 100 subjects who chose a coloured overlay.

with their overlay (mean 164.3 wpm, S.D. 29.3) than without (mean 167.1 wpm, S.D. 35.5), but this difference did not reach statistical significance (paired *t*-test, $p = 0.37$). It should be noted that the above *t*-tests are for paired data because a within-group factor is being investigated. Each subject acts as their own control when their rate of reading with the filter is compared with the rate of reading without any filter.

More than two-thirds (68%) of subjects who chose a coloured overlay read faster with the overlay than without. Thirty-eight percent read more than 5% faster with the overlay than without compared with 9% of subjects who read more than 5% faster without the overlay than with it. 2% of subjects read more than 25% faster with the overlay than without it: none read more than 25% faster without than with.

Only 38.5% of subjects who used the control filter read faster with this than without. 23% read more than 5% faster with than without and 23% read more than 5% faster without than with. None of these subjects read more than 25% faster with the control filter than without or vice versa.

Relationship between symptoms, coloured overlay and rate of reading

The symptoms and behavioural signs (e.g. 'rubs eyes') from the questionnaire were used to compare the 100 subjects who chose an overlay with the 13 subjects who did not choose an overlay (see *Table 3*, columns 2–3). Similarly, the questionnaire results were used to compare the 38 subjects who read more than 5% faster with their preferred overlay with the subjects who did not (see *Table 3*, columns 4–5). The combined score of VPD and visual discomfort (see above) was not significantly greater in subjects who read more than 5% faster (see below) with their overlay than in subjects who did not read more than 5% faster with their overlay (Mann–Whitney, $p = 0.75$).

Although this was not recorded, it was anecdotally noted that many of the subjects who did not have English as their first language at home spoke English at school. It is interesting that the subjects with English as their first language were more likely to be those who read significantly faster with their overlay. The mean

Table 3. Comparison of symptoms from questionnaire

Variable	Control	Overlay	<6% Faster	>5% Faster
n	13	100	62	38
Males	85%	57%	58%	55%
Mean age	26	26	26%	26
English first language	39%	67%	58%	82%*
Difficulty at school with reading	0	10%	10%	11%
Difficulty at school with spelling	0	17%	18%	16%
Difficulty at school with writing	0	13%	16%	8%
Difficulty at school with maths	15%	18%	19%	16%
Difficulty at school with other	15%	7%	6%	8%
Any of the above five difficulties at school	31%	40%	42%	40%
History of turning eye	8%	7%	7%	8%
History of eye exercises or patching	0	11%	10%	14%
Words in a book blur	8%	26%	24%	29%
Words in a book jump	0	13%	13%	13%
Words in a book change size	0	7%	8%	5%
Words in a book fade	8%	3%	2%	5%
Double vision when reading	0	18%	19%	16%
Sore or tired eyes when reading	39%	77%**	77%	76%
Holds reading unusually close or far away	0	5%	7%	3%
Closes or covers one eye	8%	5%	3%	8%
Frequently rubs eyes	15%	21%	16%	29%
Blink excessively	8%	7%	8%	5%
Skips, re-reads, or omits words or lines	8%	31%*	39%	40%
Reads slowly	15%	38%	37%	40%
Poor general co-ordination	0	4%	5%	3%
Light sensitive	23%	21%	24%	16%
Proportion with more than 12 headaches a year	23%	26%	32%	37%
Proportion of headache sufferers whose headaches were 'quite often' or 'very often' associated with reading	13%	22%	21%	23%

The relevant proportions (see text) were compared with the χ^2 test and statistical significance is represented by $^*p < 0.05$; $^{**}p < 0.01$.

rate of reading without overlays was faster in those with English as their first language (165, S.D. 31.8) than in the others (162, S.D. 38), but this difference did not approach significance (t-test, =0.66).

Discussion

Sample characteristics

Our subjects were not given an eye examination, and it is possible that some of their symptoms might be attributable to optometric problems, such as uncorrected refractive errors or binocular or accommodative anomalies. These problems are unlikely to account for the benefit from coloured filters (Evans *et al*., 1995, 1996; Evans, 2001; Scott *et al*., 2002), and are unlikely to have a significant effect on the proportion of subjects reading more than 5% faster with their overlay (see below). Most (80%) of the subjects had received professional eyecare at some time, and 40% had received an eye examination in the last year. So uncorrected optometric problems seem unlikely to be a major factor in our sample.

The proportion of subjects who did not have English as their first language is high (36%), but many of these reported speaking English at school and they may have been bilingual in their household. Certainly, all the subjects in the study were found to speak clear fluent English and all were sufficiently proficient at reading English to participate in a UK degree course. It would be interesting for future research to extend the present findings to an adult population in the workplace and this could aim to specifically compare subgroups who have English as their first language with those who do not.

The prevalence of difficulties at school (40%) also seems high in the present sample, but this may just reflect the general nature of the questions (see Appendix) which asked whether subjects had *any specific difficulties at school* with reading, spelling, writing or maths.

Diagnosis of Meares–Irlen syndrome

Two methods are used to assess the benefit from coloured overlays in Meares–Irlen syndrome: voluntary sustained use or the immediate effect on performance at the WRRT. The criterion of voluntary sustained use is most commonly used with children where it is typically taken to be about one-half to one school term (Evans, 2001). The WRRT criterion that is usually used is that a more than 5% improvement in rate of reading represents a clinically significant benefit (Wilkins *et al*., 1996).

Sensitivity refers to the proportion of individuals with a condition who are correctly identified and *specificity* refers to the proportion of individuals who do not have the condition and who are correctly identified. Based on the literature, *Table 1* shows calculations of the sensitivity and specificity of the $>5\%$ criterion for identifying subjects who will demonstrate a sustained benefit. Test recommendations (Wilkins, 2001) and previous work (Wilkins *et al*., 1996) support the 5% criterion that we adopted.

Clearly, the two different criteria (sustained benefit and 5% WRRT) identify slightly different groups of children as suffering from Meares–Irlen syndrome. It is unclear at present which criterion is most valid and until a reliable objective marker for Meares–Irlen syndrome is identified precise diagnostic criteria will remain somewhat arbitrary. Several studies have identified pattern glare as a consistent correlate and likely cause of Meares–Irlen syndrome (Evans, 2001), and a new pattern glare test (I.O.O. Marketing Ltd, London, UK) may aid diagnosis in the future.

It seems quite likely that the sustained benefit criterion will result in an underestimate, as apathy will lead many children to stop using the overlay. Eyecare practitioners frequently see children with, for example, myopia who discontinue spectacle wear despite a readily apparent improvement in visual acuity with spectacles. Conversely, in cases of unilateral hypermetropia, when there is no benefit apparent to the child from spectacle wear, it is usually very difficult to persuade children to continue to wear spectacles. So, based on the example of refractive error, it seems likely that some children who derive a genuine benefit from an overlay will fail to use it on a sustained basis, yet very few who do not derive a genuine benefit will use it on a sustained basis.

In the present study, the only criterion for which data were available was the immediate effect at WRRT. This allows a comparison with previous research involving children (*Table 1*). Even if data had been available based on a sustained voluntary use criterion, this would not have allowed direct comparison with previous research as all three previous studies that have looked at sustained use have used different time periods (from 8 weeks to 10 months; *Table 1*) and the proportion of subjects continuing to use their overlay decreases with time (Jeanes *et al*., 1997).

Comparison of present results with data for children

The present data suggest that a higher proportion (89%) of unselected adult students report immediate beneficial perceptual effects from coloured overlays than the equivalent proportion (49–60%; *Table 1*) of children. In the present adult population, a very similar proportion of subjects (34%) pass the 5% WRRT criterion compared with the proportion of children passing this criterion (22–36%; *Table 1*).

The most common choices of overlay colour in our subjects (*Figure 4*) are rather different to those obtained for children (Wilkins *et al*., 2001). It would be interesting for future research with larger samples of adults to investigate this.

General discussion

Our adult subjects who chose an overlay read on average 3.8% faster with their overlay than without and this difference was statistically highly significant. The proportion of our subjects who read more than 5% faster with their overlay than without was high (38%) compared with 23% of a control group who read more than 5% faster with a control filter than without.

Previous research used a similar control filter and 'cover story' and showed that this is associated with a significant placebo effect (Bouldoukian *et al*., 2002). It might therefore be concluded that in view of the minimal effect of the control filter on the rate of reading of our control group, the marked improvement in rate of reading of our experimental group with their coloured overlay is unlikely to be attributable to a placebo effect. However, some caution is needed in making this interpretation as our participants were not randomly assigned to groups. In particular, it is possible that the control group were less co-operative or less suggestible than the experimental group and therefore reported less symptoms and showed a minimal benefit from colour. However, *Table 3* shows that the control group did report symptoms and actually reported *more* light sensitivity than the experimental group. This may militate against the hypothesis that they were less suggestible than the experimental group.

As noted above, *Table 3* shows that the subjects who chose an overlay were only marginally more likely to recollect symptoms than those who did not. In addition to these 'recollected symptoms', we also obtained 'immediate symptoms' when participants viewed text during the overlay test. Wilkins *et al*. (2001) argued these immediate symptoms may be more reliable than recollected symptoms and we found that the immediate symptoms were significantly more prevalent in subjects who subsequently chose an overlay.

Anecdotal comments during the testing suggested that our subjects were generally unaware of the research suggesting that overlays were used to alleviate symptoms. It would seem intuitively likely that the symptom that would be most likely to be associated by naïve subjects with a benefit from filters is photophobia. Therefore, the finding that photophobia was one of the few symptoms that was not associated with a preference for an overlay suggests that the association between symptoms and overlay preference was not because of subjects' expectations.

In the present study, the experimenter was aware of the identity of the participant and subjects and experimenters were aware of the identity of the filters. It is not possible to mask subjects during overlay testing (they can clearly see the colour of overlay). It might have been feasible to mask the experimenter (e.g. to shield the experimenter's view of the subject), but we felt that it was more desirable to allow the experimenter to observe participants so as to check the proper use of the overlay (e.g. that specular reflections were being avoided). Care was taken to ensure that identical instructions were given to all participants in all conditions. A double-masked research design is possible using the Intuitive Colorimeter and precision tinted lenses. These methods have been used in previous double-masked randomised-controlled trials to demonstrate that coloured filters are effective for reasons that cannot be solely attributed to a placebo effect (Wilkins *et al*., 1994; Robinson and Foreman, 1999). The testing with these instruments is lengthy and would not have been feasible in the present study where a large number of adults needed to be tested.

No problems were encountered in using the Wilkins Intuitive Overlays and WRRT in this adult population. The present study was designed to investigate an unselected population of adults and no pre-selection occurred. Optometric data were not obtained, although previous studies have assessed the optometric correlates of Meares–Irlen Syndrome. These studies have found a slightly higher prevalence of subtle binocular and accommodative anomalies, but the results suggested that these anomalies are not major aetiological factors in Meares–Irlen Syndrome (Evans *et al*., 1995, 1996; Evans, 2001; Scott *et al*., 2002).

In summary, more than one-third of the sample demonstrate a significant benefit (more than 5% improvement in rate of reading) when using coloured overlays. These results suggest that the prevalence of Meares–Irlen Syndrome in this adult population is similar to the prevalence in children. Clinicians should be as prepared to consider a need for coloured filters in adults as they are in children.

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Appendix Questionnaire

First name----------Last name----------Course----------
Born----------Date tested----------First language----------
Tick if had any specific difficulties at school with the following:
Reading ☐ Spelling ☐ Writing ☐ Maths ☐ Other----------
Last eye examination----------
Has anyone ever noticed your eye(s) turning inwards or outwards? Yes ☐ No ☐
Have you ever received eye exercises or patching? Yes ☐ No ☐

Visual Symptoms (with any Rx usually used for reading)

When you are reading or writing in a book, is it normally clear? Yes ☐ No ☐
Do words in a book ever:
- Go blurred? Yes ☐ No ☐
- Jump around? Yes ☐ No ☐
- Go smaller/bigger? Yes ☐ No ☐
- Fade or disappear? Yes ☐ No ☐

Do you ever experience double vision when reading (see two things when there is only one)? Yes ☐ No ☐
If you do experience double vision when reading, how often is it:
hardly ever/rarely, only if reading for a very long time/when reading for a moderate time/often, if reading for a fairly short time
Do you ever experience sore or tired eyes when reading? Yes ☐ No ☐
If you do suffer from sore or tired eyes, how often:
hardly ever/rarely, only if reading for a very long time/when reading for a moderate time/often, if reading for a fairly short time
Have you or anyone else ever noticed that you do any of the following?

	Yes	No	If so, please give details
Holds reading unusually far away:	☐	☐	----------
Closes or covers one eye:	☐	☐	----------
Frequently rubs eye(s):	☐	☐	----------
Blinks excessively:	☐	☐	----------
Skips, re-reads or omits words or lines:	☐	☐	----------
Reads slowly:	☐	☐	----------
Light sensitive:	☐	☐	----------

Approximately how many times have you had a headache (migraine or otherwise) in the last 3 months?
For some people headaches can be triggered by, or tend to follow, near visual tasks such as reading, sewing, computer work, etc. To what extent do you think that your headaches are triggered by reading:
not at all/rarely/occasionally/quite often/very often