# AN INTERDISCIPLINARY APPROACH TO DYSLEXIA

## PAPER 1

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*(Presented in Sydney, October, 1972)*

I want to thank the Orthoptic Association for giving me this opportunity to talk to such a wide audience.

Let me say something about how the problems of dyslexia appear to me, which may not be the way they appear to you. Most dyslexic people I see are in a child health care setting, and I find that most of them are part diagnosed. It is always part, because, no matter how far the diagnostic procedure has gone, there is usually still more to do. I would prefer to say "described and understood" to "diagnosed", because the diagnosis gives an impression of a procedure which is formal and relatively specific, and this does not necessarily apply in these cases.

Almost all the parents are concerned parents. Some may be anxious, some tense, some very aggressive, and many of them depressed to some degree. These are levels of concern that the parents exhibit because their children have been revealed to them as being intractable kinds of learning problems. In some cases you can register these levels of concern and take them into account in your prognosis of what you can hope to achieve. I think it is reasonable and natural for all parents to be exhibiting some level of concern, and frustration and to hope that something better can be achieved in the individual case.

There is the tremendous impact of the initial diagnosis which may have been offered at school, or in an educational guidance clinic or may even have been suggested by a friend. You often have to handle the falsely informed parent, to whose child a label has been applied, whose child has "dyslexia", a term which is bandied about a great deal in the community. You may be confronted with a child who shows signs of all round retardation, in which case you have the problem of assisting the parent to face up to the sum of the implications of that more generalised condition. But I do not think that relieves you in any way of the responsibility of dealing with problems that are very similar, in many ways, to the ones that are associated with children who actually have dyslexia type learning problems. One of the jobs, of course, is to handle the frustrations of the parent concerning the system. As a general statement, I should say that there is a problem of helping the child to achieve some self respect in the knowledge, as he often has, that he is different from other children in the school and in the community. It is a matter of helping him over a prolonged period of time through rather difficult periods, to an understanding that he is a person who is worthwhile in himself, that there are many things that he is capable of doing and that he is capable of making both others and himself happy, given the right types of opportunity. With the parent, the task is, in my opinion, a somewhat easier one, though it may appear, in the early stages, to be the more difficult.

The contract that is entered into involves these concerns and not infrequently some particular group, or some particular specialist, is the pivot of the whole treatment programme. This pivot group can be from any specialist area; the psychologist, for example, may co-ordinate all of the various diagnostic and remedial measures which are undertaken, but any specialist in any of the disciplines belonging to a team for the treatment of these disorders may undertake the co-ordination.

I think that we have an obligation to carry out some **optimally exhaustive diagnostic** procedure in any case that is presented.

I will outline the procedure for an assessment of a child with a handicap. A full coverage of sensory and motor functions, testing of visual and perceptual functions and testing of laterality and of any right/left confusions which may exist are required. Close observation is terribly important with these children. I want to say that whatever tests are used they have to be interpreted and sometimes it is not so much the formal aspects of tests and the objective scores which are derived; as the observations on behaviour that are made whilst the tests are going on that are important. The psychologist, for one, has a very good opportunity to record a lot of verbal and nonverbal behaviour in the course of any testing session, no matter what tests he happens to be using. Of course there have to be reading, spelling and writing tests, and these call for the sharpest observation of all. It is in this area that one can make observations and set them down for the future remedial teachers who are going to be involved in the case, and these are the things that teachers and remedial teachers want to know about because ultimately they are going to be charged with the responsibility for applying some system and getting the best learning possible out of the child. They want to know specifically what it is that the child is able and is not able to do and an abstract report from any discipline will not necessarily give them very much guidance in that direction.

What is the team to deal with this problem? I don't know, but frequent members listed are ophthalmologists, audiologists, paediatricians, neurologists and psychologists, but I would like to add orthoptists, optometrists, special teachers, speech therapists, and perhaps there are many others who could figure because I am not particularly discipline-oriented in this; I believe that there are people who develop specialist inclinations and directions in their work within any discipline and, providing they are prepared to be flexible and open-minded, there is a lot that can be achieved by people in probably the most unlikely associated disciplines. Those mentioned are some that I would include in a team approach, but I am using the word "team" somewhat loosely; I would think of this in most communities as being a loose, inter-referral structure and if the members of that team are aware of their own limitations then they will take advantage of the structure that exists.

Now shortcut diagnosis is something that worries me. I often hear people saying that it is possible to determine the diagnosis of dyslexia with a few quick flicks of the wrist and a couple of diagrams, and a short one-minute performance from the child. Psychology has been very good on that kind of trick for a long time. We have been producing major tests and then shortening them, and I would warn that the correlations of the shortened forms of the tests with the major form of the test are often only moderate. These are shorter forms to which a great deal of effort has been applied and a good deal of psychometric acumen was needed to produce them. Now when one produces an ad hoc procedure and bungs it on as a short way to diagnosis, I believe that the risks are very great indeed that false diagnoses will be made. I cannot see the necessity of engaging in this kind of activity when, with a bit of open-mindedness and flexibility, it is possible for people to make referrals and, since they are interested in saving themselves time, to actually save themselves time and get the specialist that they know is capable of doing a job in a certain area to carry it out. And I say that as much in criticism of psychologists as anybody else. The all round diagnostician is a possibility, but a rarity I believe. Nevertheless he may exist and if he does, then he is a force unto himself, but he will spend most of his time in diagnosis - I am sure of that; and the all round diagnostician with such composite abilities could probably not afford to use that time up when other people could be relied upon to do the job.

Each specialist and each speciality has some important individual contribution to make. For example, the cerebral palsy specialists probably know a great deal about the critical developmental behaviours which may lead to learning problems in later life. They also know something about the application of remedial methods in relation to motor performance. I am thinking of techniques such as the Bobath technique where sequential reflex organisations may be manipulated. I would say that we know nothing of that in the specific learning disability field, and this is an area of specialising to which we could turn with great profit. It is also an area from which people could turn to us and give us the benefit of their knowledge.

Most of us, I think, are committed to pragmatism when we handle these children: we do what works and sometimes we have little idea of what it is we are doing, except that it works. We have not much theory to go on and some of us don't place much trust in the theory that does exist. So many of us become pragmatists up to a point. But, I think, we need to know ultimately just what is going on underneath and we should not discourage or ridicule basic research or intermediate level research in relation to these problems.

This open versus closed mind that I am talking about affects whole orientations. I have spoken about the rather restrictive, narrow and destructive attitudes on EEG as something that affects me personally. You hear, "It is an educational problem", "It is a medical problem." It is both of those things. It is many other kinds of problems too, but if any particular speciality can arrogate to itself the authority to advise on the whole diagnosis and treatment of this condition, then it is time that the guide lines were laid down in the literature, because we would all like to know more about it. We have to face our own limitations in respect to diagnosis and treatment all the time, In my own case, they are prodigious indeed.

The speaker then went on to outline research projects which had been conducted in Newcastle, by himself and colleagues:

(a) psychological and educational response of severe reading disability children to drug therapy over a period of four months;

(b) motor-skill profiles of children (M. Lawson);

(c) perceptual thresholds when auxiliary sensory stimulation is applied (Fenelon and Wortley, to appear in Perceptual and Motor Skills);

(d) change in spatial distribution of the EEG of learning problem children under treatment by Nitrazepam (Fenelon, Holland, and Johnson, (1972) Cortex, 8:4:444–464

(e) left-right visual half-field identifications of verbal and non-verbal stimuli, presented by computer (Fenelon, Hall and Kelly, to appear in Cortex);

(f) a study with Mrs. Dunlop and Dr. Dunlop, where orthoptic examination indicators were combined successfully to categorise subjects as learning disability cases or normals (Dunlop, Dunlop, and Fenelon, to appear in Cortex).

Editor's note:- As Mr. Fenelon left for an overseas lecture tour shortly after giving us this paper, he did not have any opportunity of revision. The minor changes made by the editor to the original draft, despite the care taken to preserve the author's meaning, may not have captured all of the author's views nor the subtleties of the author's desired emphasis.

# AN INTERDISCIPLINARY APPROACH TO DYSLEXIA

## PAPER 2: THE BINOCULAR BASIS OF DYSLEXIC CONFUSION

Dr. D.B. Dunlop

*(Presented in Sydney, October, 1972)*

**Basic Concept**

The basic concept underlying this study and the new method of binocular testing is that the two eyes do not make an equal contribution to the function of the central binocular region and that this difference in central visual function is necessary and should be related in a specific manner to the lateralisation of other special functions within the nervous system such as speech and the normally right handed motor system.

It has been known for a long time that children suffering from a certain type of specific reading and writing difficulty were more likely to be left handed or ambidextrous or to belong to families so affected (Berlin 1887). Such children appear to lack the ability to develop normal lateralisation of special functions to the appropriate cerebral hemisphere so that effective specialisation of development can proceed.(Rosennerger 1970)

Many investigators have sought to correlate this crossed laterality of motor and other functions with some similar crossed laterality of visual functions, but without success. (Walls, 1951, White, 1969)

We believe their failure was due to the fact that the great majority of their test procedures involved essentially monocular activities like aiming a gun, looking through keyholes or the super-imposition of monocular images without true fusion. Berner and Berner (1953) first suggested the necessity of maintaining binocularity but even their stereoscopic tests rely on suppression which is the breakdown of binocular function to the monocular state.

The new test described in Mrs. Dunlop's paper, is specifically designed to maintain the patient in the fully binocular state, in his central field of vision, despite relative movements of lateral control features, as in Ogle's experiments with disparate images in stereopsis (1953)and Burian's similar studies (Adler, 1965).

From a practical point of view the new test has shown a statistically high degree of correlation with the patient's clinical state (Dunlop, Dunlop & Fenelon, 1973). This means that we may now, for the first time by ocular tests, differentiate one group of children with visual learning problems from normals.

The concept of a master eye and a minor eye has been declared to be "neurologically unsound" (Flax 1966), even by such eminent experienced neurologists as John Money (1968); we must therefore re-examine the neuro-physiology underlying the concept.

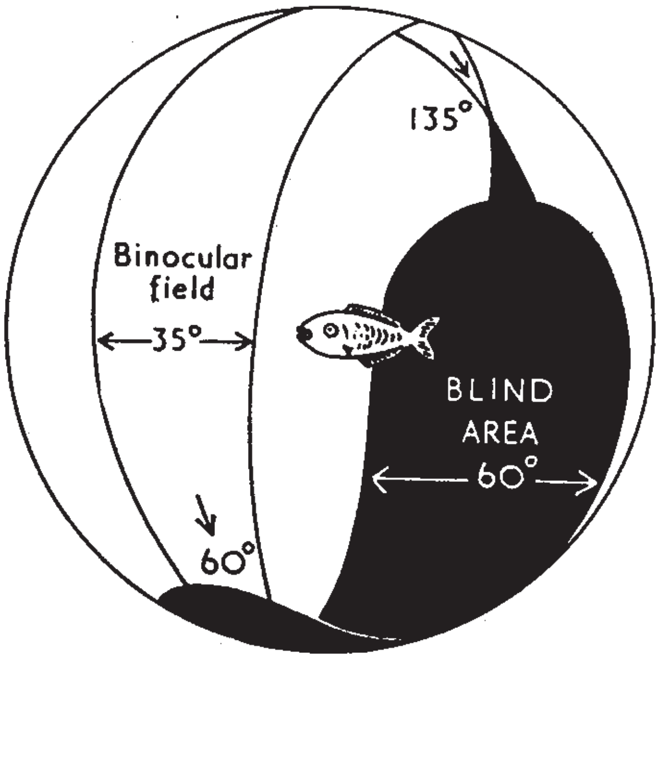
The critics state that since the visual fields are divided down the midline and there is an equal and symmetrical distribution of visual nerve fibres from each eye to each hemisphere, neither eye can dominate the visual process.

But let us look at the situation in greater detail and consider the actual visual functions involved in each part of the fields of vision. The work of Julesz, Hubel and Weisel, Blakemore, Bishop & Pettigrew should indicate that you must abandon many of your old concepts of binocular vision. We will first consider the lateral areas of the fields of vision, then the overlapping areas of binocular vision and finally the central mid-line areas of special binocular sensitivity and high acuity.

**Dissection of the Visual Fields into Three Distinct Areas with Three Distinct Functions**

The light stimuli from each lateral field activates the nasal half of the ipsilateral retina; all the nerve fibres from the nasal retina cross in the optic chiasm to the contra-lateral geniculate body and eventually the contralateral lateral visual cortex. No one will deny that each eye is totally dominant in its own far lateral field of monocular vision. The relevant contralateral cortical cells receive impulses from one eye only. The function of this lateral dominance is to enable the animal to react quickly and unequivocally to important stimuli in its peripheral field of vision on either side. The reaction in all species is to turn the visual apparatus so that the object of interest is now pictured on the central region of the visual field where high visual acuity and high stereo-acuity are available.

FIGURE 1(FROM DUKE ELDER)




THE BINOCULAR VISUAL FIELD OF A TORPEDO-SHAPED FISH WITH LATERALLY DIRECTED EYES

The field of vision is not a flat area but is curved in 3 dimensions with horoptors suitable for the activity of the animal. Thus the fish has a very extensive total field of vision but a narrow binocular field which extends from below and in front to above and behind (Fig. 1, Duke Elder 1958). The rabbit similarly has a binocular field in front, above and behind. This enables the pursued animal to use his binocular functions to assess the nearness of the safety of his burrow in front and simultaneously the closeness of his death-dealing enemy behind or above, e.g. the fox or the eagle. (Fig. 2, Duke Elder 1958).

**FIGURE 2 FROM DUKE ELDER**

FIGS. 805 AND 806.—BINOCULAR FIELDS.

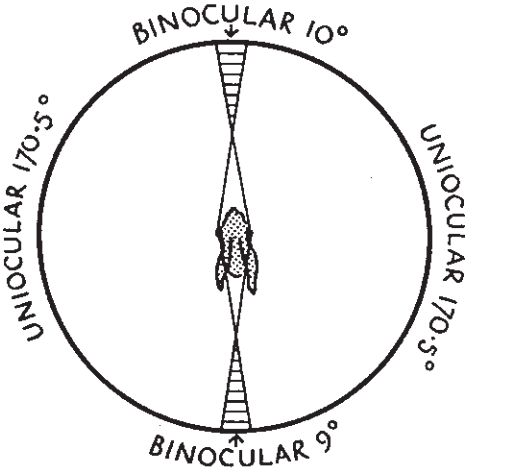



FIG. 805.—The panoramic field of a hunted animal (the rabbit) with a small binocular segment in front (10°) and behind (9°), and a large uniocular area (170·5° on each side).

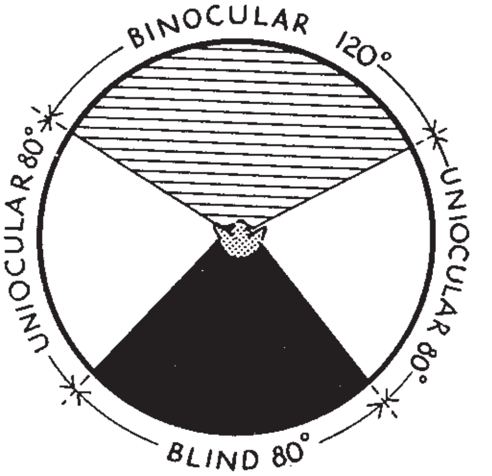



FIG. 806.—The binocular field of a predator (the cat) showing a large anterior binocular area (120°) a large posterior blind area (80°) with relatively small uniocular area (80°).

**Survival Depends on Accurate Distance Assessment**

The essential point is that his central field is used for the assessment of distance. Although his binocular field is narrow it is his quickest and most accurate means of judging his margin of safety (Rubin & Walls). It is his best way of measuring his chance of survival. It does not need to be wide in the rabbit. He just has to assess his enemy's distance behind and the distance of safety in front. It needs to be wider in the hunting animal, such as a cat, which must be able to assess the distance of the most opportune member of a group of prey which may be spread out camouflaged in front of him. He has no binocular field behind because he does not need it; but he has a fairly wide binocular field in front so that he can measure relative distances of several prey and their escape routes at the same time.

How does this distance measuring mechanism work? Hubel and Weisel (1962) have demonstrated that there are special binocular cells in each para-striate cortex which respond best when each eye is stimulated simultaneously and in the same manner in very specific small areas of each field of vision. These "receptive areas" are accurately located in a permanently fixed relation to each other and to the other parts of the field of vision. The receptive field of one eye rarely corresponds exactly to the receptive field of the opposite eye and this lack of correspondence is called "disparity."

The receptive areas can be mapped out very accurately by putting a needle in the appropriate visual cortex of a conscious, but immobilised cat so that the activity of a singular binocular cell is recorded while discrete areas of the field of each of the cat's eyes are suitably illuminated, separately and together, at different degrees of disparity (Pettigrew, 1972). Some of these cortical cells respond poorly or not at all when only one eye field is illuminated but all respond much more actively when the corresponding receptive field of each eye is stimulated simultaneously at the correct degree of disparity. The response is quickly inhibited if the disparity becomes too large or too small, indicating that these cells respond to stimuli from specific horoptors at a definite distance in front of the animal (Joshua and Bishop, 1970). In those binocular receptive areas recorded away from the midline it is found that the corresponding areas in each eye are not equal. There are differences in area, and in intensity of response contribution, indicating that the receptive area of one eye is used as a reference against which the stimulus on the receptive area of the other eye is compared. This comparison is made by single cortical binocular cells which receive one nerve fibre from each eye, one ipsilateral and one crossed (or contralateral). (Barlow, Blakemore and Pettigrew, 1967)

The majority of these reference or controlling areas are found in the contralateral eye. In considering the distribution of nerve fibres this would be appropriate because the crossed fibres are the oldest phylogenetically and the more recently developed and expanding function of binocular comparison is mediated by the phylogenetically younger ipsilateral fibres (Holmes., 1945).

**Contralateral Dominance of the Lateral Alerting Areas**

To summarise, we find that both the far peripheral field and the non-central areas of the binocular field of vision are dominated by the contra-lateral eye. To quote Bishop (1972) "There is a clear cut dominance of one eye over the other at the cellular level."

From a functional point of view the lateral field is seen as an alerting mechanism while the non central binocular areas are "relative distance" measuring areas, assessing distances of non central points of interest in relation to each other and to the central fixation area of maximum interest.

The central midline binocular region is quite different to the lateral areas in structure, neuronal connections and function.

**The Essentially Different Midline Binocular Region**

The distance of any one point of interest from the individual can be assessed by a single cortical binocular cell which is comparing a receptive field from one eye with a receptive field from the other eye, provided that the point of interest is not on the midline, or very close to the midline. Fig. 3.

The relative distances of two points of interest, neither of which is on the midline, can be assessed by the relation of the activity of two binocular cells within the same hemisphere, provided that the two points of interest are on the same side of the midline and not on or very near the midline. Fig. 3 (Mitchell & Blakemore, 1970)

The distance of any point of interest which is actually on the midline must be assessed by a totally different mechanism.

**FIGURE 3 FROM DAVSON**

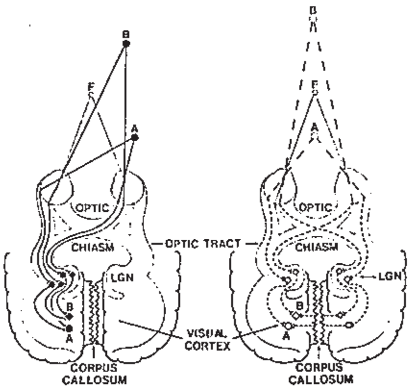



Fig. 333. The possible neural system for binocular depth perception in the split-brain human. On the left is the arrangement of neurones which enabled the subject to recognize the depth of the peripheral objects A and B, relative to the fixation point, F. For both objects the image in the right eye falls on nasal retina and that in the left upon temporal, and all the information projects to the left optic tract. The messages from the two eyes remain segregated at the lateral geniculate nucleus (LGN). Solid circles represent neurones within whose receptive field the image of A falls. Solid diamonds are cells to which object B projects. The two binocular cells, A and B, shown as large symbols in the cortex, encode the disparities of the objects. In this case the sectioned corpus callosum is of no hindrance. The binocular information is processed entirely in the left hemisphere and the judgements can therefore be vocalized.

In the right diagram objects A and B lie directly in the midline and, therefore, their images fall on temporal or nasal retina, respectively, in *both* eyes. The interrupted lines and open symbols in the visual pathway show the neurones normally responsible for the recognition of the disparity of these objects. The binocular cells A and B in the cortex receive one of their inputs from a fibre from the opposite visual cortex, crossing in the corpus callosum. Section of the commissure has severed this link and binocular integration is impossible. (Mitchell & Blakemore, *Vision Res.*)

If the point is just beyond fixation its image will fall on the nasal half of the retina in each eye and the resulting nerve impulses will each travel by crossed fibres through the optic chiasm to a cell in the opposite visual cortex on each side. Comparison of the receptive fields must now be made, not within a single cell in the contra lateral cortex but by the comparative integration of the activities of two cells, one in each hemisphere. This comparison can only be made by transfer of information across the corpus callosum.

Similarly, if the point of interest is just within fixation (closer) its image will fall on the temporal half of the retina in each eye and the resulting nerve impulses will each travel by uncrossed fibres to a cell in the ipsilateral visual cortex on each side. Again comparison can only be made via the corpus callosum.

Experimentally, callosal units have been recorded which could serve this purpose (Berluchi, Gazzaniga and Rizzolatti, 1967).

Choudhury, Whitteridge & Wilson (1965) have confirmed the function of these units by recording specific cortical cells before and after callosal section and before and after cooling of the corresponding point on the opposite visual cortex.

Hubel and Wiesal have recorded simultaneously the activity of separate cortical cells at the junction of areas 17 & 18 in each visual cortex and have found that some had receptive fields which overlapped the midline. Blakemore (1970) has shown that the centres of some receptive fields can be on the wrong side of the midline by as much as 1½ °. The size of each one of a pair of these overlapping receptive fields is much more equal than that of relative receptive fields in more lateral regions (Bishop, 1972).

Clinically, it has been proved that patients who have suffered a division of their corpus callosum lose stereopsis for objects in front of or behind fixation on the midline, but retain stereopsis for objects to the right side or the left side of the midline (Mitchell & Blakemore, 1970).

Stone (1965) has shown histologically that there is a midline overlap of the temporal and nasal retinal elements and this overlap has been shown to persist in the lateral geniculate body (Sanderson & Sherman. 1971) and the cortex (Leicester, 1968).

So the anatomical and neurophysiological differentiation of the central midline region of the visual function has been effectively established and it is important to realise that this differentiation results in greater stereo-acuity (ability to judge small differences in the distances of objects from the observer). (Rubin & Walls, 1965)

Human vision is not concerned with stationary objects nearly as much as with relative movement of parts of its field.

Much of the analysis of visual function is in terms of a static two dimensional situation. Each should be regarded as applicable only for an instant in the constantly changing three and four dimensional real model.

Many different analyses of lateral transverse movements are available but few of the all important (to the subject) "far to near" movements. Blakemore's discovery of constant depth columns of cortical cells in contrast to constant direction columns should emphasise the necessity for more clinical investigation of the central "near-far" distance assessment function.

The central region also has another extremely interesting attribute. It is subject to reversals which are not apparent to the observer. In other words the subject cannot differentiate "right versus left" or "left versus right" lateral reversals presented on the midline unless he has been specially trained to do so.

Many investigators have found that normal animals cannot distinguish mirror images: N.S. Sutherland with the octopus, Karl Lesley with rats, David Thomas, Nancy Wells, Michael Corballis and Ivan Beale with pigeons, John Noble with monkeys and Sir Frederick Bartlett and Norman Haber with humans (Corballis & Beale, 1971).

Noble's experiments with monkeys who had had the optic chiasma divided by midline sagittal section are particularly revealing. (Fig. 4) (Noble, 1966).

Each occipital lobe of an animal so treated can receive direct visual impulses only from its ipsilateral eye. With the chiasm divided, the only other communication of the occipital lobe with the contralateral eye is via the corpus callosum.

Noble trained monkeys with divided chiasms to react to an asymmetric figure (e.g. 7) with one eye occluded. When they were tested with the opposite eye covered and the originally occluded eye open, they reacted to the mirror image of the test figure (e.g. ꓶ).

Berluchi (1968) has shown that it is possible to train one half of the brain of an animal to react to one stimulus and the other side to react to the opposite provided that both optic chiasm and the corpus callosum are divided and the animal is trained with alternate eyes appropriately occluded.

FIGURE 4 FROM DAVSON

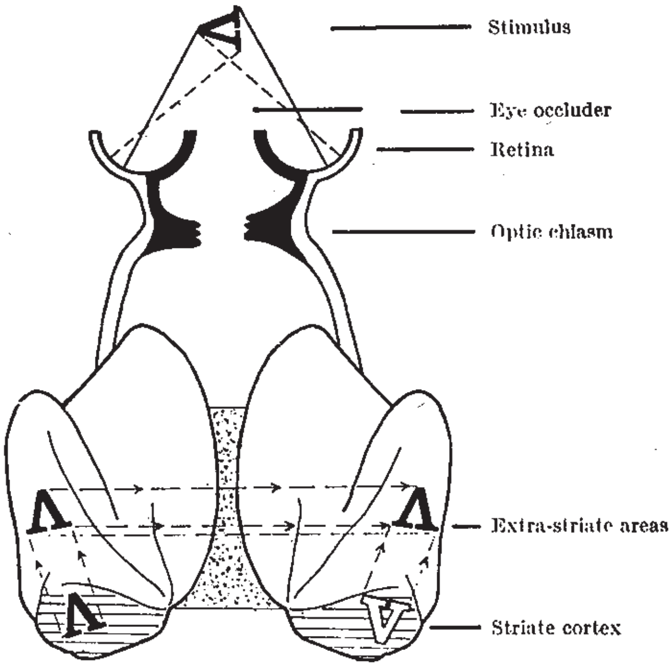



Diagram to explain mirror-image reversal. With right eye occluded, the input to left striate cortex is propagated to extrastriate areas (Λ) and is laterally reversed in crossing the midline via the forebrain commissures (stippled). When the left eye is occluded the input to the right striate area (V) does not match the stimulus (Λ) transposed from the left hemisphere; it does, however, match its mirror-image. (Noble, *Nature.*)

Beale, Corballis (et al 1972) etc. have shown with pigeons "that normal birds showed a tendency to respond to mirror-image sloping lines as equivalent, whereas split brain birds do not. This is consistent with the view that the inter-hemispheric commissures are critical to mirror image confusion." They further remark that "the finding is of possible significance in understanding mirror-image confusions of reading and writing commonly observed in children and in cases of dyslexia."

It is about the midline that reversals occur. They occur when the individual has no means to distinguish left from right.

But why should he differentiate R/L or L/R profiles? Nothing in Nature requires such differentiation and it should be no surprise that birds, fish and animals cannot distinguish reversed figures. The fish that swims up his pool looking at the left bank with his left eye need recognise no difference in the lateral reversal of this scene as he swims back again with the same bank on his right side surveyed by his right eye.

And to the rabbit either profile of the fox is equally dangerous.

Nowhere in Nature is the animal required to differentiate lateralisation. Even trained humans have difficulty in assessing laterality of remembered picture profiles. (Bartlett & Haber).

Only in man's world of symbolic communication and in the use of complex tools is the special technique of the L v R code necessary.

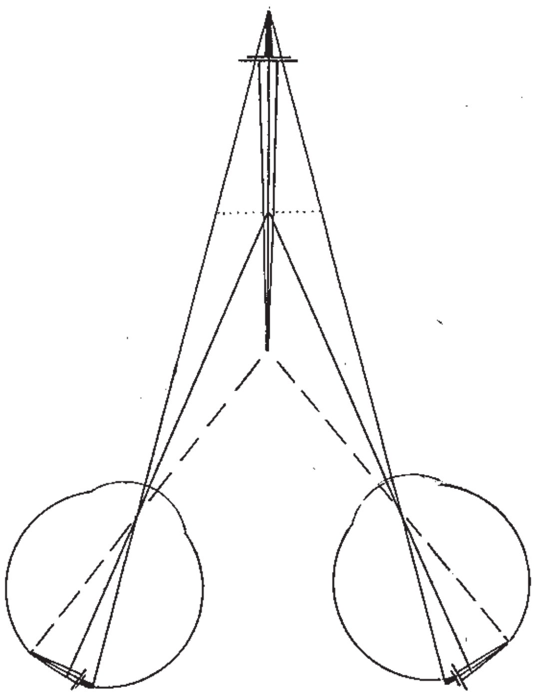
And having adopted this special technique of codifying asymmetric symbols and objects, what mechanism does man use to decode the information thus hidden from animals and the uninitiated? He can hardly escape the necessity to use the mechanism which yields the highest visual acuity. The central 2°- 5° of his visual field which has the highest cone density, (Davson, 1972). The same narrow central region which yields his highest stereo-acuity (Ogle, 1962)- The region where receptive fields are found on the "wrong side" of the midline (Blakemore, 1970) and where naso-temporal overlap occurs (Stone, 1965).

He uses his age old "relative distance" survival mechanism.

Over countless milleniums the developing animal has evolved more and more special nerve pathways (up to 50% uncrossed nerve fibres in the human) to effect a more and more accurate and rapid assessment of relative distance. Now suddenly man has chosen to convert this "too near, too far" assessment mechanism to a "left of centre versus right of centre" mechanism.

From the diagram (Fig. 5) one can see how this transformation works.

FIGURE 5



If a sword is pointing between the eyes of a frightened observer he cares little if he sees the right side of the sword with his right eye or the left side with his left eye or the fused stereo combination of both. He watches the point which will first hurt him and the hand behind that will guide the weapon. He is vitally interested in both, and, if he fixes his focus half way in between, so that both point and hand are in relatively good focus, the image of the sword will lie from right to left across the midline of his right retina and from left to right across the midline of his left retina.

Here we see the primary reason for the animal's acceptance of L & R images as equal and the basis of the decoding dilemma of the individual who wants to use his far near distance assessment mechanism for "right versus left" lateralisation assessment.

Using lateralised symbols for communication , modern man must accept one image as the standard correct orientation and reject the other as incorrect. Thus it is essential for one eye to become the master or reference eye in the central binocular region when it is used for interpreting symbols. (Note that it is not one half of his central field which becomes dominant, but one whole central field. )

It is astounding that this transformation of function should fortuitously work so consistently when one considers that no such transformation was necessary to the first nomadic hunters nor to the later more civilised tillers of the soil.

Up till this century the majority of humans were illiterate and had no use for such a lateralised decoding mechanism. Now, almost every human is expected to make a successful attempt to learn the code. It is not surprising that a few fail or find great difficulty.

But why do they fail?

It can be seen from the previous explanation and diagrams that there is normally little necessity or opportunity for dominance of one image on the narrow central binocular field over the other. And if the animal is itself perfectly symmetrical it would have no internal mechanism with which to attach a significance to a lateralised element of its environment. It would have no decoding mechanism.

Here, at last, we can see some significant meaning in the frequent finding that patients with severe dyslexia have faultlessly equal vision in each eye.

The individual must develop some means of attaching significance to right or left. If he is unable to do so he will remain in a state of permanent dilemma. The more perfectly symmetrical his functions, the more difficult is his dilemma.

It thus becomes clear that some "lateralisation" of the central visual function is essential. While the lateral receptive fields of both the binocular and monocular areas will each dominate the individual cells of the contra lateral visual cortex, due to their essentially fixed primordial neuro-anatomy and physiology, the receptive fields of the central binocular region with their double crossed and double uncrossed representation in the two occipital lobes carry no such obligatory dominance.

But some relative difference must be developed or imprinted before the central binocular area can be used for the modern symbolic decoding and coding involved in reading and writing.

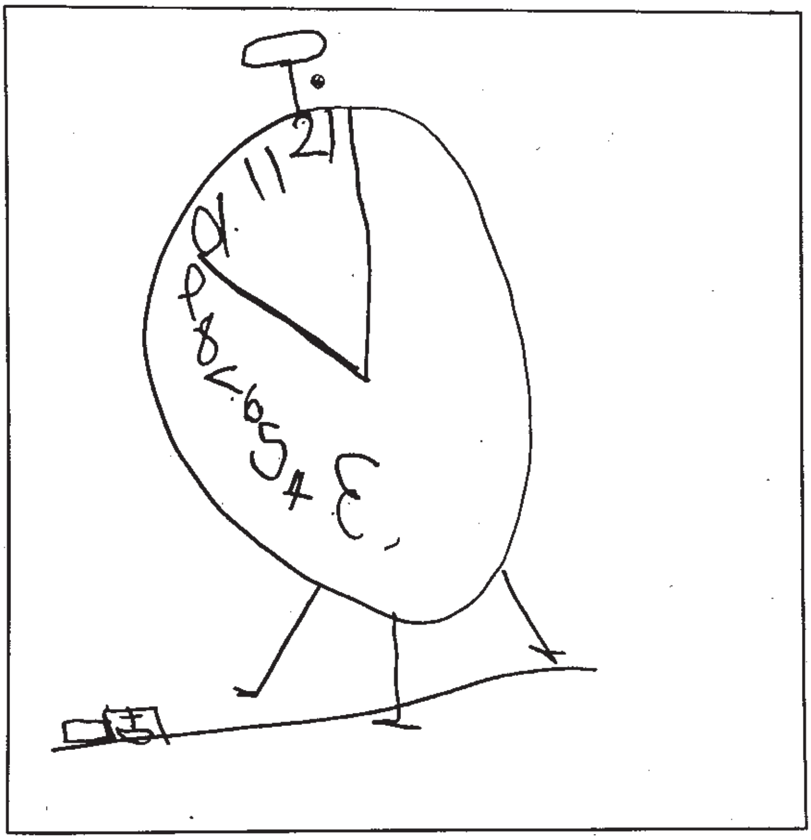
If the individual fails to achieve a consistent and reliable lateralisation of his central visual functions he will be no more able to tell whether any one symbol or any group of symbols are correctly orientated, than a totally colour blind person can assess whether an object is coloured or not. He can only keep guessing and wondering how other people find the task so easy. Like the partially colour blind, he will develop various tricks which seem to help him to guess a little better. He will twist his book and turn his head and may achieve some degree of lateralisation by keeping the image in a more peripheral part of his visual field so that a natural lateralisation is achieved.

But as soon as he reverts to the central high acuity region of his visual field he will be just as confused as ever. Eventually he may become quite distressed whenever he is asked to use his central field for symbolised detail. In such a situation a normally happy child will suddenly become fidgety and upset, almost hyperactive, as he squirms to avoid the insoluble confusion of his central visual field. He seems to try to avoid fixing his eyes with "movements oculaires inutiles." Lesèvre (1964). Just as the occasional cases of strabismus will exhibit "horror fusionis" this child will exhibit "horror confusionis centralis."

The spacial arrangements of his work become wildly erratic as he desperately tries to write in his lateral field of vision or anywhere off centre; letters and groups of letters (up to a few degrees wide) become reversed and sequentially muddled as he guesses which image is acceptable; and if he twists his book and his head far enough in opposite directions ($>45^\circ$ is enough) he may achieve inversions of letters (Corballis & Beale).

The figure of the 6 year old boy's drawing of a clock from McDonald Critchley's book "The Dyslexic Child, (1970)" shows all these features except inversions (Fig. 6).

FIGURE 6



Drawing of a clock, showing severe spatial difficulties, neglect of the right half of the dial, and various rotations and reversals.

The child was an intelligent boy of 6 years 8 months with a family history of dyslexia. Seen again at the age of 9 years and 1 month, his reading and spelling ages were at a 7-year level. His spontaneous drawing of a clock was then well executed.

This boy was able to draw a clock successfully a few years later but he still was unable to overcome all his reading (decoding) problems.

This case illustrates the fact that, as with strabismus, it is necessary to initiate the correct pattern of visual function early in life for best facilitation of the definitive neural pathways. (Schiffman, Lawson, 1970).

We have been discussing the most difficult of the dyslexic type of visual problems. A different type arises where the individual eventually achieves visual lateralisation but allows the eye which does not correspond to the cerebral lateralisation of his speech centre and motor functions to become the master or reference eye.

Here again, reversals of the central part of the binocular image and the resulting confusion of visual sequences occur owing to the natural tendency of callosal transfer to give preference to the mirror image, while the more direct neuronal pathways give the opposite lateralisation.

Both these types of case will tend to occur much more readily in families whose hereditary features lead to a low emphasis on lateralisation.

Thus we can understand how the change demanded of man's central binocular visual function, which has been violently sudden in relation to the time scale of man's development as an animal, has caused great difficulty for those who cannot adapt themselves to the new sophistication of the visual environment.

We can help such individuals very substantially and perhaps almost eliminate this specific problem if we can develop tests to isolate those who lack the ability to lateralise easily and if we can show them early in life how to achieve lateralisation of central binocular vision corresponding to that of other functions lateralised for more efficient specialisation.

The orthoptic test Mrs Dunlop will describe is only a beginning. Once the neurophysiology of central binocular vision and the essential necessity of developing harmonious lateralisation of various functions is recognised, many other and possibly better tests will be evolved (e.g. using Julesz stereograms) and suitable regimes of treatment should be developed.

Other implications of these concepts within the area of symptomatic phorias and strabismus are already becoming evident and will be the subject of later communications.

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# AN INTERDISCIPLINARY APPROACH TO DYSLEXIA

## PAPER 3: DYSLEXIA – THE ORTHOPTIC APPROACH

*Patricia Dunlop, D.B.O. (London)*

*(Presented in Sydney, October, 1972)*

In this paper are described a pattern of ocular conditions found in a group of children with specific developmental dyslexia, and a new orthoptic test which will demonstrate a distinct difference in the visual functions of the children with this type of dyslexia.

Up to the present, orthoptists have seen only those children with learning difficulties who have distinct muscle imbalance. While this does occur in some cases of learning difficulties it is not characteristic of "specific developmental dyslexia." These children usually have good vision and only a small degree of muscle imbalance. It is the analysis of binocular vision in this specific developmental group which I would like to discuss.

In the early stages of the work I tried the usual methods of determining the controlling eye and found them to be unsatisfactory, largely because, at the point of decision, the patient was actually monocular in the central field. So this new test was specifically developed to determine the reference or controlling eye in the central binocular field in the binocular state as opposed to the monocular state.

It would be better to call this a test for the "reference" eye because it is essentially different to the test described by the Berners' and others for the so-called "controlling" eye (Berner & Berner, 1953, Bettman et al. 1967, Helveston et al. 1970).

Ogle (1962) notes that the phenomena of directional difference of fused disparate images within Panum's area is a possible basis of tests for ocular dominance.

Assessment of the reference or controlling eye is carried out using a pair of fusion slides on the synoptophore and performing disjunctive movements so that some fusion disparity within Panum's area is apparent. Thus it is possible to discern the eye used as a reference while central fusion is still maintained.

FIGURE 1

Fusion slides with indicators (large and small trees) used to determine reference eye.

Figure 1 shows the pair of slides used in the synoptophore to determine the reference or controlling eye in central binocular vision. The fused image of the two slides subtends an angle of 5° on the retina. The child fixes on the door which is about 1° and both trees, the indicators, are seen 1° to either side. Disjunctive movements are carried out until fusion breaks giving the measurement of the amplitude of fusion. The child is further questioned on the movement of one or other tree which occurs before fusion breaks. This movement of the tree is more easily seen in divergence than in convergence because in convergence the accommodative element can be confusing. Divergence must be done very slowly and fixation maintained steadily on the central object, only answers taken before fusion break occurs are valid as alternation quickly takes place after fusion breaks.

Mr. Fenelon selected children for an experimental and a control group. The group consisting of 15 experimental and 15 control children was sent in random manner so that, at the time of testing, I was unaware of the category to which each child belonged.

All these children had passed the routine school medical service examination as being without significant ocular defect. These experimental children were severely retarded readers and were diagnosed as follows:-

1. reports of marked reading retardation from school and home
2. average or near average intelligence
3. low achievement in standardised reading tests
4. presence of specific dyslexic signs, e.g. inversions of letters; reversals of letters and words
5. no history of brain damage
6. normal childhood health
7. absence of uncorrected sensory defect
8. normal school attendance
9. no deprivation of educational opportunity

The normal or control group were of average or above average intelligence with no evidence of learning problems.

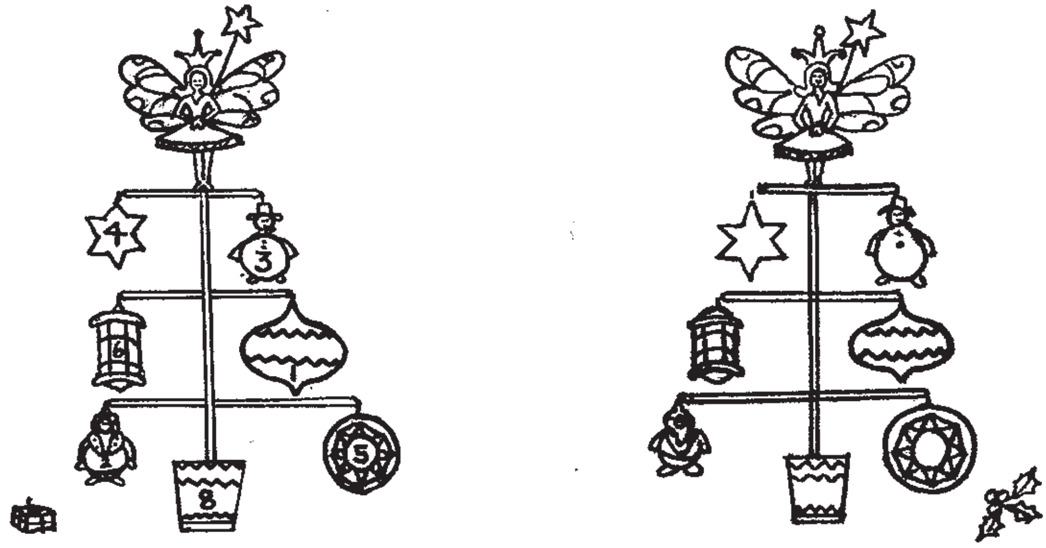
Table 1 shows the defects found and their statistical significance. (See Page 19)

**Visual acuity** was generally equal in both groups and was about the level of 6/6. Unequal visual acuity was in the order of ½ line difference. The esophoria found in these subjects was the group 4 type of esophoria, Mayou (1968). The esophoria measured on the Maddox Rod is small 2-3$^{\Delta}$ and the Maddox Wing measures exophoria between 2..6$^{\Delta}$. While this imbalance is small, it is consistent in the children with specific dyslexia.

**Convergence** is generally up to 6-8 cms (but can be only 12-15 cms). This is not well maintained and voluntary convergence is poor. Sometimes there is head retraction on attempting full convergence. Convergence deficiency has previously been noted in children with learning difficulties, Guthrie and Bermingham (1972).

**Stereopsis** is present but is defective, in that its appreciation is slow and often needs stimulation. On using the Titmus-Wirt card they manage up to 80 secs of arc disparity with ease (stereo-acuity). One sometimes sees the child trying to view the spots from one side in order to appreciate the depth. However, a more complex pattern of eight stimulus objects (see Fig. 2) used on the synoptophore and placed in the central binocular field gives rather poorer results and stimulation is often necessary (stereo-perception).

FIGURE 2



Stereoscopic slides used to test stereopsis

It must be realised that, as Ogle (1962) states, "that the magnitude of the stereoscopic depth perception must be carefully distinguished from the stereoscopic acuity or the precision of that depth."

The lack of significance of the crossed hand and sighting eye (a monocular test as shown in Table 1) is a finding supported by, and all too evident in, the massive accumulation of papers which have ineffectively attempted to correlate the dominant (or sighting eye) with the dominant hemisphere. Walls (1951) Lederer (1961), Gronwall & Sampson (1971) Norn (1969).

Certain factors show a significant difference when one group is compared with the other, but prediction from single indicators is hazardous and it is advisable to seek effective combinations of variables. Esophoria is not a good single predictor, but it shows possibilities in combination with defective stereopsis and crossed correspondence (handedness and reference eye). This triple combination mis-classified only one member of each group. The chi-squared value was 19.2 ($\underline{p} < 0.001$), which is highly significant.

Attempts by other authors to use the Berners' concept (1953) of the controlling eye to correlate ocular and cerebral lateralisation, e.g. Bettman (1967) and Helveston (1970), have produced disappointing results because the authors have failed to realise the difference between the truly binocular state and the monocular state which immediately follows the breakdown of binocular vision. No definitive results are likely from investigations which fail to distinguish between observations made in a truly binocular state and those observations based on suppression, alternation or retinal rivalry. In all these conditions binocular vision has already broken down. A significant feature in the two most recent of such investigations using the Berners' test is the author's inability to demonstrate any control" in half their cases, even the normals. Bettman, (1970) Helveston, (1970).

TABLE 1

ORTHOPTIC EXAMINATION DATA SUMMARY

NUMBER OF SUBJECTS DEMONSTRATING OCULAR CONDITIONS

| Groups | Unequal Visual Acuity | Convergence Deficiency | Defective Stereopsis | Crossed Corres-pondence* | Crossed Dominance** | Esophoria | Exophoria |
|---|---|---|---|---|---|---|---|
| Normal (n= 15) | 3 | 4 | 0 | 1 | 3 | 7 | 6 |
| RD (n =15) | 5 | 13 | 9 | 10 | 8 | 11 | 4 |

(* *Reference eye in binocular vision opposite to handedness)*

(** *Sighting eye in monocular viewing opposite to handedness)*

Differences exist in the incidence of ocular conditions in the two groups. These differences are statistically significant for:-

Convergence Deficiency *chi$^2$ = 8.7, ($\underline{p}$<0.005)

Defective Stereopsis *chi$^2$ = 5.2, ($\underline{p}$<0.025)

Crossed Correspondence (handness and reference eye) *chi$^2$ = 9.1, ($\underline{p}$<0.001)

but **not** significant

Crossed handedness– Sighting Eye *chi$^2$ = 1.4

Combination of Esophoria, Defective Stereopsis and Crossed Correspondence

*chi$^2$ = 19.2, ($\underline{p}$<0.001) is highly significant.

*(All chi-square tests involved a single degree of freedom and Yates correction was applied).*

The main value of these new procedures must be the fact that it gives us a new ability to predict the child at risk before his disability is magnified by habitual confusion and subsequent failure and frustrations. It may also prove to be useful in the assessment of treatment. As in any work on binocular function, the earlier treatment is initiated the more likely it is to be successful.

Treatment of the dyslexic child must involve multiple workers in multiple disciplines. The main treatment will always be Educational. The Orthoptist can help in an attempt to establish normal laterality and to alter the reference eye to the side which corresponds with the child's cerebral dominance. It is known that the sighting eye becomes fixed early in life, but the reference eye can be altered until a much later age.

The concept of the reference eye in relation to laterality has application in other fields, such as in symptom-producing heterophoria and the effects of acquired defects of visual acuity, including the effects of prolonged occlusion in some cases.

Orthoptic treatment of children with learning difficulties is only experimental at present. Further well controlled research programmes will have to be instituted including workers in all the disciplines involved, to truly assess the merit of orthoptic procedures. The value of orthoptic treatment will have to be assessed by remedial teachers and psychologists with adequate and detailed assessment of each child before and after treatment. The orthoptist on her own is not in a position to assess the true value of her treatment.

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