Vision and Dyslexia

A review of:
Creavin A.L et al 2015 Ophthalmic abnormalities and reading impairment: Paediatrics
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A New Study¹ is unconvincing in its argument that there is no link between dyslexia and physiological visual deficit. The study’s protocol points to the importance of inter professional collaboration.

Conclusion of the study
The majority of dyslexic children had normal results on all ophthalmic tests, which supports the consensus in the literature that dyslexia is not caused by vision abnormalities. Vision based therapies are not justified or likely to help

Introduction / Hypothesis

Definition of dyslexia
dɪsˈleksɪə/
noun: dyslexia

A general term for disorders that involve difficulty in learning to read or interpret words, letters, and other symbols, but that do not affect general intelligence.

Origin
Simple Dyslexia
The word Dyslexia emerged in the late 19th century: coined in German from dys- ‘difficult’ + Greek lexis ‘speech’ (apparently by confusion of Greek legein ‘to speak’ and Latin legere ‘to read’).

The original intention was to describe a condition where the individual had difficulty reading. It is easier to understand dyslexia directly related to a visual deficit (albeit complicated by subtle binocular vision difficulties), than the popular psychological view that it is due to a (birth) defect in central processing; a mental disorder1 2.

This psychological point of view is difficult to prove unless the cortical defects can be demonstrated in a longitudinal study, which shows them in a neonate who then goes on to become dyslexic.

It seems simpler to suppose that these anomalous brain scans are due to degraded sensory stimulation from one or both eyes (simple dyslexia).

This would open the door to an optometric solution rather than a life-time of palliative care and continuing difficulties, which this Bristol based study concludes is the only solution.

Review (Creavin A.L et al)
Confinement of Institutional Expertise
Science is painstaking and laborious and this distinguished group of consultant Paediatricians must be congratulated on the length and breadth of this study; working closely with Orthoptist and Psychologist colleagues in the hospital environment, in which they practice.

There was no Optometric involvement

Sometimes the results of research are as important for what they don’t find as what they do. In a perverse way this work and the media attention it attracted, may be the first step towards a real understanding of the cause and prevention of dyslexia and its correlates dyspraxia, dysgraphia, dyscalculia and attention deficit hyper activity disorder (ADHD)

Difference between Orthoptics and Optometry
The study was based on an orthoptic assessment of 5822 children between the ages of 7 and 9 Orthoptists and Optometrists differ in their understanding of the role of refraction and the accommodation/vergence reflex in fine binocular control.

Orthoptists generally do not need to measure fine motor control. They do not refract or measure fixation disparity to assess sensory fusion. For instance traditional orthoptic tools like patching and cycloplaegia both mitigate against binocular vision. Orthoptic exercises in the absence of a full refractive and prismatic correction will habituate an underlying accommodation led binocular instability and patients will very often be non-compliant.

For experienced optometrists cycloplaegia is a method of last resort. It is traumatic and prevents the measurement of the normal relationship between accommodation and vergence, which is essential to the refractive management of binocular instability and amblyopia; amblyopia is a physiological adaptation to binocular deficiency. It might be reasonable to say that Orthoptics is concerned with the gross assessment of binocular control and Optometry with its fine measurement. Orthoptics is mainly concerned with ocular pathology and Optometry with physiological (normal) variations.

Understanding these differences may begin to explain why the study found no significance in the relationship between vision and dyslexia. Broader inter professional collaboration could be considered before presenting any conclusion to the National Institute for Health can Care Excellence (NICE) for national implementation.
Predisposition to dyslexia

Binocular instability at the near point causes attention to swap constantly from the dominant to the non-dominant eye. This is the primary predisposing factor to simple dyslexia. It leads to the secondary signs and behavioural difficulties categorised by Psychology and attributed to mental disorders. It is likely that the grey area between normal binocularity (orthophoria at distance and near and acuities of 6/5 R+L) and manifest squint, is where these binocular deficits cause difficulty. It is in this area where vision needs to be measured most carefully.

The study concluded that there were “normal results on all ophthalmic tests” and that dyslexia is not caused by vision abnormalities. It might have said less ambiguously that the majority of dyslexic children had normal results “on all orthoptics based ophthalmic tests”.

The conclusions are based on the results from these tests so it would be helpful to see if they have the necessary sensitivity.

1-11, Tests done in the research (with optometric comment)

1. History and Symptoms
   20 minute protocol and questionnaire
   
   Comment
   The protocol was driven by hospital based orthoptists and a psychologists definition of dyslexia, which may have biased the research protocol.

2. Reading speed
   By completion of the Neale Analysis of reading ability scale (NARA II)
   
   Comment
   The Neale analysis of reading ability is not well known amongst optometrists. It is an assessment tool for children between the ages of 6 and 12. Trained psychologists recorded reading speed errors and comprehension.

   Reading speed may not be a reliable guide to an underlying binocular vision problem. One of the adaptations to dyslexia in bright children is speed-reading which relies on skilful use of the peripheral visual system and recognition of words by their first and last Letters. When this is true the sense of the passage will not be impaired by binocular instability in all children, it is important to separate out the speed-readers when looking for significance using this test.

   A better measure is tracking or the rate of individual character recognition or Dynamic Fixation, which measures the ability of the eyes to move accurately from one point in space to another.

   The Neale test has its origin in the recognition of severe learning difficulties. Reading this publication is difficult, it gets bogged down in the explanation of variables and dense statistical analysis. Frustratingly there was no illustration of the test but it seems to rely on reading smaller and smaller lines of words of the same font. The complexity of the test may derive from the lack of understanding of the relationship between reading and binocular stability. This may be why psychologists have accepted that dyslexia is difficult to diagnose in bright children.
3. Vision
Part of this group are amblyopes with a history of patching assessed from questionnaire

Comment
These children, especially those with manifest squint or dense foveal suppression scotomas in the amblyopic eye, fall outside the grey area and are unlikely to be dyslexic. They should be added to the data with caution. Including them suggests that the authors may not have a clear model on which to base their hypothesis.

Learning difficulties can occur if the non-squinting eye has accommodative insufficiency. These difficulties would not be due to binocular instability but an inability to see clearly when reading (binocular amblyopia or a lesser degree of amblyopia in the “better” eye).

4. Acuity
Current acuity accurately tested in the clinic

Comment
The hypothesis was that vision is an important determinant in the aetiology of dyslexia so its measurement is critical to the scientific validity of the study.

The paper doesn’t describe how acuity was measured. It is not clear what it means by acuity, which is normally specified by date after a full refraction and binocular vision assessment, in the standardized conditions of the consulting room. It is possible that unaided vision is being described as acuity. This lack of rigor on the measurement of vision (unaided or with present spectacles) and visual acuity undermines confidence in the results.

If acuity is not accurately measured then the effect of the intervention (for instance a reduction in amblyopia) cannot be determined.

5. Contrast sensitivity
Pelli –Robson chart for each eye

Comment
The Pelli-Robson chart was developed to facilitate the detection of various diseases, which impair visual function. Contrast Sensitivity Function (CSF) is a useful indicator of visual performance but not specific. It could be restricted in its use to patients in whom ocular disease is suspected.

A physiological deficit in binocular function won’t necessarily lead to a loss of contrast sensitivity. Four data groups need to be separated:

- Amblyopes,
- Binocularly deficient,
- A combination amblyopia and binocular dysfunction
- The pathological,

It is not clear that the study did this and therefore what useful information the Pelli –Robson chart added.

It is more useful to measure vision (unaided or with existing spectacles) at high and low contrast using Ballie Lovie LogMAR charts. This gives an indication of contrast sensitivity and vision (not visual acuity). It acknowledges the limitation of a measurement of monocular vision as being the cure all for the investigation.

Low contrast vision at near is also measured in the CReST test recognizing the importance of contrast sensitivity, which can be related to the other diagnostic tests (see below).
The diagnostic elements of occupational visual performance and tracking

Vision at high and low contrast is one of the key diagnostic elements of visual performance, the others include:

- Visual acuity after refraction
- Eye Dominance\textsuperscript{11}
- Objective muscle balance (Von Graefe\textsuperscript{12})
- Sensory fusion (Mallet\textsuperscript{13} and Brock String)
- Colour preference and Light sensitivity\textsuperscript{14}
- Accommodation facility\textsuperscript{15}

Tracking (Dynamic Fixation\textsuperscript{8} and Rate of individual character recognition CReST\textsuperscript{7})

Tracking is an analytical test (involving more that one diagnostic element), but does give a strong indication of a predisposition to reading difficulties and dyslexia. Dyslexia itself is a multifactorial problem often involving all the elements of visual performance. Each element may be identified and corrected to produce the optical correction. The tracking tests can then be repeated on subsequent occasions to demonstrate an improvement.

6a. Need for glasses

Estimated mean sphere refractive error by Cannon R50 auto refractor

Comment

It is disappointing that so little importance is attributed to refraction that it is measured using an auto-refractor without taking the astigmatism into account. This may reflect the less critical importance of non-cycloplagia refraction in orthoptics and why it is not considered a factor in dyslexia.

If auto refraction were reliable\textsuperscript{16} (proximal accommodation for example) all optometrists would use it and save 2 or 3 hours work per day.

6b. Need for glasses defined as

- Hyperopia in either eye \( \geq +2.00 \) sphere equivalent
- Myopia \( \geq -1.50 \) sphere equivalent

Comment

This definition eliminates the greater part of the subjects who would be most strongly predisposed to dyslexia.

Astigmatism is not taken into account; a sign of extra ocular muscle tension across the cornea. +1.50 combined with accommodative insufficiency can have disturbing effects on binocular balance (decompensated eso phoria).

A normal refraction is +0.5 to +0.75\textsuperscript{17}. Emmetropia is incipient myopia and significant in it own right (latent hyperopia controlling divergence excess\textsuperscript{18}).

It is possible that all myopes have the predisposing signs to dyslexia which themselves lead to the mechanical stresses inside and outside the globe causing the stretching effect (axial myopia) and increased corneal curvature (refractive myopia) that leads to short sight.\textsuperscript{4, 19}
7. Muscle Balance

- Eye alignment: strabismus (Squint)

Comment
A protocol, which includes data from manifest squinters and monocular suppression, may not be looking in the right place for evidence connecting vision and dyslexia

8. Binocular function Measured by Cover test and a prism bar

Clinically significant
- Strabismus 2 ^ (prism dioptes) or greater
- >= 10^ ESOP unaided at near
- >= 15^ EXOP unaided in the distance

Comment
In terms of vision and dyslexia micro strabismus and squints greater than 2 dioptres are outside the grey are where dyslexia might be expected to occur. This data should be dealt with separately

Heterophoria of less than 10 esophoria at near or less than 15 of exophoria in the distance was recorded as clinically not significant. On cover test these phorias are large and very obvious and almost always de-compensated.

Distance esophoria and near exophoria don’t seem to have been considered. This eliminates perhaps the most important area of data when looking for the connection between vision and dyslexia

The researchers seem unaware of the importance of small heterophorias measured objectively (Von Gaefe^{12}). This may be because surgeons are concerned with manifest or intermittent tropia, which needs medical or surgical treatment.

The Moreton study^{4} and experience in general practice^{20} confirms that any heteroporia can contribute to binocular vision difficulties

Optometrists will be aware that movement of 3 diopters or less is difficult to see with the cover test. Any observable movement at distance or near is significant^{2}. Muscle balance was not measured objectively. Any heterophoria should be investigated and related to the other diagnostic elements of binocular visual performance.

9. Focusing and forming a single image (Sensory fusion)

- Worth 4 dot test

Comment
The Worth 4 dot test does not measure sensory fusion, it confirms the first level of binocular overlap in the TNO book for stereopsis^{21}

Fixation disparity measures the quality of sensory fusion and isn’t mentioned. This level of detail does not appear to be part of Hospital based orthoptics. Fixation Disparity is key to understanding the relationship of vision to dyslexia.
10. Motor fusion significance defined as:
   - 20° prism (at distance?)
   - 4° prism at near

Comment
The direction of prism was not specified. It is not clear if these prisms were used to confirm microstrabismus or measure fusional reserves. One off measures of fusional reserves may not give a reliable indication of sustained vergence facility.

11. Stereo acuity
   - Randot stereo test as 40cm

Comment
Stereopsis is an analytical test (involves more than one of the elements of visual performance). So it is not useful in attributing a specific diagnostic element of vision performance to a dyslexic tendency. For instance weak accommodation and convergence insufficiency can support each other (via the accommodation /vergence reflex) to give a briefly normal level of stereopsis, which is difficult to sustain.

TNO is a global test for stereopsis involving peripheral vision may be more reliable to measure base levels and improving stereopsis because it has no monocular clues. Randot is a local (central control) test.

11. Near point of convergence and mean unaided near point of accommodation
   - RAF rule

Comment
The RAF rule can exaggerate the level of accommodation in children who can't focus at near or are slightly amblyopic. The children may not be sensitive to blur and misinterpret the effect of increasing image size as the target is brought towards them. This makes the letters bigger and apparently easier to see.

The RAF rule measures a one off ability to achieve a maximum level of accommodation; real life is about a sustained level of accommodation (accommodation facility). This can be initially assessed by a +1.00 binocular addition at near and asking if the test type is better or worse.

Omissions

Colour preference and light sensitivity
There is evidence that colour has an effect and ideally should not be ignored without an attempt at explanation. The choice of colour can also give an indication of the degree of light sensitivity.
Yellow filters absorb ultraviolet and blue light and increase contrast by removing the veiling background haze caused by this part of the spectrum. Mild amblyopes find contrast enhancement very helpful.

Blue filters absorb yellow light at the peak sensitivity, which the light sensitive find difficult. The degree of light sensitivity seems to be related to the degree of the binocular deficit.

Eye dominance
One of the strongest predisposing signs of dyslexia is a paresis in the dominant, aiming eye. Unless eye dominance is measured and Type I and Type II dominance types are separated, significance in the data as less likely to be achieved.
Sensory fusion (Mallet test)
Binocular stability can be assessed by the quality of sensory fusion. Fixation Disparity can be measured with the Mallet test or a single bead on the Brock string at 40 cm. These tests allow the prescription of prism and an assessment of sensory fusion for instance

• Alternating
• Intermittent
• Partial
• Complete.

Any improvement in tracking following the correction of decompensation can be measured using the CReST test.

Summary
The gross treatment and measurement of Binocular stability practiced by orthoptists may not sensitive enough to demonstrate a connection between vision and dyslexia.

Orthoptists deal with ocular pathology and manifest deviations working closely with the Ophthalmologist and Paediatrician. Optometrists are concerned with physiological deficits, whose more subtle effects are correctable with specs and/or contact lenses

Dyslexia is not pathological but the result of a physiological deficit of binocular vision at the near point.

Part of the importance of understanding this is that amongst children there may be some whose signs and symptoms mimic dyslexia but have a more serious pathological origin. Effective Optometric referrals to the hospital eye department could be delayed if the possibility of simple dyslexia isn’t first eliminated in a Schoolvision or binocular vision assessment

Conclusion
It is telling that reading impairment was defined according to the Diagnostic And Statistical Manual Of Mental Disorders. This is a prejudice that the authors were aiming to disprove. It would have helped to include an optometrist in the study to avoid the ambiguity that “all ophthalmic tests” were used.

The tests were mostly analytical (involving more that one diagnostic element {variable} of visual performance) and designed to reveal gross and often pathological anomalies of binocular vision.

Optometric binocular vision tests are designed to measure and correct physiological deficits in visual performance, so have far greater sensitivity towards the measurement of binocular vision problems that can lead to simple dyslexia (the precursor to Psychology defined dyslexia).

It may be too early to present the findings of this paper to the National Institute For Health And Care Excellence (NICE) as a basis for managing specific learning difficulties.

The authors did not want to raise hopes and expectations. This is understandable, but it illustrates how unintentionally pervasive institutional bias can be and how important it is, for professions to collaborate with others, outside their experience.

The primacy of vision in Humans means that it touches every part of our existence and may be the great unifying force of our time.

(Geraint Griffiths is Chair of the Association of Sport and Schoolvision Practitioners)
## References


6. Typoglycaemia Typoglycemia The mind’s ability to decipher a mis-spelled word if the first and last letters of the word are correct. The word Typoglycemia describes Teh mdin's atbiliy to dpeihecr a msi-selpeld wrod if the fsirt and lsat tteets of the wrod are cerorct. by Stuart Jackson December 21, 2005

7. CReST in the Moreton Study2 Patent Pending Patent pending GB 1303234.7


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