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Predicting the long-term use of overlays in children: the Pattern Glare Test

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Abstract

Aim: **To determine whether the Institute of Optometry Pattern Glare Test (PGT) could be used as a sensitive tool to predict the continued use of coloured overlays for reading in schoolchildren aged 7 to 12 years and to compare its sensitivity with that of the Wilkins Rate of Reading Test (WRRT) and the Developmental Eye Movement (DEM) test.**
Methods: **Twenty-six children referred for a coloured overlay assessment in relation to difficulties with literacy skills were recruited to the study. An assessment took place which included orthoptic examination, coloured overlay assessment, PGT, WRRT and DEM test. The overlay chosen was provided for use at home and at school and follow-up took place 13–15 weeks later. Overlay usage was then analysed in relation to the scores recorded at the initial visit for PGT, WRRT and DEM test.**
Results: **Nineteen children were still consistently using their overlays at the follow-up visit. No statistically significant difference was found in the PGT score of those children who consistently used overlays (group 1) compared with those who did not (group 2) (unpaired *t*-test, $p = 0.62$). The PGT was found to have 53% sensitivity in predicting those children who would consistently use overlays, compared with 79% for the WRRT and 77% for the DEM test.**
Conclusion: **This study did not find the PGT to be a sensitive tool for predicting those children who would consistently use overlays in comparison with the WRRT and the DEM test.**

Key words: Coloured overlays, Developmental Eye Movement Test, Meares-Irlen syndrome, Pattern Glare Test, Wilkins Rate of Reading Test

Introduction

People experiencing symptoms of visual discomfort and distortions on reading ('visual stress') that are relieved with the use of an individually selected coloured filter are reported to be suffering from 'Meares-Irlen syndrome' (MIS).[1] Wilkins *et al.*[2] and Bouldoukian *et al.*[3] have shown in placebo-controlled trials that individually prescribed coloured filters reduce the visual symptoms of MIS and increase reading speed significantly more than a control filter. Coloured filters may take the form of overlays when reading, or lenses worn as spectacles when reading and writing.

The efficacy of the Wilkins Rate of Reading Test (WRRT) and the Developmental Eye Movement (DEM) test as objective methods to predict the continued use of coloured overlays on reading in children have been reported in the literature.[4–7]

The Institute of Optometry Pattern Glare Test (PGT) has been advocated and marketed as being helpful in identifying those with reading difficulties who are likely to benefit from using coloured overlays. However, to date no data on the sensitivity of the test for predicting the continued use of overlays in children has been reported.

The PGT provides a method of scoring visual perceptual distortions. Pattern glare is described as visual perceptual distortions experienced on viewing striped patterns, and people suffering from MIS are particularly prone to pattern glare.[8] The test comprises three test plates (patterns) of square-wave gratings with spatial frequencies of 0.5, 3 and 12 cycles per degree (cpd) respectively. People suffering with pattern glare will experience most visual perceptual distortions when viewing the 3 cpd grating and the pattern glare score can be recorded as the sum of the distortions reported on this plate. Care must be taken when using the test not to present the patterns to those with a history of photosensitive epilepsy as the test gratings can induce seizures in this group.[9,10] Evans and Stevenson[8] conducted studies to determine the normative values for the PGT and concluded that an abnormal degree of pattern glare is present if a person scores more than 3 on the 3 cpd grating. The studies also concluded that the 0.5 cpd grating functions as a control to identify highly suggestible individuals likely to respond positively to any question about visual perceptual distortions.

The aim of this research was to determine whether the PGT can be used as a sensitive tool to predict the continued consistent use of coloured overlays in schoolchildren aged 7 to 12 years and to compare this with the WRRT and the DEM test.

Methods

The research design for the study was quantitative, prospective and cross-sectional.

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The Ethics Committee (NRES Committee Yorkshire & The Humber – South Yorkshire) reviewed and approved the study.

Inclusion criteria

All children aged 7 to 12 years referred to the Orthoptic Department as new referrals for a coloured overlay assessment in relation to difficulties with literacy skills were invited to take part. Participants seen previously by other professionals and prescribed overlays were included in the study; however, prior usage was noted as a potential confounding variable.

Exclusion criteria

Participants with manifest squint, latent squint measuring more than 10^{Δ}, visual acuity of less than 6/9 in one or both eyes (with glasses if refractive correction was required), near point of convergence of 10 cm or worse, prism fusion range of less than 25^{Δ} base out and 8^{Δ} base in at 33 cm (with glasses if required), or accommodation of less than 8 cm in one or both eyes (with glasses if required), were excluded from the study. Also excluded were children who had not undergone a refraction test in the past 6 months and those with a history of epilepsy.

Procedure

A consent form was signed by the legal guardian for each child at the initial visit, after the opportunity to ask questions.

The same examiner carried out all testing in a quiet room and assessments on each individual were conducted at one afternoon session. Lighting at the examination desk level was 450 lux from surface ceiling-mounted fluorescent 5 foot single T12, 65 watt warm white lamps with prismatic diffuser type and no fluctuation from external natural daylight.

To ensure suitability a case history was taken and the following tests were performed, with glasses if required unless stated otherwise, and fixing 6/12 (Snellen or Reduced Snellen as appropriate): Snellen visual acuity in each eye separately at 6 m; cover test at 33 cm and at 6 m with and without glasses at both distances; prism cover test (if latent squint was present) at 33 cm and at 6 m; ocular motility testing without glasses; convergence on the RAF rule with the spot/line target; accommodation on the RAF rule in each eye separately and both eyes together; and prism fusion range at 33 cm using a prism bar.

Coloured overlay assessment, with glasses if required, using Cerium overlays then took place. The child was shown the test material, which consisted of a block of non-word text of 12 point font size, and asked about visual perceptual abnormalities. An overlay was placed over half the text and the child was asked if the perceptual abnormalities were better on the coloured side or on the white uncovered side. The child was asked whether the dull surface or shiny surface of the overlay was best and the remaining overlays were then presented in that fashion. Overlays which were reported as better than the uncovered text were then compared with each other and by a process of elimination one colour was selected as the best. This colour was then combined with a second overlay – a double overlay in the preferred colour as well as combining with the neighbouring colour on either side in the colour spectrum – until the best single or double overlay arrangement was selected.

The PGT was presented to the child at a distance of 40 cm without the chosen overlay. They were asked to look at the dot in the centre of the square-wave grating on pattern 1 (0.5 cpd) and pattern 2 (3 cpd) and after 5 seconds were asked to report any distortions seen in the gratings from a checklist of: colours; bending of lines; blurring of lines; shimmer/flickering; fading; shadowy shapes; or other (to be specified). The number of distortions reported on each grating was recorded. The scores of distortions reported on the 3 cpd grating was considered amongst the group who continued to use the overlay against those who did not, whilst the scores on the 0.5 cpd pattern functioned as a control grating.

The WRRT was performed using the small text version as per the procedure described by Wilkins *et al*.,[5] with and without the overlay. The child was asked to read each word out aloud in correct order as fast as possible in each of the four passages of text (A to D) and was told to stop reading after 1 minute. Deductions were made for errors and the total number of words read correctly in the minute was recorded. To control the effects of practice and fatigue the test was performed with overlays, without overlays, without overlays and finally with overlays. The average score with and without overlays was recorded and the percentage change in performance with colour was then calculated using the following equation:

$$\frac{\text{words read with overlay}}{\text{words read without overlay}} - 1 \times 100.$$

The DEM test was performed as per the procedure recommended by Garzia *et al*.,[11] with and without the overlay, with glasses if required. The child was asked to read out the numbers in the vertical tests (A and B) and the horizontal test (C) as quickly as possible. The vertical score, horizontal score and ratios were compared with the mean values for the child's age to determine whether automaticity problems, horizontal scanning problems, or both, were present. The same strategy for assessment with and without overlays was used as described for the WRRT, with an average score on horizontal test (C) calculated for two trials with overlays and two trials without overlays. The percentage change in performance with colour was calculated using the following equation:

$$\frac{\text{horizontal time without overlay}}{\text{horizontal time with overlay}} - 1 \times 100.$$

The testing sequence for the PGT, WRRT and DEM test was counterbalanced to take account of the effects of fatigue during testing.

All children had been able to select their preferred overlay on assessment and this was issued for use at home and at school. An information sheet produced by Cerium was given to the parent, which advises on the

Table 1. Mean WRRT scores for both groups with and without overlays at first visit

Group	Mean (SD) WRRT (words per minute) without overlay	Mean (SD) WRRT (words per minute) with overlay	Mean change in WRRT (%) using overlay
Group 1 ($n = 19$)	62 (28)	76 (27)	34
Group 2 ($n = 7$)	70 (26)	71 (27)	0.7

Table 2. Mean DEM test horizontal time scores for both groups with and without overlays at first visit

Group	Mean (SD) horizontal DEM time (seconds) without overlay	Mean (SD) horizontal DEM time (seconds) with overlay	Mean change in DEM (%) time using overlay
Group 1 ($n = 13$)	77 (24)	61 (17)	28
Group 2 ($n = 4$)	60 (14)	57 (13)	6

appropriate use of the overlay. Contrary to the advice on the information sheet, the researcher advised parents to refrain from obtaining precision tinted lenses until after the follow-up visit.

A further information sheet was posted to the school Special Educational Needs Co-ordinator (SENCO) with a feedback form to be distributed to the child's class teacher(s), to be completed in the week preceding the follow-up visit and returned to the researcher in a pre-paid envelope. This information was intended to indicate a 'yes, used consistently without undue prompting' or a 'no/rarely used' response to overlay usage.

Data handling and data analysis

Participants were assigned to groups according to overlay usage (group 1, overlays used consistently; group 2, overlays not used). Statistical analysis on the data was performed using an unpaired *t*-test of the PGT scores in each group. A two-factor mixed measures analysis of variance (ANOVA) was performed on the mean scores with and without overlays on WRRT and DEM tests for both groups. Correlation analysis using Pearson's correlation coefficient of determination was used to investigate for any relationship between the PGT scores and the scores from the WRRT and the DEM test respectively, as well as for any relationship in performance on the WRRT and the DEM test. Only the horizontal reading task data were used for analysis on the DEM test. It was not possible to perform a power calculation for the study as there is no known standard deviation data for the PGT.

Results

Twenty-nine participants were invited to take part and 26 participants fulfilled the inclusion criteria (10 males). Feedback forms from the teachers were received for all 26 children. Participants were assigned to either group 1 (overlays used consistently: $n = 19$) or group 2 (overlays not used consistently: $n = 7$). This feedback was based on the teacher having full-time class hours per week with the child except for 3 children, 2 of whom had 5 hours class time with the teacher and 1 who had 15 hours class time.

Three participants failed to attend their follow-up visit and therefore verbal parental feedback was obtained for 23 participants. The feedback response differed between school and home for 5 participants, 4 of who were allocated to group 1 (see Discussion).

The mean ages of groups 1 and 2 were 9.7 years (range 7 years 1 month to 11 years 11 months) and 9.8 years (range 7 years 3 months to 11 years 10 months), respectively. Twenty of the 26 participants had received prior exposure to overlay usage, ranging from 1 month to 2 years.

All participants were able to perform both the PGT and the WRRT; however 9 participants were unable to perform the DEM test due to:

- too visually uncomfortable (3 participants),
- numbers moved around too much (1 participant),
- responses too erratic to record (1 participant),
- insufficient co-operation to complete more than one trial (4 participants).

One participant completed three trials of the horizontal DEM test but got lost repeatedly and was unable to complete one trial without the overlay; however the data completed were still included for analysis.

Pattern Glare Test

No statistically significant difference was found in the PGT score of those children who consistently used overlays (group 1) compared with those who did not (group 2) (unpaired *t*-test, $p = 0.62$). The mean (SD) number of distortions on pattern 2 (3 cpd) of the PGT was 3.26 (1.7) in group 1 and 2.86 (2.0) in group 2 ($p = 0.62$).

Effect of overlays on performance of the WRRT and DEM test

Table 1 shows the mean (SD) score on the WRRT in words per minute for each group with and without overlays and percentage change with overlays. Two-factor ANOVA showed a significant change in performance on the WRRT with overlays ($p < 0.05$) and a significant interaction between groups 1 and 2 ($p < 0.05$) such that group 1 showed the increase.

An improvement in performance of greater than 25% was present in 53% of participants.

Table 2 shows the mean score on the DEM horizontal test for each group in time taken to complete the test with and without overlays and percentage change with overlays. Two-factor ANOVA showed the change in performance on the DEM with overlays to be statistically significant ($p < 0.05$); however, the difference in effect of overlays between the two groups did not reach statistical significance ($p = 0.10$).

An improvement in performance of greater than 25% was present in 54% of participants.

Correlation of performance: PGT, WRRT and DEM test

Correlation analysis was performed between the PGT

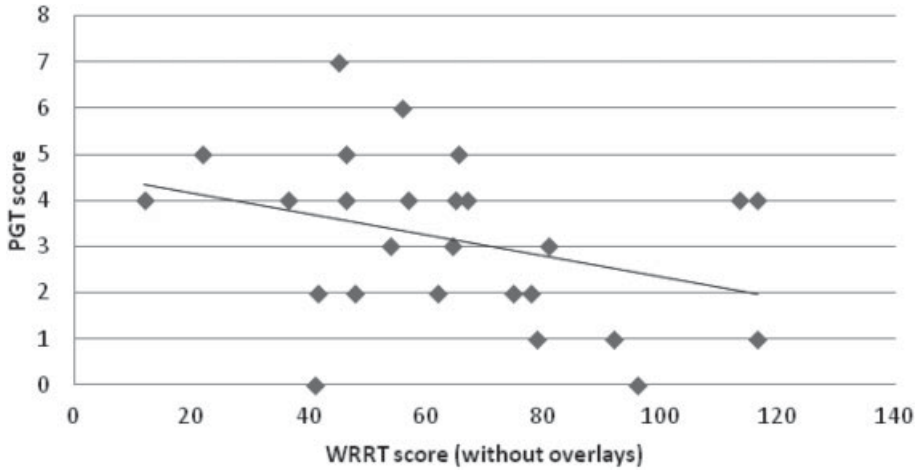

Fig. 1. PGT and WRRT score (without overlays).

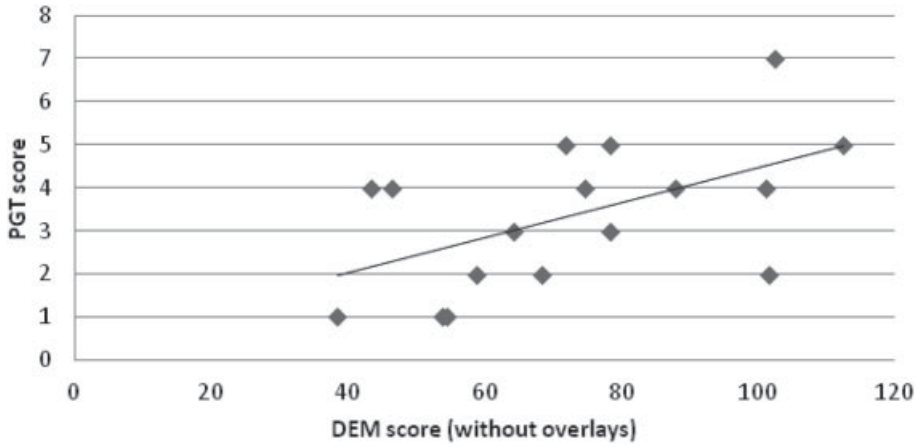

Fig. 2. PGT and DEM test score (without overlays).

and WRRT/DEM test without overlays as the PGT score is measured without overlays only. Analysis between the PGT and either the WRRT or DEM test did not reveal any significant correlations. The correlation analysis plots for the PGT and WRRT and the PGT and DEM can be seen in Figs. 1 and 2. The WRRT and DEM test showed a statistically significant correlation both with and without overlays. Participants with low scores on the WRRT were found to take longer to complete the DEM test ($r^2 = 0.73$, $p < 0.01$ with overlays; $r^2 = 0.90$, $p < 0.001$ without overlays).

Predictive value of the PGT, WRRT and DEM test

Using the criterion of an abnormal degree of pattern glare present for those scoring greater than 3 distortions on the 3 cpd pattern of the PGT,[8] this study found the PGT to have 53% sensitivity in predicting those children who were consistently using their overlay beyond 3 months (10 of 19 participants). Using the criterion of a change in reading speed with overlays of greater than 5% giving a positive indication for consistent overlay use,[1,5] the WRRT and DEM test were found to have sensitivities of 79% (15 of 19 participants) and 77% (10 of 13 participants), respectively, in predicting those children who consistently used their overlay beyond 3 months.

Discussion

In this study the PGT correctly predicted only 53% of children who would consistently use overlays, compared with 79% for the WRRT and 77% for the DEM test. Hollis and Allen[12] found a score of greater than 3 on the PGT to be a reliable predictor of a significant change in reading speed, but their study was performed in adults with a mean age of 35 years and therefore it is not possible to draw direct comparisons with our childhood population.

Evans and Stevenson[8] found that approximately 70% of their 100 participants (aged 10 to 86 years) reported no distortions on pattern 1. This is in contrast to the findings from this study, in which only 19% of participants reported no distortions on pattern 1 and 39% of participants had equal to or a greater number of distortions on pattern 1 as those reported on pattern 2.

This suggests that a large proportion of the participants in our study were highly suggestible individuals. However, there are no normative data available for children only.

The WRRT predicted 79% of children who would consistently use overlays in this study. This figure is slightly higher than Wilkins *et al*.[5] (73% sensitivity) and considerably higher than that found by Northway[4] (60%). The DEM test predicted 77% of children consistently using overlays, compared with 88% found by Northway.[4]

The majority of children in this study who consistently used overlays showed improvements in performance when using overlays on both the WRRT and the DEM test, whilst those who did not consistently use overlays generally did not. A significant correlation was found between the WRRT and DEM test both with and without overlays. Those with lower scores on the WRRT were found to take longer to complete the horizontal task of the DEM test. Northway[4] also found a statistically significant correlation between the WRRT and DEM test; however, she found a considerable difference in the sensitivities of the two tests to predict the continued use of overlays. She postulated several reasons for this, including: differences in the design of the test material; the closely spaced words on the WRRT may be cognitively and visually too complex for some children with automaticity and scanning difficulties and thus the benefits with overlays are not readily seen against wider problems with cognitive processing; perhaps the wider spaced single-digit numbers on the DEM test constitute a cognitively and visually less demanding task, with less lateral masking making identification of the numbers easier. The findings in this study that 9 participants were unable to undertake the DEM test would imply, in contrast to Northway's postulation, that the DEM test was more visually challenging than the WRRT, as all participants were able to complete the latter. Possibly the visual perceptual demands of the DEM test proved more difficult for those with significant visual perceptual difficulties.

The current theory for the aetiology of MIS attributes the symptoms of visual stress to localised cortical hyperexcitability of neurones in the orientation columns of the visual cortex, caused by pattern glare. This gives rise to the visual discomfort and perceptual illusions of motion, shapes and colour on the page, relief being achieved by use of a coloured filter.[13–15] One would therefore expect the PGT to have a high sensitivity in detecting those children gaining a beneficial effect on reading with overlays and thus continuing to consistently use them. The results from this study did not find this. However, a confounding variable exists in that 20 of the participants in the study had received prior exposure to overlay usage, ranging from 1 month to 2 years, and had been referred with a view to subsequent possible referral for Precision Tinted lenses in the absence of any orthoptic anomaly requiring treatment. It is possible that those participants who had been using coloured overlays prior to the study may have become less sensitive to the spatial frequencies on the PGT and this could have adversely affected the scores. Of the 6 participants without any prior exposure to colour, 3 consistently used overlays and only 1 of the 3 had an abnormal PGT score. Similarly, differences in the rate of reading with colour may reduce over time. Therefore whilst it would have been preferable if participants had not had any prior exposure to the use of colour, in this study sample the PGT proved to be less sensitive in detecting those consistently using overlays when compared with the WRRT and DEM test.

Participants were assigned to groups according to the feedback received from the SENCO on overlay usage, as this was considered to be most representative of the child's behaviour for the majority of the time for reading tasks.

Parental feedback for 5 participants differed from that received from the SENCO. Four of these participants belonged to group 1. For 3 of these, parental feedback indicated that whilst the overlay was not used regularly, other observations pointed to a possible beneficial effect: 'Does help but can manage without it', 'Reads better with it but has to be prompted to fetch it, finds it impractical but agrees it helps', 'Switches main light off to read and uses side lamp'. For the remaining participant, the class hours contact time was only 5 hours. Additionally no significant improvement in performance on the WRRT or DEM test was found for this participant. Therefore it is questionable whether this individual was correctly assigned to group 1.

One participant indicated that the overlay was used at home but not at school. Improvements in performance with overlays on both the WRRT (13%) and DEM test (21%) for this individual were found. Peer pressure and not wanting to be identified as 'different' from classmates could be a possible explanation for why the overlay was not used at school but was used regularly at home.

Prior use of coloured overlays in 20 of the participants could account for the high proportion of participants in group 1, as they had already been observed in the classroom as 'overlay users'. However, instruction was given to parents and school teachers in the correct use/supervision of overlays during the study, and feedback on usage during this period only was used.

Some children did not show increases in performance on either the WRRT (21%) or the DEM test (23%) but did consistently use their overlays. MIS can vary in its severity amongst individuals[16] and it is possible that those with milder symptoms are gaining benefit that is not measurable with the WRRT or DEM test. It may be that the physical effort of reading is reduced, enabling the focus to move away from struggling with the visual perceptual difficulties of actually seeing the text to being able to read more effortlessly and gain better comprehension of the text. Migraine sufferers may show a preference for the use of colour as a result of reduced frequency of headaches with colour.[15] A history of migraine or family history of migraine was not considered in this study but would have been useful data to include. Other factors could be involved in some individuals, such as: consistently used the overlay through force of habit; the notion that it is the 'right thing to do'; or enjoying the attention that using an overlay brings.

Whilst an increase in performance on the WRRT and DEM test with overlays can provide the clinician with an

indication that prescription of overlays is warranted and likely to be of use, the only way to be sure if an overlay will be used consistently in the long-term (and therefore assumed to be of beneficial effect) in those who do not show an improvement in performance on the objective tests available to date, is to go ahead with a trial period of overlay use.

Conclusion

The results from this study found the PGT to be a less sensitive tool for predicting those children who would consistently use overlays in comparison with the WRRT and the DEM test, detecting only 53% of children consistently using overlays for more than 3 months against 79% and 77% sensitivities, respectively, for the WRRT and DEM test. No significant difference was found in the scores on the PGT between those children who consistently used overlays and those who did not.

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