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The Interpretation of Emotion from Facial Expression for Children with Visual Processing Problems

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A significant proportion of people with learning difficulties have social problems, which are often considered to be the product of school failure. However, a number of studies have suggested that these social skill problems may relate to the inability to decode subtle visual cues of body language and facial expression. The majority of studies of facial expression, however, have viewed learning disability as a unitary condition, without taking account of specific sub-types which may have more difficulty in processing visual cues, especially for facial emotion. This study investigated children aged 8 to 12 years who were divided into three learning disability sub-groups: 1) a visual-perceptual sub-type called Irlen Syndrome (n=41); 2) a group with learning disabilities, but no indications of Irlen Syndrome (n=30); and 3) a normally achieving control group (n=31). The Irlen Syndrome sub-group had significantly lower scores for interpreting emotion from facial expression than the two other groups. The learning disabled non-Irlen sub-group also had significantly lower scores than the control group, but with much smaller levels of significance than those between the Irlen and control groups.

It has been recognised that a significant proportion of individuals with learning disabilities/ Dyslexia have social problems (Baum, Duffelmeyer, & Geelan, 1988; Bryan, 1998; Kuhne & Wiener, 2000; Rock, Fessler, & Church, 1997; Sabornie, 1994). These social difficulties are often considered to be influenced by school failure (Bruck, 1986; Maughan, Pickles, Hagell, Rutter & Yule, 1996; Wilchesky & Reynolds, 1986). There is also the possibility, however, that the negative social behaviours identified in people with learning disabilities might relate to the neglect of subtle social cues (Toro, Weissberg, Guare, & Liebenstein, 1990), the inability to effectively decode such cues (Crick & Dodge, 1994; Perlmutter, 1986), or deficits in making social inferences (Bruno, 1991).

Facial expression has been identified as critical to the development of social responsiveness (Semrud-Clikeman & Hynd, 1991), and children having difficulties in processing visual-spatial stimuli may have problems in identifying

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minor differences in facial expression (Holder & Kirkpatrick, 1991). Spafford and Grosser (1993) hypothesised that visual anomalies which can cause poor recognition of complex visual patterns of letters and words may generalise to poor interpretation of the complex visual pattern of postures and gestures involved in body language. Semrud-Clikeman and Hynd (1991), and Shapiro and Gallico (1993) also emphasised that people with learning disabilities may have problems in understanding the subtle visual cues of facial expression, as well as in using human expressions.

A number of studies have suggested that children with learning disabilities are less skilled in interpreting facial expression than normally achieving peers (Axelrod, 1982; Bachara, 1976; Badian, 1983; Holder & Kirkpatrick, 1991). Holder and Kirkpatrick (1991), in particular, found such children were significantly less accurate in interpreting emotion from facial expression and took more time to identify specific facial emotions than normally achieving peers. These studies, however, viewed learning disability as a unitary disorder, and only made comparisons between this group and a group with no learning disabilities. It is likely that there may be a variety of sub-types in the area of learning disability (Eden, Stein, Wood, & Wood, 1995; Harandek & Rourke, 1994; Robertson, 2000; Shafrir & Siegel, 1994), and separate assessment of such sub-types may be needed to ascertain whether there is a differential impact (Little, 1993).

One sub-type is described as having poor visual-spatial problem-solving skills, as well as emotional and interpersonal disturbances (Bender & Golden, 1990; Gross-Tsur, Shalev, Manor, & Amir, 1995). Rourke (1987, 1988; Rourke & Fuerst, 1991) identified this sub-type as a non-verbal learning disability, which included primary deficits in tactile perception, visual perception and internalised social-emotional problems, such as withdrawal and depression. The possibility that a non-verbal or visual sub-type of learning disability may have difficulties interpreting facial expression was investigated by Dimitrovski, Spector, Levy-Shiff, and Vakil (1998), with children who had a learning disability being divided into three sub-types: those with verbal deficits; those with non-verbal deficits; and those with verbal and non-verbal deficits. It was found that all three learning disability groups were less accurate than a non-disabled control group in interpreting emotions from facial expression, with children in the non-verbal learning disability groups being less successful at interpreting emotions than those with a verbal disability.

The possibility of a visual-perceptual sub-type of learning disability has also been put forward by Irlen (1991a). She proposed a specific visual-perceptual dysfunction, which has been called Irlen Syndrome, and is considered to be unrelated to skills normally assessed by an optometric examination (Evans, Busby, Jeanes, & Wilkins, 1995; Evans, Wilkins, Brown, Busby, Wingfield, Jeanes, & Bald, 1996; Scott, McWhinnie, Taylor, Stevenson, Irons, Lewis, Evans, & Wilkins, 2002). People with Irlen Syndrome report a shadowing and doubling of letters and words while reading, as well as a blurring and movement of print and a reduced span of focus (Irlen, 1991b), and such distortions may generalise to the misperception of subtle differences in facial expression and body language (Spafford and Grosser, 1993). Surveys of children and adults with Irlen Syndrome report a lack of confidence and low self opinion (Irlen & Robinson, 1996; Robinson & Foreman, 1999a; Whiting, Robinson, & Parrot, 1994), which may be in part related to difficulties in interpreting social situations. Cotton and Evans (1999) also found that children with symptoms of Irlen Syndrome were more anxious and neurotic, with

lower self-concepts than children with a learning disability who did not have the syndrome. Bulmer (1994) found that adults with symptoms were less eager to socialise and felt inadequate.

The concept of a visual processing problem called Irlen Syndrome, which is unrelated to normal optometric problems and can be influenced by the use of coloured filters, remains controversial. However, recent evidence related to causal mechanisms and to the effects of coloured filters on reading achievement have provided support for this syndrome. The symptoms described by Irlen have been related to a deficit in the magnocellular visual neurological pathway (Demb, Boynton, Best, & Heeger, 1998), which may cause an overlapping of visual images between consecutive eye fixations when reading (Boden & Brodeur, 1999), and a number of functional imaging studies support the magnocellular deficit hypothesis. These studies have identified a diminished or delayed visual evoked potential for poor readers along the magnocellular pathway in response to moving stimuli (Brannan, Solan, Ficarra, & Ong, 1998; Romani, Conte, Callieco, Bergamaschi, Versino, Lanzi, Zambrino, & Cosi, 2001; Slaghuis & Ryan, 1999). Chase, Ashourzadeh, Kelly, Monfette, and Kinsey (2003) reviewed the evidence and undertook a series of studies which found coloured filters influence magnocellular function and may have an effect on reading performance. Coloured filters have also been found to lead to changes in visual evoked potentials for people with symptoms of Irlen Syndrome (Lewine, 1999). Numerous controlled studies have also reported improvements in reading with the use of coloured filters. These studies have reported improvements in reading when using coloured plastic overlays or coloured computer monitors (Bouldoukian, Wilkins, & Evans, 2002; Croyle, 1998; Jeanes, Busby, Martin, Lewis, Stevenson, Pointon et al., 1997; Scott et al., 2002; Tyrrell, Holland, Dennis, & Wilkins, 1995; Wilkins & Lewis, 1999; Wilkins, Lewis, Smith, & Rowland, 2001; Williams Le Cluyse, & Littell, 1996), as well as improvements in eye strain, headaches and reading when using coloured lenses (Evans, Patel, & Wilkins, 2002; Harris & MacRow-Hill, 1999; Irvine & Irvine, 1997; Lightstone, Lightstone, & Wilkins, 1999; Robinson & Conway, 2000; Robinson & Foreman, 1999a, b; Solan, Ficarra, Brannan, & Rucker, 1998). A number of studies have used placebo controls (Bouldoukian et al., 2002; Jeanes et al., 1997; Robinson & Foreman, 1999a; Wilkins, Evans, Brown, Busby, Wingfield, Jeanes, & Bald, 1994; Wilkins & Lewis, 1999). Not all recent studies, however, have reported positive results (Cotton & Evans, 1990; Martin, McKenzie, Lovegrove, & McNicol, 1993), which is to be expected, as reported improved print clarity will make word recognition easier, but is unlikely to lead to the development of word recognition skills without additional reading tuition (Robinson & Foreman, 1999a).

Whiting and Robinson (2001) found significant differences in the ability to correctly interpret facial emotion and in time taken to identify emotions between a group of children with Irlen Syndrome and normally achieving controls. The Whiting and Robinson (2001) study, however, only compared children with Irlen Syndrome and normally achieving controls, and did not address the question of whether children with visual processing problems (Irlen Syndrome) differ in ability to interpret facial emotion from children with learning disabilities who have no visual processing problems, as found by Dimitrovski et al. (1998).

The present study aimed to continue the investigation of Whiting and Robinson (2001) with an additional focus on a population of students with learning disabilities but no symptoms of Irlen Syndrome. As well as

assessing the ability to identify emotion on faces, a measure of the ability to recognise faces was included. Anecdotal comments from people with severe symptoms of the syndrome suggests they experience a narrowing of span of recognition to one word or less when reading and such people may have difficulties with general facial recognition. Such a measure introduces another aspect of visual perceptual processing, as well as allowing investigation of whether ability to recognise faces is independent of ability to recognise facial affect. This study also aimed to assess possible age and sex differences, as there have been conflicting reports from previous studies of differences in facial interpretive ability with age and sex (Dimitrovski et al., 1998; Holder & Kirkpatrick, 1991). Two research questions were investigated:

1. Does the accuracy of facial recognition differ in children with learning disabilities related to visual processing (Irlen Syndrome) when compared to children with other learning disabilities of a non-visual origin and when compared to normally achieving peers?

2. Does the ability to interpret facial affect (accuracy and time taken for interpretation) differ in children with learning disabilities related to visual processing (Irlen Syndrome) when compared to children with other learning disabilities of a non-visual origin and when compared to normally achieving peers?

3. Are there differences in ability to recognise faces and interpret facial expressions according to age level and sex?

Method

Subjects

The study involved 103 children aged 8-12, allocated to three sub-groups (Table 1):

1. Children with learning disabilities related to visual processing (Irlen Syndrome) (n=42).

2. Children with learning disabilities not related to visual processing (n=30).

3. Children with no learning disabilities (n=31).

The subjects with a learning disability were identified by educational and psychological personnel and by standardised testing as having learning difficulties and literacy problems. Many of these children were referred to the Children's Centre, University of Sydney, or the Special Education Centre, University of Newcastle for assessment of learning disabilities/literacy problems. Children with no learning disabilities were recruited from regular school situations, with teacher assessment, school achievement data and standardised testing used as the basis for selection, as outlined in procedures.

Measures

All participants were initially assessed on the following measures:

1. The Scotopic Sensitivity Syndrome - Screening Manual (Irlen, 1991b). The Screening Manual consists of three sections: i) a questionnaire relating to reading and writing performance, light sensitivity and eye strain; ii) a series of visual tasks, and iii) an assessment of the extent to which performance on these visual tasks and reading is improved by the use of coloured plastic overlays. Only children with a high level of symptoms were included in study group 1. The criteria for high level symptoms on the screening manual is a score of 16 or more out of 32 items relating to reading difficulties, strain and fatigue, and a score of 8 or more out of 14 on each of the visual tasks. Students without learning disabilities were screened for Irlen Syndrome using the Group Screening Survey (Wilson & Thomas, 1994). Validity studies by Tyrrell, Holland, Dennis, and Wilkins (1995) and Gray (1999) found significant associations between scores on the screening

manual and reading achievement (p<.01). A similar significant association has been found for group screening methods (Robinson, Hopkins, Davies, 1995; Wilkins, Lewis, Smith, & Roland, 2001). High test-retest reliability (p<.001 to p<.0001) has also been documented by Jeanes, Busby, Martin, Lewis, Stevenson, Pointon, and Wilkins (1997), Robinson and Foreman (1999a), and Wilkins (1997).

2. *The Learning Disabilities Diagnostic Inventory (LDDI)* (Hammill & Bryant, 1998). This inventory requires the class teacher to rate the child on a series of behaviours in the categories of listening, speaking, reading, writing, mathematics and reasoning. For each behaviour category, there are 15 research validated questions which must be rated on a scale of 1 (frequently) to 9 (rarely). For this study, the reading, writing, mathematics and reasoning categories were used. Content was validated by a panel of 36 experts and the scales subjected to item and confirmatory factor analysis. All scales except listening had a goodness-of-fit value exceeding 0.9 (listening had one value of 0.87 and one of 0.9). For criterion-prediction validity, the scales correctly identified 86% of students with problems. Test-retest reliability coefficients exceeded 0.8. Inter-rater reliability averaged 97%. Internal consistency was above 0.9.

3. *The Test of Facial Recognition* (Benton, Sivan, Hamsher, Varney, & Spreen, 1994). In this test, the subject is presented with a single front view photograph of a face and asked to identify it in a display of six front view photographs appearing below the photograph (6 items). This is followed by the presentation of a single front-view photograph of a face with instructions to locate it 3 times from a display of 6 faces. The face is displayed either in front view or three quarter view, with 3 faces being other faces. The short form of the test was used as it was considered more suited to children aged 8-12 who were also being asked to undertake other tests. This test was validated on people with brain injury, on adults, and on children aged 6-14 with IQs between 85 and 116, with negative correlations of -0.37 to -0.47 between scores on cerebral function and facial recognition (Benton et al. 1994). The correlation between the short and long forms of the test is 0.84 (Ferracuti & Ferracuti (1992).

4. *The Word Attack and Word Identification Sub-tests of the Woodcock Reading Mastery Tests - Revised* (Woodcock, 1995). The word identification sub-test requires the subject to identify isolated words. Initially, there are 3 words on a page, but this increases to 9 on a page. The word attack test measures the ability to use phonic and structural analysis to pronounce words which are nonsense words (letter combinations that could be but are not actual English words), or words used very infrequently in English. There are initially 2 words on a page, but this increases to 6 on a page. Split-half reliability for Word Identification is reported between 0.91 and 0.97 and for Word Attack, 0.89-0.91. Concurrent validity with the Woodcock-Johnson Reading Tests was reported as 0.82-0.83 for Word Identification and 0.74-0.90 for Word Attack.

5. *Pictures of Facial Affect* (Ekman & Friesen, 1976). The test consists of 110 35mm black and white slides of adult male and female faces expressing the emotions of fear, sadness, surprise, anger, happiness and disgust, with the subject having to identify the required emotion. Ekman and Friesen (1976) reported interjudgement agreement ranging from 70% to 100%, and Safer (1981) reported interjudgement agreement as 89.2% for males and 91.9% for females. A more recent study (Mazurski & Bond, 1993) has further confirmed the high levels of rater agreement, with 64% to 100% agreement

being achieved. Holder and Kirkpatrick (1991) used a subset of 36 slides to accommodate the likely abbreviated attention spans of children with learning disabilities and cited Ekman, a co-developer of the instrument, as suggesting that a subset of 36 slides would maintain the validity of the instrument. In this study, the original 110 slide presentations was reduced to 48 in order to accommodate the likely shortened attention spans of younger children, especially those with learning disabilities. The 48 pictures chosen (4 male and 4 female for each of the 6 emotions) were selected using the same criteria as Dimitrovski et al. (1998), namely those within each category reported by Ekman and Friesen (1976) to have the highest interjudge agreement. The reported mean agreement for this subset of 48 pictures was 94.9%. In order to reduce the effects of variables such as poor reading and poor test taking on the test score, the instrument was administered individually, as photographs rather than slides, and with participants' responses recorded by the examiner rather than using the standard multiple choice answer sheets.

Russell (1994) claims that the use of photographs with preselected, posed facial expressions, forced choice responses and lack of contextual information (with its access to multiple dynamic cues), challenges the ecological validity of assessment of emotions. Photographs do not include facial movement and other body movements, and also do not involve voice inflections which occur simultaneously with facial expression (Holder & Kirkpatrick, 1991). Bryan (1998), however, claims that in real-life situations, social cues are often subtle, only available for very short periods of time and may be contradicting or confusing. He argues that interpreting facial cues in photographs may be easier than interpreting non-verbal cues in real-life situations and thus group differences identified in studies of facial affect using photographs are likely to be maintained in the more complex real-life tasks. He states that studies using more realistic presentations, including videos and social scenarios, have obtained similar results to studies using photographs. Crick and Dodge (1994) claim that single trial studies are attempting to measure processes that occur repeatedly over time in the real world and, as a consequence, they may significantly underestimate the actual amount of variation in social adjustment.

Procedures

Children identified as having a learning disability by educational and psychological personnel were assessed with the Scotopic Sensitivity Syndrome Screening Manual (Irlen, 1991b) to identify whether there were visual processing problems. All participants with a score indicating high symptoms of Scotopic Sensitivity/Irlen Syndrome were included in the visual disability sub-group, while participants with a score indicating minor or no symptoms were included in the disability group with no visual processing problems. Once allocated to a group, the participants were assessed on the battery of tests in the following order: Facial Recognition (Benton et al., 1994), Word Attack and Word Identification (Woodcock, 1995), and Facial Affect (Ekman & Friesen, 1976). The measures were all administered at one setting. Assessment on the Facial Affect test was preceded by practice in interpreting emotions using six pictures not included in the testing subset. The practice session involved confirming correct responses and explaining incorrect responses until it was clear that the child understood what was required. The number of correct responses was recorded, as well as time taken in seconds to complete the test. The LDDI

Table 1

Means and Standard Deviations for age (in years and months) for males and females, Irlen Syndrome, Learning Disability and Control groups

Group	N	Mean	Std. Deviation
Males	63	10.1	1.5
Females	40	10.0	1.3
Irlen Syndrome			
Male	28	10.3	1.4
Female	14	9.4	1.3
Total	42	10.1	1.4
LD			
Male	19	9.7	1.5
Female	11	10.2	1.2
Total	30	9.9	1.4
Control			
Male	16	9.8	1.5
Female	15	10.4	1.3
Total	31	10.1	1.4

Table 2

Means and standard deviations of results of all tests for the Irlen, Learning Disability and Control groups.

Test	Group	N	Mean	Std. Deviation
Word Identification (age in months)	Irlen	42	92.4	13.6
	LD	30	95.9	12.03
	Control	31	162.6	53.3
Word Attack (age in months)	Irlen	42	84.5	10.9
	LD	30	91.9	12.8
	Control	31	189.1	47.6
Facial recognition	Irlen	42	32.7	4.5
	LD	30	41.2	5.17
	Control	31	41.4	3.5
Facial Affect (score)	Irlen	42	31.2	4.6
	LD	30	36.6	3.4
	Control	31	40.1	4.4
Facial Affect (time in seconds)	Irlen	42	128.7	51.4
	LD	30	83.4	35.9
	Control	31	68.7	14.8

was completed by each child's regular class teacher.

Children within regular schools who were identified as not having a learning disability were also screened with the Irlen Syndrome Group Screening Test to confirm that there were no visual processing problems. Once this sub-group was identified, they were assessed on the same measures as the experimental group, and in the same order. If any of these participants showed signs of a learning disability, as indicated by a stanine of 6 or below on the LDDI, they were excluded from the study.

Results

The age of participants in this study is disaggregated in Table 1. The groups were similar in age profile, but it is possible that older children might perform better on tests than younger children, or that ability to interpret emotion on faces improves with age (De Paulo & Rosenthal, 1978; Izard, 1971). However, there was no appreciable relationship between age and test results (Facial Recognition, $r = 0.009$; Facial Affect (Score) $r = 0.16$; Facial Affect (Time) $r = -0.13$). Age was thus not further considered in the analyses.

The Learning Disabilities Diagnostic Inventory was used to determine whether students had a learning disability of any kind. The groups were compared on the results of this instrument using the Mann-Whitney test for comparison of means. Results showed that the Irlen group differed from the Learning Disability group only on the Writing scale (Irlen mean rank, 32.1, Learning Disability mean rank 42.7, $p < .05$.) The Learning Disability group differed from the Control group on the four scales, Reading, Writing, Maths and Reasoning ($p<.001$ in all cases). The Irlen group differed from the control group on the four scales ($p<.001$ in all cases). Thus, in terms of the likely presence of a learning disability, the Irlen and the Learning Disability groups both differed from the control group. On all scales, the control group mean stanine was above 8, indicating they were "unlikely" to have a learning disability (Hammill & Bryant, 1998).

Table 2 presents the means and standard deviations for results of the four tests administered to the three groups.

The background variables were then observed to see whether in fact the groups appeared to be representative of learning disabled and normal readers on Word Attack and Word Recognition. Differences between groups were examined using T-tests, and as would be assumed from the results on the Learning Disabilities Diagnostic Inventory, there were significant differences on Word Attack and Word Recognition between the control group and the other two groups. The Learning Disability group differed from the control group on Word Attack ($t = -10.8$, $df = 59$, $p<.001$) and on Word Identification ($t = -6.68$, $df = 59$, $p<.001$). The Irlen group also differed from the control group on these variables (Word Attack, $t = -13.8$, $df = 71$, $p< 001$; Word Identification, $t = -8.2$, $df = 71$, $p<.001$). There were also differences between the Learning Disability and Irlen group on Word Attack ($t = -2.67$, $df = 70$, $p< .001$), with the Learning Disability group performing better.

However, analysis of variance revealed that the groups were significantly different on the tests of Facial Recognition and Facial Affect, over and above sex (Facial Recognition $F(2,94)=43.64$, $p<.001$; Facial Affect – Score $F(2,94)=38.42$, $p<.001$; Facial Affect – Time $F(2,94)=25.57$, $p<.001$). On Facial Recognition, the Learning Disability group was similar to the Control group (Predicted Means 41.0 and 41.5 respectively), while the Irlen group differed (32.7). On Facial Affect (Score), the Learning Disability and Control groups differed (36.8 and

39.9), and the Irlen group did less well (31.2). On Facial Affect (Time), the Learning Disability and Control groups also differed (79.9 and 69.6) while the Irlen groups again did less well (i.e., took much longer)(128.3). Thus the Irlen group of learning disabled students performed significantly less well than the Learning Disability group on all three measures.

When effect sizes were calculated (Table 3) for the differences between group means, large differences were found between both Irlen and Learning Disability groups and the Control group on the basic reading skills of Word Identification and Word Attack. This is as expected for groups that have been shown to have a learning disability. The differences were greater for the Irlen group. On the test of Facial recognition the Irlen group differed from the Learning Disability group by almost as much as they differed from the control group, a large effect of more than one standard deviation. This was true also of the test of Facial Affect, for both score and time. The Irlen group performed worse than the Learning Disability group by approximately one standard deviation on both these factors. The Learning Disability group also differed from the control group, but by a small to moderate amount, as Table 3 shows. Hattie (1992) has argued that in a complex system (such as the system involved in learning and recognising facial affect) an effect size of 0.4 is significant, although he supports random assignment of subjects as a prerequisite for this form of analysis.

Relationship between sex and performance.

Multivariate analysis of variance (Facial Affect (Score), Facial Affect (Time), Facial Recognition, by the three groups (Irlen, Learning Disability and Control) and by sex showed that

Table 3

Comparison of pretest means in Facial Recognition Test, Word Identification Test, Word Attack Test, and Facial Affect Test

Test	Comparison	Effect Size
Word Identification (age)	Irlen & Control	-1.40
	Irlen & LD	0.27
	LD & Control	-1.30
Word Attack (age)	Irlen & Control	-1.71
	Irlen & LD	0.61
	LD & Control	-1.62
Facial Recognition (score)	Irlen & Control	-1.46
	Irlen & LD	1.35
	LD & Control	-0.05
Facial Affect (score)	Irlen & Control	-1.41
	Irlen & LD	1.10
	LD & Control	-0.81
Facial Affect (time in seconds)	Irlen & Control	1.20
	Irlen & LD	-0.90
	LD & Control	0.52

there were no effects for sex using the Wilks Lambda Criterion. This was investigated because it is commonly observed in clinical studies that boys are more affected than girls in respect of learning disabilities. The present finding is, however, supported by previous studies of facial affect (Dimitrovski et al., 1998; Holder & Kirkpatrick, 1991; Thomas, 1979), although there was a consensus in some earlier literature that females are more accurate interpreters of facial expression than males (Hall, 1978; Safer, 1981).

Discussion

The finding of significantly low scores for facial recognition and interpretation of facial affect in a study group with learning disabilities related to visual processing confirms previous results obtained by Dimitrovski et al. (1998) using a similarly modified version of the Pictures of Facial Affect test. The group with learning disabilities not apparently related to visual perceptual deficits also had significantly lower scores than the Control group for Facial Affect, although these differences were not as marked as the differences between the visual processing problem (Irlen) group and controls. This result also parallels the findings of Dimitrovski et al. (1998) that children within the visual processing (non-verbal) disability sub-group were less successful at interpreting facial emotions than those with a verbal disability.

The findings of this study and the study by Dimitrovski et al. (1998) supports the claims by Holder and Kirkpatrick (1991) and Spafford and Grosser (1993) that children having difficulties in processing visual-spatial stimuli may have difficulty in interpreting body language, particularly facial expression. The findings of this study could also support the claims by Rourke (1987, 1988) and Rourke and Fuerst (1991) that a sub-type of learning disability identified as having poor visual-spatial problem-solving skills are more likely to have interpersonal disturbances. However, it must be remembered that a number of social information processing variables are needed to account for social behaviour (Crick & Dodge, 1994).

Difficulties understanding facial expression and other non-verbal cues may also lead to lowered self-esteem, less personal-social interaction and possibly increased reactive behaviour (Cooley & Triemer, 2002). Crick and Dodge (1994) suggest that socially maladjusted children may become withdrawn because of negative interaction with peers, as suggested by Rourke (1987, 1988) for a visual-spatial sub-type of learning disability. They may selectively attend to negative cues more that their peers, leading to negative views of social interaction (Crick & Dodge, 1994). Peer relationships are also very important to child development (Bryan, 1998), with classroom interactions between teachers, students and their peers having a significant influence on academic progress (Kershner, 1990). To limit assessment of school learning problems to difficulties in literacy and mathematics ignores the importance of social interactions and reduces the possibility that such children will be effectively helped or the nature of their problems fully understood.

Rock et al. (1997) and Rourke (1995) emphasise the need for a coordinated approach which reflects all of the student's presenting needs, including the promotion of social skills and the understanding of cues of social interaction. This approach could include training students how to express their own feelings and how to interpret the expressions and emotions of other people (Dimitrovski et al., 1998; Roffman, Herzog & Wershba-Gershon, 1994). Such training may facilitate the development of broader communication skills and help develop

social competence, improve self-esteem and reduce problem behaviour (Vallance, Cummings, & Humphries, 1998). Barnhill, Cook, Tebbenkamp, and Myles (2002) found an 8 week social skills program increased friendships and improved ability to read non-verbal communications. Grinspan, Hemphill and Noewicki (2003) found a 4-week program improved ability to use information from facial cues, as well as reducing social anxiety.

It would be useful to screen children likely to have difficulties with non-verbal cues at an early age, before poor self-esteem, behaviour problems and lack of motivation become a barrier to school success (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; McLesky, 1992). For such children, interpretation of facial affect would be a high priority because of its importance in identifying human emotion (Burgoon, Buller, & Woodall, 1996). Such an approach, however, would require the training of teachers so that they are adequately prepared to deal with such problems and are able to effectively teach the skills required. It may also require the provision of sufficient trained support staff in areas such as crisis intervention and counselling (Rock et al., 1997).

It should be noted that the differences between groups in interpreting facial affect found in this study may not depend on Irlen Syndrome as the sole explanation. Problems with facial perception and interpretation are characteristic of people with a wide range of behavioural, attentional and emotional problems. Children with symptoms of Autism have been found to be less proficient at recognising facial expression or emotionally expressive gestures (Celani, Battacchi, & Arcidiacono, 1999; Davies, Bishop, Manstead, & Tatham, 1994; Hobson, 1991; Loveland, Nagy, Pearson, & Dodds, 2001). Recent evidence also suggests that people with Schizophrenia have difficulty recognising facial emotions (Mandal, Pandey, & Prasad, 1998; Schneider, Gur, Gur, & Shtasel, 1995), which may be caused by a disturbance in visuospatial processing of facial emotions (Streit, Wolwer, & Gaebel, 1997).

It could be speculated that visual processing difficulties which cause problems in interpreting facial affect may have a similar causal basis across a number of disabilities. Richardson and Ross (2000) hypothesise that abnormalities in fatty acid phospholipid metabolism may be a factor in a wide range of disorders, with phospholipid anomalies identified in people with visual processing problems and Dyslexia being similar to those identified in people with Schizophrenia (Horrobin, Glen, & Hudson, 1995; MacDonnell, Skinner, Ward, Glen, Glen, MacDonald, Boyle, & Horrobin, 2000). Robinson, McGregor, Roberts, Dunstan, and Butt (2001) and Sparkes, Robinson, Dunstan, and Roberts (2003) found anomalies in fatty acids in children an adults with Irlen Syndrome, as well as indicators of immune system dysfunction which may influence the metabolism of fatty acids. A number of studies have also found abnormalities with smooth pursuit eye movements in people with Schizophrenia (Abel, Levin, & Holzman, 1992; Radant & Hommer, 1992; Ross, Olincy, Harris, Sullivan, & Radant, 2000), with a restricted visual scanning style across faces (Kurachi, Matusi, Kiba, Suzuki, Tsunoda, & Yamaguchi, 1994; Streit et al., 1997), and similar eye movement problems are frequently reported in people with Irlen Syndrome (Fletcher & Martinez, 1994; Robinson & Foreman, 1999b; Solan, Ficarra, Brannan, & Rucker, 1998; Tyrrell, et al., 1995). There are also some reports of similarities in neural anomalies between individuals with a number of developmental disorders such as Learning Disabilities, Autism and Attention Deficit

Hyperactivity Disorder (Diamond, 2000).

The findings of difficulties in social interaction and interpretation of facial expression in a variety of diagnostic categories also raises the question of overlap in current disability terminology. Broad diagnostic categories currently in use, such as learning disability, Autism, Attention Deficit Hyperactivity Disorder, and Schizophrenia could include overlapping clinical disorders, which may cause confusion about diagnosis and appropriate treatment. Hardman and Morton (1991) found that 98% of subjects who were clinically dependent (referred to a drug and alcohol rehabilitation centre) also had symptoms of dyslexia and 89% had symptoms of Attention Deficit Hyperactivity Disorder. There is a need to look at the complex and confusing ways in which learning disabilities, attention problems and affective disorders may interact. One disability may look like another, a primary disorder in one area may lead to problems in another area, or a person may have a significant disorder in a number of areas. This confusion may be moderated if sub-categories, such as visual processing disability, are identified across a range of currently used broad diagnostic entities.

This study has shown that there is a group of individuals who have learning disabilities and who find the recognition of faces and of facial affect as difficult as they find reading tasks. The study would have been enhanced by the inclusion of other measures such as rapid naming of pictures to explore the time factor in the recognition of facial affect (Nicholson & Fawcett, 1994, 1995). Clinical experience, and also the variance in scores among the Irlen group suggests that a case study approach to elucidate the performance and difficulties of participants with very poor performance on such tasks would be revealing.

Nevertheless, there is sufficient evidence to suggest that if people with visual processing problems are clearly identified, they could possibly be targeted as being at greater risk of developing personal and social problems, with more emphasis being placed on this area in their individualised intervention program.

References

Abel, L., Levin, S., & Holzman, P. (1992). Abnormalities of smooth pursuit and saccadic control in schizophrenia and affective disorders. *Vision Research*, *32*(6), 1009-1014.

Axelrod, L. (1982). Social perception in learning disabled adolescents. *Journal of Learning Disabilities, 15*, 610-613.

Bachara, G. (1976). Empathy in learning disabled children. *Perceptual and Motor Skills, 43*, 541-542.

Badian, N. (1983). Dyscalculia and nonverbal disorders of learning. In H. R. Myklebust (Ed.). *Progress in learning disabilities* Vol. 3 (pp.235-264). New York: Grune & Stratton.

Barnhill, G., Cook, K., Tebbenkamp, K., & Myles, B. (2002). The effectiveness of socials kills intervention targeting for adolescents with Asperger Syndrome and related pervasive developmental delays. *Focus on Autism and Other Developmental Disabilities*, *17*(2), 12-119.

Baum, D., Duffelmeyer, F., & Geelan, M. (1988). Resource teacher perceptions of the prevalence of social dysfunction among students with learning disabilities. *Journal of Learning Disabilities, 21*, 380-381.

Bender, W., & Golden, I. (1990). Sub-types of students with learning disabilities as derived from cognitive, academic, behavioural, and self-concept measures. *Learning Disability Quarterly, 13*, 183-194.

Benton, A., Sivan, A., Hamsher, K., Varney, N., & Spreen, O. (1994). *Contributions to neuropsychological assessment: A clinical manual*. New York: Oxford University Press.

Boden, C., & Brodeur, D. (1999). Visual processing of verbal and nonverbal stimuli in adolescents with reading disabilities. *Journal of Learning Disabilities*, *32*(1), 58-71.

Bouldoukian, J., Wilkins, A., & Evans, B. (2002). Randomised controlled trial of the effect of coloured overlays on the rate of reading of people with specific learning difficulties. *Ophthalmic and Physiological Optics*, *22*, 55-60.

Brannan, J., Solan, H., Ficarra, A., & Ong, E. (1998). Effect of luminance on visual evoked potential amplitudes in normal and disabled readers. *Optometry and Vision Science*, *75*(4), 279-283.

Bruck, M. (1986). Social and emotional adjustments of learning disabled children: A review of the issues. In S. J. Ceci (Ed.),. *Handbook of cognitive, social and neuropsychological aspects of learning disabilities* Vol. 1(pp.361-380). Hillsdale, NJ: Erlbaum.

Bruno, R. (1981). Interpretation of pictorially presented situations by learning disabled and normal children. *Journal of Learning Disabilities, 14*, 350-352.

Bryan, T. (1998). Social competence of students with learning disabilities. In B. L. Wong (Ed.), *Learning about learning disabilities* (2nd ed.). San Diego, CAL: Academic Press.

Bulmer, J. (1994). *Sensory overload and general well-being: Can adults be helped by using Irlen lenses?* Unpublished BSc Honours Thesis, Chester College of Higher Education, UK.

Burgoon, J., Buller, D., & Woodall, W. (1996). *Nonverbal communication: The unspoken dialogue*. NY: McGraw Hill.

Celani, G., Battacchi, M., Arcidiacono, L. (1999). The understanding of the emotional meaning of facial expression in people with autism. *Journal of Autism and Developmental Disorders*, 29(1), 57-66.

Chase, C., Ashourzadeh, A., Kelly, C., Monfette, S., & Kinsey, K. (2003). Can the magnocellular pathway read? Evidence from studies of colour. *Vision Research*, *43*, 1211-1222.

Cooley, E., & Triemer, D. (2002). Classroom behaviour and the ability to decode nonverbal cues in boys with severe emotional disturbance. *The Journal of Social Psychology*, *142*(6), 741-752.

Cotton, M., & Evans, K. (1990). An evaluation of the Irlen lenses as a treatment for specific reading disorders. *Australian Journal of Psychology, 42*(1), 1-12.

Crick, N., & Dodge, K.. (1994). A review and reformulation of social information-processing mechanisms in children's social adjustment. *Psychological Bulletin, 115*(1), 74-101.

Croyle, L. (1998). Rate of reading, visual processing, colour and contrast. *Australian Journal of Learning Disabilities, 3*(3), 13-20.

Davies, S., Bishop, D., Manstead, S., & Tantam, D. (1994). Face perception in children with autism and Asperger's syndrome. *Journal of Child Psychology and Psychiatry*, 35, 1033-1057.

Demb, J., Boynton, G., Best, M., & Heeger, D. (1998). Psychophysical evidence for a magnocellular pathway deficit in dyslexia. *Vision Research*, *38*(11), 1555-1559.

De Paulo, B., & Rosenthal, R. (1978). Age changes in nonverbal decoding as a function of increasing amounts of information. *Journal of Experimental Child Psychology*, 26, 280-287.

Diamond, A. (2000) Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development, 71*(1)*,* 44-56.

Dimitrovski, L., Spector, H., Levy-Shiff, R., & Vakil, E. (1998). Interpretation of facial expressions of affect in children with learning disabilities with verbal or non-verbal deficits. *Journal of Learning Disabilities, 31*(3), 286-292, 312.

Eden, G., Stein, J., Wood, M., & Wood, F. (1995). Verbal and visual problems in reading. *Journal of Learning Disabilities, 28*(5), 272-290.

Ekman, P., & Friesen, W. (1976). Pictures of facial affect (Slides). Palo Alto, CA: Consulting Psychologists Press.

Evans, B., Busby, A., Jeanes, R., & Wilkins, A. (1995). Optometric correlates of Meares-Irlen Syndrome: A matched group study. *Ophthalmological and Physiological Optics, 15*(5), 481-487.

Evans, B., & Patel, R., & Wilkins, A. (2002). Optometric function in visually sensitive migraine before and after treatment with tinted spectacles. *Ophthalmological and Physiological Optics*, *22*, 130-142.

Evans, B., Wilkins, A., Brown, J., Busby, A., Wingfield, A., Jeanes, R., & Bald, J. (1996). A preliminary investigation into the aetiology of Meares-Irlen Syndrome. *Ophthalmic and Physiological Optics, 16*(4), 286-296.

Ferracuti, F., & Ferracuti, S. (1992). Taratura del campione Italiano. In *Test di riconoscimento di volti ignoti.* Firenze: Organizzazioni Speciali.

Fletcher, J., & Martinez, G. (1994). An eye movement analysis of the effects of scotopic sensitivity correction on parsing and comprehension. *Journal of Learning Disabilities, 27*(1), 67-70.

Foorman, B., Francis, D., Fletcher, J., Schatschneider, C., & Mehta, P. (1998). The role of instruction in learning to read: Preventing reading failure in at-risk children. *Journal of Educational Psychology*, *90*(1), 37-55.

Gray, J. (1999). Visual perceptual difficulties and eye behaviour: Irlen syndrome and eye colour. Unpublished Doctor of Philosophy dissertation, Univer. of Bristol, UK.

Grinspan, D., Hemphill, A., & Norwicki, S. (2003). Improving the ability to elementary school-age children to identify emotion in facial expression. *The Journal of Genetic Psychology*, *27*(1), 88-101.

Gross-Tsur, V., Shalev, R., Manor, O., & Amir, N. (1995). Developmental right-hemisphere syndrome: Clinical spectrum of the nonverbal learning disability. *Journal of Learning Disabilities*, *28*, 80-86.

Hall, J. (1978). Gender effects in decoding nonverbal cues. *Psychological Bulletin*, *85*, 845-856.

Hammill, D., & Bryant, P. (1998). *Learning disabilities diagnostic inventory*. Austin, TX: Pro Ed.

Harandek, M., & Rourke, B. (1994). Principal identifying features of the syndrome of nonverbal learning disabilities in children. *Journal of Learning Disabilities, 27*(3), 144-154.

Hardman, P., & Morton, D. (1991). The link between developmental dyslexia, ADD, and chemical dependency. *Environmental Medicine, 8*(3), 61-72.

Harris, D. & MacRow-Hill (1999). Application of Chroma-Gen haloscopic lenses to patients with dyslexia: A double-masked placebo-controlled trial. *Journal of the Optometric Association*, *70*(1), 629-640.

Hattie, J. (1992). *Self concept*. Hillsdale, N.J.: Erlbaum.

Hobson, R. (1991). Methodological issues for experiments on autistic individual's perception and understanding of emotion. *Journal of Child Psychology and Psychiatry, 32*, 1135-1158.

Holder, H., & Kirkpatrick, S. (1991). Interpretation of emotion from facial expression of children with and without learning disabilities. *Journal of Learning Disabilities, 23*(3), 170-177.

Horrobin, D., Glen, A., & Hudson, C. (1995). Possible relevance of phospholipid abnormalities and genetic interactions in psychiatric disorders: The relationship between dyslexia and schizophrenia. *Medical Hypotheses, 45*, 605-613.

Irlen, H., & Robinson, G. (1996). The effect of Irlen coloured filters on adult perception of workplace performance: A preliminary survey. *Australian Journal of Remedial Education, 1*(3), 7-17.

Irlen, H. (1991a). *Reading by the colors*. New York: Avery.

Irlen, H. (1991b). *Scotopic sensitivity syndrome - screening manual*. Long Beach, CA: Perceptual Development Corporation.

Irvine, J., & Irvine, E. (1997). *Scotopic sensitivity syndrome in a single individual (a case study)*. Naval Air Warfare Centre, Weapons Division, China Lake, California, April.

Izard, C. (1971). *The face of emotion*. New York: Appleton-Century Crafts.

Jeanes, R., Busby, A., Martin, J., Lewis, E., Stevenson, N., Pointon, D., & Wilkins, A. (1997). Prolonged use of coloured overlays for classroom reading. *British Journal of Psychology, 88*, 531-548.

Kershner, J. (1990). Self-concept and IQ as predictors of remedial success in children with learning disabilities. *Journal of Learning Disabilities, 23*, 368-374.

Kuhne, M., & Wiener, J. (2000). Stability of social status of children with and without learning disabilities. *Learning Disability Quarterly, 23*(1), 64-75.

Kurachi, M., Matsui, M., Kiba, K., Suzuki, M., Tsunoda, M., & Yamaguchi, N. (1994). Limited visual search on the WAIS Picture Completion test in patients with schizophrenia. *Schizophrenia Research, 12*(1), 75-80.

Lewine, J. (1999). *Changes in visual evoked magnetic field for people with SSIS*. Fourth Biannual Australasian Irlen Conference. Newcastle, Australia, May 20-22.

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

Little, S. (1993). Nonverbal learning disabilities and socioemotional functioning: A review of recent literature. *Journal of Learning Disabilities, 26*(1), 653-665.

Loveland, K., Nagy, E., Pearson, D., Reddoch, S., & Dodds, K. (2001). *Intermodel perception of emotion in autism*. Conference proceedings. Third International Clinic and Scientific Meeting: Myalgic Encephalopathy/ Chronic Fatigue Syndrome, Sydney, Australia, 1-2 December.

MacDonnell, L.., Skinner, F., Ward, P., Glen, A., Glen, A., MacDonald, D., Boyle, R., & Horrobin, D. (2000). Type IV cPLA2 in red blood cells: Evidence for differences between two subgroups on dyslexia-type adults and controls. *Schizophrenia Research, 41*, 228-259.

Mandal, M., Pandey, R., & Prasad, A. (1998). Facial expressions of emotions and schizophrenia: A review. *Schizophrenia Bulletin, 24*, 399-412.

Martin, F., MacKenzie, B., Lovegrove, W., & McNicol, D. (1993). Irlen lenses and the treatment of specific reading disability. An evaluation of outcomes and processes. *Australian Journal of Psychology*, *45*(3), 141-150.

Maughan, B., Pickles, A., Hagell, A., Rutter, M., & Yule, W. (1996). Reading problems and antisocial behaviour: Developmental trends in comorbidity. *Journal of Child Psychology and Psychiatry, 37*(4), 405-418.

Mazurski, E., & Bond, N. (1993). New series of slides depicting facial expression of affect: A comparison with the Pictures of Facial Affect series. *Australian Journal of Psychology, 45*(1), 41-47.

McLesky, J. (1992). Students with learning disabilities at primary intermediate and secondary grade levels: Identification and characteristics. *Learning Disability Quarterly*, *15*(1), 13-20.

Nicolson, R., & Fawcett, A. (1994) Reaction times and dyslexia. *Quarterly Journal of Experimental Psychology, 47A,* 29-48.

Nicolson, R., & Fawcett, J. (1995). Dyslexia is more than a phonological disability. *Dyslexia: An International Journal of Research and Practice, 1,* 19-37.

Perlmutter, B. (1986). Personality variables and peer relations of children and adolescents with learning disabilities. In S. J. Ceci (Ed.), *Handbook of cognitive, social, and neuropsychological aspects of learning disabilities* Vol. 1 (pp.339-359). Hillsdale, NJ: Erlbaum.

Radant, A., & Hommer, D. (1992). A quantitative analysis of saccades and smooth pursuit during visual pursuit tracking: A comparison of schizophrenics with normal and substance abusing controls. *Schizophrenia Research, 6*(3), 225-235.

Richardson, A., & Ross, M. (2000). Fatty acid metabolism in neurodevelopmental disorder: A new perspective on associations between attention deficit/hyperactivity disorder, dyslexia, dyspraxia and the autistic spectrum. *Prostaglandins, Leukotrienes and Essential Fatty Acids, 63*(1/2), 1-9.

Robertson, J. (2000). Neuropsychological intervention in dyslexia: Two studies on British pupils. *Journal of Learning Disabilities, 33*(2), 137-148.

Robinson, G., & Conway, R. (2000). Irlen lenses and adults: A small scale study of reading speed, accuracy, comprehension and self-image. *Australian Journal of Learning Disabilities, 5*(1), 4-13.

Robinson, G., & Foreman, P. (1999a). Scotopic Sensitivity/Irlen Syndrome and the use of coloured filters: A long-term placebo controlled and masked study of reading achievement and perception of ability. *Perceptual and Motor Skills, 89*, 83-113.

Robinson, G., & Foreman, P. (1999b). The effects of Irlen coloured filters on eye movement. *Behavioral Optometry*, 7(4), 5-18.

Robinson, G., Hopkins, B., & Davies, T. (1995). The incidence of scotopic sensitivity syndrome in secondary school population: A preliminary survey. *The Bulletin for Learning Disabilities, 5*(1), 36-56.

Robinson, G., McGregor, N., Roberts, T., Dunstan, R., & Butt, H. (2001). A biochemical analysis of people with chronic fatigue who have Irlen Syndrome: Speculation concerning immune system dysfunction. *Perceptual and Motor Skills*, *93*, 486-504.

Rock, E., Fessler, M., & Church, R. (1997). The concomitance of learning disabilities and emotional/behavioral disorders: A conceptual model. *Journal of Learning Disabilities, 30*(3), 245-263.

Roffman, A., Herzog, J., & Wershba-Gershon, P. (1994). Helping young adults understand their learning disabilities. *Journal of Learning Disabilities, 27*(7), 413-419.

Romani, A., Conte, S., Callieco, R., Bergamaschi, R., Versino, M., Lanzi, G., Zambrino, C., & Cosi, V. (2001). Visual evoked potential abnormalities in dyslexic children. *Functional Neurology*, *16*(3), 219-229.

Ross, R., Olincy, A., Harris, J., Sullivan, B., & Radant, A. (2000). Smooth pursuit eye movements in schizophrenia and attentional dysfunction: Adults with schizophrenia, ADHD, and a normal comparison group. *Biological Psychiatry, 48*, 197-203.

Rourke, B. (1987). Syndrome of nonverbal learning disabilities: The final common pathway of white-matter disease/ dysfunction? *The Clinical Neuropsychologist, 1*, 209-234.

Rourke, B. (1988). Socioemotional disturbances of learning disabled children. *Journal of Consulting and Clinical Psychology, 56*, 801-810.

Rourke, B. (1995). Treatment program for children with NLD. In B. P. Rourke (Ed.), *Syndrome of nonverbal learning disabilities: Neurodevelopmental manifestations* (pp.497-508). New York: Guilford.

Rourke, B., & Fuerst, D. (1991). *Learning disabilities and psychosocial functioning: A neuropsychological perspective*. New York: Guilford.

Russell, J. (1994). Is there universal recognition of emotion from facial expression? A review of cross-cultural studies. *Psychological Bulletin, 115*(1), 102-141.

Sabornie, E. (1994). Social-affective characteristics in early adolescents identified as learning disabled and nondisabled. *Learning Disability Quarterly, 17*, 268-279.

Safer, M. (1981). Sex and hemispheric differences in access to code for processing emotional expressions on faces. *Journal of Experimental Psychology: General, 110*, 86-100.

Schneider, F., Gur, R. C., Gur, R. E., Shtasel, D. (1995). Emotional processing in schizophrenia: Neurobehavioural probes in relation to psychopathology. *Schizophrenia Research, 17*, 67-75.

Scott, L., McWhinnie, H., Taylor, L., Stevenson, N., Irons, P., Lewis, E., Evans, B., & Wilkins, A. (2002). Coloured overlays in schools: Orthoptic and optometric findings. *Ophthalmological and Physiological Optics, 22*, 156-165.

Semrud-Clikeman, M., & Hynd, G. (1991). Specific nonverbal and social-skills deficits in children with learning disabilities. In J. E. Obrzut & G. W. Hynd (Eds.), *Neuropsychological foundations of learning disabilities* (pp.604-629). San Diego, CA: Academic Press.

Shafir, U., & Siegel, L. (1994). Subtypes of learning disabilities in adolescents and adults. *Journal of Learning Disabilities, 27*(2), 123-134.

Shapiro, B., & Gallico, R. (1993). Learning disabilities. *Pediatric Clinics of North America, 40*, 491-505.

Slaghuis, W., & Ryan, J. (1999). Spatio-temporal contrast sensitivity, coherent motion and visual persistence in developmental dyslexia. *Vision Research*, *39*, 651-668.

Solan, H., Ficarra, A., Brannan, J., & Rucker, F. (1998). Eye movement efficiency in normal reading disabled elementary school children: Effects of varying luminance and wavelength. *Journal of the American Optometric Association, 69*(7), 455-464.

Spafford, C., & Grosser, G. (1993). The social misperception syndrome in children with learning disabilities: Social causes versus neurological variables. *Journal of Learning Disabilities, 26*(3), 178-189, 198.

Sparkes, D., Robinson, G., Dunstan, H., & Roberts, T. (2003). Plasma cholesterol levels and Irlen syndrome: A preliminary study of ten- to seventeen-year-old students. *Perceptual and Motor Skills*, *97*, 743-752.

Streit, M., Wolwer, W., & Gaebel, W. (1997). Facial-affect recognition and visual scanning behaviour in the course of schizophrenia. *Schizophrenia Research, 24*, 311-317.

Thomas, C. (1979). An investigation of the sensitivity to nonverbal communication of learning disabled and normal children. *Dissertation Abstracts International*, *40*, 5007A. (University Microfilms No. 80-04639)

Toro, P., Weissberg, R., Guare, J., & Liebenstein, N. (1990). A comparison of children with and without learning disabilities on social problem-solving skill, school behavior, and family background. *Journal of Learning Disabilities, 23*, 115-120.

Tyrrell, R., Holland, K., Dennis, D., & Wilkins, A. (1995). Coloured overlays, visual discomfort, visual search and classroom reading. *Research in Reading, 18*(1), 10-23.

Vallance, D., Cummings, R., & Humphries, T. (1998). Mediators of the risk for problem behaviour in children with language learning disabilities. *Journal of Learning Disabilities, 31*(2), 160-171.

Whiting, P., & Robinson, G. (2001). The interpretation of emotion from facial expression for children with a visual sub-type of dyslexia. *Australian Journal of Learning Disabilities, 6*(4), 6-14.

Whiting, P., Robinson, G., & Parrot, C. (1994). Irlen coloured filters for reading: A six year follow up. *Australian Journal of Remedial Education, 26*(3), 13-19.

Wilchesky, M., & Reynolds, T. (1986). The socially deficient LD child in context: A systems approach to assessment and treatment. *Journal of Learning Disabilities, 19*, 411-415.

Wilkins, A. (1997). A system of precision: Ophthalmic tinting and its role in the treatment of visual stress. In C. M. Dickinson, I. J. Murray, & C. Corden (Eds.), *John Dalton's colour vision legacy* (pp.695-708). London: Taylor & Francis.

Wilkins, A., Evans, B., Brown, J., Busby, A., Wingfield, A., Jeanes, R., & Bald, J. (1994). Double-masked placebo-controlled trial of precision spectral filters in children who use coloured overlays. *Ophthalmological and Physiological Optics*, *14*, 365-370.

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

Wilkins, A., Lewis, E., Smith, F., & Roland, F. (2001). Coloured overlays and their benefits for reading. *Journal of Research in Reading*, *24*(1), 41-64.

Williams, M., Le Cluyse, K., & Littell, R. (1996). A wavelength specific intervention for reading disability. In R.P. Garzia & R. London (Eds.), *Vision and Reading*. St Louis: Mosby.

Wilson, E., & Thomas, G. (1994). *Group screening book for Irlen syndrome*. Sydney: Irlen Clinic.

Woodcock, R. (1995). *Woodcock reading mastery tests - revised*. Circle Pines, MN: American Guidance Service.