

**THE INTERPRETATION OF EMOTION FROM
FACIAL EXPRESSION FOR CHILDREN WITH
IRLEN SYNDROME**

P.R. Whiting, University of Sydney, NSW, Australia
G.L. Robinson, University of Newcastle, NSW, Australia

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Contact: Dr P. R. Whiting
Faculty of Education
A35
University of Sydney, NSW 2006
Australia

While investigation of people with specific learning disabilities/Dyslexia has largely highlighted the effects on academic achievement, motivation and self image, there is also a need to understand the effects of such disabilities on social skills. The development of social skills is increasingly recognised as important for such people (Semrud-Clikeman & Hynd, 1991; Spafford & Grosser, 1993), and a number of studies have indicated that a significant proportion of individuals with learning disabilities/Dyslexia exhibit social problems and have low social status (Baum, Duffelmeyer, & Geelan, 1988; Bickett & Milich, 1990; Bryan, 1998; Kuhne & Wiener, 2000; McIntosh, Vaughan, & Zaragoza, 1991; Margalit, 1998; Rock, Fessler, & Church, 1997; Sabornie, 1994; Stone & La Greca, 1990).

These social difficulties have often been considered to be products of school failure (Bruck, 1986; Gever, 1991; Horne, 1982; Maughan, Pickles, Hagell, Rutter, & Yule, 1996; Wilchesky & Reynolds, 1986), or other psychological problems (Bryan, 1998; Parrill-Burnstein, 1981; Rock, Fessler, & Church, 1997). There is also the possibility that cognitive processing deficits which are sufficient to cause problems in academic learning may also cause difficulties in interpreting social events (Bender & Wall, 1994; Holder & Kirkpatrick, 1991; Kavale & Forness, 1996; Pearl, 1987; Reynolds, Elksnin & Brown, 1996; Rock, Fessler, & Church, 1997; Spafford & Grosser, 1993; Tur-Kaspa & Bryan, 1993). It has been claimed 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).

In particular facial expression has been identified as critical to the development of social responsiveness (Semrud-Clikeman & Hynd, 1991). Infant development of accurate perceptions of maternal facial expressions is claimed to be important for the development of attachment behaviours and social adequacy (Ainsworth, 1979), and children having difficulties in processing visual-spatial stimuli may have problems understanding the human interactions and expressions necessary for social skill development (Holder & Kirkpatrick, 1991; Kaslow & Cooper, 1978). Perception of minor differences in facial expression is important to the understanding of the intent of others (Holder & Kirkpatrick, 1991), and difficulties in this area may lead to deficits in social referencing (Bandura, 1986). 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).

The studies of interpretation of facial expression cited above, 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 (Bakker, 1990; Eden, Stein, Wood, & Wood, 1995; Harandek & Rourke, 1994; Kohonen, 1991; Robertson, 2000; Shafir & Siegel, 1994; Spreen & Haaf, 1986), and separate

assessment of such sub-types may be needed to ascertain whether there is a differential impact (Little, 1993).

One sub-type has been identified as having poor visual-spatial problem-solving skills, as well as emotional and interpersonal disturbances (Bender & Golden, 1990; Gross-Tsur, Shalev, Manor, & Amir, 1995; Kohornen, 1991). Rourke (1987, 1988; Rourke & Fuerst, 1991) described this sub-type as a non-verbal learning disability, which included primary deficits in tactile perception, visual perception and accommodation to novel tasks. He claimed this sub-type was particularly prone to internalised social-emotional problems, such as withdrawal and depression. The possibility that a non-verbal or visual sub-type of learning disability is more likely to have problems interpreting social situations has been raised by a number of other researchers. 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 there may be problems in understanding the subtle visual cues of facial expression, as well as in using human expressions. The ability of this sub-type to interpret facial expression was investigated by Dimitrovski, Spector, Levy-Shiff, and Vakil (1998) who found that a non-disabled control group had better interpretive ability than a learning disabled group, and those in the verbal disability sub-group had better interpretive ability than those in the non-verbal disability sub-group.

The concept of a visual-perceptual sub-type of learning disability has recently been highlighted by Irlen (1991a) in her development of the use of coloured filters. 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). There have been reports of a high familial incidence of symptoms (McLachlan, Yale, & Wilkins, 1993; Robinson, Foreman, & Dear, 1996, 2000; Wilkins & Neary, 1991), which further suggests that Irlen Syndrome may be considered a distinct sub-type of learning disability.

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. A large number of controlled studies have also reported increased print clarity and improvement in reading and visual processing when using coloured filters (Croyle, 1998; Lightstone, Lightstone, & Wilkins, 1999; Robinson & Conway, 2000; Solan, Ficarra, Brannan, &

Rucker, 1998; Tyrrell, Holland, Dennis, & Wilkins, 1995; Whiting, Robinson, & Parrot, 1994; Wilkins, Lewis Smith, & Rowland, 2001), including studies using placebo controls (Jeanes, Busby, Martin, Lewis, Stevenson, Pointon, & Wilkins, 1997; Robinson & Foreman, 1999a; Wilkins, Evans, Brown, Busby, Wingfield, Jeanes, & Bald, 1994; Wilkins & Lewis, 1999) and such improvements may also generalise to improved perception of social situations. There have been reports of increases in perception of ability to cope with school and work tasks and in confidence when using coloured filters (Irlen & Robinson, 1996; Robinson & Conway, 1994, 2000; Robinson & Foreman, 1999b), and while such improvements may relate to increased expectations of academic/workplace success, they may also relate to improved confidence in social situations (Spafford & Grosser, 1993).

The present study aimed to investigate the ability to interpret facial expression in children with Irlen Syndrome. An additional objective was to evaluate whether the improved print clarity reported when using coloured filters generalised to improved perception of facial expression. Reported improvements in clarity may assist the recognition of different facial expressions, but if such expressions have been previously difficult to interpret they may not have been effectively learnt. Three research questions were investigated:

- 1) Does the accuracy of interpretation of facial expressions and time taken to interpret them 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) Are there differences according to age level and sex?
- 3) Does the application of Irlen filters make a difference in the ability of participants with Irlen Syndrome to recognise faces or to interpret facial affect?

METHOD

Participants

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

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 participants with a learning disability were identified by educational and psychological personnel 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 and school achievement data used as the basis for selection.

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 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 et al. (1995) and Gray (1999) found significant associations between scores on the screening manual and reading achievement. A similar significant association has been found for group screening methods (Robinson, Hopkins, Davies, 1995; Wilkins, Lewis, Smith, Roland, Manning, & Evans, 2000). High test-retest reliability has also been documented by Jeanes et al (1997), Robinson & 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 being more suited to children aged 8-12 who were also being asked to undertake other tests. This test was validated on older adults, and separately on children aged 6-14 with IQs between 85 and 116 (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. 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 those within each category reported by Ekman and Friesen (1976) to have the highest interjudge agreement. 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.

It has been claimed 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 (Russell, 1994). Bryan (1998), however, emphasises that in real-life situations, social cues are often subtle and only available for

very short periods of time. These cues may also be contradicting or confusing. Bryan (1998) 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 also emphasises 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

Participants who were initially 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 for Facial Recognition (Benton et al., 1983), Word Attack and Word Identification (Woodcock, 1995), and Facial Affect (Ekman & Friesen, 1976). The LDDI 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. Any participants with a score indicating moderate symptoms or above were excluded from the study. 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.

For all three sub-groups, re-testing on all measures (except the Irlen Syndrome Screening Manual and the LDDI) occurred 3 months after the initial test administration. For the visual processing disability sub-group, this re-testing at 3 months ensured that they had received and used their appropriate coloured filters for at least two months.

Analysis

The data was examined to determine:

1. the relationship between learning disability and interpretation of facial affect;
2. the relationship between type of learning disability and interpretation of facial affect;
3. the effect of age and sex on interpretation of facial affect;

4. the effect of using Irlen coloured filters on the interpretation of facial affect for the learning disabled-visual sub-group;
5. the relationship between ability to interpret facial affect and word recognition/word attack skills.
6. the relationship between ability to recognise faces, ability to recognise facial affect, and type of learning disability.

RESULTS

Participants in the study were primary school students aged between 8 and 12 years. The ages of the participants in the Irlen Syndrome group, the Learning Difficulty group, and the Control (non-LD) group are in Table 1. Though the groups were in geographically different locations, they appeared to be comparable in respect of age.

Table 1: Means and Standard Deviations for age (in years and months) for males and females, Irlen Syndrome, LD and Control groups

Group	N	Mean	Std. Deviation
Males	63	10.1	1.48
Females	40	10.0	1.33
Irlen Syndrome	42	10.1	1.42
LD	30	9.9	1.41
Control	31	10.1	1.44

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, LD mean rank 42.7, $p < .05$.) The Learning Difficulty 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 all scales ($p < .001$ in all cases).

Pretest Results

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

Table 2 Means and standard deviations of results of all tests for the Irlen, LD 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)	Irlen	42	128.7	51.4
	LD	30	83.4	35.9
	Control	31	68.7	14.8

Differences between groups were examined using T-tests, and as assumed, there were significant differences on Word Attack and Word Recognition between the control groups and the other two groups. The LD 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, $t = -8.2$, $df = 71$, $p < .001$). Effect sizes are reported below.

There were also differences between the LD and Irlen groups on Word Attack ($t = -2.67$, $df = 70$, $p < .001$), with the LD group performing better.

On the tests of Facial Recognition and Facial Affect, the LD group was similar to the control group, with the exception of a small difference on Facial Affect (score) ($t = -3.45$, $df = 59$, $p < .01$) and Facial Affect (time) ($t = 2.1$, $df = 59$, $p < .05$). However, the Irlen group differed significantly from the LD group on all these measures (Facial Recognition, $t = -7.4$, $df = 70$, $p < .001$; Facial Affect (score), $t = 5.44$, $df = 70$, $p < .001$ and (time), $t = 4.15$, $df = 70$, $p < .001$). The effect sizes are given below (Table 4).

Relationship between sex and performance.

Over all, there were no large differences between males and females on Facial Affect or Facial Recognition. None of the groups showed significant differences between male and female participants on any test except for a small difference in the LD group on Facial Affect (score) $t = 2.49$, $df = 28$, $p < .05$, with the females performing better than the males. There was a moderate effect size for Facial Recognition in the Irlen group (0.60) with the males performing better, and for Facial Affect (score) and (time) for the LD group (0.87 and

0.59 respectively). In each case the females performed better than the males. Overall, however, these sex differences did not affect the group results.

Effects of Age on results

As shown in the table above, the groups were very similar in age distribution. However, Pearson correlations between age and results were calculated to observe any relationships. There were no significant relationships between age and test results on the tests under consideration, as shown in Table 3.

Table 3: Relationship between test results and age of participants.

Test	Correlation
Facial Recognition	0.009
Facial Affect (score)	0.16
Facial Affect (time)	-0.13

When effect sizes were calculated for the differences between group means, large differences were found between both Irlen and LD groups and the Control group on the basic reading skills of Word Identification and Word Attack. This is as expected for groups that shown to have a learning disability. The differences were greater for the Irlen group. On the test of Facial Recognition however, the Irlen group differed from the LD 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 LD group by approximately one standard deviation on both these factors. The LD group also differed from the control group, but by a small to moderate amount, as Table 4 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.

Table 4: Comparison of pretest means in Face Recognition Test, Word Identification Test, Word Attack Test, and Face 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
Face Recognition (score)	Irlen & Control	-1.46
	Irlen & LD	1.35
	LD & Control	-0.05
Face Affect (score)	Irlen & Control	-1.41
	Irlen & LD	1.10
	LD & Control	-0.81
Face Affect (time)	Irlen & Control	1.20
	Irlen & LD	-0.90
	LD & Control	0.52

Post Test Results

The numbers of participants differed somewhat in the post-test results, because a few of the LD group left the state in the intervening three months.

Results for the three groups on each of the variables of interest are shown in Table 5.

Table 5: Post test means and standard deviations for Irlen, LD and control groups on tests of Facial Recognition, Facial Affect (score) and (time).

Test	Group	N	Mean	Std. Deviation
Facial recognition	Irlen	42	38.4	5.1
	LD	25	42.3	5.1
	Control	31	42.6	3.8
Facial Affect (score)	Irlen	42	37.8	6.3
	LD	25	38.4	4.0
	Control	31	40.7	4.5
Facial Affect (time)	Irlen	42	99.5	40.9
	LD	25	77.1	21.8
	Control	31	61.8	11.5

T tests on these post-test results showed that the Irlen and LD group did not differ on Facial Affect (score) ($t = -.37$, $df = 65$, $p = .71$), but did differ on Facial Recognition ($t = -3.02$, $df = 65$, $p < .01$). Irlen and LD also differed on time, ($t = 2.536$, $df = 65$, $p < .05$). The LD group did not differ from the Control group on Facial Recognition ($t = -.25$, $df = 54$, $p = .81$) nor on Facial Affect (score) ($t = -2.01$, $df = 54$, $p = .05$), but they did differ on Facial Affect (time), $t = 3.35$, $df = 54$, $p < .01$), because they took longer to complete the test. The Irlen group differed from the control group on all tests (Facial Affect (score) $t = -2.15$, $df = 71$, $p < .05$; Facial Affect (time), $t = 4.98$, $df = 71$, $p < .001$; Facial Recognition, $t = -3.85$, $df = 71$, $p < .001$). The

effect sizes for these differences are shown below.

Table 6: Effect sizes for post-Test results in tests of Facial Recognition, Facial Affect (score) and (time).

Test	Comparison	Effect Size
Face Recognition (score)	Irlen & Control	-0.84
	Irlen & LD	0.72
	LD & Control	-0.07
Face Affect (score)	Irlen & Control	-0.50
	Irlen & LD	0.10
	LD & Control	-0.30
Face Affect (time)	Irlen & Control	1.02
	Irlen & LD	-0.62
	LD & Control	0.83

Effect of Visual Perceptual Adjustment

Participants in the Irlen group were supplied with individually precision-tinted colour filters after pre-testing. On average, they had worn these for 2 months before post-testing.

Although the Irlen group still differed from the Control group on tests of Facial Recognition and Affect, there was a reduction in effect size between pre and post-testing for the Irlen group, as Table 7 shows:

Table 7: Change in effect size between pre and post testing between Irlen and Normal groups:

Test	Pretest	Posttest	Difference
Facial Recognition	-1.46	-0.84	>0.62
Facial Affect (score)	-1.41	-0.50	>0.91
Facial Affect (time)	1.2	1.02	>0.18

There was not a similar reduction in effect for the comparison between the LD and the Control groups, as Table 8 shows. For the LD group, performance on Facial Recognition remained virtually the same or deteriorated marginally, while performance on Facial Affect improved, but by about half as much as the Irlen group. The difference in time taken to achieve those scores however increased slightly. These results reflect the fact that the LD group somewhat improved their score on time for Facial Recognition, as did the Normal group. The Normal Group, however, did not improve their performance on correct responses, while the LD group did.

Table 8: Change in effect size between pre and post testing between LD and Normal groups

Test	Pretest	Posttest	Difference
Facial Recognition	-0.05	-0.07	<0.02
Facial Affect (score)	-0.81	-0.30	>0.51
Facial Affect (time)	-0.52	0.83	<0.31

The difference between LD and Irlen decreased pre-post owing to the improvement in Irlen scores. Because LD scores on Facial Affect (time) also improved, the difference was slight in that factor.

Table 9: Change in effect size between pre and post testing between LD and Irlen groups

Test	Pretest	Posttest	Change
Facial Recognition	1.33	0.72	>.61
Facial Affect (score)	1.1	0.1	>1.0
Facial Affect (time)	-0.9	-0.62	>0.28

DISCUSSION

The finding of significantly low scores for facial recognition and interpretation of facial affect in a group with learning disabilities related to visual processing confirms previous results obtained by Dimitrovski et al. (1998). The group with learning disabilities not apparently related to visual perceptual deficits however, were similar to normal readers on these tests, except for the time factor. This may reflect the observations made by Nicolson and Fawcett about the apparent difficulty dyslexics have with speeded and automatic tasks (Nicolson & Fawcett, 1994, 1995) including picture naming and lexical access. Their performance on this factor was not as poor as that of the Irlen group, however.

This study has further found that intervention by the application of specifically tinted coloured lenses to modify the child's visual perception appears of itself to have effected a change in ability to recognise faces, and facial emotion. While the effect sizes for these effects are strong, there is a much weaker effect for time taken to recognize emotion, and that no doubt reflects the part that learning plays in recognizing such facial affect. It may also reflect the difficulties with speeded tasks that dyslexics seem to have, referred to earlier. The current study was not however able to differentiate between these effects.

The findings of this study and the study by Dimitrovski et al. (1998) supports the claims by Rourke (Rourke, 1987, 1988; Rourke & Fuerst, 1991), as well as others (Kohornen, 1991; Gross-Tsur et al., 1995; Spafford & Grosser, 1993), that children with a non-verbal/visual

processing type of learning disability are more likely to have difficulties in social interaction, especially with interpretation of subtle visual cues critical to understanding social events. Given the critical importance of interpreting facial cues in any social interaction, these results suggest that children with visual processing problems are likely to be particularly disadvantaged, although it must be remembered that a number of social information processing variables are needed to account for social behaviour (Crick & Dodge, 1994). However, one may easily imagine a classroom scenario where a teacher expresses anger or disgust at a student's actions and the student misinterprets the degree of emotion involved, failing to respond in a manner considered appropriate by the teacher.

It could be hypothesised that some form of central nervous system dysfunction causing visual processing problems may lead to impaired communication, resulting in a lowered self-concept and poor social interaction. This in turn may lead to further lowered self-esteem, less personal-social interaction and possibly increased reactive behaviour. Crick and Dodge (1994) suggest that socially maladjusted children may become withdrawn because of negative interaction with peers. They may selectively attend to negative cues more than their peers, leading to negative views of social interaction (Crick & Dodge, 1994). Peer relationships are 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). The usual diagnostic batteries for children with a learning disability do not include assessment of social skills. To limit assessment of school learning problems to difficulties in literacy and mathematics ignores the importance of social interactions and reduces the possibility that we will effectively help such children or fully understand the nature of their problems. Intervention programs for such children usually concentrate on academic skill building rather than on the development of social skills, and yet longitudinal evidence suggests a link between significant social and workplace problems in later life and social adjustment in childhood (Minskoff, Sautter, Hoffman, & Hawks, 1987; Parker & Asher, 1987; White, 1985).

Rock et al. (1997) 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 teaching 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), with the hope that facilitation of broader communication skills will help develop social competence, improve self-esteem and reduce problem behaviour (Vallance, Cummings, & Humphries, 1998). Such an approach 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).

The finding that children with learning disabilities have difficulty interpreting emotion from facial expression is paralleled by findings in a variety of other areas of disability. Hobson (1986, 1991) found that children with autism were significantly less proficient at recognising facial expression or emotionally expressive gestures. Davies, Bishop, Manstead, and Tantam (1994) found a similar significant difference in processing facial stimuli which was hypothesised to reflect a general perceptual deficit. Celani, Battacchi, and Arcidiacono (1999) found such children were significantly worse at perceiving emotional expression in faces than a group with Down Syndrome and a group with normal development, while Schultz (2000) used functional Magnetic Resonance Imaging to assess the neural organisation of people with autism and concluded that they perceive faces as if they were objects.

There is also a substantial amount of evidence to suggest that people with schizophrenia have difficulty processing facial expressions and recognising facial emotions (Borod, Martin, Alpert, Brozgold, & Welkowitz, 1993; Cramer, Weegmann, & O'Neill, 1989; Mandal, Pandey, & Prasad, 1998; Schneider, Gur, Gur, & Shtasel, 1995). Recent evidence suggests this may be caused by a disturbance in visuospatial processing of facial emotions (Streit, Wolwer, & Gaebel, 1997), and neurocognitive difficulties (Kee, Kern, & Green, 1998).

Problems with social interaction have also been identified in one sub-group of children with Attention Deficit Hyperactivity Disorder (ADHD). Kinsbourne (1991) identified a sub-group who he called "overfocussed" because they become "stuck" or overly focussed on certain activities. Among the characteristics he identified for this group was difficulty reading non-verbal cues such as faces. Other studies have identified a significantly lower social and emotional functioning in adolescents with ADHD when compared to their non-disordered peers (Lufi & Parish-Plass, 1995; Wilson & Marcotte, 1996). Tracey and Gleeson (1998) found adolescents with ADHD reported significantly less concern about others' feelings and about relationships with others than did non-disordered adolescents.

The findings of difficulties in social interaction and interpretation of facial expression in a variety of diagnostic categories raises the question of overlap in current disability terminology. Broad diagnostic categories currently in use, such as learning disability, autism, ADHD, and schizophrenia could include overlapping clinical disorders, which may cause confusion about diagnosis and appropriate treatment. The visual processing difficulties which cause problems in interpreting facial affect for people with learning

disabilities may have a similar causal basis for difficulties in interpreting facial expression in people with autism and schizophrenia and for one sub-group of people with ADHD. Cade, Privette, Fregly, Rowland, Sun, Zele, Wagemaker, and Edelstein (2000) found similar patterns of peptide abnormalities in people with autism and schizophrenia, with a diet free of gluten and casein, or dialysis plus a diet free of gluten and casein, leading to a decrease in these peptide abnormalities and to improvements in clinical behaviour. These results led to speculation by the authors that both disorders may be due to the same basic deficit.

A number of other authors have suggested that there is a substantial overlap in the diagnostic categories of learning disability and ADHD (Parry, 1996; Reynolds, Elksnin, & Brown, 1996), with the possibility that they have a common neurological or genetic influence (Hay & Levy, 1996). A possible overlap between one visual processing sub-type of learning difficulty (Irlen Syndrome) and ADHD, was identified by Williams, Littell, Reinoso, and Greve (1994), who found that the use of colour filters resulted in improved attentional processing for subjects with ADHD. There are also examples of a possible overlap between Irlen Syndrome and autism. Pemberton (1999) reported a case study of a child with autism who had significant improvements in social interaction as a consequence of the use of coloured filters. 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, Wolwer, & Gaebel, 1997), and similar eye movement problems are frequently reported in people with Irlen Syndrome (Fletcher & Martinez, 1994; Robinson & Foreman, 1999b; Solan et al., 1998; Tyrrell, Holland, Dennis, & Wilkins, 1995). There are also some reports of similarities in brain differences between individuals with a number of developmental disorders such as LD, autism and ADHD (Diamond, 2000).

The possibility of overlapping categories of diagnosis has been put forward from a variety of sources (Anderson, 1997; Cohen, 1994), and 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 be enhanced by long-term replication and the inclusion of other measures

such as rapid naming of pictures to explore the time factor in the recognition of facial affect. 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.

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