

# Optometric assessment and management in dyslexia

Dyslexia has been described as a language coding problem<sup>1</sup> and can be considered to be synonymous with the term specific reading problem. It is not related to social, emotional, economic or obvious disease (e.g. Down's syndrome) problems and can only be diagnosed by an educational or child psychologist. There may be a difficulty with reading, spelling, understanding language that is heard, and clear expression when speaking or writing. Some sufferers may have difficulty with speaking clearly or with handwriting. Others have difficulty with right and left or the concept of before and after. Others may have less severe or even mild difficulty in one or two other areas such as organising. Some have additional problems such as attentional deficits. No two dyslexics are alike; each has individual strengths and weaknesses<sup>2</sup>.

An unexpected gap exists between the potential for learning and school achievement, i.e. their academic skills are 'out of step' with their general ability. It is important to remember that not all have problems with reading<sup>3</sup>. It is a medical problem and is considered to be caused by a 'minimal brain dysfunction', also described as a differential brain function. Rosen et al<sup>4</sup> noted that there can be one or more (up to fifty) affected sites or lesions in the brain, in which small cortical areas have abnormally arranged cells.

Research has indicated that up to 15% of the population may be dyslexic and that fewer than one in ten will actually be identified as needing help and be able to receive formal diagnosis. A proportion will overcome early difficulties but for the majority learning difficulties are likely to persist and to have deleterious consequences on their later careers<sup>2</sup>.

People are born with dyslexia and often other members of the family are dyslexic or have a difficulty learning to read and spell. Dyslexia is not out grown, although most dyslexics develop coping strategies (e.g. avoiding reading). Dyslexics may have a wide range of talents, for example in art, drama, maths and sports, yet they may have difficulty remembering things or organising themselves<sup>2</sup>.

This article will concentrate on the optometric assessment and management of those who have dyslexia but the techniques described are equally valid for anyone who is under achieving at school or work whether they are formerly diagnosed as dyslexic or not.

Vision has been defined as a continuous and integrative process that can be divided into three components: (1) visual acuity, including refractive status; (2) visual efficiency, which is composed of oculomotor, accommodative and binocular vision skills; and (3) visual perceptual-motor skills, which represent the ability to recognise and discriminate visual stimuli and interpret them correctly in the light of previous experience<sup>3</sup>. While it is recognised that all of these components are equally important the emphasis will be placed on visual efficiency

## Vision problems and dyslexia

A useful model has been put forward in an attempt to relate vision problems, dyslexia and other general problems<sup>1</sup> (Figure 1). A general

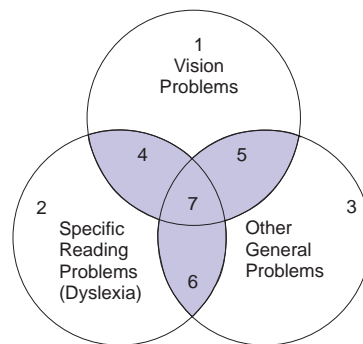


Figure 1

reading problem due mainly to vision problems, such as high, uncorrected hyperopic astigmatism would fall into circle 1. An individual with dyslexia and a concurrent vision problem would fall into area 4. From the diagram it can be seen that optometric evaluation would be useful for those people who fall into circle 1 and in particular areas indicated by and in particular areas indicated in Figure 1 by 4, 5 and 7.

Visual disorders such as hyperopia, convergence insufficiency, poor fusional vergence reserves, fixation disparity, hyperphoria, anisometropia, accommodative dysfunctions, among other dysfunctions have been shown to adversely affect reading performance and sustainability<sup>2,3</sup>.

This article will focus on the assessment of vergence and accommodative ability and the management of vergence and accommodative dysfunction. The assessment techniques and management strategies described below are not intended to be prescriptive or in any way describe a gold standard; there will be other tests and management lines that practitioners will use and consider better than those described here. The protocol described here was learnt and adopted by the author by combining experience obtained from the Specific Learning Difficulties Clinic at the Institute of Optometry, from general optometric practice and from information obtained from the literature (see below for a list of useful texts). Information on the assessment and management of saccadic and pursuit eye movements and fixation can be obtained from Griffin et al<sup>1</sup>.

## Visual perceptual distortions and symptoms

Some children and adults, who have difficulty with reading, experience visual perceptual distortion and complain of asthenopic symptoms when viewing a page of print. The letters may appear to move, jumble or to blur; white paper may glare and cause eyestrain or headaches. The resulting visual and physical discomfort is very likely to interfere with reading, and often attention and concentration are reduced. These distortions can be caused by a conventional optometric anomaly such as hyperopic astigmatism, a deficit in the binocular vision system (reduced visual efficiency), by Meares-Irlen Syndrome or a combination of some or all of these. Lightstone and Evans<sup>5</sup> have suggested a sequential assessment and management plan to determine the cause of these signs and symptoms.

## Meares-Irlen Syndrome

Visual perceptual distortions and asthenopic symptoms alleviated by individually prescribed coloured filters are considered to be due to Meares-Irlen Syndrome<sup>6</sup>. These distortions and symptoms can occur quite independently of any eye problem in people whose sight is otherwise perfect. Meares-Irlen Syndrome may be due to pattern glare, which has been described as an over sensitivity to the stripy line pattern that dark print makes on a white page<sup>7</sup>. This can occur in a person with or without dyslexia and probably does not cause dyslexia but can however, hinder educational rehabilitation. Some people with specific reading and learning difficulties may not voluntarily report experiencing these visual distortions and symptoms, and it is therefore important to remember that it may take detailed and sensitive questioning from an experienced practitioner to elicit these problems.

## Binocular vision (visual efficiency) evaluation

The two main binocular vision related problems that occur are vergence and accommodative disorders. The vergence and accommodative mechanisms must be functioning efficiently to facilitate accurate sustained and reading. These two anomalies can occur together or independently and are amenable to treatment with lenses or eye exercises. These are varied and are chosen to match the individuals age and specific problem.

## Vergence disorders

Vergence disorders are very common in non-presbyopic subjects and can result in ocular discomfort, headaches, diplopia, blurred vision and fatigue during reading and other near point tasks. Some subjects do not have asthenopia because they avoid near-point tasks.

## Tests of vergence function

Simons and Grisham<sup>8</sup> concluded that the demand to co-ordinate and maintain clear, single binocular vision can be substantial when binocular anomalies are present and that exophoria at near and weak vergence reserves are related to reading difficulty. Binocular instability is characterised by low fusional reserves and an unstable heterophoria<sup>9</sup> and has been described as a correlate of dyslexia<sup>10</sup>.

Clinical tests of vergence function can be grouped into four categories: (1) convergence amplitude (synonymous with the term near point of convergence), (2) horizontal vergence reserves, (3) vergence facility, (4) jump prism. Fixation disparity and the aligning sphere or prism is also discussed as one study<sup>11</sup> found a significant correlation between fixation disparity and reading performance

### 1. Convergence amplitude

Also termed the near point of convergence (NPC), this is most accurately measured with a RAF rule (Figure 2). In order to check for fatigue it is useful to measure NPC three times at the beginning of the testing session and twice at the end. The value can be noted in terms of the break point, which occurs when the subject reports diplopia, (subjective result) or when the clinician has noticed one or both eyes of the subject diverge (objective result). It is also useful to note the recovery point, i.e. when the subject reports single vision or the observer notices that both eyes are pointing to the test target. Both break and recovery can be

Figure 2



measured to the nearest 0.5 cm. A remote near point of convergence (NPC) with a break greater than 10 cm is considered to be the most consistent finding in subjects with convergence insufficiency. See Table 1 for Morgan's normative values.

Fatigue needs to be assessed as the subject may be able to produce one clinically acceptable result with the RAF rule, but the NPC may increase with further testing. Interestingly in the author's experience many subjects report the occurrence of visual symptoms only after several minutes of reading and cannot sustain a good reading performance for any substantial period of time.

### 2. Horizontal vergence reserves

These (synonymous with the terms fusional reserves and prism vergence) can be measured in several ways. Orthoptists tend to use a prism bar (step vergence). Those optometrists with an interest in this field often use a Risley rotating prism (smooth vergence) either monocularly in a trial frame, or binocularly in a phoropter. The results differ according to which procedure is used so when recording results it is important to note the instrument used. The procedure described below relates to the use of a prism bar.

Base-in and base-out values for near are usually the most useful when investigating reading dysfunction, although distance values can also be obtained. The blur, break and recovery points for both base directions need to be obtained. The patient is asked to inform the clinician when the letters become blurred, double or move to one side (i.e. suppression indicated). Base out prism is slowly introduced before one eye until blur, diplopia, or suppression is reported. If blur is reported, the amount of prism is increased until diplopia or suppression is reported which is the base-out break point. The prism power is reduced until fusion is reported, which is the recovery finding. The same procedure can be conducted for the to determine the base-in findings<sup>1</sup>.

This is a direct measure of fusional vergence. The blur point is reached when the subject has used all available fusional reserves and has to use accommodative convergence to keep the test target single. As accommodative convergence is brought into play the subject accommodates and the test target becomes blurred. The break point corresponds to the point when the subject no longer has any fusional or accommodative vergence remaining and the test target becomes double. It is possible to have a normal convergence amplitude (NPC) as measured with the RAF rule

Test	Expected Finding	SD
<b>Cover Test (near)</b>	3 exo	3
AC/A ratio	4/1	2
<b>Smooth vergence</b>		
Base-out (near) break	21	6
Base-in (near) break	21	4
<b>Step vergence</b>		
Children 7-12		
Base-out (near) break	23	8
Base-in (near) break	12	5
<b>Near point of convergence</b>		
accommodative target break	2.5cm	2.5
recovery	4.5cm	3
<b>Amplitude of accommodation</b>		
Push-up test	18- <sup>1</sup> / <sub>3</sub> age	2
<b>Monocular Accommodative Facility Children</b> (2.00 flippers, calling out letters on accommodative cards)		
6 years old	5.5cpm	2.5
7 years old	6.5cpm	2
8-12 years old	7.0cpm	2.5
<b>Binocular Accommodative Facility Children</b> (2.00 flippers, calling out letters on accommodative cards)		
6 years old	3.0cpm	2.5
7 years old	3.5cpm	2.5
8-12 years old	5.0cpm	2.5
<b>MEM retinoscopy</b>	+0.50	0.50
<b>Negative relative accommodation</b>	+2.00	0.50
<b>Positive relative accommodation</b>	-2.37	1.00
<b>Vergence facility</b>		
Scheiman et al <sup>18</sup> used 12 base out and 3 base in prisms for a paediatric population; 114 fifth and sixth grade (US) children (ages not provided). Mean vergence facility was 12.13 ± 4.00. They concluded that the expected finding (with these prisms) was 15 cpm, and anything less than 12 cpm 'should reliably detect symptomatic children'.		

Table 1  
Morgan's normative values for binocular vision testing

push up test and still have a vergence problem. This is described as fusional vergence dysfunction.

The blur, break and recovery findings can be used to establish the boundaries of the zone of clear, single binocular vision and in the application of the criteria of Sheard and Percival in clinical case analysis.

### 3. Vergence facility

Vergence facility has been defined by Griffin et al<sup>1</sup> as the rate at which positive and negative fusional vergences respond in a given period of time. This can be assessed with prism flippers and is recorded as the number of cycles per minute (CPM) that a stimulus can be fused through alternating base-in and base-out prism. A test distance of 40 cm is usually used with either the Bernell vectogram S0/V9 Acuity Suppression Slide (Figure 3) or the OXO letters

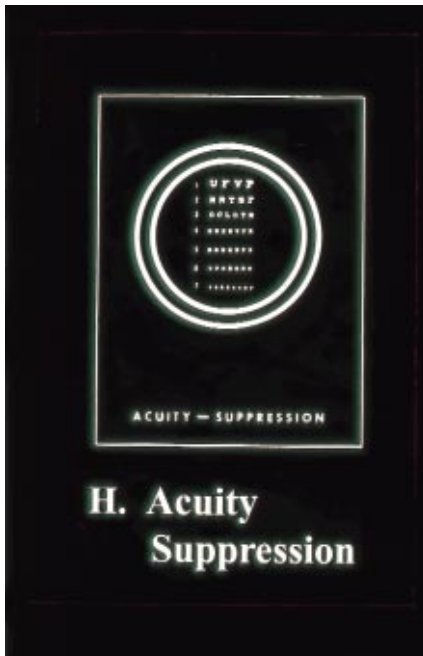


Figure 3

and the vertical fixation disparity bars on the near Mallett Unit with polarising filters.

Vergence facility testing is an attempt to capture the ability of the fusional vergence system to respond rapidly and accurately to changing vergence demands over time. It measures stamina and sustainability where sustainability is defined as the ability to maintain vergence at a particular level, rather than to rapidly alter the level, for a sustained period of time. Holding the prism flipper in front of the eyes until the subject experiences ocular discomfort assesses sustainability.

Various combinations of base-in and base-out lenses have been described in the literature, including 4Δ base-in/16Δ base-out, 5Δ base-in/15Δ base-out and 8Δ base-in/8Δ base-out. The author currently uses 6Δ base-in/18Δ base-out but some authorities may consider the base-out prism to be too high. With 4Δ base-in/16Δ base-out flippers one study showed that 5 year olds had a mean of 7.6 cycles per minute and 12 year olds had a mean of 13.0 cycles per minute. With the 5Δ base-in/15Δ base-out and 8Δ base-in/8Δ base-out flippers mean values were similar for the two tests, ranging from 11.3 to 14.1 cycles per minute. The standard prism now seems to be the 8Δ base-in/8Δ base-out. Griffin and Grisham<sup>12</sup> concluded that with this prism flipper that the criterion for inadequate performance is a facility of less than 5cpm.

Some clinicians put less emphasis on the quantity of cycles per minute and more on the quality of vergence movements, that is, any discomfort, grimacing or tendency to pull away from the flippers. The ease with which the subject overcame the prisms can be noted.

#### 4. Jump prism

Values for near and distance can be determined by the introduction of loose base-out prism in large increments and increasing in strength. The examiner should watch for a fusional eye movement and for recovery on removal. The maximum prism that the subject can just overcome is recorded.

#### 5. Fixation disparity

This is a condition in which the images of a binocularly fixated object do not stimulate exactly corresponding retinal points but still fall within Panum's fusional areas, the object thus being seen singly. The existence of fixation disparity indicates that there is a slight over convergence (eso-fixation disparity) or under convergence (exo-fixation disparity) of the lines of sight under binocular conditions. This misalignment is very small, since sensory fusion would not otherwise be possible. Fixation disparity usually is measured in minutes of arc. If it were expressed in prism dioptres, it would usually be less than 0.25Δ and most always would be less than 0.75Δ. Fixation disparity can be described as the accuracy of the vergence system<sup>1</sup>.

#### Aligning sphere or prism

The near Mallett Unit can be used to detect the presence of a fixation disparity and allow the examiner to determine the prism power that reduces the fixation disparity to zero<sup>13</sup>. Fixation disparity can be detected using the Mallett Unit by subjective alignment of two small green Nonius bars, one seen by each eye. Other than the bars used for alignment, all features of the test target are seen binocularly. The subject must view through Polaroid filters. Vertical bars are used for the assessment of horizontal fixation disparity and horizontal bars are used for assessment of vertical fixation disparity.

Subjects should be encouraged to report even the slightest displacement, no matter how small it may seem. Some subjects may report that the bars move or vibrate, others may report that the bars or perhaps just one bar fades. These observations should be noted, as they are a sign of binocular instability. Typically, the right eye sees the top vertical bar and the bottom bar is seen by the left eye. Thus if the subject reports the top line being to the right of the bottom line, an eso-fixation disparity exists; if the top line is to the left of the bottom one, an exo-fixation disparity exists.

The amount of base-in prism or negative spheres required to reduce an exo-fixation disparity to zero or the amount of base-out prism or positive spheres required to reduce an eso fixation disparity to zero use to be referred to as the 'associated phoria'; however, the terms aligning prism or aligning sphere may be more appropriate to describe this type of eye deviation.

Stress associated with the use of fusional convergence can result in asthenopia. Clinical fixation disparity detection is a useful diagnostic

tool because it is related to fusional convergence effort. Many clinicians feel that a complete work-up of vergence disorders should include analysis of dissociated heterophoria and fusional vergence findings and analysis of fixation disparity. Because the testing conditions and the variable measured are different, analysis of fixation disparity and analysis of dissociated heterophoria and fusional amplitudes do not completely substitute for each other. It is possible for a subject without a significant dissociated heterophoria to have a fixation disparity.

#### Prescribing from the Mallett Unit

Mallett introduced the idea that the existence of fixation disparity indicates that fusional convergence has not adequately compensated for a heterophoria. A subject with an uncompensated phoria is one who has dissociated heterophoria and aligning prism with the same prism base orientations. Using this concept, Mallett recommended some prescription guidelines. For the young uncompensated exophore, base-out vision training or the minus add that reduces fixation disparity to 0 should be given. For the older uncompensated exophore, the base-in prism indicated by the associated phoria should be prescribed. In a subject with uncompensated esophoria at distance, the treatment of choice is the base-out prism of the associated phoria, and for the near-point uncompensated esophore, the plus add that eliminates the fixation disparity or a combination of a plus add and base-out prism can be used.

#### Accommodative disorders

Accommodative disorders in non-presbyopic subjects can result in blurred vision, headaches, ocular discomfort, and other difficulties associated with near work. Accommodative dysfunction in non-presbyopes is relatively common. Hoffman and Rouse<sup>14</sup> related asthenopic symptoms to several accommodative dysfunctions. The treatments for non-presbyopic accommodative disorders, plus lens additions and vision training, are very effective in relieving ocular symptoms.

#### Tests of accommodative function

Clinical tests of accommodative dysfunction can be grouped into four categories: (1) amplitude of accommodation, (2) accommodative facility, (3) tests that directly or indirectly assess lag of accommodation, (4) relative accommodation.

##### 1. Amplitude of accommodation

This is a measure of the maximum amount of accommodation an individual can exert and is usually measured using a RAF rule with the smallest text readable. It should be conducted monocularly and binocularly and repeated at least three times for each situation in order to assess for fatigue. Testing should be conducted

through the best optical correction if required with a threshold visual acuity target (smallest resolvable at 40cm). The target is brought closer to the observer as they attempt to maintain clarity of the letters. The endpoint is the point at which the letters first become blurred and remain so as testing proceeds. This distance is converted directly into dioptres using the scale on the RAF rule and compared to the value expected from the Hofstetter formula (minimum expected amplitude of accommodation given by  $15 \text{ minus } 0.25 \text{ the patient's age}$ )<sup>1</sup>.

## 2. Accommodative facility

This determines the speed of accommodative change. The dioptric accommodative stimulus is alternated between two different levels. The subject reports when a letter target is seen clearly after each alternation in accommodative stimulus. The examiner counts the number of cycles completed in one minute (one cycle being the change from one stimulus level to the other and back again). Accommodative stimulus can be varied either by lens power changes or by viewing distance changes. The first is referred to as 'lens rock' and the latter as 'distance rock', indicating that the accommodative stimulus is 'rocked' back and forth.

The standard method of testing accommodative facility (as described by Griffin et al<sup>2</sup>) is a lens rock procedure using a pair of +2.00D lenses on one side of a flipper bar and -2.00D lenses on the other side. The test is begun with the +2.00D lenses over the subject's refractive correction. A test distance of 40 cm is usually used with the reduced Snellen letters at a 6/6 to 6/12 acuity demand for monocular testing. This type of target has no suppression control and it is more appropriate to use either the Bernell vectogram SO/V9 Acuity Suppression Slide (Figure 3) or the OXO letters and the vertical fixation disparity bars on the near Mallett Unit with polarising filters for binocular testing. Some clinicians suggest that it may be better to train the monocular accommodative facility prior to the binocular facility, especially if the binocular lens rock performance is limited by fusional vergence dysfunction. In this case it would be appropriate to use reduced Snellen letters at near, since suppression would not be a problem.

The subject is told to fixate the target pointed to by the clinician and to say the letter aloud when it is seen clearly. The flipper should be rotated from plus to minus lenses and back to plus each time a letter is identified correctly. The number of letters correctly identified in one minute divided by two gives the accommodative facility rate in cycles per minute. When testing is binocular suppression can be monitored by the subject wearing red and green glasses, placing red and green strips on the letters.

Cut-offs for test failure used by many clinicians for +2.00D/-2.00D flippers and a 40 cm viewing distance for children and adults up to 30 years of age are less than 11 cycles per minute for monocular testing and less than 8

cycles per minute for binocular testing<sup>1</sup>. During binocular lens rock testing, adjustments in fusional vergence must occur to compensate for the changes in accommodative vergence. Therefore subjects may pass the monocular lens rock but fail the binocular lens rock facility if a vergence disorder is present.

## 3. Lag of accommodation

During accommodation for near-point viewing, the retina usually is conjugate with a point slightly behind the object of regard for near-point targets, accommodative response is slightly less than the accommodative stimulus. The amount by which the dioptric accommodative response is less than the dioptric accommodative stimulus is the lag of accommodation (also described as accommodative accuracy). This category of accommodation tests can be further divided into (1) tests that measure the lag of accommodation and (2) tests in which lens power is changed to alter accommodative stimulus to the point at which dioptric accommodative stimulus and dioptric accommodative response are equal. Examples of the first are monocular estimate method (MEM) dynamic retinoscopy. Examples of the last-mentioned are low neutral dynamic retinoscopy. A test card with an aperture in the centre is used for dynamic retinoscopy so that the examiner can observe the retinoscopic reflex close to the subject's visual axis through the aperture.

In MEM dynamic retinoscopy the amount of the lag of accommodation is estimated by judging the width, speed and brightness of the retinoscopic reflex. The test card and the retinoscope are placed at the same distance from the subject's spectacle plane, usually 40 cm (Figure 4). With the retinoscope in the plane mirror mode, with motion indicates a lag of accommodation and an against motion indicates a lead of accommodation. Neutrality indicates

Figure 4



that the accommodative stimulus and accommodative response are equal. The examiner's estimate of the amount of plus power that would be required to neutralise the with motion is the estimate of the lag of accommodation. The estimate of the lag can be confirmed by very briefly placing a plus lens equal in power to the estimated lag over one eye and quickly checking to see whether neutrality is observed. The lens should only be in place a half-second or less so that a change in accommodative response is not induced. School age children are reported to have a mean lag of 0.34D. Most non-presbyopic subjects have lags of 0 to 0.75D with MEM retinoscopy.

Low neutral dynamic retinoscopy yields the lens power with which the dioptric accommodative stimulus and dioptric accommodative response are equal. The retinoscope and the test card are maintained at the same distance from the subject, usually 40 cm from the spectacle plane. Testing is started with the subject's distance refractive correction in place. If a lag is observed, plus lenses are added in 0.25D steps until a neutral retinoscopic reflex is observed. The lens power added for neutrality is recorded. If, for example, the test result is +0.75D with a 40cm distance, then the accommodative stimulus is 0.75D less than the 2.50D for the test distance, or 1.75D. Since the neutral was observed at that point, the accommodative response is also 1.75D.

## 4. Relative accommodation

Tests are the plus-to-blur (or negative relative accommodation [NRA]) and the minus-to-blur (or positive relative accommodation [PRA]) tests. During testing the accommodation is varied while the convergence is stable. Measurements are difficult with a trial frame and are best made with a phoropter. The subject is instructed to view a near target, usually at 40 cm, through their distance refractive correction. To assess the positive relative accommodation minus lenses are added in steps of -0.25 D, at approximately 2-second intervals while the observer is asked to keep a near-threshold visual acuity target at 40 cm clear. The end point is reached when the observer first reports that the letters appear blurred and remain so as the testing proceeds. Positive lenses are added until the test target becomes blurred. The positive lenses are removed and then negative lenses are added until the target again becomes blurred. This is also an indirect assessment of the vergence system since the vergence demand remains constant while the accommodative demand varies.

## Morgan's normative values

Morgan developed a set of norms from a statistical study of clinical data from a non-selected group of 800 pre-presbyopes. Morgan determined the mean and standard deviation for several findings. He arbitrarily set one-half standard deviation on either side of the mean as his normal range (Table 1).

## Management of vergence and accommodative dysfunction

Vision training can be used to increase positive fusional vergence and negative fusional vergence. It may also be able to increase the amplitude of accommodation. Latency and velocity of convergence or accommodative responses or both can also be improved with vision training by which the patient develops an increased self-awareness of visual processing and eventually automaticity of processing. Personal experience has highlighted that compliance is improved when a series or combination of exercises, of increasing difficulty are used, with regular (two weekly) review. Training is best conducted both at home and in the practice where regular visits can be used to reinforce procedures and emphasise improvement and continually reassess the techniques that have been recommended.

### Push-up training

This is a common technique used to improve positive fusional convergence and the near point of convergence. The subject brings a fixation object closer in the mid-line until it feels as if the object will split in two or until it does. This is repeated several times so that the subject is able to bring the object closer before diplopia occurs. If small letters are included in the fixation object for better control of accommodation, this technique can also be used to improve the amplitude of accommodation when indicated. To check for suppression it is important to have the patient be aware of physiological diplopia occasionally during the push-up training<sup>1</sup>. Variations of this technique are described below.

### Pen to lid

This is a simple exercise that can be used with young children or as part of a combination of exercises for any age group. A standard 'Biro' type pen and lid are required. The subject should be instructed to hold the pen and lid at arms length and the with both eyes open to inset the writing end of the pen into the smaller of the two apertures in the pen lid. This can be repeated 10 times at arms length and further repeated at half arms length and then again at around 10 cm<sup>15</sup>. There is no suppression control for this exercise but it still forms a useful introduction.

### Brock string

This provides a simple, but very useful and versatile, training technique. One end of the string is tied to a chair, doorknob, or other object, while the other end is held against the nose. The subject is instructed to maintain singleness of the bead being fixated. The bead is moved closer to the subject for push-up training or farther away from the subject for push-away training. Vergence facility can be improved by having the subject alternate fixation between two or more beads. One advantage of the Brock string is that it provides obvious suppression

controls. The string should appear to be an X crossing at the fixated bead, due to physiological diplopia as should the beads not being fixated.

### Dot card

This works in a similar fashion to the Brock string but has the advantage of having letters on one side, which can be used to train accommodative dysfunction (Figure 5). The use of this card is limited to those subjects who have reasonable vergence and accommodative function to allow clear and single fixation of the dot or letter at the far end of the card. The presence of physiological diplopia acts as a suppression control.

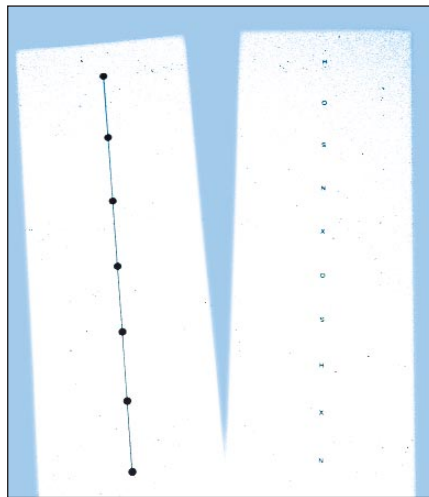


Figure 5

### Dinosaur card

This is a stereogram similar to the well known cats card but it is more versatile as it can be used to train both negative and positive fusional convergence and has three levels of difficulty (Figure 6). It is a target, which makes use of chiasmatic fusion. This is fusion achieved by converging to fixate two laterally separated targets, similar enough to be fused, such that the right eye fixates the left target and the left eye fixates the right target. During chiasmatic fusion exercises the accommodative stimulus remains constant and depends on the distance from the spectacle plane to the target. The convergence stimulus depends on the target distance and the amount of lateral separation of

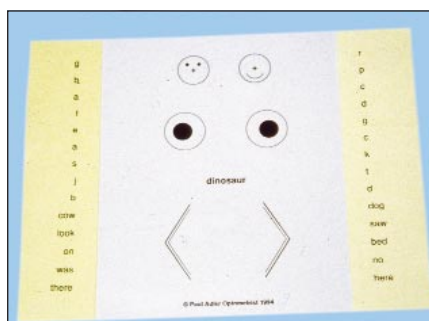


Figure 6

the fused targets, a greater separation yielding a greater convergence stimulus<sup>16</sup>.

### Binocular lens rock

This is a technique used to improve accommodative facility. A pair of plus lenses and a pair of minus lenses (usually +2.00 and -2.00D, but may be lower powers at the start of a training program), in a lens flipper bar are used to vary the accommodative stimulus. The plus lenses decrease the accommodative stimulus, while the minus lenses increase the accommodative stimulus. The convergence stimulus remains constant, so a change in the accommodative convergence must be accompanied by an equal magnitude but opposite direction change in fusional vergence. Therefore, binocular lens rock training may improve fusional vergence as well as accommodative facility. With a target at 40 cm and +2.00/-2.00D flippers, the accommodative stimulus alternates between 0.50 and 4.50D, while the total convergence stimulus remains constant at 15Δ.

Accommodative facility training can also be done with a distance rock procedure. The subject alternates fixation between a distance target and a near target. The targets should contain letters or figures close to the subject's best corrected visual acuity. Hart charts are examples of charts often used for this purpose (see Figure 7). The subject clears one letter on the distance chart and then clears one letter on the near chart, alternating between them as quickly as possible. The charts are usually placed at 3 to 4m and 40cm. Similar targets can be constructed using word processing software or with letters and text cut from newspapers.

### Convergence amplitude and vergence reserves

The Institute Free-space Stereograms (IFS) (Figure 8) have been developed and described by Evans<sup>17</sup>. The exercises are not novel but have

Figure 7





Figure 8

several subject friendly aspects, which make them extremely useful for vision training. They have a step by step user-oriented approach, with child friendly terminology and follow a self-contained approach so they can be carried out at home with minimum practitioner involvement. There are in built self-tests so users can regularly check that they are carrying out the exercises properly. There are four exercise cards with various targets that elicit a wide range of vergence angles with in built suppression checks. Evans<sup>17</sup> recommended the IFS for decompensated exophoria at near, binocular instability, convergence insufficiency, and intermittent exotropia at near.

### Vergence facility

This can be trained either at home or in the practice by using prism flippers. The subject is instructed to fuse a near target (SOV9 slide or near Mallett Unit Nonius bars with polarising filters) as quickly as possible after each rotation of the flipper. Accommodative stimulus remains constant as the vergence demand changes. Base-out prisms on one side of the flipper increase the convergence stimulus for a near target, and the base-in prisms on the other side decrease the convergence stimulus. See **Table 1** for normative data.

### Conclusion

There is now no doubt that vision problems and in particular binocular vision anomalies can seriously affect the ability to learn to read although it is also readily accepted that vision problems are not a direct cause of true dyslexia. All children and adults who are reading or learning underachievers, whether a formal diagnosis of dyslexia has been made or not, require a detailed evaluation of visual function, especially of the binocular vision system, at an early stage in their remediation.

### References

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### Useful reading

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2. *Optometric Management of Learning-Related Vision Problems*. (1995) Schieman and Rouse. Mosby. ISBN 0-8151-6385-7.
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### Useful contacts

1. Kay Pictures, PO Box 380, Tring, Herts, HP23 5NL; dot cards and dinosaur cards.
2. Paul Adler, 50 High St., Stotfold, Hitchin, HERTS, SG5 4LL, tel. 01462 732393; dinosaur cards, Brock strings, flipper bars without lenses and SOV9 Suppression slide.
3. IOO Marketing Ltd Tel: 020-7378 0330 for IFS exercises.