Visual factors in Specific Learning Difficulties

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Introduction

This article reports the results of a clinical study that aimed to determine whether there were any predictive factors to indicate the presence of Meares-Irlen syndrome (also known as visual stress or MISViS) and therefore whether such factors can help to identify which patients would benefit from receiving precision tinted lenses (PTLs). A secondary goal was to investigate whether PTLs bring about a greater improvement in reading performance than coloured overlays.

The effect of using coloured overlays or PTLs to help patients with specific learning difficulties (SpLD) or MISViS is already well documented.[1] The mechanism as to how the tint works is not fully understood but it is theorised to be related to hyper-excitability of the visual cortex.[2,3] A clinical sign of this is a sensitivity to striped patterns[4] (pattern glare - PG) and such tests may have potential in helping to diagnose the condition.[5-9] Certain patterns can provoke some degree of visual discomfort,[10] and this discomfort can be associated with headaches.[11,12] Some people, however, are affected more severely resulting in migraines or difficulties with reading.[13] One study found that a significant degree of MISViS affects about 12.5% of the general population and 31% of those people with dyslexia.[14] As such, it would be useful to predict the likelihood of MISViS and the effects of treatment with coloured overlays and/or PTLs. Particular factors considered in this study were age, sex, visual acuity (VA), ocular dominance, binocular vision, stereoacuity, accommodation, convergence, refraction, and fixation disparity.

Method

The clinical records of 244 patients were retrospectively studied. All patients had been referred to and were examined at the same optometric practice to investigate the possibility of MISViS due to reading difficulties. Referrals were received from a variety of professionals including school special needs teachers, disability officers from tertiary colleges, optometric colleagues, orthoptic colleagues, or through self-referral.

The clinical protocol followed for visual assessment was that described by Lightstone and Evans[15] and as suggested following an extensive clinical audit by Evans et al.[16] The clinical protocol has recently been elaborated upon in a book by Allen et al.[17] Typically, patients had a full optometric examination, which included retinoscopy and subjective refraction. The eyes were examined to exclude any pathology that would require referral. The binocular vision status was assessed by a variety of tests; the ocular motor balance was determined with a cover test, motility was performed, accommodation and near point of convergence (NPC) were determined using a RAF push-up rule, stereoacuity was measured using the Lang Stereo test card and fixation disparity was measured using the near Mallett Unit.[18] Fixation disparity assessment particularly included a report of whether the patient observed any movement of the nonius markers; the presence of movement but no misalignment indicated binocular instability. Ocular dominance was determined by the sighting/pointing method and colour vision was assessed using the Isihara plates.

PG was assessed using the Institute of Optometry (IoO) PG Test.[8] The test involves presentation of three cards, each with a horizontal grating of either 0.5, 3 or 12 cycles per degree (cpd). Patients who are prone to visual stress find the 3cpd grating uncomfortable and report distortions of the grating; such patients were recorded as positive for PG. Positive PG was also recorded if the difference between the results of the 3cpd and 12cpd cards was greater than 1.

All patients then had an overlay assessment using the intuitive overlays (Figure 1).[1] Patients' preference for overlays was noted and their rate of reading with and without the overlay was determined using the Wilkins rate of reading test;[19] an improvement in the rate of reading by 5% or more, or if the patient felt "more comfortable", were indications to prescribe the coloured overlay. Thereafter, patients who felt an improvement with the coloured overlay were then assessed for PTLs using the Intuitive Colorimeter; patients who felt no improvement with the use of the overlay did not have follow-up colorimetry assessment. The procedure for colorimetry followed that described by Wilkins.[21] Once the subject has determined the most suitable hue and saturation for the lenses, they are ordered either in plano form or, if required, with the patient's refractive correction; if there was a clinically significant refractive error, then this was prescribed.[20] Where a refractive error was found to be within the normal range then this was only prescribed if there was a significant improvement in the rate of reading.

The procedure undertaken differed from the protocol as set out by Lightstone and Evans[15] in that if a binocular deficiency was noted no action was taken until after assessment with the overlays and, if required, PTLs. If there was no improvement in the rate of reading with the overlays then the binocular deficiency was addressed. If, however, an improvement was noted after a trial period (typically 6-8 weeks) with the overlays, PTLs were supplied. Exceptions were some referrals from orthoptic and optometric colleagues for a colorimeter assessment alone. These patients had a full assessment in their previous clinic and had used coloured overlays for between 4-6 months already.

Results

In order to determine the predictive factors for MISViS, those patients who received (and felt a positive effect from) PTLs were diagnosed with MISViS, whilst those who did not have PTLs were diagnosed as non-MISViS, and all of the visual assessments conducted were compared between these two groups.

Of the 244 patients in this study, 141 were male and 103 were female. The mean age of all patients was 12.5±8.5 years (range 6 to 50 years). The mean age for those patients with MISViS (16.2±10.2 years) was significantly higher that those without MISViS (10.3±6.2 years) (independent samples T-Test, $t=4.3$, $p<0.05$). Significantly more females (n=50) were found to have MISViS compared to males (n=32) (Chi-square, $x^2 = 7.94$, $p<0.05$).

Eighteen patients had unaided vision of less than 6/12 in one eye and in this group there were seven cases of strabismic amblyopia and 11 cases of refractive amblyopia. Fifty four patients were found to require a refractive correction, without an anomaly of binocular vision. Of the remaining 190 patients, cover test revealed 86% to be orthophoric, 13% to be exophoric and only 1% were esophoric. Those patients with heterophoria were within normal ranges and showed good recovery on the cover-uncover test.

Vision Assessment		MISViS (n = 82)	Non-MISViS (n = 144)	Significance
NPC (cm)		7.8 ± 3.0	7.1 ± 2.9	t=0.05 p=0.40
Stereoacuity (seconds of arc)		538 ± 67	544 ± 129	U=5904 P=0.50
Amplitude of Accommodation (D)		7.4 ± 2.5	9.8 ± 3.0	t=7.75 p<0.05
Binocular Vision (minutes of arc)		9.0± 3.6	8.4 ± 3.3	t=0.20 p=0.50
Ocular Dominance	**Right**	50	87	X^2=0.85 p=0.50
	Left	5	9	
	Crossed	27	48	
Pattern Glare	**Positive**	76	64	X^2=4.35 p<0.05
	Negative	6	80	
Fixation Disparity	**Present**	46	57	X^2=0.004 P=0.95
	Absent	36	87	

Table 1. Comparison of visual factors for those subjects with MISViS and those without. All

Table 1 summarises the comparison of visual factors between people with MISViS and those without MISViS. Patients with amblyopia were excluded from the analysis as binocular assessments cannot be made. There was no significant difference in the NPC (independent samples T-Test, t=0.05, p=0.40), stereoacuity (Mann Whitney U-Test, U=5904, p=0.50), binocular vision (independent samples T-Test, t=0.204, p=0.50), and fixation disparity (chi-square, x^2=0.004, p=0.95) between those with MISViS and those without. Similarly, ocular dominance was not found to be significantly different (chi-square, x^2=0.85, p=0.50). In contrast, the mean amplitude of accommodation (7.4±2.5D) of those with MISViS was significantly lower than those without MISViS (9.8±3.0D) (independent samples T-Test, t=7.75, p<0.05). Similarly, PG was significantly more prevalent in those people with MISViS compared to those without (x^2=4.35, p<0.05).

Coloured overlays

In this study, 115 patients (43%) were supplied with coloured overlays. Table 2 gives the colour preferences of patients for the overlays and the effects of these filters on the rates of reading. There was no predominant colour preferred by patients, with yellow, aqua and pink being the most frequently chosen. Orange, purple and grey were the least frequently chosen. All filters apart from purple and grey produced a significant increase in the rate of reading, with the largest improvement occurring with the rose coloured overlay (19%) and the lowest improvement occurring with the purple overlay (1.7%) (Table 2).

Rates of Reading

There was a significant difference in the mean rate of reading between no correction or filter (66.5±31.0 wpm), refractive correction only (68.0±26.6 wpm), coloured overlays (70.5±33.7 wpm) and PTLs (95.0± 31.2 wpm) (single factor ANOVA, F=19, p<0.001). Pair-wise comparisons revealed that PTLs produced a significantly faster rate of reading than coloured overlays (independent samples T-Test, t=7.81, p<0.05) whilst coloured overlays in turn produced a significantly faster rate of reading compared to no correction or filter (t=3.20, p<0.05). There were no significant differences in the rate of reading between coloured

Filter Colour	Proportion Preferring this Colour (%)	Mean Rate of Reading Without Filter (wpm)	Mean Rate of Reading With Filter (wpm)	Change in Rate of Reading (%)	Significance	
					t	p
Yellow	18.8	65.6	73.3	11.7	4.15	<0.05
Aqua	16.6	57.0	61.2	7.4	2.96	<0.05
Pink	14.8	70.7	74.7	5.6	1.86	<0.05
Mint Green	9.9	71.4	80.2	12.4	2.34	<0.05
Lime Green	9.4	75.0	82.4	9.9	3.15	<0.05
Blue	8.1	71.2	79.5	11.8	3.02	<0.05
Rose	7.6	68.4	81.4	19.0	3.09	<0.05
Orange	6.7	67.2	71.8	6.7	2.02	0.05
Purple	4.5	86.5	88.0	1.7	0.65	0.40
Grey	3.6	79.2	82.2	3.8	0.994	0.25

Table 2. Preference of coloured overlay and the effect on rate of reading (in words per minute – wpm). Statistical analysis was conducted using the paired samples T-Test.

overlays and refractive correction alone (t=0.39, p=0.40) and between refractive correction alone and no correction or filter (t=1.42, p=0.10).

Discussion

The sample in this study contained a greater proportion of males than females, which is a similar figure to another study[22]. This suggests that boys are more likely to experience problems with reading than girls. However, considering the presence of MISViS, the results of this study indicate that females are significantly more likely to receive PTLs. This would seem to indicate that whilst boys have more reading problems compared to females, they are less likely to suffer from MISViS.

The age of patients with MISViS is significantly higher than those who do not have MISViS. This may reflect the fact that older people tend to do more visually demanding tasks, which is more likely to precipitate symptoms of MISViS. A number of patients were also referred to the practice by the local university. In addition, adults are sometimes prescribed with PTLs for alleviation of the symptoms of migraine[42], which tends to affect females more than males and first occurs during adolescence.[43]

There was no significant difference in NPC, stereoacuity, binocular vision, ocular dominance and fixation disparity between patients with MISViS and those without. These findings, which are all assessments of binocular function, suggest that binocularity is not a major factor in predicting reading difficulties. Indeed, a large proportion of people without MISViS had a fixation disparity, which suggests that this may be a correlate of MISViS but not necessarily causal of it. Furthermore, patients remarked that the nonius markers on the Mallett Unit were moving or were intermittently suppressed, which may be a consequence of the perceptual instability that results from MISViS, rather than a binocular vision anomaly per se, since these participants did not typically have other signs of binocular vision anomalies.

Accommodation

It was found in this study that patients with MISViS had significantly lower levels of accommodation than those without MISViS. This supports previous reports that poor accommodation is a factor in reading difficulties.[23-25] However, it is suggested that reduced accommodation is a correlate of MISViS and not necessarily causal of it.[23-25]

The levels of accommodation observed in this study were below the norms expected. According to Hofstetter,[26] accommodation ranges from 17.0D in 4-year-olds to 4.0D for 50-year-olds. However when comparing a control group with a group of patients with dyslexia, Buzelli[27] found accommodation was slightly higher in those with dyslexia compared to those without, a finding at odds with the present study.

Allen et al.,[28] in their controlled study, have shown that in patients with MISViS the use of coloured overlays improves their rate of reading. In addition, using a remote eccentric photorefractor and viewing a cross on a background, they also showed that when the chromaticity of the background matched the overlay, the accommodative lag was reduced in the study group compared to the control group.

Pattern Glare Test

It has been shown that people with PG display hyper-excitability of the visual cortex[12] and this is the strongest visual correlate of MISViS.[29,30] The results of the present study confirm this finding, since PG was significantly more prevalent in patients with MISViS compared to those without. The results of this study also revealed, however, that a large proportion of people without MISViS also experienced PG (n=64/244). This would seem to indicate that whilst the presence of PG is associated with the supply of PTLs, it may not necessarily confirm that PTLs are required. Certainly a negative response on the PG test suggests that it is less likely that patients will benefit from PTLs, which can be a useful indicator to the clinician.

Coloured Overlays

The use of overlays resulted in an improvement in the rate of reading compared to without the overlays, and this was significant in all cases apart from purple and grey. This matches the findings of previous studies.[31-34] The majority of subjects chose a colour in the yellow-blue part of the spectrum, with yellow being the most popular; this is likely to reflect the fact that the eye is more receptive to images along the blue/yellow axis of the chromaticity graph.[35] However, the greatest improvement in rate of reading was achieved with the rose overlay. This finding is in keeping with Wilkins et al. [36] Indeed, in their study using coloured light as opposed to coloured filters, the majority of subjects preferred blue or green light, but there was considerable variability and the optimal colour was highly specific to each individual.[36]

In the present study, the lowest improvements in rate of reading were achieved with the purple and grey overlays. Patients who selected these colours also had the fastest rate of reading without an overlay, which suggests that the degree of difficulty was lower in the first place.

It is interesting to speculate whether, in a classroom situation, using coloured paper (not white) would benefit poorer readers. With the increased use of white boards in schools, undiagnosed visual stress may cause reading problems. Indeed, although the present study was a retrospective clinical analysis, previous prospective double-masked randomised

controlled trials[1,37] indicate that the benefit from coloured filters cannot be solely due to a placebo effect.

Rate of Reading

Using the criteria that PTLs would only be supplied if patients showed a long-term benefit to overlays, 39.3% of patients seen in this study received PTLs. The rate of reading with PTLs was significantly improved compared with coloured overlays, spectacles (refractive correction only) and with no refractive correction or filter. Previous studies[1,16,38] have shown that PTLs provide benefit to patients with MISViS, with Wilkins et al.[39] reporting a 25% increase in the rate of reading in 5% of children given overlays.

Correction of refractive error alone did not produce a significant improvement in the rate of reading and therefore, in the absence of any clinically significant refractive error, each patient should be assessed individually to determine whether there is any benefit in the supply of spectacles to help with reading.

Conclusion

This study has identified that age, sex, accommodation and the presence of pattern glare are significant factors to consider for MISViS. The absence of pattern glare suggests that it is less likely that a patient will need precision tinted lenses. Binocularity did not appear to be a major factor. Coloured overlays can help to improve rates of reading, but the greatest improvement is achieved with PTLs.

About the Author

Lindsay Bater graduated in 1978 from The City University, London. He was awarded an MPhil in 1982 and DipCL in 1986. After qualifying he spent two years at the Department of Ophthalmology, University of Otago, Dunedin in New Zealand. On returning to the UK he moved to Swansea where he and his wife run three practices. The author would like to thank Professor Bruce Evans for his encouragement and guidance in producing this article and Dr. Alan Dobbins for his assistance in the statistical analysis.

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MCQs

1. What proportion of the general population can be affected by MISViS (Meares/Irlen syndrome or Visual stress)?
    a) 10.5% of the general population
    b) 12.5 % of the general population
    c) 15% of the general population
    d) 17.5% of the general population

2. The presence of pattern glare is reported as positive if:
    a) The number of distortions on the mid frequency grating is less than 3
    b) The number of distortions on the mid frequency grating is 3 or more
    c) The number of distortions on the high frequency grating is less than 3
    d) There is no difference in number of distortions between plate 2 & 3

3. Which of the following statements about accommodation in learning difficulties is TRUE?
    a) It is usually associated with reading difficulties
    b) The amplitude is generally lower than normal

c) It is a correlate of MISViS, not necessarily causal
d) All of the above

4. Which coloured overlay produced the greatest improvement in the rate of reading?
a) Aqua
b) Pink
c) Lime green
d) Rose

5. Which of the following statements about pattern glare is TRUE?
a) It is always present in MISViS
b) It is never present in MISViS
c) It is a cause of MISViS
d) It is correlated to MISViS but is not causal of it

6. What was the improvement in the mean rate of reading with PTLs compared with no correction or filter, in this study?
a) 10%
b) 25%
c) 43%
d) 75%

MCQ Answers

1. b
2. b
3. d
4. d
5. d
6. c