

Visual Stress and its treatment

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Summary

- it is now established that coloured filters reduce visual stress and increase reading speed
- optimal benefit from coloured filters requires lenses that are prescribed individually and with precision
- current provision under the NHS is incomplete

Introduction

In 1964 the respected neurologist MacDonald Critchley¹ cited a case of a dyslexic child who was unable to read words on white card but could read words printed on coloured card. In 1980 Olive Meares described a syndrome of symptoms (visual perceptual distortions, eyestrain and headache) that some people experience when reading and which can be alleviated by using coloured card or coloured filters². In the early 1980s Helen Irlen developed a proprietary treatment system for this syndrome³, which later became known as Meares-Irlen Syndrome or Visual Stress. Irlen claimed that the coloured filters need to be prescribed with great precision and different people need different colours. This attracted considerable controversy, especially since she claimed that the filters could only be obtained from her organisation.

In the late 1980s Wilkins developed an instrument, the *Intuitive Colorimeter*⁴, that facilitated a double-masked randomised placebo controlled trial of the use of precision tinted lenses in Meares-Irlen Syndrome⁵. This randomised controlled trial, funded by the MRC, demonstrated that sufferers do indeed need different colours, and that the required colour needs to be defined with precision. Another double-masked randomised placebo-controlled trial was conducted by Robinson and Foreman^{6,7}. This Australian study was independent of the MRC study, but found similar results: coloured filters help people with visual stress and need to be individually and precisely prescribed.

The mechanisms that underlie the benefit from coloured filters remain uncertain⁸ although recently the weight of evidence has turned in favour of the following explanation.

Unpleasant images and stripes

Images (from contemporary art and from photographs of rural and urban scenes) are sometimes classified as “unpleasant”. Unpleasant images have more power at spatial frequencies near 3 cycles/degree⁹. Some people find them very aversive, other people are relatively unaffected. In a few people stripes with this spatial frequency can trigger migraines or epileptic seizures^{10,11}.

Text as stripes

Text is striped partly because of the lines. The lines have a spatial frequency within the range that causes discomfort¹². Individual words are also striped because of the neighbouring letter strokes. The stripes from the letter strokes have a spatial frequency within the range that causes discomfort, and striped words take longer to read, even for fluent readers. Reducing the periodicity of the stripes by varying the inter-stroke spacing can increase reading speed in poor readers¹³.

Distortions

People who dislike stripes tend to have frequent headaches. They see many perceptual distortions involving motion, shape and colour. Migraineurs are particularly affected^{14,15}.

Some people see distortions not only in stripes but also in text¹⁶. It is now widely recognised that sensitivity to striped patterns (susceptibility to pattern glare) seems to play a key role in producing these symptoms, and that coloured filters can reduce the distortions and increase reading speed¹⁷⁻²⁰. In addition to direct evidence implicating pattern glare in the aetiology of visual stress²¹⁻²³, several studies have excluded other potential mechanisms²²⁻²⁶. Although these studies suggest that optometric anomalies are not causes of visual stress in the *majority of cases*, a thorough eye examination is important in the differential diagnosis of visual stress²⁷.

Individual differences

There is no one colour that helps everyone: the best colour needs to be individually selected. This statement is supported by both randomised controlled trials^{5-7,28}, and by single masked clinical trials^{20,25,29-32}. Additionally, a recent experiment directly addressed the issue of the precision with which the coloured filters need to be prescribed¹⁷.

People who read more quickly with their chosen coloured overlay see more distortions in striped patterns³³. These people can be identified objectively by the decrease in search speed that occurs when the search task is surrounded by a pattern of stripes³⁴.

Colour choice

In order for susceptible individuals to obtain an effective filter it is important to sample a large number of colours. The *Intuitive Overlays* are coloured transparencies that are placed over the page when reading. They are

available in colours that sample the UCS diagram efficiently³⁵. They are designed so that 30 evenly spaced chromaticities can be obtained systematically by using the overlays singly, or in pairs with the same or similar chromaticity, one on top of another. The Cerium overlays have similar properties but some other systems have a range of colours insufficient to increase reading speed effectively³⁶.

Overlays examination

The overlays examination requires illumination similar to that under which the overlays will be used. Two identical passages of text of appropriate size are used, side by side, over which overlays can be placed and compared. The overlays are compared in pairs, and the best of each pair retained, the other being replaced by another overlay. If the patient finds the choice difficult, the choice is repeated when all overlays have been assessed. Double overlays are used if symptoms remain³⁷.

Prevalence

In 6 studies of normal unselected children in mainstream schools, about 20% used their chosen overlay long-term¹⁸. Those that used their overlays read faster with them: 5% read more than 25% faster¹⁸⁻²⁰.

Reading speed

Reading speed can be measured quickly and efficiently using the *Rate of Reading Test* in which randomly ordered common words are read aloud for one minute³⁸. The words are high-frequency and therefore familiar to poor readers. The random word order means that the words cannot be guessed from context but have to be seen to be read. The text is meaningless so readers are unaware of their errors. The text is small to increase fatigue. The benefit from overlays can be rapidly ascertained as an increase in reading speed, as measured by this test. Although the *Rate of Reading Test* is not a typical reading task it has been shown to predict performance when text is read silently for comprehension¹⁸. An overlay needs to be of a size sufficient to cover the text, but it does not have to cover the surround³⁹. Individuals who find coloured overlays helpful usually prefer coloured lenses⁴⁰. The optimal colour for lenses is not the same as for overlays⁴¹, and it can be selected with

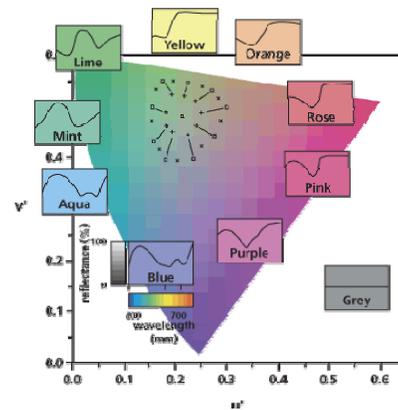


Figure 1. The *Intuitive Overlays*. The chromaticities of the nine coloured overlays are shown in the inner ring. The outer ring shows the chromaticities of two overlays placed one upon the other. The isolated points are those from combinations of overlays with neighbouring chromaticity. The lines connect the chromaticities of single overlays with those from two overlays of the same colour.

far greater precision. Coloured lenses also have practical advantages over overlays, because lenses are easier to use when writing, reading a white board in class, and using a computer. Coloured overlays are therefore used for screening, with the precision tinted lenses representing the preferred treatment.

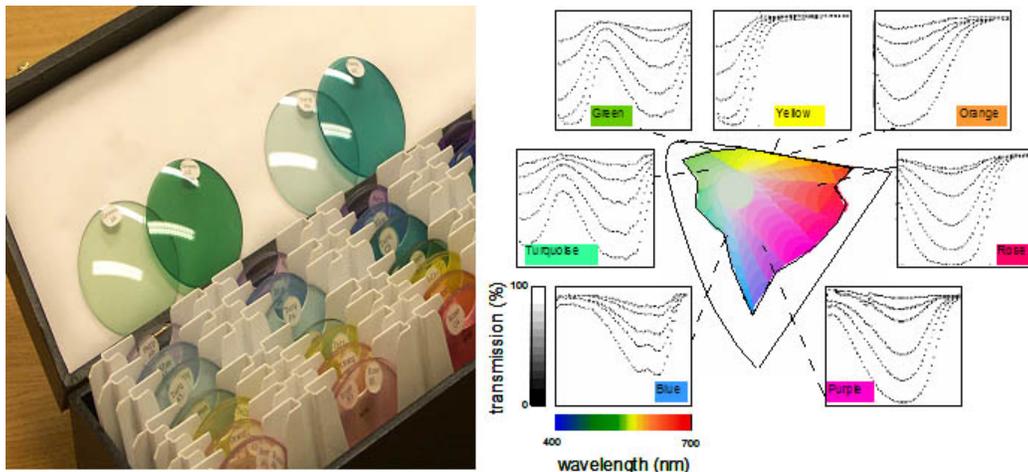


Figure 2. With the *Intuitive Colorimeter system*, tinted trial lenses can be combined to provide a close approximation to any required chromaticity. Lenses from only two dyes are necessary: those with neighbouring chromaticity.

Coloured lenses

The colour for lenses can be selected while the eyes are colour-adapted using the *Intuitive Colorimeter*, an instrument that illuminates a page of text with coloured light, allowing the hue, saturation and luminance to be varied independently^{4,42}. The optimal tint can then be matched in coloured trial lenses. Under conventional lighting the lenses result in a spectral power distribution almost identical to that in the *Intuitive Colorimeter*⁴³, allowing observers with colour vision anomalies to be tested. The *Intuitive Colorimeter system* will provide lenses that closely approximate any chromaticity. The lenses have a smoothly varying spectral transmission that minimises metamerism (under different types of lighting)³⁷.

Each individual reads most quickly with a particular individual optimal chromaticity. Departures from this optimum, whether in hue or saturation, result in slower reading. The greater the difference in chromaticity the slower the reading, unless the CIE colour difference (ΔE^*) exceeds about 100, in which case the speed is similar to that under white light¹⁷. Despite this specificity, calculations suggest that most tints offer at least some benefit under most types of lighting¹⁷.

Several different tinting systems are available, but most have only a few tints. Indications are that at least 1000 tints are needed to provide sufficient precision to increase reading speed optimally⁴⁴.

The examination with the Intuitive Colorimeter

With the *Intuitive Colorimeter system* the typical examination and prescription has 6 stages, usually taking 20-30 minutes⁴⁵ :

1. The optimal chromaticity is selected using the *Intuitive Colorimeter*. 12 hues are compared. Saturation is optimised at those hues that improve perception, and these are then compared. The eyes remain colour adapted while hue and saturation are alternately adjusted by small amounts to find the best chromaticity.
2. The matching combination of tinted trial lenses is calculated using a computer program.
3. The trial lenses are offered to the patient and the combination adjusted, if necessary.
4. The combination of lenses constitutes the (calibrated) colour prescription which is sent to a dyeing company.
5. Spectacle lenses are dipped into two dyes to obtain the appropriate spectral transmission.
6. A spectroradiometer and computer program check the transmission and supply individual information for the prescribing practitioner and patient³⁷.
7. Using trial lenses the practitioner carries out a visual check of the colour of the supplied spectacle lenses.

Neurological disorders involving visual stress

The patients who benefit from precision spectral filters include those with

- reading difficulty (double-masked trial of lenses)⁵
- photosensitive epilepsy (open trial of lenses)⁴⁶
- migraine (small-scale double-masked trial of lenses)²⁸
- autism (open trial of overlays)⁴⁷
- multiple sclerosis (double-masked trial of overlays)⁴⁸

All these disorders are associated with an increased risk of seizures, suggesting cortical hyperexcitability. There is good convergent evidence for cortical hyperexcitability in migraine^{49,50} and for pattern glare in consequence^{51,52}.

An hypothesis

Pyramidal neurons share inhibitory interneurons. Strong stimulation leads to a local depletion of GABA. The local impairment of inhibition results in a

spread of excitation⁵³. It is hypothesised that this spread of excitation results in the inappropriate firing of cortical neurons and the perception of illusions/distortions. Colour redistributes the excitation. Comfortable colours redistribute excitation so as to reduce excitation in hyperexcitable areas. It can be inferred that “colour redistributes excitation” because in visual area V2 colour is mapped topographically⁵⁴ and in V3 and V5 the spectral sensitivities of neurons show large variation although their primary function is spatial and motion processing⁵⁵.

Evidence

Blood oxygenation in the visual cortex (as evidenced by the fMRI BOLD signal) shows an increase in response to stripes with spatial frequencies in the aversive range⁵⁶. In migraineurs this increase is abnormally large at these spatial frequencies. In a preliminary study the abnormal increase has been shown to be reversed in V3 when precision tints are worn, but not when control tints are worn⁵⁷.

Clinical protocol

The *Intuitive Colorimeter* was patented by the MRC in 1994 and there are now over 250 of the instruments in use in the UK, mostly by community optometrists and a few by hospital orthoptists. A clinical protocol was published over 10 years ago⁵⁸ and is widely followed by colorimeter users. The clinical decision tree is shown in Figure 3. There has been considerable coverage of this subject in courses for both optometrists and orthoptists, including in an MSc module established about 10 years ago. There have also been symposia at international conferences specifically aimed at users of the *Intuitive Colorimeter*, which have been well-attended. A Society for Coloured Lens Prescribers has recently been set up to oversee the administration of a Code of Conduct to which members of the society subscribe. Evidence-based practice is codified and ratified by the society.

Conclusion

Coloured filters are a safe intervention for visual stress and have been widely used over the last 15 years. The efficacy has been demonstrated in three independent randomised controlled trials.

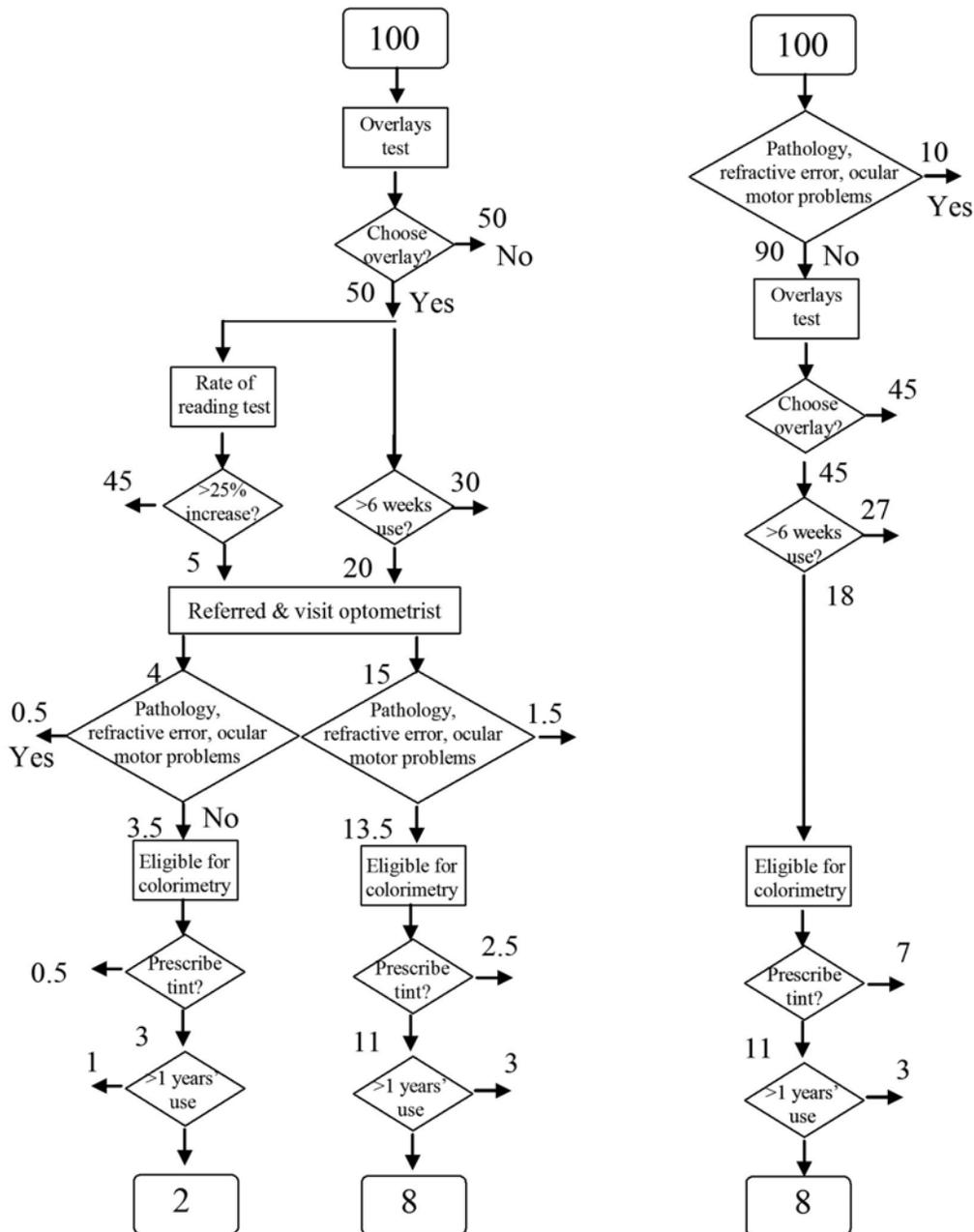


Figure 3. With >25% improvement in rate of reading as a criterion, 3% children tested with coloured overlays could ultimately be prescribed precision tinted lenses. With sustained use as a criterion the figure is 11%. A year later, the proportion still wearing the lenses will be between 2% and 8% of the original sample, respectively. Data from Ayrshire suggest that when no charge is made for provision, the take-up is about 80% of those who are suitable and are offered precision tinted lenses.

Further information:

Web site: www.essex.ac.uk/psychology/overlays

Video: "Reading with colour" (iOO sales, London)

Wilkins A.J. "Visual Stress", Oxford U Press, 1995

Wilkins A.J. "Reading through colour", Wiley, 2003

Intuitive Overlays: iOO sales Ltd., London

Intuitive Colorimeter: Cerium Visual Technologies, Tenterden, Kent, UK

Many of the following references can be downloaded from
www.essex.ac.uk/psychology/overlays/publications2.htm

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Declaration of Interest

The Medical Research Council holds the rights to the *Intuitive Overlays*, *Intuitive Colorimeter* and *Precision Tints*. The Council pays a discretionary *Award to Inventors* to Arnold Wilkins, based upon royalties from sales of the *Intuitive Colorimeter* and *Intuitive Overlays*. No royalties are received from sales of lenses. The second author, Bruce Evans, has no commercial interest, direct or indirect.