

Vision, Reading Difficulties, and Visual Stress

Arnold J. Wilkins
Bruce J. W. Evans

Second Edition

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Dedication

This book is dedicated to the memory of Christine Fitzmaurice. For many years, Christine helped people with visual stress and then turned her boundless energies to advocating on behalf of all individuals with this condition. She organised conferences, research, publications, and most of all people. Her tireless work on the behalf of others in more need than herself is greatly missed.

Preface

A paper in the British Medical Journal in 1896 by Morgan described a child with reading difficulty, referred to by Morgan as a case of 'congenital word blindness'. Morgan thought that the eyesight was normal in this case, although only basic vision tests would have been possible at that time. Morgan thought the child "would be the smartest lad in the school if the instruction were entirely oral." This statement highlighted an obvious yet sometimes under-emphasised feature of reading difficulty: sufferers perform much worse when they are asked to read than when they are asked to listen. Since reading requires vision and listening does not it is perhaps surprising that most people with reading difficulty today are not routinely referred for an investigation of their visual function.

There has been increasing evidence in recent years of visual factors playing a role in reading difficulties and the tide seems to at last be changing, with a growing number of teachers and parents involving eyecare practitioners when their children have difficulty reading. This book is aimed at providing these eyecare practitioners with a summary of the evidence concerning the visual conditions that they should search for, guidelines for diagnosis and, if necessary, treatment of these visual disorders.

This book is written primarily for eyecare practitioners: optometrists, orthoptists, ophthalmologists, and opticians. The book is designed to be useful for any eyecare practitioner who may wish to help children or adults who experience reading difficulty, whether in primary, secondary, or tertiary care. The book also is intended to be useful for education professionals and parents, wishing to understand more about visual conditions that can co-occur with reading difficulties.

The title of this book deliberately avoids the word dyslexia because the book is not just about dyslexia. Vision is a core component of the reading process. So, any person who has difficulty reading, or who reads competently but reluctantly, or who reads less accurately than would be expected from their other abilities, ought to consult an eyecare practitioner who has specialized in this field. This applies regardless of whether the person with reading difficulty meets the diagnostic criteria for dyslexia.

The authors of this book have between them been researching the role of visual factors in reading difficulties for over 70 years. They come from psychology and optometry backgrounds and share a passion for removing visual obstacles to successful reading. The views expressed are solely those of the authors and represent an attempt to use scientific evidence to guide best practice in this controversial clinical field.

Acknowledgment

The book is a substantial revision of an earlier book written with Professor Peter Allen. The authors thank Professor Allen for his contributions.

Disclosures

The Intuitive Overlays, Wilkins Rate of Reading Test, Intuitive Colorimeter and Precision Tinted lenses were invented by author AJW. AJW received an Award to Inventors from the Medical Research Council for the Rate of Reading Test and the Intuitive Colorimeter, based on a proportion of the royalties for these products. He has donated royalties from the latest version of the Intuitive Colorimeter (The Curve) to the University of Essex to fund student bursaries. BJWE invented the IFS system of eye exercises which are briefly mentioned in Chapter 3 and for which BJWE receives a royalty. The Intuitive Overlays, Wilkins Rate of Reading Test, Pattern Glare Test, and IFS exercises are available from i.o.o. Sales Ltd (www.ioosales.co.uk). ioo sales is a company that raises funds for the Institute of Optometry, a charitable organisation. BJWE is Director of Research at the Institute of Optometry. The Intuitive Colorimeter and Precision Tinted Lenses are available from Cerium Visual Technologies (www.ceriumvistech.co.uk). AW and BE are committee members of the not-for-profit Society for Coloured Lens Prescribers (www.s4clp.org).

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Chapter 1

Introduction

Chapter Abstract

In this chapter the structure of the book is laid out, together with the underlying rationale. Types of learning difficulty and their relation to reading difficulties are described. The key visual deficits that can accompany reading difficulties – binocular instability and visual stress – are introduced. The associated symptoms and signs are described.

Introduction to the book

This is a book of two parts. The first part (Chapters 2-5) discusses the visual factors that may be associated with difficulty reading and dyslexia. One of these factors, visual stress (which is alleviated with coloured filters), is covered in detail in the second part of the book (Chapters 6-12), which also covers the use of coloured filters in neurological disorders. There are several reasons why visual stress is covered in detail. First, it is believed to be a condition with a neurological basis, which co-occurs not just with reading difficulties but also with common neurological conditions (e.g., migraine, autism) and with other rarer, but important conditions (e.g., epilepsy, stroke, multiple sclerosis). Also, the authors are aware of a need for an up-to-date review that brings together the research evidence, discusses the controversy surrounding visual stress, and summarises clinical guidelines.

The authors' goal is for this book to be accessible not only to eye

care professionals and education professionals, but also to parents. Each section includes a lay description and there are frequent summaries in non-technical language. Scientific evidence is concisely reviewed with references to relevant literature, for those to wish to read further.

In modern society most people are literate, and reading has become one of the most important tasks we do with our eyes. Nevertheless, references to reading difficulties can be traced back as far as the early seventeenth century when few of the population could read or needed to do so.

Reading requires an individual to use their visual skills, phonetic ability (ability to analyse speech sounds) and knowledge of language to successfully recognize words and gather meaning from the written text. Given the complexity of the processes involved, it is unsurprising that there are many sources of reading difficulty. This book will concentrate on visual factors that can contribute to reading difficulties in people who do not have eye disease.

There are several eye care professions. Optometry is the largest of these. The number of optometrists exceeds the sum of all the other eye care professionals. Most optometrists work in community optical practices and carry out eye examinations and sight tests. Optometrists have a statutory duty to diagnose and correct refractive errors (e.g., short-sightedness), orthoptic problems (difficulties with eye co-ordination), and some eye diseases. Some optometrists work in the hospital eye service and in research. In community practices, optometrists work alongside opticians (dispensing opticians), who are experts on spectacle frames and lenses. Optometrists and professionally qualified opticians in the UK must be registered with the General Optical Council and only registered opticians and optometrists can dispense spectacles to children. Ophthalmologists are medical

professionals who have specialised in eyes. In the UK, nearly all ophthalmologists work in the hospital eye service where they treat eye disease, either with medicines or surgery. Orthoptists work mainly in the hospital eye service where they diagnose and treat eye co-ordination problems (e.g., strabismus). Many orthoptists are also involved in vision screening, which in the UK typically takes place once, shortly after school entry.¹ Fewer than half of vision screening services in the UK are compliant with the relevant specifications, often lacking appropriate personnel or tests.²

Learning difficulties and reading

Learning difficulties (disabilities) can be broadly classified into those that are developmental and those that are acquired. Developmental difficulties are much more common than acquired problems, which typically result from a neurological disorder. Visual stress can accompany both developmental difficulties and neurological disorders.

Learning difficulties can also be classified into those that are general and those that are specific. Learning difficulties can affect a wide range of skills including general intelligence, as measured with an intelligence test, and expressed as an IQ. Specific learning difficulties (SpLD) only affect specific skills and can occur regardless of IQ.³ Chapters 1-5 of this book concentrate on SpLD.

Since most learning is mediated by the written word, those with reading and spelling problems will struggle with education, even if they are intelligent and articulate. SpLD persist throughout life and can have deleterious consequences for careers.⁴ There are many types of SpLD.⁵ Some of the main ones are summarised below.

- Reading and spelling difficulties, *dyslexia*. The definition of dyslexia remains controversial,⁶ but a common definition is *a learning*

*difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling.*⁴ Characteristic features of dyslexia are difficulties in phonological awareness (an understanding of the sound components of language), verbal memory, and verbal processing speed.⁴ Recent thinking on the causes of dyslexia are discussed at the end of Chapter 5.

- Difficulties with writing, *dysgraphia*. Dysgraphia can manifest as poor handwriting and trouble putting thoughts on paper.
- Lack of numerical skill, *dyscalculia*.⁷ Dyscalculia refers to a wide range of life-long learning difficulties involving mathematics. There is no single form of maths disability, and difficulties vary from person to person and affect people differently in school and throughout life.
- Difficulty with co-ordination, *dyspraxia*. This condition is closely related to conditions described by two other labels, developmental co-ordination disorder and clumsy child syndrome.

The skills involved in writing, reading, listening, speaking, and reasoning overlap and so it is not surprising that people can be diagnosed with more than one SpLD. Attention Deficit Hyperactivity Disorder (ADHD) is a condition that becomes apparent in some children in the preschool and early school years. ADHD is characterised by inattention and/or hyperactivity-impulsivity.⁸ ADHD is a common condition (although sometimes over-diagnosed)⁹ that is often associated with SpLD.¹⁰ ADHD is sometimes associated with hyperactivity (ADHD) but the condition can occur without hyperactivity, when the main features are inattention and impulsivity.

Dyslexia

in the late 1800's dyslexia was called congenital word blindness.¹¹ More recently, there has been an upsurge of interest in neurological factors affecting reading partly because of new and innovative imaging technology.¹²

Dyslexia is typically described as most common in males.¹³ Although some research suggests it is equally prevalent in both sexes,¹⁴ most research supports a greater prevalence in males attributed to hormone-related protective factors in females.¹⁵

Dyslexia often runs in families,¹⁶ and relevant genes have been identified.¹⁷ Dyslexia affects 5 to 17% of the school age population¹⁸ and can have a profound effect on schooling. The term dyslexia is sometimes used indiscriminately to refer to specific or even non-specific learning difficulties. The causes of dyslexia are still debated¹⁹ although it is generally agreed that a core feature in many cases of dyslexia is a deficit in phonological abilities,²⁰ a problem in understanding the speech sound of words. But dyslexia, is more than just a phonological deficit and there is evidence that dyslexia is a multi-factorial condition.²¹⁻²³

Visual and language processing deficits often co-occur in dyslexia.²⁴ The visual problems that are particularly prevalent are introduced below and discussed at greater length later in this book. Although these visual factors are not usually the main cause of dyslexia and are probably best considered as co-occurring factors, they can contribute to a child's reading difficulties. In other words, in dyslexia the problem with reading and spelling can be due to many factors requiring a multidisciplinary approach to investigation and treatment. An eye care practitioner is one member of this multidisciplinary team.

There have been many attempts over the years to classify dyslexia into subtypes.²⁵ Typically, these classifications include three groups: an auditory or phonological subtype (dysphonetic), a visual-spatial or performance group (dyseidectic), and a mixed group (dysphonetic/dyseidectic); although other classifications have also been suggested.²⁶ The classifications are controversial: some studies suggest that dyslexia is so heterogeneous that it defies classification.²⁷ It should be stressed that the visual-spatial subgroup have difficulties with high level visual functions, not with the low level visual functions that eye care practitioners assess. In fact, such classifications are not useful as indicators of which cases should see an eye care practitioner.²⁸ Current thinking has developed beyond the concept of sub-types and unitary causes of dyslexia and instead considers dyslexia as a multifactorial condition, best considered with respect to “an additive risk factor model”.²¹ The evidence for this model and its implications are considered further at the end of Chapter 5.

It is the eye care practitioner’s role to provide appropriate investigation and management of visual factor(s) that may contribute to the difficulty reading.²⁹ Diagnosis of dyslexia is not the role of an eye care practitioner but that of an educational psychologist or teacher qualified in special educational needs. The diagnosis of dyslexia is usually one of exclusion, following specific educational tests, after other factors such as intellectual disability and gross dysfunctions of hearing or vision have been ruled out. Of course, a person does not need to have been diagnosed as dyslexic before seeking help from an optometrist. Indeed, it would seem sensible for any children whose teachers or parents suspect underachievement at school to, at an early stage, have a detailed investigation with an eye care practitioner who has specialised in vision and learning.

Key clinical visual correlates of reading difficulties

The visual correlates of reading difficulties are discussed in detail in this book and will now, by way of an introduction, be briefly reviewed. Throughout this book, priority is given to evidence-based research. As noted in Chapter 11, this means that emphasis is placed on visual factors that have been shown to be associated with reading difficulties either in matched group studies or correlational studies. Treatments or interventions are only included in this book if they are supported by research evidence, ideally randomised controlled trials.

Even if a visual condition is not, in general, associated with dyslexia, the visual condition could still contribute to difficulties with reading in individual cases. This is illustrated in case study 1.1.

Case study 1.1

A 29 year old lady consulted an optometrist for her first eye examination. She had underachieved at school and was now engaging in adult education, leading to referral to an educational psychologist. The psychologist had diagnosed dyslexia and, noting visual symptoms, suspected visual stress. Symptoms included text blurring and eyestrain. Examination at presentation revealed reduced visual acuities and a significant degree (three dioptres in the right eye; four dioptres in the left eye) of myopic astigmatism. All other optometric test results were normal.

Spectacles were prescribed and with these, the symptoms fully resolved.

In Chapters 2-5, the visual conditions that are discussed will be considered under five headings that conform to the precepts outlined earlier:

- Background
- Is the visual condition associated with reading difficulty?
- Is there evidence of the visual condition contributing in a causal way to reading difficulty?
- How is the visual condition detected?
- How is the visual condition treated?

Binocular instability

Binocular instability (Chapter 3) describes a subtle problem in coordinating the two eyes together. In the clinic, binocular instability is detected as an unstable heterophoria and low fusional reserves (for description see Chapter 3). A controlled study found that the main sign of binocular instability (low fusional reserves) is present in about 5% of good readers and in 15% of poor readers.³⁰ This does not mean that 15% of poor readers need optometric treatment because binocular instability may in some cases be subtle and may not require treatment if it is not causing symptoms.³¹ The fact that 5% of good readers have one of the signs of binocular instability shows that there is not a simple causal relationship between fusional reserves and reading ability: low fusional reserves will not necessarily make a person a poor reader.

Visual Stress

Visual Stress is sometimes called Meares-Irlen Syndrome in recognition of the two individuals who first described the use of coloured filters as a treatment for people who experience discomfort

and perceptual distortions on viewing text. The term coloured filters is used generically to describe both coloured overlays (transparent plastic sheets placed on the page) and coloured lenses.

Visual stress is arguably a form of photophobia, characterised by symptoms of perceptual distortion and discomfort when viewing certain spatially repetitive stimuli, typically text. The symptoms can often be alleviated using coloured filters of a specific individually chosen colour.³² The condition appears to have a greater prevalence in individuals who suffer from dyslexia,^{33 34} migraine,³⁵⁻³⁷ autism,³⁸⁻⁴⁰ chronic fatigue syndrome (myalgic encephalitis),⁴¹⁻⁴³ multiple sclerosis,⁴⁴ stroke,⁴⁵⁻⁴⁷ head injury⁴⁸ and photosensitive epilepsy.⁴⁹⁻⁵¹

In susceptible individuals, symptoms of visual stress are likely to occur when the visual scene contains elements of a high contrast configurations of stripes (Figure 1.1).⁵²⁻⁵⁵ Visual stress is believed to be a condition separate from dyslexia, but the two conditions can co-occur.^{4 33 34}

Reading material (which has stripes from horizontal lines and from vertical letter strokes) has the potential to elicit visual stress.^{56 57} A condition that would nowadays be called visual stress was described by Critchley (1964),⁵⁸ Meares (1980)⁵⁹, Irlen (1983)⁶⁰ and Wilkins (1984).⁶¹ The susceptibility of some individuals to reading-related visual stress has been variously termed *scotopic sensitivity syndrome*, *Irlen syndrome*, *Meares-Irlen syndrome (MIS)*,⁶² *pattern-related visual stress (PRVS)*,⁵⁴ *Meares-Irlen syndrome/visual stress (MISViS)*⁶³, and *sensory visual stress*.³¹ The history of this condition is described in Chapter 6.

Wilkins has proposed that the underlying anomaly in visual stress is a hyper-excitability of the visual cortex, possibly as a result of impaired gain control mechanisms, and that the effects of this can be alleviated in a variety of ways, including modifying the design and layout of printed text and through the use of colour.^{53 61} Although there is

considerable evidence for the existence of visual stress, the condition remains controversial (discussed later in this book). In particular, the exact mechanism is still debated and under investigation.

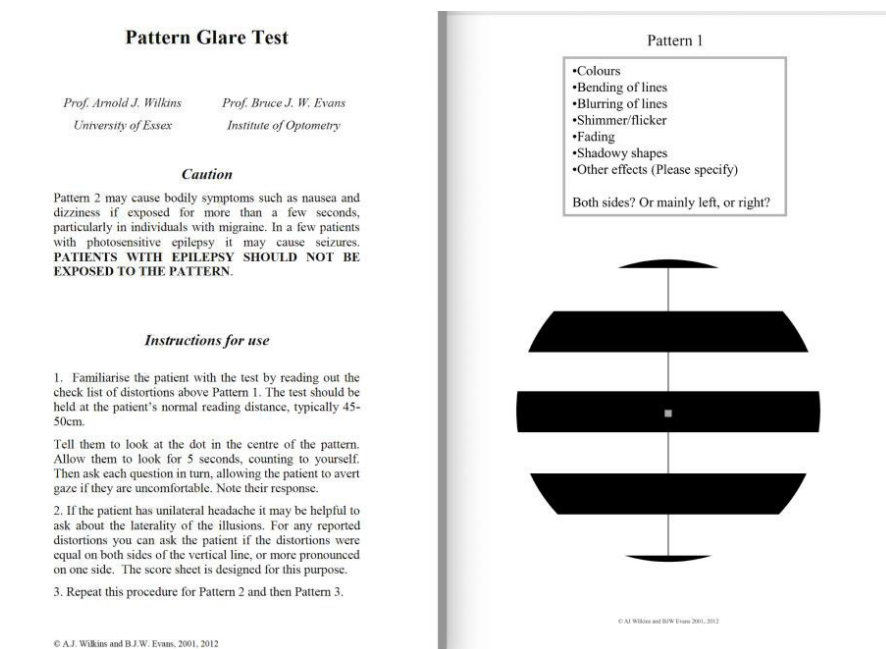


Figure 1.1. The pattern glare test, described in Chapter 10.

The prevalence of visual stress depends on the diagnostic criteria used but significant degrees of visual stress is likely to affect fewer than one in five people with dyslexia.^{64 65} Adults with dyslexia are also more likely to have visual stress than adults who are good readers, and the combination of dyslexia and visual stress adversely affects reading speed.³⁴ Visual stress, together with the various approaches to the correction of the condition using coloured filters, are discussed in Chapters 6-8.

Visual symptoms in people with reading difficulties

Eye care practitioners are in an ideal position to screen for people who may be experiencing reading difficulties by asking a few key questions when taking a patient's symptoms and history. Parents of children who have trouble learning to read often seek help from a teacher and/or an educational psychologist. Teachers and educational psychologists may recommend that the child consults an eye care practitioner who has specialised in vision and learning. Since reading involves vision, it is perhaps surprising that such a recommendation is not made more often.

A visual problem is particularly likely to be present in a person who has trouble learning to read if they report headaches and eye-strain after reading. The symptoms that are associated with the most relevant visual problems (e.g., visual stress, binocular instability) typically develop after a period of reading, and visual stress tends to be more common when viewing many lines of text in smaller fonts. This means that these visual problems may produce more symptoms in older children, who are "reading to learn", rather than in younger children, who are "learning to read". It is recommended that eye care practitioners ask, "After you have been reading for a while, do the words or letters do anything different?"

Suspicious symptoms are graphically illustrated at www.opticalm.ca, and can include:

- Letters appearing to move – this can appear in many forms including the words moving up and down, side to side, words merging, words breaking up and words moving.
- Letters appearing to blur especially with closely spaced small print

- Letters appearing double
- Letters changing size
- Letters changing contrast
- Letter or word reversals
- Colours or shapes appearing on the page
- Text appearing to flicker
- Discomfort under fluorescent lights and some LEDs
- The occurrence of headaches, nausea or dizziness
- Eyes becoming tired or sore
- The page appearing too bright

Symptoms are discussed in more detail in Chapter 10, which includes a more extensive list of symptoms and the conditions that are likely to cause these symptoms (Table 10.1).

The practitioner should be aware of the limitations in the use of symptoms as a diagnostic tool. The recall of symptoms is prone to bias; memory processes have been shown to be biased by mood, emotion and many other factors.⁶⁶ Recall of symptoms may vary and can depend on factors such as the mood at testing. Intermittent problems might be specific to certain environmental factors such as lighting or a particular task. Also, people often fail to recognise significant symptoms until the symptoms have been removed – they consider what they are experiencing to be normal. As illustrated in Table 10.1, most symptoms are non-specific: it is not possible to diagnose a visual problem with certainty from symptoms alone.

In addition to symptoms, the parent or teacher may observe behaviours or *signs* which alert the practitioner to the possibility of visual problems. Suspicious signs when reading include the following:

- Wearing spectacle lenses with tints or sunglasses when reading
- Rubbing eyes
- Excessive blinking
- Tracking the text with a finger due to difficulties in keeping place (Figure 1.5a)
- Closing or covering one eye (Figure 1.5b)
- Moving unusually close or far away from text
- Poor concentration which might be indicated by yawning, frequently looking away from the page and fidgeting
- Poor reading fluency that slows the longer the person reads

The number of signs and symptoms experienced by the person can give an indication of the severity of their susceptibility to visual stress. The reporting of symptoms provides a useful indication that an individual may warrant further investigation, as discussed in later chapters. Symptoms are more reliable when a person is asked about their symptoms whilst they are viewing text than when they are asked to recollect their symptoms.⁶⁶

Some teachers use checklists including the symptoms and signs listed above to indicate the presence of visual stress. However, these symptoms and signs can also be caused by a variety of conditions such as uncorrected refractive error (requiring glasses or contact lenses), accommodation (a focussing weakness) and/or binocular vision (eye coordination) problems, in addition to or independently of visual stress. The authors have always advocated that people with reading difficulties should have a full visual investigation by an eye care practitioner who has specialised in vision and learning (see Chapter 10). Research in recent years has helped to outline the protocol for these investigations and this will be described in Chapter 10.

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Chapter 2

Refractive errors & ocular health

Chapter Abstract

The components of a clinical optometric examination are explained, and how they relate to ocular health, visual fields, colour vision and refractive error. The possible associations with reading difficulty and techniques for treatment are set out. It is concluded that refractive errors, visual acuity, and ocular pathology are not correlates of developmental reading difficulties. However, refractive errors are common and can affect the ability to resolve detail, and therefore can contribute to reading difficulties in some cases.

Ocular health

Thankfully, eye diseases are rare in childhood. Certain pathologies can, however, significantly reduce a child's visual acuity although such reduced acuity does not necessarily affect reading under optimal conditions.¹ Eye disease is not more common in children with reading difficulties,^{2,3} but can occur in any child and an examination of ocular health is an essential part of any eye examination.

Eye disease become increasingly prevalent with age, and this can cause reduced visual acuity and/or restricted visual fields, which can impair reading. This acquired reading difficulty is very different to the developmental reading difficulty that is present in dyslexia.

Visual fields

Eye care practitioners often perform an assessment of visual fields using automated perimeters. These perimeters may be insensitive to some of the subtle visual field asymmetries that have been reported as correlates of reading difficulties (dyslexia), which are discussed in Chapter 5. In laboratory-based studies there is a continuing debate as to whether people with reading difficulties show visual field (left/right) asymmetries on verbal or visual spatial tasks⁴⁻⁶ (Chapter 5). Some researchers have found that in certain tasks individuals with dyslexia show a statistically significant right-sided bias⁷ leading to descriptions of “mini-neglect” of the left visual field in poor readers;⁸ although this was not found in a line bisection task.⁹ In any event, visual neglect is quite different to a visual field defect (subtle or otherwise) and there is no good evidence that clinically abnormal visual fields are a significant factor in reading difficulties.

In recent years, a new method of perimetry has become popular for detecting glaucoma. It uses a frequency doubling technique (FDT) that is believed to detect the magnocellular deficit in glaucoma (see Chapter 5). It has been shown that the test can also detect a magnocellular deficit in dyslexia.¹⁰ The deficit is subtle and is not likely to interfere with the clinical use of FDT to detect glaucoma,¹¹ which is extremely rare in childhood.



Figure 2.1. Frequency doubling technique for visual field testing

Occasionally, patients can acquire reading difficulties, usually abruptly, as a sign of neurological disease (e.g., stroke). Clinicians should be alert to the possibility of these rare cases, which require prompt neurological investigation. Although most reading difficulties are not due to neurological disease, routine visual field testing is a sensible precaution in children who are able to perform the test as it will help to detect some of these rare cases, when the aetiology is not apparent from the history.

Colour vision anomalies

In schools, colour is used extensively for teaching and many vocations and hobbies require some degree of colour identification. Approximately one in 12 men and one in 200 women have a congenital colour vision deficiency. This is sometimes called “colour blindness”, although this term is deprecated because people with colour vision