

The Use of Intuitive Colorimetry in Optometric Practice

Dr Simon Barnard

PhD FCOptom FAAO DipCLP DipClinOptom DipTh(IP)
Optometry Practice, London UK &
Associate Professor, Department of Optometry & Visual
Science, Hadassah Academic College, Jerusalem, Israel

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Declaration

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Acknowledgments

I wish to fully acknowledge the liberal use of
information taken from the book

Reading Through Colour

Arnold Wilkins

2003, Wiley, Chichester, England
and

Visual Stress and its treatment

Arnold Wilkins and Bruce Evans

University of Essex and Institute of Optometry

http://www.essex.ac.uk/psychology/overlays/recent_summary.pdf

Prologue

- The first version (Mark 1) of the Intuitive Colorimeter was released by the MRC to optometrists as a clinical diagnostic instrument in 1993
- 20 years of clinical use

Introduction

- In 1964 the respected neurologist MacDonald Critchley cited a case of a dyslexic child who was unable to read words on white card but could read words printed on coloured card

Critchley, M. Developmental dyslexia (Whitefriars Press, London, 1964)

- Olive Meares, school teacher from New Zealand, published a paper in *Visible Language* (1980) describing her pupils' reports of visual perceptual difficulties and how these difficulties could be reduced by covering the page with sheets of coloured plastic



- In 1983, Helen Irlen, a psychologist from California, read a paper at the American Psychological Association describing how her students reported fewer visual distortions when aided by coloured filters



Irlen, H. in The Annual Convention of the American Psychological Association, (Anaheim, California, 1983)

- Helen Irlen developed a proprietary treatment system for this syndrome
- 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

- However, without Helen Irlen's perseverance, the discovery may not have developed further and precipitated further study and research

For this reason and in recognition of these two pioneers

"Visual Stress Syndrome"

has also been named

"Meares-Irlen Syndrome"

- The next pioneer of significant importance to become involved is Professor Arnold Wilkins, who as a scientist working with the Medical Research Council at Cambridge University had a research interest in photosensitive epilepsy
- He was aware of early reports of coloured glasses, usually blue, being effective in reducing photosensitive seizures and wondered if there might be a connection with the anecdotal Irlen reports

- Aware that certain patterns were more likely to precipitate visual discomfort in some epileptic patients, he wondered if the patterns produced by text and rows of print might be connected to the visual discomfort reported by some patients viewing text

- He proceeded to develop a diagnostic instrument to enable a more scientific way of determining the optimum colour

- Arnold Wilkins named the instrument the ***Intuitive Colorimeter***

Wilkins, A., Nimmo-Smith, M. I. & Jansons, J. (1992)



- The instrument facilitated a randomised placebo control trial of precision tinted lenses in a group of patients with Meares-Irlen syndrome
- This study, funded by the MRC, showed that sufferers did respond to colour and the colour needed to be specific

Wilkins, A. J. et al. Double-masked placebo-controlled trial of precision spectral filters in children who use coloured overlays. Ophthalmol. Physiol. Opt. 144, 365-370 (1994)

- Another double-masked randomised placebo-controlled trial was conducted by Robinson & Foreman (1999). 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

Robinson, G. L. & Foreman, P. J. Scotopic Sensitivity/Irlen Syndrome and the use of coloured filters: A long-term placebo-controlled study of reading strategies using analysis of miscue. Perceptual and Motor Skills 88, 35-52 (1999b).

Robinson, G. L. & Foreman, P. J. Scotopic Sensitivity/Irlen Syndrome and the use of coloured filters: A long-term placebo controlled and masked study of reading achievement and perception of ability. Perceptual and Motor Skills 79, 467-483 (1999a)

Mechanism(s)?

- The mechanisms that underlie the benefit from coloured filters remain uncertain although recently the weight of evidence has turned in favour of the following explanation discussed by Evans (2001)

Evans, B. J. W. Dyslexia and Vision, Whurr: London, 2001

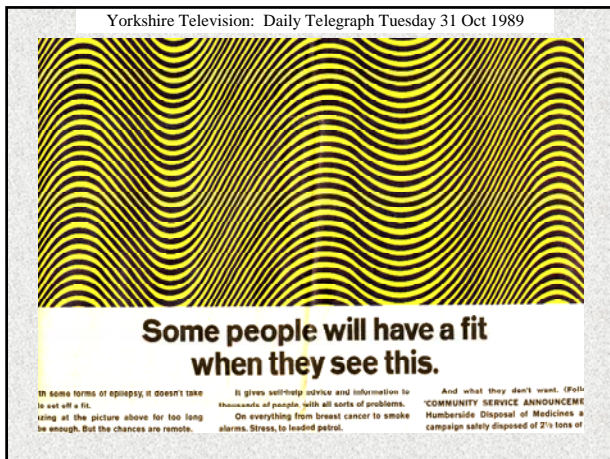
- In a few people stripes with this spatial frequency can trigger migraines or epileptic seizures

Wilkins, A. J., Binnie, C. D. & Darby, C. E. Visually-induced seizures. Progress in Neurobiology 15, 86-117 (1980).

Wilkins, A. J. et al. A neurological basis for visual discomfort. Brain 107, 989-1017 (1984)

Unpleasant images and stripes

- Images (from contemporary art and from photographs of rural and urban scenes) are sometimes classified as “unpleasant”
- Images with a frequency of 3 cycles per degree tend to be more uncomfortable
- Some people find them very aversive, other people are relatively unaffected



Text as stripes

- Text is striped partly because of the lines
- The lines have a spatial frequency within the range that causes discomfort

Wilkins, A. J., Huang, J. & Y, C. Visual stress theory and its application to reading and reading tests. Journal of Research in Reading 27, 152-162. (2004)

- 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
- 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 readers

Distortions

- People who dislike stripes tend to have frequent headaches
- They see many perceptual distortions involving motion, shape and colour
Migraineurs are particularly affected

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

Marks, D. & Ehrenberg, B. Migraine-related seizures in adults with epilepsy, with EEG correlation. Neurology 43, 2476-2483. (1993).

- Some people see distortions not only in stripes but also in text

Irlen, H. Reading by the colors: overcoming dyslexia and other reading disabilities through the Irlen method (Avery Publishing Group, New York, 1991)

- 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 stress

Evans, B. J. W. Case reports: The need for optometric investigation in suspected Meares-Irlen syndrome or visual stress. Ophthalmic Physiol Opt 25, 363-370. (2005)

- 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 speed

Wilkins, A., Sihra, N. & Myers, A. Increasing reading speed using colours: issues concerning reliability and specificity, and their theoretical and practical implications. Perception 34, 109-120. (2005).

Wilkins, A. J. Coloured overlays and their effects on reading speed: a review. Ophthal. Physiol. Opt., 448-454 (2002)

Wilkins, A. J. & Lewis, E. Coloured overlays, text and texture. Perception 28, 641-650 (1999).

Wilkins, A. J., Lewis, E., Smith, F. & Rowland, E. Coloured overlays and their benefits for reading. J. Res. Reading 181, 10-23 (2001).

In addition to direct evidence implicating pattern glare in the aetiology of visual stress, several studies have excluded other mechanisms

Evans, B. J. W., Cook, A., Richards, I. L. & Drasdo, N. 1994).

Evans, B. J. W., Busby, A., Jeanes, R. & Wilkins, A. J. Optometric correlates of Meares-Irlen syndrome: a matched group study. Ophthal Physiol Opt 15., 481-487(1995).

Evans, B. J. W. et al. A preliminary investigation into the aetiology of Meares-Irlen syndrome. Ophthal. Physiol. Opt. 164, 286-296 (1996a).

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

Wilkins, A. J. et al. (1994); Robinson, G. L. & Foreman, P. J. (1999a); Robinson, G. L. & Foreman, P. J. (1999b); Wilkins, A. J., Patel, R., Adjamian, R. & Evans, B. J. W. (2002)

- and by single masked clinical trials

Wilkins, A. J., Lewis, E., Smith, F. & Rowland, E. 2001; Bouldoukian, J., Wilkins, A. J. & Evans, B. J. W. 2002; Kriss, I. & Evans, B. J. W. 2005; Evans, B. J. W. & Joseph, F. 2002; Kriss, I., 2002; Singleton, C. & Trotter, S., 2005

- Additionally, an experiment directly addressed the issue of the precision with which the coloured filters need to be prescribed

Wilkins, A., Sihra, N. & Myers, A. 2005

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 excitation (*Meldrum & Wilkins 1984*)
- 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 and 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 topographically (*Xiao et al, 2003*)
- and in V3 and V5 the spectral sensitivities of neurons show large variation although their primary function is spatial and motion processing (*Zeki, 1990*)

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 range (*Huang et al, 2003*)
- In migraineurs this increase is abnormally large at these spatial frequencies
- In a preliminary study the abnormal increase has shown to be reversed in V3 when precision tints are worn, but not when control tints are worn (*Huang et al, 2004*)

Summary

- Text can have spatial characteristics which resemble those of stressful patterns
- Some type faces can have very stripy patterns
- Hence the distortions when reading

- There is *hyperexcitation* of neurones in the visual cortex
- These neurones are colour sensitive
- Therefore respond to precise colours
- Each person will respond to a specific and different colour

What is VISUAL STRESS?

Visual Stress refers to reading difficulties, light sensitivity and headaches from exposure to disturbing visual patterns. It can be responsible for *poor attention and rapid fatigue when reading*. The symptoms can occur despite normal vision and can often be reduced by coloured filters (overlays or lenses).

Visual Stress when reading has in the past been referred to as Meares-Irlen syndrome or Scotopic Sensitivity Syndrome.

Visual Stress (Meares-Irlen syndrome)

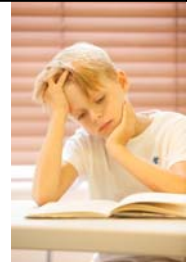
- Condition relating to reading difficulties, headaches and light sensitivity when looking at disturbing visual patterns
- Responsible for print distortion and rapid fatigue when reading
- Symptoms can occur despite normal vision and binocular function
- Many children are overlooked due to this or labelled as slow or lazy
- Removal of VS in dyslexic children allows exposure to print for longer

- Many children think what they see is normal
- 20% of population are affected, 5% to a severe degree

Tyrrell, et al (1995); Wilkins & Lewis (1999); Jeanes et al (1997), Scott et al (2002)

Symptoms

- movement of print
- letters changing shape or size
- patterns appearing, sometimes describes as “worms” or “rivers” running through print
- illusions of colour – blobs of colour on the page or colours surrounding letters or words
- rapid tiring
- headache or eyestrain



Signs

- moving closer to or away from page
- becoming restless
- using finger as a marker
- skipping words and lines
- rubbing eyes and blinking excessively
- low self esteem

At age 7, text in most literature will become smaller and more crowded. This is therefore often a common age for symptoms to manifest

Other signs

- frustration
- low self esteem

Early diagnoses of the problem is essential. The longer it takes to identify and remedy visual stress, the greater the loss of confidence

Neurological disorders involving visual stress

The patients who benefit from precision spectral filters include those with

- **Reading difficulty** (double-masked trial of lenses)
Wilkins et al (1994)
- **Photosensitive epilepsy** (open trial of lenses)
Wilkins et al (1999)

- **Migraine** (small-scale double-masked trial of lenses)

(Wilkins, Patel et al, 2002)

- **Autism** (open trial of overlays)

(Ludlow et al, 2006)

- **Multiple sclerosis** (double-masked trial of overlays)

(Wright, Wilkins, & Zoukos, 2007)

- **Stroke**

- Cortical hyperexcitability has been shown to present following stroke and visual stress symptoms resulting from stroke can be managed with spectral filters and precision tinted ophthalmic lenses.

Beasley& Davies (2012); Beasley& Davies (2013a); Beasley& Davies (2013b)

- All these disorders are associated with an increased risk of seizures, suggesting cortical hyperexcitability
- There is good convergent evidence for cortical hyperexcitability in migraine
(Welch, 2002; Welch, 2003)

How about dyslexia?

- Visual stress is NOT Dyslexia
- but VS is more common in individuals who are dyslexic
 - 50% of dyslexics also suffer from Visual Stress
- Those who fail to read due to VS are often mis-diagnosed as dyslexic
- Once the VS has been relieved the other aspects of dyslexia are easier to deal with.

Photosensitive migraine

- Migraine affects 10-12 % of the population
- 2/3 times more common in females
- 2/3 s sufferers have headache more than once a month
- 40% of migraine attacks are thought to be a result of a visual stimuli e.g. flickering lights

- These attacks can also be helped with the use of a precise colour
- This has been backed up by a study in USA using MRI scans

Huang et al 2011

Autism

- Autistic children often have issues with colour, for example only wearing a certain colour of clothes
- Published report showed that:
 - 67% of children with autistic spectrum disorders read with 11-50% improvement in rate of reading with colour
 - This is a much higher number than the normal population

Ludlow et all 2009

Diagnosis and Management of Visual Stress

Firstly.... Carry out a full eye examination

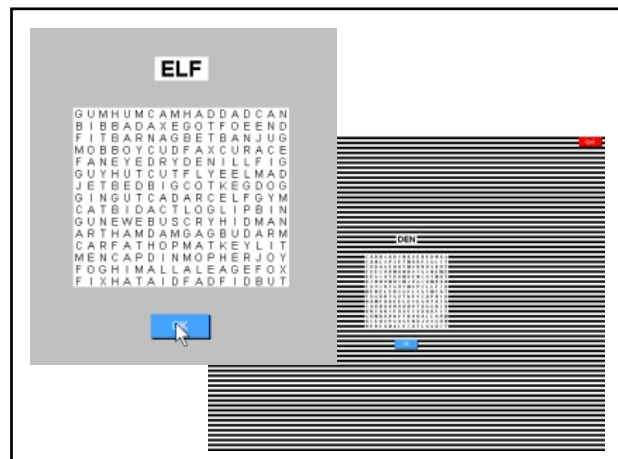
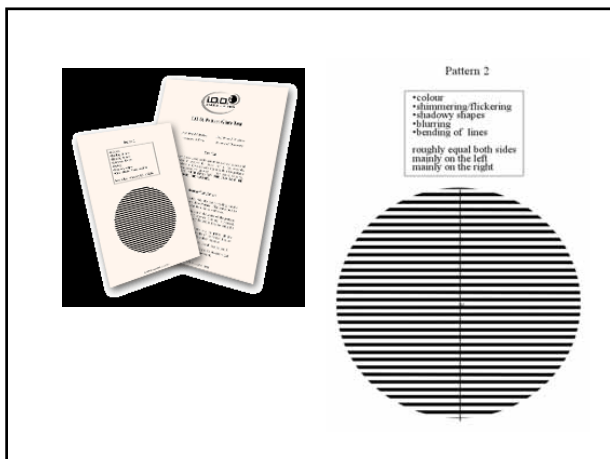
- Very necessary
- this is to rule out any refraction problems or binocular vision anomalies
- it is advised that these are rectified first before proceeding to the use of colour

Secondly....Pattern Glare Testing

Direct link between visual stress and pattern glare (Hollis & Allen 2006, Evans et al, 2008).

Two forms, manual and digital

NEXT TWO SLIDES ARE PATTERN GLARE GRIDS!



Thirdly...

Investigation of colour

- Intuitive Coloured Overlays (Institute of Optometry, London) or Cerium overlays
- Colour Screener PRO (Thomson Software)
- Intuitive Colorimetry (Medical Research Council patented instrument) Mk1 or Mk3.

Diagnostic screening with colour

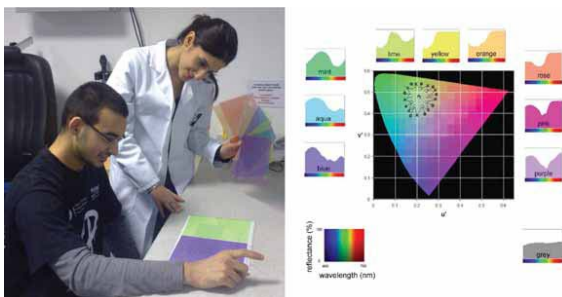
• Coloured overlays

- sheets of coloured transparency
- placed over the required text
- widely used by teachers, educational psychologists, therapists
- used only as screening
- can be used for a few weeks on a trial basis
- Advisable for children before proceeding to Intuitive Colorimetry



Coloured overlays

- Sheets of transparent coloured plastic
- 12-36 colours equally spaced around colour space
- Screening for colour
- Used in many schools and colleges, optometrists and orthoptists
- Each individual benefits from own selected colour
- Colour found subjectively by process of elimination

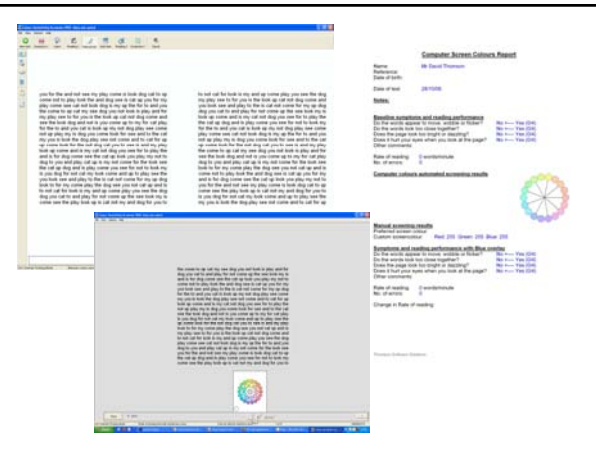


Wilkins Rate of Reading Test

- Indicates the effect on reading speed of a coloured lens
- Random word order
- Easy words

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

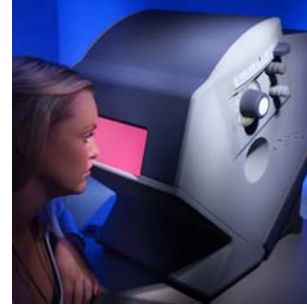
- Objective way of assessing benefit
- May be carried out before and after overlay assessment
- If 10% or more increase in ROR with chosen overlay, the patient can go direct to colorimetry without the trial period of overlay



Intuitive Colorimeter

- 500 Colorimeters internationally with 400 in the UK including orthoptists
- Under a patent owned by the MRC, who carried out much of the original research
- Offers the assessor a sequential way of determining optimal colour needed in order to prescribe Cerium Precision Tinted Lenses

Intuitive Colorimeter Mk 3



Precision Tinted Lenses

- if a prolonged benefit is found with overlays then a Colorimetry examination is recommended
- OR if an obvious improvement with the overlay is found initially you can move onto the colorimeter immediately
- optimal colour found using the intuitive colorimeter
- final colour found in assessment is incorporated into spectacle lenses
- VERY precise and individual to each person
- can be used for all tasks e.g. board work, computer work

Examination with the Intuitive Colorimeter

Examination and Prescribing with the Intuitive Colorimetry takes about 25 to 30 minutes

Step 1

Optimal **Chromaticity** and then **Saturation** are determined under light adapted conditions



Step 2

Matching combination of tinted trial lenses calculated using [computer program](#)



Step 3

The trial lenses are offered to the patient and the combination adjusted, if necessary



Step 4

The combination of lenses constitutes the (calibrated) colour lens prescription which is sent to a dyeing company

Step 5

Spectacle lenses are dipped into two dyes to obtain the appropriate spectral transmission

Step 6

A spectroradiometer and computer program check the transmission and supply individual information for the prescribing practitioner
(Wilkins, 2003)

Will a limited range of colours do?

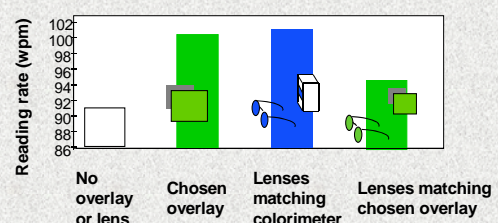
- Randomised control trials show that:
 - Different people need different colours
 - The colour needs to be individually defined with precision
 - A very wide range of colours is needed

Wilkins et al 2005

It is important to note that the optimal colour of precision lenses will likely be a different colour to the original colour of overlay chosen

**Overlays to not have the same effect as lenses**

- Not advised to tint the lenses to same colour as overlay
- Overlays provide surface colour – i.e. eyes adapted to white light
- Lenses effectively change the colour of the lighting
- Therefore optimum colour of the overlay changes differs from that of the lenses

Overlay colour vs. lens colour

Lightstone, A., Lightstone, T., Wilkins, A.J. (1999). Both coloured overlays and coloured lenses can improve reading fluency, but their optimal chromaticities differ. *Ophthalmic and Physiological Optics*, 19(4), 279-285.

Results

The degree of improvement will differ from patient to patient:

- some may experience improvements of reading age of 1-2 years in weeks
- some may experience greater comfort
- some may just be able to read for longer periods of time

<http://www.telegraph.co.uk/health/10340122/Why-Johnny-Depp-and-I-see-the-world-through-blue-tinted-spectacles.html>

Conclusions

- Visual Stress is associated with a number of conditions including dyslexia and migraine
- Colour can be prescribed to reduce symptoms in some of these patients
- The Intuitive Colorimeter is an instrument that enables the optimum colour (hue) and saturation be prescribed in the form of Cerium Precision tinted lenses

