The Use of Coloured Filters and Lenses in the Management of Children with Reading Difficulties

A Literature Review

Commissioned for

The Irlen Screening Research Project

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1.0 Background and Context

1.1 Background

The ability to read and understand written text is fundamental to learning and participation in our society. Unfortunately, there are a group of children in our schools who struggle with basic literacy some of whom have specific learning difficulties that make acquisition of reading skills difficult.

Learning to read involves an integration of language and visual skills. This includes knowledge of conventions of print and prior linguistic knowledge, including an understanding of the relationship between letters and sound. Symbols on a page combine to form not only instructional information, but can also evoke the imagery and magic of other worlds and possibilities, thus making reading not only an essential part of participating in society, but a conduit of ideas, and a source of pleasure.

Perhaps this is better explained by a true wordsmith:

Reading is "a form of telepathy. By means of inking symbols onto a page, she was able to send thoughts and feelings from her mind to her reader's. It was a magical process, so commonplace that no one stopped to wonder at it. Reading a sentence and understanding it were the same thing; as with the crooking of a finger, nothing lay between them. There was no gap during which the symbols were unraveled. You saw the word *castle*, and it was there, seen from some distance, with woods in high summer spread before it..."

Atonement, Ian McEwan 2001, p37

For most, the effortless nature of this skill belies the complexity of its acquisition. The average reader would not spare a thought for the mechanism of reading or the myriad components that make up the whole. For some however, this complexity means reading is a constant challenge, to the extent that pleasure is denied and failure often experienced.

The manifestation of reading difficulties is individual in presentation and aetiology is also likely to be individual in nature. Whilst phonological awareness is critical to understanding letter-sound relationships and thus facilitates the reading process, it is evident that a necessary requirement for reading is visual acuity. Consequently vision screening is an important part of school readiness and continued educational participation.

Vision screening in New Zealand schools occurs as part of the B4 School Check programme, which is a population, based screening programme delivered to four year olds in particular geographical areas. Vision Hearing Technicians also conduct screening in the first year of school and at Year 7. This screening programme is designed to detect visual acuity problems (short sightedness) and screens for specific visual difficulties such as amblyopia, squint and colour vision defects (Ministry of Health, 2004).

Whilst this screening is routine and is able to pick up common visual problems, there are those who consider that more complex visual difficulties impact on reading ability and that these visual difficulties are not assessed for in traditional vision screening (Hoyt 1990). For a particular group of children, it is suggested that visual perceptual difficulties cause visual stress and print distortion that interferes with the reading process and thus inhibits access to the school curriculum. This difficulty has been named Meares-Irlen Syndrome (MIS) and is the subject of this Literature Review, the purpose of which is to assess the strength of the evidence for the effectiveness of coloured glasses or overlays in the management of children with reading difficulties.

1.2 Terminology and Definitions

Given the many differing definitions in common usage, the following explanation of terminology is offered:

Specific Learning Disorder (SLD) is the term given by both the Diagnostic and Statistical Manuals of Mental Disorder, Fourth Edition, Text Revision (DSM IV-TR; American Psychiatric Association (APA), 2000) and the International Classification of Diseases, Tenth Edition (ICD 10; World Health Organisation (WHO), 2007) to a specific

learning disorder that is evidenced by a discrepancy between a child's actual achievement (as measured by standardized tests) and their ability as measured by formal cognitive testing. Further criterion include:

- that this difference would not be expected given the education of the child
- that the condition significantly interferes with academic achievement or daily living skills
- and that the achievement attained is below the chronological age of the child in question.

SLD's recognized by DSM IV-TR include Reading Disorder, Mathematics Disorder, Disorder of Written Expression and Learning Disorder Not Otherwise Specified.

Specific Reading Disorder is characterized by the DSM IV-TR (APA, 2000) as including oral distortions, substitutions, or omissions; it also notes that both oral and silent reading are characterised by slowness and errors in comprehension. The DSM IV-TR (APA, 2000) also reports that this condition has been termed dyslexia. In contrast, ICD 10 (WHO, 2007) classifies dyslexia as an additional and separate code and notes that dyslexia is an exclusionary criterion for Specific Reading Disorder.

Dyslexia is a term given to a specific learning disorder whereby a student's achievement is not matched by their ability despite access to education (Evans, Patel, Wilkins, Lightstone, Eperjesi, Speedwell & Duffy, 1999). It is usually used in reference to a specific reading disorder, however, the Dyslexia Foundation of New Zealand (DFNZ) indicate that numeracy difficulties may be the primary foci. The definition DFNZ uses for dyslexia is:

"A specific learning difference which, at any given level of ability, may cause unexpected difficulties in the acquisition of certain skills". - www.dyslexiafoundation.org.nz

Ludlow, Wilkins & Heaton (2006) note that the British Psychological Society considers dyslexia to be present when accurate and fluent word reading or spelling is not completely developed to an age appropriate level.

Until recently, the New Zealand Ministry of Education did not recognise dyslexia as a separate specific learning disorder, with Ministry guidelines being to class difficulties under

the banner of specific learning disorders. This has changed in recent times and the Ministry is currently undertaking a work programme to support its recent acknowledgment of dyslexia as a discrete and separate learning disorder.

The New Zealand Ministry of Education offers the following definition of dyslexia:

"*Dyslexia is a spectrum of specific learning difficulties and is evident when accurate and/or fluent reading and writing skills, particularly phonological awareness, develop incompletely or with great difficulty. This may include difficulties with one or more of reading, writing, spelling, numeracy, or musical notation. These difficulties are persistent despite access to learning opportunities that are effective and appropriate for most other children"*

www.minedu.govt.nz

Reading Difficulties has a broader application. Reading difficulties can occur from a wide range of causes including cognitive deficits, mental health disorders such as Attention Deficit Hyperactivity Disorder, socio-economic factors such as educational opportunity and deprivation, and sensory difficulties such as hearing loss. It is expected that these sorts of issues would be excluded or compensated for before any diagnosis of dyslexia or reading disorder is made (Nandakumar & Leat 2008).

The multitude of similar yet different definitions for reading problems illustrates the fact that definitions are not well conceptualised or defined (Cornelissen, 2005). In fact there is much overlap within these labels that makes any specificity of assessment, target or treatment difficult. Any of these labels could well encompass a very heterogeneous group of children with literacy difficulties. However, regardless of the difficulties with labeling there is no doubt that reading problems cause concern no matter the label ascribed to them (Wilkins 2005).

Meares-Irlen Syndrome (MIS) is a visual perceptual dysfunction described as Scotopic Sensitivity Syndrome by Helen Irlen, an educational psychologist, in the early 1980's. Such a syndrome was previously noted in an article by New Zealand teacher Olive Meares, hence the interchangeable term of Irlen Syndrome and Meares-Irlen Syndrome. Recent

research suggests that those who have Meares-Irlen Syndrome are those who are susceptible to reading-related visual stress. Researchers have thus adopted the term "Pattern Related Visual Stress" or PRVS (Singleton & Henderson, 2007) or Meares-Irlen Syndrome/visual stress or MISViS (Kruk, Sumbler & Willows, 2008; Nandakumar & Leat, 2008) to describe this. The term MIS will be used in this review.

1.3 Literacy in the New Zealand Context

New Zealand is a party to an international survey on literacy rates, "Progress in International Reading Literacy" (PIRLS). Information for this study was last collected in the 2005/06 school years and indicates that New Zealand children are able to hold their own internationally. Of the Year 5 children tested, the mean reading literacy achievement was significantly higher than the international mean. However, New Zealand was also noted as having the largest spread from highest to lowest performing students. In fact, 8% of New Zealand students in this sample did not meet the lowest international benchmark. This compared with an international median of 6 % of students not meeting the benchmark (Chamberlain, 2007).

The statistics collected for secondary students were slightly better, with New Zealand students in third position of OECD countries in literacy achievement. However, 15% did not reach beyond the bottom level of achievement, which although better than the reported international mean of 20%, indicates a significant percentage of students with some literacy issues. As with the primary age survey, girls tended to achieve at a higher level than boys and European/Pakeha students achieved at higher levels than Maori and Pacific Island students (Chamberlain, 2007).

Research in the United Kingdom indicates that up to a third of 11 and 12-year-old children do not meet basic literacy standards (Cornelissen, 2005). There appear to be no similar incidence or prevalence studies conducted in New Zealand and it is difficult to imagine the criteria that would be applied. Nevertheless, the DSM IV-TR estimates the prevalence of Specific Reading Disorder (including dyslexia) as being approximately 4% of the population (APA, 2000).

2.0 Description of Meares-Irlen Syndrome

2.1 History

The first documented discussion of the role of print as a factor in reading difficulties was a paper published by a New Zealand teacher and reading specialist, Olive Meares. She presented anecdotal evidence from children attending her reading clinic that suggested visual print distortions were a common feature of children with reading difficulties (Meares, 1980). Meares reported that the children she was teaching had different visual experiences of print than the perceptions of "normal" readers. Students in her reading groups described text moving, blurring, flickering and jumping. All these students appeared to consider these experiences part of the "normal" process of reading.

Meares (1980) had noticed that her reading disabled students found it easier to read text that was printed on coloured paper. She hypothesized that the contrast between white paper and black print made the task of reading unnecessarily difficult and caused the visual disturbances described by the students.

At around the same time, educational psychologist Helen Irlen recognized a similar subgroup of students in her remedial reading classes. These students, despite adequate decoding skills and reasonable sight vocabulary, continued to experience reading difficulties and were avoidant of tasks that involved reading despite standard reading interventions (Irlen, 2005).

During a reading lesson with Ms Irlen, one of the students is reported to have spontaneously placed a coloured overlay over text. This reportedly had an immediate effect on the reading ability of a classmate. Irlen subsequently obtained different coloured overlays and discovered an individual effect of colour on reading ability that she initially termed Scotopic Sensitivity Syndrome, now most commonly referred to as Meares-Irlen Syndrome (Irlen, 2005).

2.2 Characteristics

Meares-Irlen Syndrome is characterised by visual perceptual distortions and symptoms of visual stress that remain after any necessary orthoptic intervention (Blaskey, Scheiman, Parisi, Ciner, Gallaway & Selznick, 1990; Bouldoukian, Wilkins & Evans, 2002; Kriss & Evans, 2005; Mitchell, Mansfield & Rautenbach, 2008; Northway, 2003).

Visual stress is one of the hallmarks of Meares-Irlen Syndrome. It has been defined as the inability to see comfortably without distortion and discomfort (Kriss & Evans, 2005). It is sensory in origin and is related to characteristics of the visual stimulus. This is in contrast to visual stress caused by visuo-motor deficits such as defects in accommodation or binocular vision. Because of the distinction, current researchers are terming the sensory type of visual stress, Pattern Related Visual Stress (Allen et al, 2008).

Common symptoms of Pattern Related Visual Stress reported across the MIS literature include:

- Light sensitivity
- Headache when reading
- Watery eyes
- Excessive blinking
- Fatigue
- Inability to sustain attention
- Poor visual focus

Visual perceptual distortions noted in this population include:

- Blurring of print
- Movement of print
- Missing lines and individual words
- Losing one's place when reading
- Difficulty copying and evenly spacing words
- Doubling of text
- Pattern glare from multiple lines per page

Although these characteristics are documented by some researchers, there are other viewpoints that discount the groupings of these characteristics as a specific syndrome and instead view these as idiosyncratic characteristics peculiar to individuals rather than symptomatic of a particular population (e.g. American Optometric Association, 2004).

2.3 Prevalence

When combining information from multiple studies, Kriss and Evans (2005) suggest the point prevalence rate of Meares-Irlen Syndrome is approximately 20% in the general population. This figure is hard to ratify given the various figures touted in the literature. Smith and Wilkins (2007) report that over 50% of children in mainstream education will report benefit from using filters. As only half of this group will sustain usage (a criterion for diagnosis) they state 25% of school children have Meares-Irlen Syndrome though not all will have reading difficulties (Wilkins, 2005).

Singleton and Trotter (2005) speculate that 12% of the general population have MIS and estimate the prevalence amongst those with dyslexia is much higher, perhaps as great as 65%.

A newspaper article in the US Press-Enterprise reports the Irlen Institute as stating that 2000 school districts in America have implemented Irlen screening projects and more than 50,000 adults and children consequently use coloured filters or overlays (Fetbrandt, 2001). By 2004, Associate Professor Greg Robinson of the Australasian Association of Irlen Consultants (Inc) reports that 4000 schools across America screen routinely for MIS and 100,000 people have consequently been prescribed coloured filters (Robinson, 2004).

The following table indicates specific prevalence rates found in the literature. From perusal of the table, it is apparent that a consensus has not been reached for measuring prevalence of this condition. Methodological flaws in some of these studies make comparisons difficult, however, the differing prevalence rates indicate a fundamental problem in classification and description of this syndrome.

Table 1. Prevalence of Meares-Irlen Syndrome

Study	Sample	Criterion	Rate (%)
Robinson & Conway 1994	287 unselected Year 11 and 12 students and 65 Year 7 students from community secondary school	Diagnosed as "excellent or good" candidates for MIS using Irlen Differential Perceptual Schedule	25
Wilkins, Jeanes, Pumfrey & Laskier 1996	77 unselected children aged 8 – 11years	Initially selected an overlay Read 5% faster (on WRRT) >8wks voluntary use of overlay	49 20 20
Jeanes, Busby, Martin, Lewis, Stevenson, Pointon & Wilkins, 1997	152 unselected children aged 5 – 11years	Initially selected overlay >3months voluntary use >10months voluntary use	53 36 24
Wilkins et al, 2001	426 unselected children aged 6 – 8years	Initially selected overlay > 5% faster (WRRT) > 25% faster (WRRT)	60 36 5
Evans & Joseph, 2001	113 unselected University students aged 18 – 44years	Initially selected an overlay >5% faster (WRRT) >25% faster (WRRT)	88 34 2
Kriss & Evans, 2005	64 children aged 7-12years; 32 with dyslexia (d), 32 controls (c)	Initially selected an overlay (d) Initially selected an overlay (c) >5% faster (WRRT) (d) >5% faster (WRRT) (c) >10% faster (WRRT) (d) >10% faster (WRRT) (c)	84% 97% 47% 25% 31% 12.5%
Kruk et al, 2008	36 children aged 9 – 10years; 18 with dyslexia (d), 18 controls (c)	Diagnosed as MIS by blind Irlen Screeners (d) Diagnosed as MIS by blind Irlen Screeners (c)	50% 55%

Source: (modified from Kriss & Evans, 2005).
Notes: The rate column gives the proportion of the full study population who met the corresponding criterion.

2.4 Assessment of Meares-Irlen Syndrome

It is generally accepted that the presence of Meares-Irlen Syndrome is confirmed through either one of the two following criterion: (Kriss & Evans, 2005; Singleton & Henderson, 2007)

- The sustained use of a coloured overlay or filters; or,
- An improvement in the rate of reading by more than 5% when using coloured overlay or filters.

Hence, although symptomology is assessed, it is treatment response that dictates diagnosis.

A number of different protocols have been developed to diagnose Meares-Irlen Syndrome many of which include substantial self-report. Caution has been advised when ascertaining the veracity of child self report on MIS screening questionnaires leading to identification of false negatives (Kriss & Evans, 2005). There is some concern that children may not recognise symptoms of MIS because of a process of normalisation. Others may exaggerate or "fake good" to gain approval. Because of this, some clinicians have suggested that the response to coloured overlays is the real diagnostic test for MIS (Kriss & Evans, 2005).

However, response to overlays is also determined by the self-report of the child. It could also be argued that self report regarding the effectiveness of overlays may lead to false positives through both habituation (to the testing materials) and the Hawthorne effect, given the students know they are undergoing an assessment.

Assessment tools and procedures in common usage in the literature are:

- Irlen Reading Perceptual Scale®
- Intuitive Coloured Overlays®
- Assessments of Visual Stress

- Wilkins Rate of Reading Test

Irlen Reading Perceptual Scale®

This original MIS protocol was developed by the Irlen Institute that trains and certifies Irlen Screeners and Irlen Diagnosticians who are then able to practice with the endorsement of the Irlen Institute. The assessment instrument used is called the Irlen Reading Perceptual Scale® which consists of four parts including:

- questionnaires to ascertain reading efficiency, strain and fatigue;
- tasks that are considered to immediately create conditions of visual stress and fatigue;
- use of overlays to determine whether reading improves with the application of colour;
- and finally, a series of distortion pages to ascertain individual visual perceptual distortions (Irlen Institute, 1987; Kruk et al, 2008).

Intuitive Coloured Overlays®

Intuitive Coloured Overlays® have been developed by Arnold Wilkins at the Visual Perception Unit at the University of Essex. According to Kriss and Evans (2005) these are the "gold standard" instruments used to determine a diagnosis of Meares-Irlen Syndrome.

The Intuitive Coloured Overlays® are a set of nine coloured acetate overlays plus one grey overlay. By using the overlays singularly or in combination, a total of 27 colours can be sampled which represent the chromaticities found in the CIE 1976 UCS diagram. This means that the saturation level is similar for all colours. Pairing colours of neighbouring chromaticity enables sampling of higher levels of saturation (Singleton & Trotter, 2005; Smith & Wilkins, 2007; Wilkins, Lewis, Smith, Rowland & Tweedie, 2001)

A protocol has been developed for use of the overlays that involves presentation of two identical passages of randomly ordered words to an individual suspected of having MIS. These two pieces of text are placed side by side and the overlays are then systematically placed over the text and the reader asked a standard set of questions regarding symptoms of visual stress and visual perceptual distortions. The reader then chooses which overlay

(or no overlay) improves the reading experience. By a process of elimination, a favoured colour (from the 9 + 1) is selected for the individual. If an overlay is chosen but does not remove all symptoms, more saturated colours are obtained through adding combinatory overlays (Smith & Wilkins, 2007).

A competitor has recently entered the market for provision of overlays with the development of the "Reading Rulers". According to the Wilkins team, the limited colour range in the Reading Rulers (five only) limits their utility (Smith & Wilkins, 2007). Other than this study by the Wilkins group, no other literature has been found relating to the efficacy of the Reading Rulers.

Assessments of Visual Stress

Although most assessment of Meares-Irlen Syndrome is conducted by a process of measuring the subjective response to presentation of different coloured overlays, there are those who advocate for a more objective measure to be used (Allen, Gilchrist & Hollis, 2008).

Because of the universal acceptability of visual stress as a measurable component of MIS, some researchers have advocated for the use of a specific assessment of visual stress as part of a battery of measures to inform diagnosis of Meares-Irlen Syndrome (Allen et al, 2008; Singleton & Henderson, 2007). Allen and colleagues (2008), suggest that both state and trait measures should be investigated and verified before diagnosis is made. Their assessment protocol includes questionnaires and interviews regarding symptom presence and significance as a trait measure and propose the use of a specific visual test such as reaction to square wave gratings to directly assess the presence of pattern related visual stress. Singleton and Henderson (2007) have also tried this approach, using a computerized visual stress screener. However, to date this search for objective validation does not appear to have gained great momentum by others in the field.

Wilkins Rate of Reading Test

Given the agreed upon diagnostic criteria for Meares-Irlen Syndrome includes the sustained use of overlays **or** a subsequent improvement in reading, the secondary part of assessment usually includes gauging performance on a test of reading.

Because most reading tests are designed to measure linguistic function or comprehension, they are not necessarily suited for Irlen screening purposes (Bouldoukian et al, 2002; Kriss & Evans, 2005). Such tests are reported to often be printed in large text, which can mask any visual perceptual difficulties. The Wilkins group have developed a reading test designed specifically for use in screening for MIS called the Wilkins Rate of Reading Test (WRRT) (Wilkins et al, 2001). The Wilkins Rate of Reading Test was specifically designed to challenge readers with visual difficulties. The text is small and there is minimal spacing between words. The words themselves are chosen for their linguistic ease and strung together in a meaningless manner, meaning comprehension is not required nor assessed (Boudoulkian et al, 2002 ; Wilkins, 2002).

When reading from standard texts, researchers have noted that there is a time delay before the benefit of overlays is demonstrated. This is thought to be due to deterioration in performance when fatigue sets in as visual stress begins to manifest (Wilkins et al, 2001). The alleged benefit of the Wilkins Rate of Reading Test is the discovery that this test can show the benefit of overlays in as little as one minute because the test mimics visually stressful conditions (Wilkins, 2002).

2.5 Treatment

The standard treatment for Meares-Irlen Syndrome is utilisation of an individually prescribed coloured overlay or lenses (commonly referred to as Irlen filters®). Part of the diagnostic protocol includes the proviso that the condition must be alleviated by application of colour through individually prescribed overlays, lenses or filters. The benefits are stated to be both specific and idiosyncratic to the individual (Kriss & Evans, 2005).

Although originally, coloured overlays were the only form of treatment available, a further refinement of the process has reportedly occurred with the development (also by Wilkins) of the Intuitive Colorimeter®. The Intuitive Colorimeter® is a piece of equipment similar to that used by optometrists in standard visual examinations but instead of looking through prescription lenses, the Intuitive Colorimeter® allows the perceptual effects of colour to be ascertained while the eyes are concurrently adapted to colour (Wilkins Huang & Cao, 2004). From the results of the assessment with the Intuitive Colorimeter®, tints are able to be prescribed in the form of lenses (used interchangeably with the term “filters’ in the literature). The colour that is prescribed through use of the Intuitive Coloured Overlays is reportedly never the same as the colour prescribed as filters because of the differing wavelength of light involved (Wilkins et al, 2004).

The Irlen Institute (1987) also note that the use of overlays is only an intermediate step in the treatment of MIS. They advocate for the use of Irlen Filters® (glasses with coloured tints) as they believe that the use of such filters enables greater benefit because of their portability, flexibility and utility. They note that with filters, the colour is not perceived when looking through the glasses and also highlight the fact that filters are not the same colour as overlays due to the differing light wavelengths involved. In order to receive Irlen Filters®, clients are required to undertake a diagnostic procedure with an Irlen certified diagnostician. As the Irlen Institute holds proprietary ownership of the Irlen protocols, there does not appear to be a large volume of independently published literature documenting clinical trials of the procedures (Kruk et al, 2008)

The mechanism of treatment success appears to be the premise that the application of colour decreases visual stress and increases visual comfort, thus supporting extended periods of reading and enabling decoding techniques and other reading strategies to be applied. It is important to realise that whilst reduction of visual stress appears to affect visual processing ease, it does not teach reading skills (Whiting, 1993).

3.0 The Visual System and Meares-Irlen Syndrome

Because of the sensitivity to contrast and glare common in those with Irlen Syndrome, initial aetiology was thought to be related to sensitivity to particular wavelengths and frequencies of the white light spectrum (Irlen, 2005; Kyd, Sutherland & McGettrick, 1992). Scotopic is the optometric term for a dark-adapted eye and hence the initial moniker, Scotopic Sensitivity Syndrome. However, this name quickly fell out of favour as the existence of such a condition as a scotopically sensitive eye has been questioned, with some pointing to the lack of direct scientific evidence to prove that eyes have excessive sensitivity to particular light frequencies (Woerz & Maples, 1997).

Whiting (1993) postulated that retinal rods may play some role in the development of Meares-Irlen Syndrome as they are thought to be scotopically sensitive. Lewine and colleagues (Lewine, Davis, Provencal, Edgar and Orrison) used magnetoencephalographic investigation to ascertain the effect of lens wearing in individuals with MIS. They noted altered visual information processing and suggested that Irlen lenses provided normalisation of visual information processing in individuals whose visual processing was otherwise compromised.

Other early theories suggested ocular motor difficulties such as vergence, accommodative and saccadic defects played a part in the manifestation of MIS. While these ocular motor dysfunctions may indeed be associated with MIS, as the body of literature has grown, it has become clear that any valid explanation of Meares-Irlen Syndrome also needs to explain why different people report benefit from different coloured lenses (Evans, 1997).

As the years have passed, this Syndrome is now conceptualised as being a visual perceptual disorder characterised by visual stress and visual perceptual distortions (Mitchell et al 2008). Research has therefore begun to focus on aetiological mechanisms that can explain these phenomena and fit with the treatment model.

There are two predominant theories in the literature that attempt to incorporate what is known about Meares-Irlen Syndrome into a theoretical model that integrates aetiology,

assessment and treatment. Both the Magnocellular theory and the Cortical Hyperexcitability theory are described below.

3.1 Magnocellular Theory

The magnocellular theory stems from an analysis of the visual system. The lateral geniculate nucleus (LGN) is the primary visual processing area for information received via the retina. The layers of the LGN are arranged in two major divisions. The upper division, which contains approximately 80% of the cells, is called the parvocellular or sustained system. This system is responsible for mediating colour vision and detecting fine spatial details and is responsible for more detailed visual perception (Nandakumar & Leat, 2008; Singleton & Trotter 2005). The lower division of the LGN, containing approximately 10% of cells, is the magnocellular or transient system, which is responsible for locating objects in the field of vision, executing actions and responding to movement and form (Mitchell et al, 2008). Recently, a third layer has been discovered, the koniocellular layer which is believed to be responsible for colour vision though even the existence of this layer is questioned by some researchers (Nandakumar & Leat, 2008).

These visual fields interact with each other, each system receiving separate information from the retina and transmitting this to the visual cortex. The output from the three systems is subsequently combined in the visual cortex to form one unified perception (Nandakumar & Leat, 2008). The transient or magnocellular system provides information as to where objects are in space, whilst the sustained or parvocellular system answers the more basic visual question of “What is this?” (Woerz & Maples, 1997) The sustained system is reported to receive information from the transient system to prevent image overlap or blurring and thus provide visual stability (Mitchell et al, 2008). Proponents of the theory of magnocellular deficit as a causal factor in Meares-Irlen Syndrome pinpoint magnocellular dysfunction as a possible reason for visual perceptual difficulties (Ludlow et al, 2006, Mitchell et al, 2008).

Reading as a task involves periods of eye fixation followed by periods of eye movement. In order to be a successful reader, sequential scanning of individual letters is required

during each fixation period. As the magnocellular system is responsible for directing focal attention, any abnormalities in this system will therefore compromise the ability to read (Singleton & Trotter, 2005, Vidyasagar, 2005; Whiteley & Smith, 2001).

3.1.1 The magnocellular system and dyslexia

Much has been made of links between magnocellular deficits and dyslexia. In fact, some suggest that magnocellular deficits occur in up to 70% of individuals with a diagnosis of dyslexia (Whiteley & Smith, 2001). This, they believe, adds credence to the notion of this visual system being implicated in MIS given the high reported prevalence of MIS in the dyslexia population.

Deficits in the magnocellular or transient system indicate problems with visual motor processing. This has been noted in dyslexia, where poor eye movement control can be a feature (Singleton & Henderson, 2005; Singleton & Trotter, 2005).

Theories that postulate a link between magnocellular system deficits and dyslexia rest on the already established link between magnocelluar deficit and binocular instability. Such instability is theorized to potentially cue visual distortions during reading activities (Whiteley & Smith, 2001). Genetic research has also posited a link, suggesting that defects on chromosome 6 which have been linked to dyslexia are also implicated in the development of the magnocellular system (Vidyasagar, 2005).

Though early functional magnetic resonance imaging studies showed support for the link between dyslexia and transient system deficits (Eden, VanMeter, Rumsey, Maisog, Woods & Zeffiro, 1996), recent research raises doubts about the causality of such defects and suggests that because not all individuals with dyslexia have such problems, magnocellular deficits may simply be a correlate of reading problems (Singleton & Henderson, 2005).

3.1.2 The effect of colour on the magnocellular system.

In magnocellular theory, the use of colour is thought to boost magnocellular activity and therefore remediate defects in this visual system (Ludlow et al, 2006). Research suggests that cells in the magnocellular system are suppressed in red light; therefore, it would

make sense to assume that the colour blue used as an overlay would be more effective in reducing the relative contribution of the other, parvocellular pathway, thereby restoring the balance between the two systems (Wilkins et al ,2001).

Yellow has also been implicated as a colour beneficial to those with magnocellular deficits. Ludlow and colleagues (2006) suggest that it is the blue pathway that needs to be inhibited. Yellow is able to do this by boosting red and green cone input to the magnocellular visual system. Both yellow and blue filters and overlays have been found to help children diagnosed with Meares-Irlen Syndrome overcome reading difficulties (Ludlow et al, 2006, Wilkins et al, 2001).

In a recent study, Smith and Wilkins (2007) compared a new range of coloured overlays called “Reading Rulers” with their Intuitive Coloured Overlay system. The Reading Rulers have a restricted colour range that includes blue and yellow overlays to align with the magnocellular theory. The study showed that yellow and blue overlays did not appear to be sufficiently able to benefit all children in the study with regard to reading speed. Other researchers have found that blue overlays have had no effect on rate of reading and red overlays did not compromise performance as would be expected according to magnocellular theory (Iovino, Fletcher, Breitmeyer & Foorman ,1998).

Whilst these explanations do provide support for the effectiveness of yellow and blue overlays or filters, they do not adequately explain the large individual difference in the choice of and effect of coloured overlays which are individually selected from an array of differing hues and intensities (Singleton & Henderson, 2005, Wilkins et al, 2001).

3.2. Cortical Hyperexcitability Theory

The cortical hyperexcitability theory arose from research with people who experience migraine and epilepsy which showed that certain visual patterns can provoke seizures and migraines in susceptible persons (Mitchell et al, 2008). Further research has confirmed that both migraineurs and epileptics experience a hyperexcitable cortex (Wilkins et al, 2004). Ludlow and colleagues (2006) point to research with this group that has shown

benefit in reducing cortical excitation and thus symptomology through the use of colour filters.

Arnold Wilkins and his colleagues have been investigating the link between cortical hyperexcitability, visual stress and reading difficulties since the early 1990's. They suspect that visual stress (a central feature of MIS) is caused by pattern glare attributable to a hyperexcitable visual cortex (Wilkins et al, 2004). Visual grating is caused by eye movement across lines of dark text on a white page in susceptible persons. The application of colour is thought to reduce the pattern of excitation and thus reduce distortions (Bouldoukian et al, 2002; Mitchell at al, 2008; Singleton & Trotter, 2005).

The act of reading can induce visual stress because of print characteristics. Lines and paragraphs of text can be conceptualised as striped patterns which in some individuals cause perceptual distortions because of the effect of this stimulus on the visual cortex (Wilkins et al, 2004). The characteristics of stimuli that cause visual stress are very specific and relate to visuo spatial frequencies (Simmers, Bex, Smith & Wilkins, 2001).

Cortical Hyperexcitability is now recognized as the predominant theory in Meares-Irlen Syndrome (Singleton & Henderson, 2005). It appears to offer the best explanation for the mechanisms of aetiology and treatment success, though given the infancy of this research, the magnocellular theory can not be ruled out altogether and some researchers consider there may be links between the two competing schools of thought (Simmers et al, 2001).

The major difference between the two theories in terms of the link with reading difficulties is that the cortical hyperexcitability theory hypothesizes that visual stress, the central hallmark of MIS, is independent of dyslexia, whereas magnocellular proponents consider that MIS and dyslexia are linked.

3.2.1 The effect of colour on cortical hyperexcitability.

Cortical excitability suggests that areas of activation or excitability in the brain will differ for individuals. This is thought to account for the wide range of colour variation self

selected for individuals with Meares-Irlen Syndrome. The high consistency and specificity of colour choice within individuals reinforces this (Ludlow et al, 2006).

Perceptual distortions can be alleviated by covering text with a coloured filter of chromaticity specific to the individual (Wilkins et al, 2004). Wilkins and his colleagues suggest that the idea of visual stress as a result of cortical hyperexcitability has widespread utility as a unifying construct which explains both links of MIS with neurological disorders (such as migraine, epilepsy, multiple sclerosis and autism) and the idiosyncratic selection of remedial colour.

Interestingly, later research suggests that children with MIS who benefit most from coloured filters or overlays are likely to have a family history of migraine, lending to further support to the links between the two conditions and a common aetiology (Singleton & Henderson, 2005).

3.3 Visual Processing Difficulties and Dyslexia

Dyslexia has been linked to defects in the magnocellular system and there is evidence of specific defects in visual processing in some populations. As MIS is also considered to impact on reading through visual processing difficulties, it is important to consider the relationship between dyslexia and visual processing defects.

Whilst the aetiology of dyslexia has variously been ascribed to visual or visual perceptual disorders, auditory difficulties, neurological difficulties, memory problems or educational failings (Whiting, 2000), most researchers and clinicians agree that there is a phonological component to a dyslexia presentation.

Historically, there have been two main camps in the field, those that consider dyslexia has a solely phonological component and those who consider dyslexia has both a phonological and visual component (Cornelissen, 2005). With dyslexia receiving renewed attention by educators and parents, research has in turn evolved and now a general consensus

suggests a move toward an integrative view of dyslexia (Cornelissen, 2005; Evans et al, 1999; Kruk et al, 2008).

Research suggests that the visual correlates of dyslexia include both visual and perceptual distortions (Whitely & Smith, 2001; Whiting, 1994) and are characterized by deficits in the way individuals recognize, comprehend and discriminate at the primary level of visual processing (Mitchell et al, 2008). These processing deficits are hypothesized to impact on both ability and fluency of decoding in the reading process because of difficulties with letter-sound processing which is mediated by the visual system (Croyle & Solman, 1996).Difficulties in decoding are a hallmark of dyslexia (Whiting, 2000).

In particular, research has shown that performance on visual tests can predict both reading accuracy and rate, both reading markers which may be a part of a dyslexia presentation (Cornelissen, 2005).This suggests a visual dimension to dyslexia. Further evidence for a visual component is argued by Wilkins (2001), who showed that correction of a visual perceptual difficulty increased reading rate even in “good” readers, suggesting that individual differences can be related to visual problems rather than linguistic issues.

Functional magnetic resonance imaging (fMRI) has been used to demonstrate deficits in visual motion processing in individuals with dyslexia compared to controls (Eden, VanMeter, Rumsey, Maisog, Woods & Zeffiro, 1996). This is suggestive of a deficit in the magnocellular system. This visual processing deficit is hypothesized to contribute to a suspected temporal deficit in dyslexia which is implicated in the development of visuo spatial function. The authors state that the results of the fMRI provide neurophysiological evidence for visual perceptual processing deficits in dyslexia that supports optometric studies showing deficits in motion sensitivity in this population (Stein, Talcott & Walsh, 2000).

Though it is acknowledged that predominant theories of dyslexia are based on a phonological processing deficit theory (Singleton & Trotter, 2005; Whiteley & Smith, 2001), most definitions of dyslexia conceptualise it as a reading and spelling difficulty, therefore, any condition that is known to impact on reading or spelling, such as visual

problems, will have a higher prevalence in any dyslexia population (Singleton & Henderson, 2005).

Evans and colleagues (1999), suggest that some individuals with learning difficulties such as dyslexia have no symptoms of visual perceptual distortion. Others have visual perceptual symptoms with examination revealing no optometric difficulties. Yet another subgroup have visual perceptual distortions and orthoptic problems. With this latter group some will continue reporting perceptual symptoms despite orthoptic correction. It is the groups of children who report visual perceptual distortion with no, or corrected optometric function that are thought to have MIS.

Although there appears to be a greater prevalence of children with dyslexia who have a co morbid diagnosis of Meares-Irlen Syndrome, Kriss and Evans (2000) suggest that Meares-Irlen Syndrome and dyslexia are in fact two distinct disorders. They note that treatment using coloured overlays may assist any visual perceptual distortions occurring in individuals but will not assist with the phonological problems that many children with dyslexia experience.

3.4 Optometric Screening and Meares-Irlen Syndrome

One of the criticisms of early research into MIS was the lack of prior optometric screening of candidates for MIS. Many researchers considered that the visual perceptual distortions noted in this condition could in fact be symptomatic of more broadly recognized optometric deficits. This criticism has been answered by many of the researchers presently in the field, who require initial optometric screening prior to assessment for MIS. This is also noted in clinical protocols of Irlen screeners and diagnosticians who require optometric examination in order to rule out ocular motor abnormalities.

Although many children screened for MIS have been routinely screened for visual problems as part of standard population based community health programmes, it is noted that such programmes are designed to test only the most obvious ocular abnormalities and their ability to detect more subtle visual problems is debatable (Hoyt, 1990).

Early researchers such as Blaskey and her colleagues (Blaskey et al, 1990) voiced concern at the commonalities shown in symptom presentation between MIS and ocular motor abnormalities such as refractive, accommodative, binocular vision and ocular motility disorders. Specifically, the following are noted in all of these conditions and are described as part of the symptom constellation for MIS:

- Double vision
- Headaches
- Eyestrain
- Excessive blinking
- Blur
- Movement of words on the page
- Losing one's place
- Skipping lines

When adding a comprehensive optometric assessment to the MIS screening protocol, thirty eight out of forty individuals who tested positively for Iren Filters® were found to have specific vision problems (Blaskey et al, 1990).

A similar result was noted in a study looking at the effectiveness of coloured overlays on a sample of students with learning difficulties, with findings indicating that one third of the participants were treated successfully with orthoptic exercises, after optometric examination revealed significant ocular motor difficulties (Bouldoukian et al, 2002). The authors note that vision therapy does not necessarily eliminate all symptoms and that overlays or filters may still be appropriate for some of these learners.

A large-scale investigation has been conducted of all attendees of a specific learning disorders clinic over a fifteen-month period (Evans et al, 1999). The sequential clinical protocol for attendees was: Symptom questionnaire for visual stress and distortions; orthoptic examination; prescription spectacles if necessary; vision therapy for ocular motor dysfunction; and then intuitive coloured overlays or filters if symptoms were still present. The authors report that 48% of the 323 attendees were treated with conventional

optometric intervention (glasses or orthoptic exercises). Of those who were thus treated, 40% were later issued with colored filters. They report that conventional practice suggests that orthoptic abnormalities should be treated first, with treatment using coloured filters only if visual perceptual symptoms persist. As they noted 60% of individuals treated with standard optometric intervention had resolution of symptoms, they consider their research to support this fact.

In New Zealand, preliminary studies at a selection of Rotorua schools found that 70% of the students with reading difficulties and 24% of the entire Year 9 population of a local high school had undiagnosed vision problems (Anstice & Cubie, 2001).

In reviewing the literature to date, the American Optometric Association Binocular Vision Working Group conclude that evidence exists to suggest that MIS symptoms are related to identifiable visual abnormalities and that these symptoms resolve when treated with appropriate vision therapy. They also critique the existing MIS literature, noting that many studies have not controlled for the presence of visual deficits. They suggest that too much emphasis is placed on visual screening tests that may be out of date. Optometric defects may also be missed by not including an adequate battery of tests to determine ocular motor dysfunctions - which they consider may be the specific visual difficulty causing symptoms in MIS (Williams, Kitchener, Press, Scheiman & Steele, 2004).

3.5 Environmental Correlates

It has been suggested that features of the physical environment may have an impact on reports of MIS. Fluorescent lighting in classrooms is a known predictor of visual stress which is one of the components of MIS (Wilkins, 2005). It is thought that the culprit in fluorescent lighting is the rate of flicker involved which is too fast to be detected but affects the control of eye movement thus creating headache.

Wilkins (2005) also suggests that type of print can impact on symptoms of visual stress. He notes that many junior reading books have text that is too small for the developing eye to manage comfortably. He proposes text remain large whilst children are taught reading

strategies and develop phonological awareness. This would mean that any visual difficulties caused by print are not implicated in the emergence of any reading disorders.

Given the knowledge of characteristics of text that provoke pattern related visual stress, this is an area that could be remediated through better design of printed materials in terms of text qualities and print layout (Allen et al, 2008).

4.0 The Evidence to Date

There have been two general approaches to the study of MIS. The first seeks to test out the theory by attempting to measure defects or differences in visual function in those diagnosed with MIS. This is based on the premise that if MIS detects those with different visual sensitivities, some difference in visual function should be measurable (Ciuffreda, Schieman, Ong, Rosenfield & Solan, 1997; Nandakumar & Leat, 2008). The second attempts to ascertain the validity of the theory by investigating treatment efficacy.

4.1 Visual Function Studies

Evans and colleagues (Evans, Busby, Jeanes & Wilkins, 1995; Scott, McWhinnie, Taylor, Stevenson, Irons, Lewis, Evans, Evans & Wilkins, 2002) investigated visual function in dyslexia and in MIS and found pattern glare likely to be involved in the development of MIS. Their studies showed certain ocular motor characteristics to be correlates of dyslexia – reduced vergence, accommodative amplitudes and stereo-acuity. When they tested the MIS group on these optometric function measures, though they did find some anomalies similar to those found within the dyslexia population, they concluded that binocular and/or accommodative abnormalities did not appear to be underlying mechanisms to explain the reported benefits of coloured lenses in MIS, but rather these were a separate and co-occurring factor contributing to reading difficulties.

In an earlier study, investigation occurred as to whether the application of Irlen Filters® had an impact on visual accommodative processes, as previous research had indicated a

high proportion of those with a MIS diagnosis had significant oculomotor abnormalities (Ciuffreda et al, 1997). This study did not find a positive effect on accommodation through wearing Irlen Filters®. However, the sample size was small and indicated a large response variation between participants. The researchers state that a larger sample may have uncovered a meaningful difference (Ciuffreda et al, 1997).

Many of the reported studies have multiple variables under investigation. The Wilkins, Evans, Brown, Busby, Wingfield, Jeanes & Bald study (1994), not only assessed treatment efficacy, but a later paper described the optometric and visual perceptual characteristics of the children involved in the original study (Evans, Wilkins, Brown, Busby, Wingfield, Jeanes & Bald, 1996). Only children where conventional optometric treatment was required were excluded from this study (a total of nine children) due to ethical constraints of not treating diagnosed visual defects. The researchers report information on 53 of the 68 children who participated.

The data confirm earlier observations that children with MIS have subtle binocular and accommodative dysfunctions. They also discovered sub normal stereo-acuity. The researchers note that this ocular motor dysfunction as described in the participant group is often treated through vision therapy. They are of the opinion however that those with MIS benefit from coloured filters even after ocular motor correction. They suggest that ocular motor dysfunction is in fact a correlate and not an underlying cause of MIS (Evans et al, 1996).

Using a range of psychophysical tasks designed to measure specific visual perception distortions, such as contrast sensitivity, motion perception and motion coherence, Simmers and colleagues (Simmers et al, 2001) did not find a significant difference between individuals with MIS and those without. They state that they also found no significant functional visual loss/gain within individuals when wearing filters and when without. The measures used have been found to discriminate between readers with specific reading disorders and control groups of “normal” readers, but not in this case, between individuals with MIS and controls.

The Simmers group report that if it is assumed that the use of tinted lenses reduces uncomfortable perceptual symptoms, that it should be possible through using psychophysical assessment of visual function to pinpoint the underlying visual mechanism at fault. They were unable to do this (Simmers et al, 2001).

Researchers have identified specific visual processing deficits in a proportion of children who have received a diagnosis of dyslexia. This group is referred to as the dyslexia visual processing subtype (Kruk et al, 2008). Watson and Willows (1995) identified this subtype through their poor performance on measures including visual memory, visual motor integration, pattern analysis and visual discrimination.

In a recent study, the relationship between MIS (measured through the Irlen Institute protocol) and the visual processing characteristics identified by Watson and Willows was examined (Kruk et al, 2008). These researchers considered that if a link was shown between MIS diagnosis and clearly identifiable visual processing deficits, this would support the utility of a MIS diagnosis as an indicator of visual processing deficits in dyslexia. Their results did not support this conclusion with children who were diagnosed with MIS not showing the visual processing deficits noted in the visual processing deficit subtype of dyslexia. This indicates the perceptual dysfunction identified in MIS is different to the perceptual dysfunction identified in dyslexia.

There was however, a correlation found between self report (as per the Irlen questionnaire) of fatigue and eyestrain, with encoding difficulties, as well as on measures of visual attention. The authors sum up by reporting that their research has shown a link between MIS and visual perceptual processes but no link between MIS and reading. The visual processing defects that have been noted with dyslexia and which are known to predict reading performance were not impaired in the sample with MIS. This demonstrates the independent nature of dyslexia (visual subtype) and MIS and suggests that they co-exist as independent conditions (Kruk et al, 2008).

Hence, research investigating links between ocular motor dysfunction and MIS are inconclusive, particular in regards to this visual defect being causative of MIS. The

literature also suggests that studies describing visual perceptual disorders common to children with reading difficulties do not support the link between these measures of visual function and MIS.

4.2 Treatment Efficacy Studies

Whilst there have been numerous studies reported in the literature, there are only three randomized controlled trials documented. These are reported below. Much of the other research looks at the effectiveness of filters and overlays on reading rate through various methodologies. This review has organized these studies into the following areas:

- Effects of overlays on reading
- Overlays and dyslexia
- Effects of overlay on symptoms of visual stress
- Effects on reading processes
- Specificity of colour

A separate section has been included with results of the only New Zealand study that has been published.

4.2.1 Randomised controlled trials

Evidence based methodology has become an accepted and expected component of both practice and research in clinical sciences. Randomised controlled trials (RCT's) are considered to be the pinnacle of experimental research. An RCT involves comparison between at least two groups, at least one of which is engaged in treatment and uses a comparative control or placebo group who do not receive the targeted intervention. Early criticism of MIS research centered on the fact that there was no evidence of RCT's being used to determine treatment efficacy (Evans, 1997). This has been noted by researchers in the field who have responded by publishing research founded on RCT's.

Double blind conditions have greater rigour than when the individuals, the research team or those who measure the dependent variables have knowledge of the treatment group of participants. This has proved problematic to some extent in investigations of MIS, as the

presence or absence of filters or overlays is indicative of group membership. Some researchers have attempted to use “blind” testers and have engaged use of placebo filters and overlays to attempt to resolve this.

Results from the published RCT’s are presented below:

Wilkins, Evans, Brown, Busby, Wingfield, Jeanes & Bald 1994

This RCT was a double masked placebo control trial. The sample consisted of 68 children aged between 11 and 12 years of age from two state comprehensive schools, one secondary school, and a private school and from the Dyslexia Institute. Participants were recruited by their teachers and examined individually to assess prevalence of visual stress symptoms and subjective benefit from coloured overlays. Only those students who voluntarily used overlays for a period of at least three weeks were considered for entry to the study.

All students received comprehensive optometric assessment and were examined using the Intuitive Colorimeter® to ascertain optimal filter colour. When the optimal tint was found, a corresponding tint was also chosen that had similar saturation as the optimal tint but was noted to cause distortion by the participant. Use of the Intuitive Colorimeter® ensures a masked condition as children are unable to determine the colour of the filter during assessment. The students were given two sets of glasses, one with the optimal tint as lenses and the other the control tint. They were asked to wear each set of lenses consecutively for a period of one month before changing to the other lens. During the trial, all children were asked to keep a journal of visual discomfort.

Prior to the trial, all children were assessed with the Neale Analysis of Reading which provides information about reading rate, comprehension and accuracy. This test was repeated after each of the experimental and control conditions.

Results from this study indicated that 22 children reported preferring the experimental lenses, whilst 26 children reported preferring the control. When the visual diaries were examined however, it was discovered that there was a significant difference in symptom

reporting and that fewer headaches and reports of eyestrain were recorded in the student's journals when they were wearing the experimental lenses. The authors consider this supports evidence of clinical benefit.

Examination of scores on the Neale Analysis of Reading showed no statistical or clinical significance between the two conditions. The researchers did note however that there was a significant difference in reading accuracy from the pre test (when no glasses were worn) to the post test in both conditions.

Wilkins et al (1994) note that conclusions are difficult to reach given the attrition rate in the experiment and the subsequent small sample size. Between group differences are therefore difficult to prove.

This study is referred to frequently in the literature as providing evidence for the benefits of coloured overlays and filters.

Robinson and Foreman 1999(b)

This study aimed to investigate placebo effects by using control lenses of similar chromaticity as per the Wilkins et al study (1994) and to assess reading achievement and perceptions of ability over a longer period to ascertain longitudinal outcomes.

Individuals were 113 students ranging in age from 9 to 13 years at the commencement of the study, who were referred to the Special Education Centre at the University of Newcastle, for assistance with reading difficulties. All individuals had responded in a moderate to high manner in the Irlen Screening questionnaire. For the control group, 35 students from local schools who were identified by school personnel as having reading difficulties but who did not appear to have symptoms of MIS when screened were selected. All individuals had been screened for optometric difficulties within a year of the programme commencement. Students in both the treatment and control groups were considered by their teachers to be of "normal" intelligence though this was not formally assessed.

For this study, the Irlen Institute protocols were followed for assessment of MIS and diagnosis of optimal overlay. After this process, students received a further assessment through implementation of the Irlen Diagnostic protocols to ascertain appropriate filter chromaticity.

At the time of screening both experimental and control groups were assessed on the Neale Analysis of Reading and the Students' Perception of Ability Scale. These measures were repeated three to four months later and again after a further eleven to twelve month interval. All tests were administered by staff blind to the condition (optimal or placebo) of the experimental group.

Children in the experimental group were randomly assigned to one of three treatment groups: placebo tint, blue tint or optimal tint. Use of a blue tint was made because of the premise that deficits in the magnocellular system can be reduced by the use of blue filters alone. Placebo tint was ascertained in the same manner as in the Wilkins et al (1994) study. Students were told that each filter was expected to improve their reading. In both the placebo group and the blue tint group, the tints were changed to the optimal colour after 3 – 4 months of use as Robinson and Foreman noted that the major focus of their study was the long term effects of optimal colours .

Results indicated that at the time of crossover to optimal tint, out of the placebo and blue tint groups, only the placebo group showed a significant increase in reading age. For reading accuracy, it was noted that all groups improved at a significant rate over the period of the study though the treatment groups improved more than the control. The same pattern of greater increase for treatment groups was found in the measure of reading comprehension. High claims of subjective benefit were noted in all treatment groups, suggesting an effective placebo effect.

Analysis of change on the Students' Perception of Ability Scale showed that participants in both the blue tint and the optimal tint groups showed changes of significance. This was not observed in the placebo or control groups.

The longitudinal measures in this study suggested that 74 of the 88 remaining participants were still wearing their filters regularly at 18months post study commencement. The authors consider that this high compliance rate may indicate a high degree of benefit and utility of the lenses.

Although Robinson and Foreman have significantly added to the literature and point to their results confirming the long term benefit of coloured filters, it is unfortunate that both the placebo and blue tint groups were changed to optimal coloured filters in the beginning stages of the study. Early results seem to indicate that the placebo group were benefiting from their lenses at the time of crossover, but as this was not continued there is no way of knowing whether this effect would have been sustained. Robinson and Foreman note in their paper that it was not considered ethical to withhold treatment for up to 18months from individuals with reported symptoms and therefore they did not use a control group of children also experiencing symptoms of MIS. It would also appear that this was the rationale behind changing the treatment groups so early in the experiment. Whilst it appears that this was done as it was considered to be in the best interests of the children involved, this could imply bias as it suggests an apriori condition that the filters are beneficial before this has been tested in an empirical manner. It also raises questions about appropriate matching of the control group.

Mitchell, Mansfield & Rautenbach 2008

The aim of the Mitchell and colleagues study was threefold: firstly, to ascertain whether coloured lenses lead to a reduction in visual distortions of print and of visual stress and if so, if this impacted on reading ability; secondly, to investigate whether the use of specifically coloured lenses would decrease the symptoms noted in MIS such as visual overlap and blurred vision; and thirdly, to ascertain whether those children concurrently diagnosed with a visuoperceptual reading difficulty show greater improvement than those who do not.

As with the two previous studies, this was a double blind placebo controlled experiment. The independent variable was the filter condition which included: no filter control group;

placebo filter of complementary colour; and optimal tint group. The procedure used to determine filter specificity was the Intuitive Colorimeter®.

Participants were children from a remedial unit at a local primary school who were assessed as having visuoperceptual reading difficulties. Prior to commencement of the study, all children underwent comprehensive optometric examination. Of 58 children initially identified for the study, 9 failed the optometric examination and were consequently not eligible for the study. The remaining 49 children were aged between seven and eleven years old.

All individuals were assessed at pre and post stages using the Irlen Differential Perceptual Schedule Questionnaire® (IDPSQ), the Neale Analysis of Reading Ability and the Symbol Digit Modalities Test, a screening measure for cerebral dysfunction.

Each group were required to wear their filters (if in the experimental or placebo group) for a consecutive period of a month during school time and for homework activities.

Analysis of results appeared to show randomisation difficulties in the sample though the researchers were unable to identify problems with the randomisation protocol. The results that were interpreted indicated that both the optimal filter and the placebo group noted a decrease in symptoms as measured by the IDPSQ®. They also found that lenses had no effect on the Symbol Digit Modalities Test which would indicate that the lenses did not assist in the decoding of visual stimuli.

Contrary to the Robinson and Foreman (1999b) study, but similar to the Wilkins et al (1994) study, this study found no significant improvements in reading accuracy, comprehension or rate. In fact all three groups showed a similar level of change. However, the researchers note that there were some substantial within subject changes, with some participants improving their reading age markedly.

Mitchell and colleagues (2008) note the inconsistencies common to MIS research and state that they consider the evidence is still at this stage inconclusive. They note that individual

differences suggest that some children may well benefit greatly from filters but the challenge is to identify the characteristics of this group.

4.2.2 Other studies

Effects of overlay on reading

Much of the published literature includes studies where the reading ability of participants is measured first, when using optimal overlays or filters and secondly, when using a placebo tint. Bouldoukian and colleagues (2002) compared rate of reading using the WRRT on a sample of 33 individuals of varying ages when using an individually chosen overlay and with a special placebo overlay marked “Research Model”. The participants were all attendees at the Institute of Optometry who had suspected learning difficulties and persisted with visual perceptual symptoms despite optometric assessment and conventional treatment. They found that the average increase in rate of reading using optimal overlay compared to placebo was 4%.

In an early study, Robinson & Conway (1994) tested the effect of filters in a sample of 60 children referred to the Special Education Centre at Newcastle University for assistance with learning difficulties. Individuals were assessed using the IDPS® to ascertain the presence of MIS and subsequently placed into a lens using group (if positive for MIS) or a control group. The Neale Analysis of Reading Ability was used as a pre and post test measure of reading performance. A significant increase in both reading rate and in reading comprehension was detected in the experimental group. Again this does not enable adequate comparison as there is no matched control. Similar results were found in a sample of 14 children using filters and assessed with the Neale (Kyd et al, 1992). However, although this study found an increase in reading rate, they also noted a decrease in accuracy and comprehension.

A comparative study of 48 children with symptoms of visual stress revealed that the Intuitive Overlay® system increased reading rate as measured by the WRRT whereas the Reading Rulers did not (Smith & Wilkins 2007).

Wilkins and colleagues (2001) report three population based studies where children from local schools have been tested on measures of visual stress and assessed for optimal colour with the Intuitive Overlay® system. They report that around 50% of mainstream school children report benefit from using coloured overlays. Those that continued to use their overlay showed a greater increase in reading rate than those intermittent users. Use of a chosen overlay was reported as significantly increasing the mean rate of reading on the WRRT for all who used them.

In a sample of unselected university students, Evans & Joseph (2001) found that 100 of 113 individuals reported that use of a selected overlay improved text qualities and removed complaints of visual stress. These 100 individuals were reported to read on average 3.8% faster using the WRRT as a measure and 38% of this sample improved their reading rate by at least 5%

Iovino and colleagues (1998) conducted a study with the aim of examining the effects of coloured overlays on reading ability of different groups of learning disabled children. The groups were described as: reading – spelling – arithmetic disabled; reading – spelling disabled; arithmetic disabled; and attention deficit/hyperactivity disorder with no learning disabilities. Unlike the rest of the reported literature, Iovino et al (1998) did not use either the IDPS® or Intuitive Overlay® system of assessment. Instead, they chose red and blue overlays from the 3M company's coloured overhead transparencies, with the independent variable being red, blue or no overlay. They report that overlays did not differentially affect reading rate, or comprehension of those with reading difficulties. However, they did find that use of the blue transparency increased reading comprehension across all groups. Although they consider this may lend some weight to the magnocellular deficit theory of MIS, they also report that no deterioration in ability was noted when red overlays were used as would be expected were this to be the case. The researchers also note that whilst use of blue overlays increased reading comprehension across all groups, reading rate decreased with the use of blue overlays perhaps pointing to an effect on attention, causing slower more careful reading and thus better comprehension.

An early study did not show as much success as those conducted more recently. In a sample of 11 individuals of varying ages referred to a reading clinic and placed in a Irlen Filter® condition, there was no significant improvement in comprehension, accuracy or reading rate using a battery of reading tests at pre and post experimentation (Blaskey et al, 1990). The authors note that there was some change within individuals and that those who were most likely to benefit from Irlen Filters® were those readers who had adequate decoding skills at pre test.

Overlays and dyslexia

Singleton and Henderson (2007) assessed the effect of overlays with two groups of children with dyslexia, one with previously assessed high PRVS and the other without; and two control groups of children with high and low PRVS, and compared rate of reading with the WRRT. They found a significant increase in reading rate using overlays in both dyslexia groups compared to the control group. Those children with dyslexia and concurrent high PRVS (a symptom of MIS) showed the greatest increase in reading rate. A second part of the study ascertained that high PRVS was twice as common in the dyslexia group than the controls. This mirrored the results of an earlier study conducted with an adult population (Singleton & Trotter, 2005).

Effects of overlay on symptoms of visual stress

In an early study, participants in a filter treatment group reported a significant reduction in symptoms of MIS when using optimal filters compared to when using a placebo tint (Blaskey et al, 1990). However, participants who were treated with vision therapy also reported a reduction in symptoms and no longer met diagnostic criteria for MIS. Both groups at entry to treatment met criteria for ocular motor difficulties and for MIS. The group with MIS although reporting a reduction in symptoms of visual stress continued to have visual deficits, whereas the group treated with vision therapy no longer had symptoms of MIS or visual deficits.

A more recent comparative trial designed to assess the relative effects of both the Intuitive Overlays® and the Reading Rulers was conducted with 48 children aged 7 to 8 years old who described symptoms of visual stress (Smith & Wilkins, 2007). Both overlays

reportedly reduced the numbers of symptoms of visual stress reported though there was no significant difference between the two types of overlays.

Although much of the focus of the literature on the effectiveness of MIS is with individuals with reading difficulties, researchers have noted the presence of MIS in so called “normal” readers. In order to further investigate aetiology of MIS, the effect of coloured overlays on reading performance for “normal” readers has been assessed (Allen et al, 2008).

Because visual stress has been acknowledged as a central feature of MIS, Allen and his colleagues (2008) attempted to discover if the use of coloured overlays assisted visual search performance in two groups of “normal” readers, one of which was assessed as having high ratings of pattern related visual stress and the other, low pattern related visual stress.

The authors found that when overlays were used, individuals with high PRVS had a significantly greater increase in reading rate (using the WRRT) than those in the low PRVS group. This confirms other research which suggests that an improvement in rate of reading through the use of overlays should serve as a proxy diagnosis of visual stress. However, although use of overlays predicted an increase in rate of reading in individuals with high PRVS, this study also found that use of overlays did not improve performance on a visual search task, suggesting that use of colour alone is not the sole answer to PRVS (Allen et al, 2008).

Effects on reading processes

In the RCT reported by Robinson and Foreman (1999b) there was a concurrent study operating that investigated the effect of filters on reading strategies (Robinson & Foreman, 1999a). Through the use of audiotaped recordings of participant’s performance on the Neale Analysis of Reading Ability, the researchers were able to analyse reading miscues. All groups were found to improve significantly and there was not a significantly greater improvement for those participants in the optimal filters group, suggesting that use of filters may not affect reading strategies. The authors suggest that while improved print clarity can improve reading and therefore make reading skills easier to acquire, basic word

attack skills and reading strategies need to be included in any intervention to improve the overall reading ability of students with reading problems.

Specificity of Colour

Whilst colour choice for optimal filters is subjective, researchers believe that it is also in fact very specific. When individuals who normally wear filters are tested with different colours, reading speed was fastest for the preferred colour on multiple testing sessions. This specificity and consistency is thought to support the benefit of coloured filters on reading (Wilkins, Sihra & Myers, 2005).

It has been argued that demonstration of adequate test retest reliability in terms of choice of optimal colour would argue for the specificity and sensitivity of individuals to specific tints (Woerz & Maples, 1997). An experiment was therefore conducted to ascertain the test- retest reliability of choice of filter. However, this was not done using tints recommended by either the Iren protocol or the Intuitive Overlay® system because of copyright issues. The researchers used a questionnaire designed to ascertain symptoms of visual disabilities and then tested participants reporting symptoms with 24 overlays representing major colour groupings with three saturation levels. Results showed that only 36% of participants chose the identical tint at re-test. The researchers' state that for a test to be deemed reliable, test - re-test must agree at least 80% of the time.

This is in contrast to research published by the Wilkins group (Wilkins et al, 2001) who whilst reporting that 47% of children chose the same coloured overlay in a test-retest protocol, they report that a further 21% chose an overlay of similar chromaticity. They state that the expected "chance" percentage would be 8.7% and hence use this as evidence for the specificity of coloured overlays.

4.2.3 New Zealand Research

Although MIS is in part named after a New Zealander who is jointly credited with the discovery of the condition, there is only one published study investigating MIS in a New Zealand population and it is brief in nature as the report was published prior to the end of the data collection and analysis.

Anstice & Cubie (2001) undertook population based screening in a cluster of primary schools and a secondary school. Their study included comprehensive optometric assessment and screening for MIS. During the course of the study all Year 2, Year 4 Year 7 and Year 9 students were assessed, though those in Year 2 were only assessed for optometric deficits as assessment for MIS is not usually undertaken until at least 7years of age. Students were assigned to groups according to the assessment findings. These groups were: students with optometric difficulties; students with MIS; and a no visual problems control group. Pre and post assessment of reading ability was conducted using the Neale Analysis of Reading Ability. Although the study is only reported in a preliminary way, the authors report that initial findings are promising and indicate that both optometric correction and MIS intervention have had a positive effect on reading ability (Anstice & Cubie, 2001).

5.0 Controversy and Critique

The use of colour as a treatment for visual difficulties is a relatively recent development and is not without controversy. In the United States, medical and optometric opinion states that treatment with coloured filters has merely placebo benefits (Wilkins et al, 2004). Because of the subjective nature of assessment and treatment (change in symptoms) it is difficult to accurately and reliably measure change, though the same issues are found in other areas of health research such as mental health (Kriss & Evans, 2005).

The American Optometric Association (2004) goes so far as to suggest that the symptoms associated with MIS are in fact related to identifiable visual anomalies such as ocular motor dysfunctions which return to normal when treated with standard vision therapy.

Much of the research on MIS is based in the United Kingdom and there is a core group of researchers who appear to work together on different studies. This group is based around Arnold Wilkins from the Visual Perceptual Unit at the University of Essex.

Whilst Professor Wilkins is the acknowledged inventor of both the Intuitive Coloured Overlay® system and the Intuitive Colorimeter® he notes that the rights are owned by the Medical Research Council, though he receives an "Award to Inventors" (Evans et al, 1999). Though this is not uncommon in medical research, it does raise questions of impartiality. Similar concerns have been raised about the protectionism of the Irlen Institute protocols, with researchers required to be certified Irlen screeners and diagnosticians before they are able to access protocols for investigation (Kruk et al, 2008).

The recent research argues for clearer definitions in the literature, both of visual perceptual reading disabilities and of aetiological mechanisms to explain MIS (Kruk et al, 2008; Mitchell et al, 2008; Nandamkumar & Leat, 2008). The lack of clear definitions makes both operationalising of variables and selection of individuals difficult. Use of large sample sizes to increase statistical power and effective use of placebo and matched control groups are also argued for, as is the use of comprehensive optometric screening and treatment as a necessary initial step in the protocol (Allen et al, 2008; Mitchell et al, 2008).

A general critique of the literature reviewed is that most studies fail to adequately define the population of children with reading disabilities. This makes for an incredibly heterogeneous sample and increases the probability of findings not being relevant to particular groups of children with reading difficulties. It also impacts on the ability of other researchers to replicate findings. This is a disadvantage as empirical validity requires replication.

Another issue with the literature is the publication of studies where an apriori hypothesis exists that filters are in fact beneficial and hence no control group is used from the study population, instead, children without reading difficulties, or even without MIS are used as a control, thus confounding the results.

The large unselected group studies also cloud the waters, as in these studies reading difficulties are not used as a pre-requisite for group membership. Thus it appears that there are two streams of literature, one where the effectiveness of filters and overlays is

assessed with a reading disabled group and the other where the effect of filters is gauged on the response of the general population. This perhaps mirrors the focus on either increasing comfortability of reading (by alleviating PRVS) or improving reading ability. In effect, focusing on either visual remediation or educational remediation.

Using a test to determine change in rate of reading is an interesting concept as the test becomes both the diagnostic instrument (as per criteria of a 5% increase in reading rate to diagnose MIS) and a measure of treatment effectiveness. Whilst many studies can point to a significant change in reading rate in their samples, the clinical significance of a 5% change in reading rate should also be critically examined. If a reader has a current rate of 100 words a minute, a 5% change adds 5 words to that total. Is this significant for the individual? There is also a related question of "does an increase in reading rate assist those with reading difficulties"? And if so, through what mechanism? To my knowledge there is no "cut off" for diagnosis of a slow reading rate. Is there a recognized rate below which readers' are considered to have difficulties?

Analysis of the published RCT's present inconclusive results. Whilst the original Wilkins et al (1994) study shows an effect of filters on self reported symptoms of visual stress, no effect on reading was discovered in this population, half of whom were noted as having reading difficulties. In contrast, the Robinson & Foreman (1999) study did not look at reported symptoms of visual stress but did find an increase in both reading accuracy and comprehension in the experimental groups compared to the no filter control group. Both groups were noted as having reading difficulties Remember that the no filter control group did not have MIS and therefore is likely to be a different population to the experimental group making comparison invalid. Unfortunately, this study whilst having two initial placebo control groups gave these groups optimal filters after three months thus counteracting the effect. At the time of changeover, one of these groups did reportedly show a significant change in reading age. The most recent RCT by Mitchell and colleagues (2008) again showed the experimental group reported fewer symptoms of visual stress but no significant differences in reading accuracy, comprehension, or rate.

None of the RCT's have shown increase in reading rate compared to controls, whilst most of the other literature does show an increase in reading rate though this is within group as there are no comparative controls. Again, an increase in reading rate may benefit "normal" readers as it could increase reading efficiency, but is an increase in reading speed of utility to those with reading difficulties?

Remembering that the agreed on diagnostic criteria for MIS are:

1. The sustained use of a coloured overlay or filters; or
2. An improvement in the rate of reading by more than 5% when using coloured overlay or filters;

it is therefore doubtful whether this criteria is met by the RCT's presented above. In all of these studies, reading rate has not improved when groups are compared. It is not reported on whether all groups have within group differences in reading rate i.e. each group did have an increase in reading rate, therefore cancelling the effect out when compared. If this is the case, it would suggest that increase in reading rate is a natural artefact of time and/or any intervention; in other words, an illustration of the Hawthorne effect. In both the Mitchell et al (2008) and Wilkins et al (1994) study, there is also no evidence presented about the sustained use of overlays. Whilst the Robinson and Foreman (1999b) study is longitudinal in nature and therefore does provide information about the sustained use of overlays, they also report significant treatment drop outs. There are also questions about the significance of sustained use of overlays as a diagnostic and treatment effectiveness indicator. Perhaps this is merely personal preference and does not give information about treatment success.

Relying on self report for both assessment and treatment efficacy presents additional problems, particularly when working with child populations. Whilst MIS advocates report that children may have normalized symptoms and therefore under report and that children may "fake good" to gain approval from researchers, thus leading to under diagnosis, there is an alternate argument. It could be argued that children, because of their development are more likely to report symptoms when prompted than adults. Children may look for approval from adults but it would be equally, perhaps more, likely that they would answer affirmatively to symptoms if presented with a questionnaire delivered by an adult as they

may implicitly think this is the “correct” way to answer. It may be that there is a Hawthorne effect in the treatment response noted too, in that any intervention may provide support for the alternate hypothesis.

In summary, there are many issues raised by the literature which give rise to questions. Namely, issues surrounding:

- Definitional and conceptual problems;
- Methodological flaws;
- Possible conflicts of interests; and
- Difficulties in measuring or establishing effectiveness.

6.0 Conclusion & Recommendations

The literature appears to be inconclusive as to the effectiveness of coloured filters or overlays in the management of children with reading difficulties. From the evidence presented, it does appear that the use of overlays or filters can increase the comfort of reading for those who experience visual stress, some of whom may have reading difficulties. However, there is not a sufficient body of evidence as yet to state that coloured filters or overlays improve the reading ability of those with reading difficulties.

From examination of the literature, it appears that there are three critical points to consider when making conclusions about the effectiveness of coloured overlays or filters in the treatment of children with reading difficulties. These are:

- Visual function in MIS;
- The relationship between MIS and Reading Difficulties; and
- The effectiveness of intervention in MIS.

These points are expanded below:

<u>Visual Function in MIS</u>

Debate continues as to the aetiological mechanism behind the visual perceptual distortions and visual stress symptoms found in MIS. It would appear that those in the field are unable to agree on the basic pathogenesis of the syndrome. Confounding this debate is

the fact that many studies have not been able to show visual function differences between individuals with MIS and controls. It is argued that if in fact MIS is a visuo-perceptual disorder, objective tests should be able to measure an abnormality in visual function.

Some studies have shown either optometric or ocular motor difficulties in individuals with MIS and have gone on to treat this with optometric lenses or vision therapy, with the subsequent resolution of MIS. Other studies suggest that some individuals who are treated for visual problems either optometrically or through vision therapy will continue to report MIS symptomology. Because there is no “severity” indicator or “functional” description, it is difficult to know just what impact this remaining visual perceptual problem has on individuals.

Yet other studies have looked at typical visual problems seen in poor readers and have not found any relationship between these symptoms and MIS. Either visual function is not compromised in MIS, despite symptoms, or the symptoms are indicative of some other problem.

Diagnosis of MIS appears to be more of an exclusionary process than a standard part of visual examination. It seems that after all other diagnoses are excluded, MIS is considered for symptoms where there is no other explanation. This does not suggest a robust conceptualisation of the syndrome.

There remain many conceptual difficulties with the classification and aetiology of MIS. It would seem that if a medical model is used to explain a condition then the same model must be used to prove it. Such a model would need to demonstrate unequivocal understanding of the underlying pathology and mechanisms for change. This must be empirically defined and tested in order for widespread acceptance of the condition. At this point in time it appears that a well respected body of visual professionals is unable to support the presence of MIS without further investigation because of these issues.

The Relationship Between MIS and Reading Difficulties

The brief for this literature review was to examine the effectiveness of overlays in the management of reading difficulties. It is clear from reviewing the literature that reading difficulties are not a pre-requisite or condition of diagnosis of MIS. The diagnosis has two parts, the sustained use of overlays or an increase in reading rate. This does not indicate that MIS is in fact a reading disorder.

Research shows that although many individuals diagnosed with MIS have reading problems, many do not. However, I could find no systematic attempt to explain this profound difference. Are there different things happening here? Why do some individuals with MIS have difficulty reading whilst others do not? Again, this is a problem with the literature in terms of adequately defining the population.

The diagnostic criteria for specific reading disorder and dyslexia state that diagnosis is contingent on reading performance being below what would be expected given educational opportunity and cognitive ability. Hence, you can have MIS without having a specific reading disorder or dyslexia but if you have MIS and have reading difficulty you will probably meet criteria for specific reading disorder or dyslexia and will receive appropriate intervention and remediation.

It remains unclear just what effect the perceptual distortions and symptoms of visual stress reported in MIS have on reading ability. Treatment response is predicated on an increase in reading rate without having a cut- off figure indicating what an appropriate reading rate is, nor by examination of the clinical utility of a 5% increase in reading rate.

It is clear that vision has a role in reading. However, what part MIS plays in this is unclear. The literature does seem to suggest that there are many children with reading difficulties who have concurrent visual problems that could be addressed through a more comprehensive vision screening programme that assesses the presence of ocular motor dysfunction as well as visual acuity.

The Effectiveness of Intervention in MIS

In general, for a treatment to be considered "well established", it is required to be evidenced by at least two RCT's using large samples and a between group design. Studies should compare treatment to either a placebo condition or an alternative validated treatment and show a significant change in favour of the experimental group. It also requires manualised treatment protocols and for the RCT's to be conducted by independent research groups (Chambless, Baker, Baucom, Beutler, Calhoun, Crits-Cristoph, Daiutoa, DeRubeis, Detweiler, Haaga, Bennett-Johnson, McCurry, Muesser, Pope, Sanderson, Shoham, Stickler, Williams & Woody, 1998). This standard for an Empirically Supported Treatment (EST) does not appear to have been met as yet for MIS.

Notwithstanding the above issues which make effectiveness difficult to determine, there are also significant problems in the literature. The lack of RCT's is a concern and the fact remains that of the three RCT's conducted, two show effect on "comfortability" by reducing self reported symptoms of visual stress but have no effect on reading. The other study is difficult to interpret because of the lack of a matched control and the abrupt change in experimental conditions which confounds the result.

There are no studies which have been replicated and a limited amount of independent research is available. Hence results from the literature are difficult to interpret. Some very significant differences are reported within individuals in the published literature, which may suggest that the use of filters and overlays are effective in specific populations. However, the research has not yet identified specific characteristics of those who are likely to gain the most benefit.

Though the use of coloured overlays and filters are not an Empirically Supported Treatment, there are obviously many individuals who feel that they or their children have received benefit from filters or overlays as demonstrated by the large numbers of individuals throughout the world who continue to use them. There is some validity to the assertion that even if this intervention merely shows a placebo effect, by imparting a cause to children of their reading difficulties that is not related to their intelligence or ability this may have an incidental benefit of improving learning esteem and motivation

and therefore learning behaviours. Whilst this literature review finds the evidence for the effectiveness of coloured filters or overlays in the management of children with reading difficulties equivocal, it must be remembered that “just because you can’t see it, doesn’t mean that it is not there”

Given these issues, the following recommendations are made:

1. There is insufficient evidence of effectiveness to support an MIS screening programme in New Zealand at this time.
2. Should individuals choose to pursue assessment and treatment of MIS there is no evidence that this should be a matter of public health concern as there is no evidence that the assessment or treatment processes cause harm.
3. Whilst the status quo should remain, the literature in the field is continually developing and the position should be reviewed as more information and evidence becomes available.

The purpose of this literature review was to assess the strength of the evidence for the effectiveness of coloured glasses or overlays in the management of children with reading difficulties. At this point, there is insufficient evidence to recommend this approach.

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Appendix 1

Search Strategy

The materials used in the collation of this review were obtained from a number of sources and were accessed with the assistance of specialist librarians from the Ministry of Health. Initial agreement on search terms and sources was negotiated with stakeholders involved in the "Clearer Vision" study. Sources used included:

1. Searches of computerised databases including:

Eric

PsycInfo

Medline

Search terms included:

Coloured glasses

Coloured filters

Coloured overlays

Irlen Syndrome

Meares-Irlen Syndrome

Scotopic sensitivity Syndrome

Reading

Learning

Difficulties

Disability

Deficit

Disorder

Magnocellular pathway

Visual processing

2. Web based searches including:

www.irlen.com

www.minedu.govt.nz
www.dyslexiafoundation.org.nz
www.4Dschools.org.nz
www.educationcounts.govt.nz
www.aaic.org.nz

3. The personal collection of books, journal articles, conference abstracts and related materials supplied by David Wardell, Director, Irlen Diagnostic Ltd.

4. Searches of reference lists of publications described in (1) and (2) above.

5.Given the scope of the project, it was agreed that literature would be limited to that which was published from 2000 onward apart from agreed seminal work in the field and specific references provided by the stakeholders. A further limit was set by agreeing to omit literature which investigated the effect of coloured filters on migraine and epilepsy.

The review attempted to uncover any New Zealand based information or research. Unfortunately, apart from the early work by Olive Meares, the only literature able to be accessed was a paper published by the Clearer Vision study.