2. PREFACE

2.1 SUBJECT OF INVESTIGATION

Modern research into the cause of dyslexia will be investigated. Comparisons between neurological and linguistic theories will be analyzed and the effectiveness of using both in helping and understanding dyslexic people.

NEEDS, INTERESTS AND PROBLEMS DETECTED

Many researchers and educators view dyslexia either as just a neurological problem, a brain disorder, or just a lingual problem, isolated from each other. This leads to two diverse viewpoints as to how dyslexia should be tackled. However, I feel my research will show that these theories not only overlap in some areas, but also how converging them and looking at dyslexia as a whole problem, would improve understanding and thus produce better remedial methods. I also hope to show how special talents of the dyslexic can be harnessed.

2.2 JUSTIFICATION OF THE THESIS THEME:

Dyslexia effects around "10% of the UK population" and occurs to a lesser or greater degree in most countries of the world.[1] In the UK this means that in each average class of pupils there will be at least 2 or even 3 who will have this condition. Thus, dyslexia has a large impact on the education system and on society as a whole. I hope that through bringing together independent studies that have a bearing on dyslexia, along with current research, this will contribute to a better understanding and even possible earlier detection of the disorder.

3.1 GENERAL INFORMATION

Dyslexia can be likened to the dysfunction of an engine, which is dependent on many factors, internal and external. However, research into the causes of dyslexia rarely considers the whole engine, working together. Rather, many just look at one component without looking at its relation to the whole. Corrective measures for dyslexia should employ understanding of the many factors involved.

3.2 SPECIFICATIONS

Dyslexia is the result of neurological factors, such as low neural transmission speed, right cerebral hemisphere dependence. It has a genetic component, also. However, dyslexia is more apparent in certain language groups than others and is affected by nutritional changes.

CONTENTS

INTRODUCTION

Albert Einstein, a revered scientist, who has often been described as a genius, was twice sacked from teaching because of his poor spelling. How could it be that a man of such intelligence could not spell? The answer is because he had Dyslexia. What is Dyslexia exactly? Though there is continuous debate as to how to define Dyslexia, it is commonly accepted and identified as the inability to read and write at the expected levels for age and intelligence, despite adequate instruction. This condition has mystified the scientific community for many years due to its paradoxical nature. It was first described by W. Pringle Morgan, M.B. from Seaford, Sussex in The British Medical Journal, 7th November 1896, as "congenital word blindness."[2] This was based on his studies of a 14 year-old boy called Percy and was the first diagnosis of this particular disorder. To quote his findings, he says, "In spite of laborious and persistent training, Percy can only with difficulty spell out words of one syllable". Interestingly, he adds, "The schoolmaster who taught him for some years says that he would be the smartest lad in the school if the instruction were entirely oral."[3] Thus, dyslexia is not the result of a lack of intellect. The term "Dyslexia" was coined by Rudolf Berlin, literally "dys" meaning "difficulty with" and "lexis" meaning "words" in Greek.[4] It was first recognized by the British Parliament in the Chronically Sick and Disabled Persons Act of 1970. Thus, Dyslexia now constitutes a Special Educational Need in the UK, as defined by the 1993 Education Act. It is, therefore, classed as one of several Specific Learning Difficulties (SpLD). Other SpLDs include Dyspraxia, motor and co-ordination difficulties, Attention Deficit Disorder, with or without hyperactivity and Autism. Interestingly, Dyslexics may display more than one SpLD.

Since education, and indeed life as a whole, depends heavily on the ability to read and write; the difficulties dyslexics experience in doing these tasks has caused understandable concern to parents and teachers alike. However, there are even wider sociological implications of this disorder. What are they? Surprisingly, over a third of male prisoners in the UK are dyslexic, which is ten times the proportion in the general population! Why? Some have suggested that it is because there is a lack of understanding about Dyslexia and thus, those with this disorder have often been dismissed by teachers as being lazy or stupid. A negative cycle then ensues and the dyslexic child becomes disaffected. Jane Amphlett, who works with dyslexics at the Pentonville Prison, says that, "the majority of my students have been excluded from school by the time they are 11 or 12 years old!"[5] These ones experience humiliation and frustration and low self-confidence. One case study I interviewed during my research commented on this kind of frustration saying, "I was always in the lowest sets at school, I was embarrassed. Now, I can't cope with bills, cash machines or forms. Last year I went to a gym but the rowing machine had a computer to set the speed, I was too mixed up and confused when the attendant showed me what to do, I haven't been back. Work for me has always been hard and dirty, anything manual."[6] Does this not highlight the need for continued research into the causes, effects and possible remedies for Dyslexia? It is the purpose of this thesis to do just that, to bring together current theories into the causes of dyslexia, both from a neurological and linguistic perspective. To examine the links and connections between them and to consider seemingly unrelated disorders to see what they can reveal about dyslexia. I hope this will contribute to a greater understanding of dyslexia and ultimately help those suffering with it.

CHAPTER ONE: Studies of the Cerebral Hemispheres in Relation to Dyslexia

According to the British Dyslexia Association (BDA), Dyslexia has now been generally accepted as a brain disorder. Why have some come to this conclusion? One reason is that it has been found that most dyslexics are ambidextrous, which means they tend not to be left-handed or right-handed, but mixed-handed. In addition, studies comparing the brain activity of Dyslexics with non-Dyslexics have shown variations. Also, Dyslexia is 4-6 times more likely to affect boys than girls. Why? In this section, research into the above findings will be considered and their effect on reading and writing will be analyzed.

The Functions of the Left and Right Hemispheres

It is commonly understood that the human brain is divided up into two cerebral hemispheres. In most individuals one hemisphere is dominant, that usually being the left hemisphere, and produces right-handedness. There are a number of alternative combinations of dominance in existence; however, left hemisphere dominance is the most common arrangement. According to Lyndall Hendrickson of the Flinders University of South Australia, "92% of the human population are left-hemisphere dominant."[7] Even more than half of the left-handed or ambidextrous population still have left hemisphere dominance. Bever and Sherman in 1988, however, made an interesting discovery regarding dyslexics. They found after extensive examinations of the physical brain, that dyslexics have an abnormally formed symmetrical brain as opposed to having the normally occurring larger left hemisphere. So, both hemispheres were virtually of equal size in the dyslexic. What does this suggest about the brain functions of a dyslexic person? We must first understand what role the left and right hemispheres have and how this would affect reading and writing.

The left and right halves of the cortex, though separate structures, are connected by 200 million nerve fibers called the corpus callosum. So-called "split-brain" experiments, whereby the corpus callosum is severed, has revealed much about the different functions of the two hemispheres. Robert Ornstein from San Francisco, for example, compared electrical activity in both sides of the brain during different mental activities. He did this by observing the alpha waves of the brain, when the brain is relaxed alpha rhythms range from 8-10 cycles per second. If the alpha waves decreased in intensity this meant that greater use of this particular hemisphere was employed. Analytical tasks, such as mathematical problems, showed greater use of the left hemisphere, where as spatial tasks, perception of depth, recognition of faces and appreciation of music showed greater activity in the right hemisphere. It has been generally accepted from various studies, like these, that the "left hemisphere is more specialized in serial processing, that is to say, analysis that involves processing information one piece after another; whilst the right hemisphere is specialized in parallel processing, that is, taking several pieces of information together and forming a synthesis of them."[8] To illustrate, in writing, for example, one takes an idea, breaks it down into sentences, then into words and then in to letters, which are written one after the other. This is a serial or analytical process. However, recognizing a face, a person does not analyze the image feature by feature, instead it takes a large number of elements and synthesizes them into a whole. This is parallel or synthetic processing.

Linguistic abilities have long been associated with the left hemisphere, specifically the Broca's area in the temporal cortex behind the ear. However, the right hemisphere is linked with well-developed verbal abilities. For example, studies have shown that when the right hemisphere suffers injury, patients often find it difficult to understand figures of speech, puns and humor. It is from research such as this that many have felt that in most dyslexics there is a greater dependency on right brain functions. For instance, in strong verbal abilities some dyslexics have been found to excel. In fact, the British Dyslexia Association states in their definition of Dyslexia that, "some (dyslexics) display strong oral skills."[9] This explains why famous dyslexics have been found to hold positions in comedy, acting and poetry. What about spatial tasks associated with the right hemisphere? Gordon discovered in 1980 that Dyslexics did better than average on right hemisphere tasks, such as model orientation, form completion and block design, than they did on left hemisphere tasks, such as serial sounds, circles and word production. Further details highlighting the dyslexic's ability in spatial areas will now be discussed along with comparisons with Autism. The Dyslexia Research Trust feels there are strong similarities between the Dyslexic and the Autistic. What is the fundamental connection? From my research it appears the link lies in the usage of the right hemisphere.

Link with Autism and Autistic Savants

One of the main findings with regards to autism is their dependency on right brain functions and the suppression of the left. In extreme cases, as with autistic savants, this has caused some to display exceptional and extraordinary abilities, in certain fields, linked with the right hemisphere, such as the arts. It is of great significance to note that dyslexics can also excel in these fields and many occupy positions in the fields of engineering and architecture. Alan MacDowell has researched the compensating abilities of the dyslexic and often uses the phrase "the gift of dyslexia". He has formed a company called Fulcrum, which is a Birmingham-based employment agency dedicated to promoting the benefits of employing dyslexics. Why? In his words "Dyslexics are very intuitive, capable of thinking visually."[10] He describes a dyslexic engineer who has no need of computer aided design tools because he can visualize three-dimensional design images with ease. This accelerated spatial thinking, "the ability to perceive and hold in mind the structure and proportions of a figure, grasped as a whole," can be observed in the autistic and the dyslexic.[11] Einstein, mentioned at the outset, a dyslexic himself, described his dependence upon visual imagery for his thinking. Though mathematics is usually attributed to the left analytical hemisphere, Hanley in 1935, a mathematician-psychologist, described the importance of visual imagery in mathematical calculations saying in part "it’s the ability to perceive number and space configurations and to retain these as a mental pattern."[12] This adds weight to the reasons why Einstein could discover the complex theory of relativity. Einstein himself said that his ideas came to him initially as pictures and images. It was not through rational analysis or step-by-step calculations that he arrived at his conclusions, but rather in a flash, so to speak, a result of creative, intuitive and synthetic thinking. Some autistic savants are capable of almost instant mathematical calculations, also, faster than a calculator.

Obviously, not all dyslexics will display these extraordinary abilities, just as not all autistics display savant talents. However, the fact that they do occur to a greater or lesser degree in dyslexic people, gives us a window into the role the hemispheres are playing. It seems, therefore, that where there is extreme suppression of the left hemisphere functions in autistics or autistic savants, in dyslexics this is not so dramatic. As was mentioned earlier, they are usually mixed-handed, ambidextrous, suggesting that the left hemisphere is still playing a large and active role in brain processing. Going back to Einstein, for example, he still had the ability to put the theory of relativity into words and mathematical symbols after it had come to him, thus employing left hemisphere functions. It seems in the dyslexic the left hemisphere is not passive but neither is it dominant, or as dominant as it is in the non-dyslexic. Some have proposed the idea that in dyslexics there could be an atypical division of labor between the brain hemispheres. Why would this cause a problem in reading, though, for the dyslexic?

The Role of the Left Hemisphere in Reading

To understand the importance of the role of the left hemisphere in reading, we need to first analyze exactly how a person reads. Edmund Huey, who published his pioneering work, "The Psychology and Pedagogy of Reading," in 1908, was one of the first to attempt a detailed study of reading. His work remains one of the most comprehensive studies on reading even now. Huey found, firstly, that reading is "not a smooth process as one might imagine, but rather it is a process whereby the eye moves from one point of fixation to another, taking a quarter of a second to do so."[13] This results in 4 fixations per second. He found that on average 2 or 3 words were taken in during each fixation. Then, the visual information is sent on its way to the brain taking a few hundredths of a second. The brain, then, takes around a quarter to a half of a second to process the visual data and whilst this is taking place, the eye is already moving onto the next point of fixation. Thus, the eye is usually a phrase or two ahead of what one is consciously reading. Another important factor in reading is our peripheral vision, that is, visual data that is off-centre to the Fovea, where sharpest perception occurs, i.e. seeing out of the corner of the eye, so to speak. So, words that lie ahead of the current point of fixation will be partially transmitted to the brain. On the basis of this slightly blurred view of what is coming in the text, the brain will tell the eye where to move next, and thus, it can decide to jump or skip over redundant words and can concentrate on the most useful and relevant parts of the text. Thus, the brain is sifting out and editing information, which requires quick analysis and the ability to predict accurately where the text is going. This is a key point in this discussion. In addition to this, the brain relies on non-visual information in reading, as in information not actually being read, and makes decisions as to how to read a word based on previous experience and knowledge. To explain this point, it has been found, that "in one fixation the brain can only process 4 or 5 letters."[14] Now, although the brain has this upper limit as to how much visual information it can process, i.e. it cannot read more than 4 or 5 letters at a glance, when we read, we do so at a much quicker pace. How is that possible? It is due to the brains ability to recognize words based on existing awareness of it. It is able to make reference to previous visual impressions of a familiar word. That is why one has to slow down in reading when one comes across a new and unfamiliar word. To illustrate that this fascinating function takes place, allow me to conduct an experiment on you the reader! The next page will have a box containing 25 letters at the top of the page. Glance at the box for a brief moment, this will be one fixation of visual input. See how many letters you actually see during this time. Do not glance at the second box further down the page during this fixation.

JLHYLPAJMRKHMOEZXPESLM

How many letters did you see in this one brief input of visual information? Likely you will have only seen 4 or 5, probably clustered around the point where you happened to be focusing. Is that correct? Now look at the box below, this is also a sequence of 25 letters, and thus, is the same amount of visual information.

SNEEZE FURY HORSES WHEN AGAIN

This time you will have probably seen twice as much. This demonstrates your brains ability to use non-visual information to perform the task of word recognition. Hence, you did not need to read every single letter in the word "horse," for example, before you could identify the word. Thus, the brain is editing and analyzing information to allow for instant recognition of a word; it sifts out the unnecessary and burdensome visual information to arrive at a conclusion more speedily. It is similar to when a person skim reads a text, we may sacrifice the insignificant conjunctives, such as "and", for instance, to extract the meaning more rapidly. This is done on a smaller scale in all reading. Therefore, reading is a complex process requiring highly skilled analytical functions to undergo it successfully. Where does all this analyzing take place? Predominantly in the left hemisphere.

Could it be, then, that the dyslexic doesn't or isn't able to employ the left hemisphere sufficiently enough to be able to make sense of the sensory input. Do dyslexics lack the much needed editing skills required to decipher the visual information? One of the case studies I questioned during my research made some interesting points that would seem to corroborate this idea. He said that the words on the page all seemed to blend together, so words that came further along in the sentence would mix in with the current word being read. This would suggest, then, perhaps, that the brain is not able to distinguish the visual input coming from the peripheral vision, or from the next point of fixation, as distinct from the current point of focus. In effect, seeing too much information simultaneously, a trait of the right hemisphere, and not being able to process words one at a time; as in bring them to conscious thought in order, a left hemisphere function. Interestingly, in the case of autistic children, Professor Allen Snyder and Professor John Mitchell of the Centre for the Mind at the Australian National University in Canberra claim that "they seem to be innately aware of shape and other details that we suppress in order to instantly identify an object." Snyder told New Scientist: "In normal people the brain edits out most of the information, leaving a single useful idea which becomes conscious. In savants this suppression doesn't happen so they see the picture in fantastically detailed components, like the individual pixels of a photograph."[15] He also claims that these skills can be lost as one acquires language abilities since they trigger the development of a part of the analytical part of the brain, the left. So, perhaps, in dyslexics there is, also, this overload of information during reading, the brain is taking in too much. This could explain why many dyslexics complain about words and letters seemingly dancing around the page. However, some studies suggest this could be due to delayed or slow neural transmission, which will be discussed in chapter two. From my studies, I feel that there could be a combination of problems occurring, one exacerbating the other. Why do some dyslexics, though, see things in reverse order? Does the answer also lie in the enhanced right-brain functions of the dyslexic? In addition, why are boys more likely to have dyslexia than girls, again is the answer in hemisphere development? This will be discussed next.

Reading in Reverse

An interesting study conducted by Swedish psychologist, Dr. Paul Parlenvi produced an intriguing result. He believes that dyslexics see printed matter in reverse order, possibly because their reading ability originates in the right half of the brain instead of the usual left. Therefore he theorized that turning reading matter upside down to reverse the lettering order should help to solve the problem. One Englishman commented, after trying Parlenvi's system, that he "could now virtually read anything, despite having no success with trying the standard treatments for dyslexia in Britain, for nine years."[16] This would perhaps explain, also, why dyslexics often write "mirror writing", as in they write from left to right, reversing the shape of letters so that you can, in fact, place a mirror beside the text and read it normally. It is not surprising then, that Leonardo Da Vinci wrote this way, he was also a dyslexic, famous for displaying extraordinary right hemisphere abilities. It could also explain why dyslexics find it hard to distinguish words or numbers that are almost reversible, such as 96 or 69, "dog" or "god." Many of my case studies complained about this occurrence. However, I asked 5 of them to try reading text upside down and the only one that reported an improvement was the one who was left-handed, the others were unusually right-handed. I found this an interesting result, which possibly adds weight to Parlenvi's idea that the reading process is being dealt with by the right hemisphere, especially in left-handed or ambidextrous dyslexics. Why would dyslexia affect more boys than girls, though? Is this also due to hemisphere development?

Testosterone- A Possible Cause

Dr. Darold Treffert, author of Extraordinary People, thinks that testosterone may play a role in stunting the growth of the left hemisphere. After studying the Autistic savant syndrome, which also is 6 times more likely to occur in men than in women, he claims that prenatal interference in way the brain develops is responsible. Is this a possible cause for the gender differences in dyslexics? Does testosterone interfere with the development of the left hemisphere in dyslexics, perhaps not to the same degree as in the autistic, but enough to impede their reading and writing ability and to exhibit on a smaller scale the talents of some autistics? It is possible.

Still, a question remains, which came first? Is dyslexia the symptom of a brain disorder or the cause? Some argue that due to poor neural circuitry and slow neural transmission found in dyslexics, the brain is receiving confusing messages to start with. I feel this would hinder the development of left hemisphere functions. It would not be able to build its reference library of words, so to speak, as discussed earlier, if it never received an accurate impression of the words to start with. I will elaborate on this further in my conclusion. A consideration of the findings briefly mentioned above will now be considered.

CHAPTER TWO: A Neurobiological Basis For Dyslexia.

As was mentioned in chapter one, dyslexics often complain that words and letters seem to move around. Another common symptom that dyslexics exhibit is that many have a tendency to be clumsy, displaying a lack of co-ordination. Also, the normal milestones of development, such as crawling, walking, learning to speak are often delayed in dyslexics. Why? Is there a connection? Dr. John Stein of Oxford University's Physiology Department, who specializes in vision, has championed a new theory regarding dyslexia. He feels it is linked to unstable eye control. The reason for this conclusion is based on some interesting findings with regards to the neural circuitry of the brain in dyslexics. First, I will consider the findings and then discuss what relation this would have on reading and writing.

The Role of Magnocells

John Stein, along with his colleague Joel Talcott, developed an experiment. Subjects were asked to watch two computer screens displaying what looked like a snowstorm of tiny dots moving around the screen randomly. This is similar to what we call "white noise" on a poorly tuned television set. Then Talcott would make some of the dots move in the same direction. The challenge was to see how many dots had to move together before the viewer noticed. From a series of studies, it was found that people with dyslexia are less likely to spot the change: they needed more dots to be synchronized before they noticed the movement. This seemingly simple experiment has also proved to be a good way of measuring how severe a case of dyslexia is. It was found that "the poorer the ability to detect the change in motion, the worse the reading and spelling."[17] This convinced Stein that the visual system has an important part to play in dyslexia.

What causes this difference in visual acuity? Stein suggests that the visual defect lies in a set of very large nerve cells called magnocells. These cells form a pathway from the retina to the area where information about images seen from the left and right eyes first combines- the lateral geniculate nucleus- and then travels onwards to the visual cortex. This pathway is known as the "M-pathway". The magnocells' large size and their thick insulating coats made up of the fatty substance called myelin, enable them to carry electrical impulses (the essential messages of the nervous system) faster than other nerves. In effect these are the cables of the brain. Their speed is crucial to their role of telling the visual cortex about rapid changes or movements. Steins point can be demonstrated if you move your finger from left to right across the eye. Stein claims that to know that the finger is moving, there has to be a signal that travels fast enough to the brain in order for it to calculate and time those events very accurately. Stein asserts that, "In young children the degree of stability of the eyes when they are fixating on a word correlates with the sensitivity of the magnocell system."[18] So, in effect, the more sensitive the magnocellular system is, that is, the more speedy its response to visual changes etc. the more stable the eye will be. Thus, impairment of the magnocell system would cause instability of the retina. Is there any physical evidence, though, that the magnocells are not functioning to their full potential in the brain of dyslexic people?

Studies Corroborating Steins Theory

Margaret Livingstone and Albert Galaburda from Harvard Medical School in Boston, used scalp electrodes to track the electrical signals to the brain. They found that the M-pathway of dyslexics is slower to send impulses from the retina to the visual cortex than in non-dyslexic M-pathways, the difference being 50 milliseconds. This equates to doubling the normal transmission time. In effect, the difference between hitting a ball and missing it altogether, for instance. Livingstone and Galaburda also examined post-mortem brain tissue from people who had dyslexia. They found that the M-pathway neurons looked abnormal under the microscope. Many appeared in the wrong place and were often significantly smaller than usual.

Further evidence comes from Guinevere Eden, who worked with Stein at Oxford, before moving to the US National Institute for Health. In 1996, she reported that people with dyslexia have less brain activity than usual in the part of the visual cortex that detects motion, known as V5. Later, Johnathon Demb and David Heeger from Stanford University in California confirmed and extended these findings, showing that there are also defects in the primary visual cortex, known as V1, the first cortical region to receive visual information. Both V5 and V1 depend heavily on the M-pathway neurons for their input.

So, it seems it has been established that a problem does exist in the M-Pathway of dyslexics, but how does the ability, or lack of it, to detect motion at high-speed affect reading?

The Impact of the Magnocellular System on Reading

Although text does not move, reading is not a smooth process. As was discussed in chapter one, in a series of quick eye movements punctuated by brief pauses (fixations), the retina obtains a sequence of images from a page of text. The brain then lines up each image next to the previous one to gain a smooth impression. Normally, the M-pathway controls these eye movements. Thus, defects in the M-pathway could easily cause difficulties in reading and writing. Stein has found that many dyslexics find it difficult to hold their eyes steady between eye movements. This is because the M-pathway is failing to send adequate stabilizing messages to the brain. If the eyes are not steady, they will send images to the brain that are moving slightly, which may explain why dyslexics often complain that words seem to dance around on the page, as mentioned earlier.

Stein claims that if a person lacks control in their eye movements during critical periods of development, they may never lay down reliable visual impressions of words, which is vital in reading. Hence, as a consequence of this, they have problems identifying and recognizing words later on. As was discussed in chapter one, the brain utilizes non-visual information to decide how a word should be read, based on previous experience and knowledge of that word. However, if previous experience is lacking, and knowledge is inaccurate and confusing, then records stored by the brain will be inconsistent and unreliable. It is, thus, easy to see how problems can develop in this area. However, some have argued that if dyslexia is a visual defect, why does it only become apparent when reading?

The P-pathway

Those with dyslexia have no trouble when it comes to their perception of color, shape and texture, so how can it be asserted that it is a visual defect. Stein points out that color, shape and texture are conveyed to the visual cortex by a set of smaller neurons, known as the Parvocellular pathway, or "P-pathway". The M-pathway and the P-pathway combine their efforts to create the visual scene. In addition, subtle defects in perceiving any one aspect of this visual scene are usually compensated for with both pathways working together. However, reading and writing requires attention to finer details, to small and uniformly sized symbols. This is different to observing a view of the countryside, for example. The separation of visual scenes into these two processing pathways may explain why some dyslexics find their reading is improved when they wear tinted glasses or cover the text with colored sheets of acetate. Stein believes that this is because the visual burden is shifted from the M-pathway to the P-pathway, due to reducing the contrast of the black ink on a white page. Why would this work, though?

The Use of Coloured Tints to Improve Reading

David Harris, a researcher at the Ultralase Clinic in Chester, was intrigued by patients who told him that tinted glasses prescribed to remedy poor color vision also helped their reading. So, he took 47 children and adults diagnosed as having dyslexia and fitted them with different colored lenses to find out which color made it easiest for them to read.

All the volunteers were then given reading tests with and without lenses, and with lightly tinted "placebo" glasses, which had been described to the subject as being specially made to improve reading. The results were that "on average subjects were reading 6 words per minute faster than when they wore the "placebo" glasses and 12 words faster with the most effective colored lenses. This was a 15 % improvement."[19] Why? Stein believes that the defective magnocells respond more strongly to yellow-orange light, so colored lenses help by filtering this light. Recently, Gill Hebb of the Dyslexia Research Trust, has also found that people using blue filters for reading have a hypersensitive magnocellular system. Again, suggesting certain colors stimulate the magnocells more than others and thus, this adds weight to Steins theory.

Now, let’s return to the question of eye movement, or what has been termed in the field of dyslexia as the "wobbly eye" syndrome.

Controlling Eye Movement in Dyslexics

If Professor Stein's theory is correct, reading problems would be alleviated, if the unstable eyes of dyslexics could be steadied. Stein tested this theory by asking 144 severely dyslexic children to take part in an extensive study. Half of them were randomly selected and given an opaque eye patch to cover their left eye. Three months later, those who had been given the eye patch to wear had greater eye control and their reading had greatly improved in comparison to the group who did not wear the patch. This advantage was maintained throughout the nine-month study, so that when the study concluded, those using the eye patch were eight months ahead in their reading abilities, than of those not wearing the patch. One girl, a 17 year old teenager with a lazy right eye commented, that the patch forced her defective eye to work and thus, after 6 months she no longer needed to wear the patch nor any corrective tinted glasses to read. Stein argues that this method prevents "the two differing views of both eyes interfering with each other and crossing over, a process that is normally monitored and compensated for by the M-pathway."[20]

Still, there are other characteristics of dyslexics yet to be explained, such as their clumsiness. Has Steins’ work got wider implications going beyond just the visual problems faced by dyslexic people? Is dyslexia just a symptom of a larger disorder?

The Wider Application of Stein's Work

Cognitive Neuroscientist Paula Tallal of Rutgers University in Newark concurs with Stein in feeling that dyslexia is a result of broader abnormalities in the nervous system.

Tallal has shown that dyslexics also have a problem with sound, which again is linked with the speed by which a message is processed and thus, not dissimilar to what occurs visually in dyslexics. She found that dyslexics "fail to hear two pure tones if they are presented too close together."[21] For example, a doorbell may do this with its rapid version of "ding-dong". Most people notice the difference if the gap between the two tones is about 40 milliseconds or more, but people with dyslexia find this too rapid to detect. Sounds such as "ba" and "da", which are also hard for dyslexics to discriminate, involve similarly rapid changes in sound frequency. We hear "t" and "d" differently only because an array of sensors in the cochlea detects frequency changes with each letter. Could it be that there is an equivalent to the M-pathway in the auditory system? A system designed to spot changes or transients, as they do visually.

Supporting this view, Galaburda and colleagues have discovered that there are large neurons similar to magnocells, in the sound processing area of the brain known as the medial geniculate nucleus. These cells are less numerous and smaller than normal in people with dyslexia. What about the motor functions affecting coordination?

The Role of The Cerebellum

Dr. Levinson raised the point that if dyslexics have problems with all sorts of higher brain functions like hearing, vision, timing and memory, then they should be severely mentally impaired, whereas in fact they are often very intelligent. He believes, therefore, that the problem starts with the cerebellum, which fine-tunes all the messages that are coming in and out of the brain. The cerebellum when unwound it is almost as big as the cerebral cortex and thus, it plays a vital role in monitoring and controlling everything we do. The cerebellum distinguishes between what is "self" and not "self", so to speak. It predicts the sensory consequences of our own movements and can, therefore, ascertain that any additional sensations are a consequence of external factors. It is also responsible for automatic functions. Dyslexics have difficulties in situations governed by the cerebellum, such as coordination and timing. Is there any evidence that the cerebellum is at fault in dyslexics?

Caroline Rae of the MRC Magnetic Spectroscopy Unit in Oxford has shown that chemical reactions of the body's "automatic pilot", the cerebellum, are slightly different in people with dyslexia and thus, could explain why they are less coordinated than normal. Recently, Professor Rod Nicholson and Dr. Angela Fawcett have found, after 12 years of research using brain-scanning techniques at Sheffield University, that the cerebellum is under-performing in dyslexics. They claim that dyslexic children find it difficult to do anything automatically. In fact, it was shown that dyslexics only use 10% of normal brain activity in carrying out familiar tasks. This would explain why dyslexic children even when reading well, are less fluent and need more time and effort to read than their classmates of the same age. To illustrate, the driving of a car is an automatic function, however, if you were to drive in a foreign country, on the opposite side of the road, for example, this function would now require concentrated effort and may be mentally tiring. Reading for dyslexics is like this, a tiring struggle, demanding a great deal of mental energy. The majority of my case studies complained of tiredness when reading. Is reading, therefore, for the dyslexic like reading for the first time, every time, almost? If that were the case, it would, indeed, be difficult to negotiate the task.

The findings discussed in this chapter suggest that dyslexia may be a symptom of a much bigger problem and not an isolated disorder. It seems that the essential systems guiding movement, compensating for and detecting changes are dysfunctional in the dyslexic. Why, though, do defects in the M-pathway neurons arise in the first place? Is there a genetic disorder? These questions will now be addressed.

CHAPTER THREE: Dyslexia- The Genetic and Nutritional Factors

Geneticist Tony Monaco and Simon Fisher, from The Wellcome Trust Centre for Human Genetics in Oxford, studied the genes of 200 families with at least 2 dyslexic children in the family. It was found that the dyslexics shared a group of genes found on a particular part of chromosone-6, which is close to the genes controlling immune responses (the MHC complex) and play an important part in the development of reading skills. The possible connection with immune development is of special interest because this system has recently been shown to regulate the development of the visual magnocellular neurons, discussed in chapter two, and it may shed some light on the "high incidence of autoimmune conditions that are found in dyslexics."[22] Since autoimmunity is the inability of the body's internal defense mechanism to recognize its own body cells, which in turn leads it to attack them, Stein speculates that the magnocellular system, discussed previously, is impaired in dyslexics as a consequence of having been attacked by the body's own defenses. Let us consider the impact of an autoimmune response on the brain and then analyze the feasibility of such an assertion.

Autoimmune Studies

It is interesting to note at this point that the leading theories with regards to the causes of autism are that it comes as a result of an autoimmune reaction. Like dyslexics, H.H. Fudenberg of the NeuroImmuno Therapeutics Research Foundation, states, "the gene for classic autism has been localized to human chromosome-6, the sight of human immune response genes."[23] Thus, it has been found that the autistic person seems to have a genetic predisposition to immune system malfunctions, also, one of these being autoimmunity. To corroborate this, recent scientific findings have shown multiple immune system abnormalities in autistic individuals. Dr. V.K. Singh's, for instance, who has done extensive studies in this field and is a leading scientist in the Autism Autoimmunity Project, found that antibodies against the brain and other body elements have been detected in autistic individuals. So, indeed there is a strong genetic link, between dyslexia and autism, that being chromosone-6, and it is apparent that both suffer from autoimmune disorders, but is there any specific evidence that autoimmunity could cause dyslexia?

After extensive research on this question, I did find a very interesting study that does link autoimmunity with dyslexia.

Autoimmunity and Dyslexia

Two reports, published in late December 1999, described the very high incidence of autism in children whose mothers had received live virus vaccines in the postpartum period, prior to conception and during pregnancy. Following these reports, F. Edward Yazbak, in his article Autism: The Vaccination Connection, discusses 22 case studies. These were mothers, who had received live virus vaccinations during the said periods and had subsequently had at least one child who developed Autism. The study in general showed that early and severe derailments of the immune system can lead to profound neurological damage. What does this mean exactly? Well, derailments seem to occur in conjunction with environmental "insults", as they are called, such as pre- or post-natal viral infections or vaccination. However, the principle cause of the breakdown in the immune response is due to a genetic predisposition to immune system malfunctions, linked with chromosone-6. Thus, a viral "insult" in predisposed persons, can ultimately lead to a state of autoimmunity. As dyslexics have this same predisposition also, could an "insult" create an autoimmune response in them? Two of the case studies following did show a connection.

1/A mother who was born in 1953 delivered her first child in November 1984 and was given a rubella vaccine shortly thereafter. This girl who was not breastfed is normal. The mother then had three miscarriages before conceiving her second child, a boy who was born 9/8/1987. Again the mother was given a rubella vaccine shortly after delivery, and this time she breastfed her baby for four months. This boy "was a happy healthy infant and he began walking around 12 months." He received his first MMR (Mumps, Measles Rubella) at the age of 29 months. " He was approaching three when I became concerned with his inability to produce understandable verbal language" states the mother. A long list of medical and educational diagnoses was exhausted before the diagnosis of autism was confirmed. She says, "I have always felt there was a strong connection". The third child, a daughter was born on 11/28/1988. Mother was given yet a third postpartum rubella booster and also breastfed this child who now has severe dyslexia, ADHD and learning disabilities.

2/ This mother, born in 1971 was routinely vaccinated as a child. She had a miscarriage on 1/6/1993 at 28 weeks gestation. Four weeks later, she was given an MMR booster because she was rubella-susceptible. On 3/10/1994, she delivered a boy four weeks prematurely. This boy reportedly has ADHD, motor dyspraxia and sensory integration dysfunction. Her second boy was born on 7/8/1995. He has been diagnosed with "autistic spectrum disorder." His symptoms started before he was one. The last boy was born on

12/22/1996. Like his oldest brother he has been diagnosed with sensory integration dysfunction and dyspraxia, both motor and verbal. All three boys were breastfed and routinely immunized.[24]

From considering these examples, it can be seen firstly, that there is a genetic factor, since these mothers both had more than two children with predisposed autoimmune vulnerability, linked with chromosome 6. Secondly, it seems the "insult" in the form of a vaccination caused deterioration of mental capabilities in the children. Thirdly, we see the link between the two disorders, dyslexia and autism, especially in case study one. However, case study two had children with dyspraxia, a condition very closely linked with dyslexia, both have very similar symptoms i.e. lack of motor co-ordination etc. Interestingly, one of my case studies had a nephew with autism and a nephew with dyslexia, again supporting this genetic link. Fourthly, it can be concluded that the same autoimmune response responsible for autism could be the cause of dyslexia, also.

Exactly what could be under attack during the autoimmune response that would cause such an effect on brain functions? What is of particular relevance here, I feel in the case of dyslexia, are studies that have shown that autoimmune reactions can have a damaging effect on the myelin sheath. As previously mentioned Stein speculates that the damage to the magnocellular system in dyslexics could be the result of an autoimmune response. The substance that is crucial to the function of magnocells is the myelin sheath. Hence, damage to the sheath would cause magnocell impairment. First, let us look at the role of myelin in more detail and then consider studies that have shown a link between autoimmune disorders and myelin.

A Look at Myelin

Myelin is a membrane that forms around nerves, enveloping the axon and is found at low levels in the brain. It is composed of protein and lipids (non-water-soluble fats). The myelin sheath, as it is known, around nerves speeds the transmission of impulses along nerve cells; much like the plastic layer round a copper wire in an electrical flex, it prevents leakage of the nerve impulse. The speed at which a nerve impulse travels is known as its conduction velocity. In human nerve fibers, values range from 1 and 3ms-1 in unmyelinated fibres and between 3 and 120ms-1 in myelinated fibers. These myelinated connections form the wiring circuitry of the central nervous system, i.e. the brain and spinal cord, and peripheral nervous systems of the body. As has been established in chapter two, it was found that "the M-pathway of dyslexics is slower to send impulses from the retina to the visual cortex than in non-dyslexic M-pathways, the difference being 50 milliseconds. This equates to doubling the normal transmission time." Since there exists a problem in dyslexics with reference to the speed of impulse transmission and as we have just noted, the myelin sheath has a direct effect on conduction velocity, it is reasonable to assume that there may be a connection. Could damage to the myelin sheath be the result of an autoimmune response, since autoimmune disorders are common in dyslexic individuals?

Autoimmune and Myelin

G. Trottier et al reported in his article, "Etiology of Infantile Autism: A Review of Advances in Genetic and Neurobiological Research", saying, "there appears to be a genetic basis for a wide "autistic syndrome" and autoimmunity may also play a role.

Antibodies against the Myelin Basic Protein (MBP) are often found in children with autism."[25] Another study discussed in the Journal of Allergy and Clinical Immunology stated this: "Children with autism have been shown to have a high incidence of circulating auto antibodies to MBP and to neuron-axon filament protein (NAFP) compared with healthy controls or controls with other disabilities. Subacute viral infections of the central nervous system have been postulated to play a role in children who develop normally before undergoing autistic regression. In one instance, a healthy boy having a typical case of roseola (HHV-6) at 15 months experienced severe regressions of language and social behavior soon afterward. The presence of antibodies against MBP and NAFP, along with elevated levels of HHV-6 antibodies, suggests an autoimmune response to this neurotropic virus, resulting in autistic regression."[26]

These studies show that damage to the myelin sheath can be caused by an autoimmune response. They also show that such damage does have an impact on neurological activity and can produce learning difficulties.

Since it is well established that a high proportion of dyslexics also have autoimmune disorders and that they share the same genetic immune susceptibility as autistics, linked with chromosome 6, is it not reasonable to conclude that they could also experience the same specific autoimmune response that has a direct impact on the myelin sheath. This would certainly add weight to Steins theory. It also raises new questions with regards to the cause of dyslexia. Are vaccinations or viral infections to blame for the disorder, also, as some have proposed in the case of autism? Could the disorder be prevented through genetic screening for immune vulnerability and acting accordingly? Could the potential for developing dyslexia be detected earlier and thus, be compensated for almost immediately. This would save the many lost years of education due to the delays in diagnosing the disorder. The ages my case studies were when they were diagnosed as having dyslexia ranged from 15 to 31! This represents a great loss of valuable time.

If dyslexia, though, is the result of an autoimmune response and is genetically inherited, why have some recent studies in the field of nutrition had some success with dyslexics, particularly with regards to essential fats? I feel there could also be a connection with Myelin here.

Nutritional Studies

There is a wide spectrum of conditions in which deficiencies of highly unsaturated fatty acids (HUFA) appear to play a role. Adequate supplies of HUFA are essential for the normal development of the brain and for maintaining optimal brain structure and function. In fact, Dr. Udo Erasmus states that, "half of the weight of our brain, the fat-richest organ in our body, is essential fatty acids."[27] So, what are essential fatty acids exactly? Basically, biochemists describe a certain series of essential fatty acids as the "Omega-3" series. Included in this series are EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). EPA primarily reduces inflammation and blood clots within the cardiovascular system and has been shown to reduce the risk of Lupus, Rheumatoid Arthritis and even asthma. (It is interesting to note that these are common autoimmune disorders). DHA has been identified as an essential fatty acid in the brain, nerve and eye tissue. It is especially important in the development of an infant's visual acuity and motor skills, which are often impaired in dyslexics. These EFA's can be obtained from fish oils, certain seeds and they are also provided through breast milk.

The Role of Essential Fatty Acid's in Learning

Dr. Erasmus conducted an interesting study with rats. The mother rats were deprived of Omega-3 essential fatty acids. The results showed that the mother then produced pups with permanent learning difficulties. Dr. Erasmus states, also, from his studies, that a deficiency in Alpha Linolenic Acid (LNA), or Omega-3, not only results in learning disabilities, but also the impairment of vision and a lack of motor coordination in humans. As discussed, these are the very things common to dyslexics. So, could including EFA's in the diet of dyslexics help?

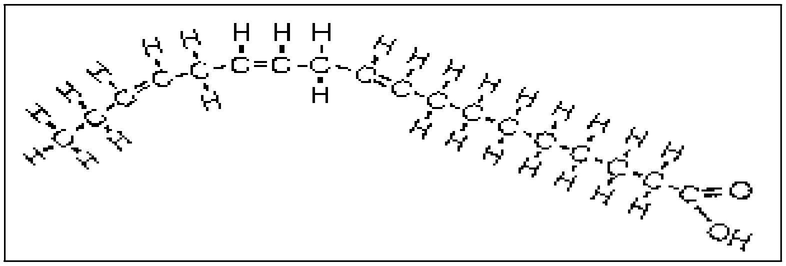
Dr. Alex Richardson conducted a study at a special school where most of the students had dyslexia. He and his colleagues divided a group of 40 children, aged between 8 and 12 years. One group had fish oils added to their diet for 3 months and then the other group took the fish oil capsules for the following 3 months. The study found stark differences in the children's scores, the abilities of the dyslexic children were greatly improved. They found that children taking the EFA's were more relaxed and thus, their ability to pay attention was much enhanced, also. Dr. Richardson noted, too, that, "children with physical signs of EFA deficiency were more likely to be particularly poor readers."[28]

These findings proved true in one of the case studies discussed in this thesis. Thomas, who is said to have a combination of learning difficulties, being autistic and dyslexic, finds it difficult to relax whilst at school and thus, his lack of concentration was repeatedly mentioned in the reports from his SNA (Special Needs Assistant). His mother commented that he often complains of headaches when he returns home from school. When it was time for Thomas to take exams, which is a particular stressful time for him, EFA's were added to his diet without his knowledge, mixed in with his normal food consumption. The difference was remarkable. Not once did he complain of having a headache, which was highly unusual given the demanding mental tasks he was undergoing and his scores showed an improvement. The question is, though, why would EFA's work? Is there a link with the myelin sheath?

Essential Fatty Acids and Myelin

If EFA deficiency causes symptoms linked with slow nerve transmission speeds, (i.e. visual impairment, clumsiness) and, as has been established, myelin has a large role to play in this, then it seemed to me that there might be a connection. Especially since myelin is predominantly a fatty substance, composed of protein and lipids (non-water-soluble fats). From researching this point, I found some studies that claimed that "damage to myelin can be the result of saturated fatty acids and that, unsaturated fatty acids, fatty acids that have carbon double bonds (explained later) are not deleterious to myelin."[29] It has been found, however, in "certain autoimmune disorders, that the properties of very long chain saturated fatty acids (VLCSFA), fatty acids with no carbon double bonds, may allow it to concentrate in the myelin sheath and may cause a local immune response resulting in the destruction of the sheath. However, fatty acids with shorter chains and double bonds, or kinks, are less likely to insert into or solubilize the myelin sheath."[30]

Omega 3 is one of these shorter chain fatty acids with 3 double bonds, classed as an Essential Fatty Acid, as can be seen from the diagram below.



This diagram shows 18 carbon fatty acids, represented by the letter "C" with three double bonds at the 3, 6, and 9 carbon positions. What does this mean? Well, counting carbon's from the left, at point 3 you will see that there is a pair of carbons, both with only one hydrogen molecule (represented by the letter "H") and that they cause a kink in the chain, these are known as double bonds. The diagram shows three double bonds. As the first double bond occurs at point 3, this chain is known as Omega 3. These double bonds cause this chain to be "unsaturated" in the sense that not all the carbons are saturated with hydrogen on both sides. When all the carbons are saturated, the chain becomes straight, with no kinks.

It is interesting to note the damage that very long chain fatty acids can do to the myelin sheath of those with a propensity towards autoimmune disorders. It seems therefore, that the studies with regards to nutrition are not isolated from studies with regards to genetics; they do in fact overlap. Thus, it can be said, that those with defects detected on chromosone-6 and who have a predisposition to immune disorders have a higher sensitivity to certain environmental factors. If dyslexia is the result of the above, why are those in certain language groups more likely to be dyslexic than others? Let us see.

CHAPTER FOUR: Dyslexia- The Linguistic Perspective

The International Book of Dyslexia recently published some interesting findings with regards to the prevalence of dyslexia throughout the world. A sample of these statistics is as follows:

Belgium 5%

Britain 8-10%

Czech Republic 2-3%

Finland 10%

Greece 5%

Italy 1.3%

Japan 6%

Nigeria 11%

Norway 3%

Poland 4%

Singapore 3.3%

Slovakia 1 to 2 %

USA 8.5-10% [31]

It is interesting to note that the occurrence of dyslexia varies in different countries and language groups and is more likely to occur in English reading nations. Even in Nigeria, which shows the highest percentage of dyslexic people, English is the main language used in school and education. If dyslexia is a brain disorder, one would expect equal proportions of dyslexia occurring throughout the world. So, why does this variance occur? To answer this question, differences in language structure need to be discussed.

The Structure of Language- A Comparison

The languages of the world can be categorized as follows:

- Transparent (Russian, Spanish, Portuguese, Polish, Welsh, Italian)
- Non-transparent (English)
- Morphophonemic (Chinese)
- Transparent, agglutinal (Hungarian)
- Mixed (Japanese)

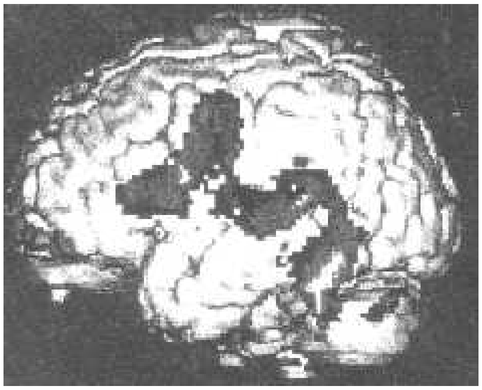
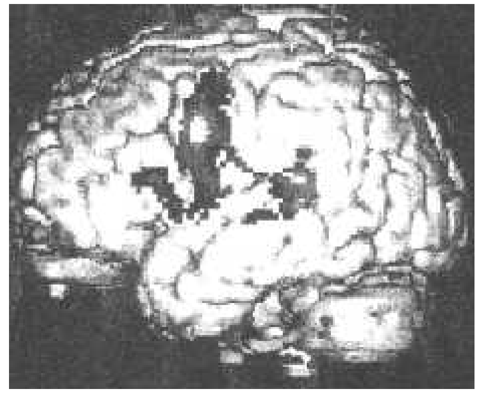
Comparing the above with world statistics discussed earlier, it can be seen that Dyslexia is less likely to occur in language groups that are transparent and more likely to occur in non-transparent language groups. What does this mean, though, exactly? To compare English with Italian, for example, English has 40 phonemes, the actual sounds required to pronounce all its words. However, English has 1,120 different ways of spelling these 40 phonemes.[52] The phoneme represented by the letter "c", for instance, as in the word "cat", can also be represented by the letter "k" in "king" and even "ch" as in "chemist". To add to the confusion, consider words such as cough, bough, dough and tough, the "ough" combination here does not represent one phoneme, but many. So, English is a perplexing language because, not only are the same phonemes represented by different letters, but the same letters are represented by different phonemes! Thus, English is a highly irregular and illogical language and is notorious for these inconsistencies. It is, therefore, classed as a non-transparent language. Italian, on the other hand, needs only 33 combinations of letters to spell out its 25 phonemes! It is, thus, far simpler because the rules for pronunciation and stress are consistent. It is therefore, classed as a transparent language. Other transparent languages are the same, strictly phonetic, that is they deviate rarely from a standard system guiding spelling and reading. Hence, the same letter is always used for the same sound. If this were true in English then we would see "cat" spelt "kat" or "king" spelt "cing" but we would not see both combinations in existence.

Another way that languages differ is in the size of their vocabulary. The English language has almost "one million words" and has the largest vocabulary in the world.[32] In fact, English borrows words from other languages of the world, i.e. "bon voyage", "bon apetit", "c'est la vie" from French. This complicates matters further, for English readers, by introducing other phonological rules into English. For example, if in English one was to follow our own phonetic rules, irregular though they are, to pronounce "c'est la vie", one might pronounce "c'est" like "best" or "vie" like "die". Instead, English readers are expected to comprehend foreign phonetic laws along with their own irregular ones. Due to this, many have argued that the English language is at fault and that this is why English reading countries report higher figures for dyslexia than in Italy, for example, where dyslexia is virtually unheard of. Indeed, one researcher, in his address at the First International Convention for Multilingualism and Dyslexia held in Manchester, UK, stated that, "English is a dyslexic language!" He went on to claim that English causes dyslexia saying, "the spelling and lack of regularity in phonological patterns (in English) is indeed an obstacle to reading and spelling efficiently." A number of studies corroborate this idea. Esther Geva, of The Ontario Institute for Studies in Education at the University of Toronto, conducted studies of families who were multi- or bi-lingual. Dr. Geva's studies showed that if one is dyslexic in one language, it does not mean one will be in all languages. Also, she found a correlation with regards to the differing degrees of transparency as mentioned earlier, that is, the closer the sounds and orthography (spelling) of a language correspond the easier it will be to read. Thus, in one study, students whose families spoke English, but had poor word recognition when reading English, had much higher word recognition when they read Hebrew, which is a very transparent language.

Still, the vast majority of the English reading population do successfully negotiate the complex task of reading and writing English. Also, in transparent language groups, dyslexia does still manifest itself; it does still exist. Therefore, the fault cannot lie with just the language itself. Can studies of the brain have something to reveal here?

Brain Differences

A study of Hopi Indian children in Arizona was interesting. It indicated that their very transparent language required greater use of the right-hemisphere of the brain, than do non-transparent languages. Dr. Bennett Shaywitz, who co-directs the Centre for the Study of Learning and Attention at Yale University, reported an interesting finding based on the brain scans of dyslexics, by a team of scientists from France, Britain and Italy. Please see an example of the actual scans below.

These scans show a marked difference in the brain activity of the non-dyslexic (left) and the dyslexic (right) whilst reading. Thus, it can be seen that there is more brain activity, represented by the darker areas of these images, in the non-dyslexic than in the dyslexic, in specific points of the brain. What do these points correspond with? These points in the brain are where links between vision, sound and meaning are made. Therefore, "links between language and visual cues are strongest in the non-dyslexic and are quite weak in the dyslexic."[33] What implications does this have and how is it related to lingual studies regarding dyslexia? Well, firstly, it was found that all dyslexics, regardless of their linguistic background show this same lack of neural activity in this specific area. So, why is dyslexia more prevalent in non-transparent languages? It has been proposed that transparent languages do not depend on linking visual cues to meaning, as much as non-transparent languages do. This is because they have a set of unchangeable phonological rules to guide them.

To illustrate this, let us consider an interesting study by Uta Frith of University College, London, which corroborates this idea. Professor Frith showed that differences in the structure of languages lead to different strategies for reading and pronouncing words. So, English and Italian speakers were asked to read words and pronounceable non-words, i.e. "cauruntle". It was found that English speakers took longer to begin reading each word, and were even slower when they had to apply a pronunciation to a made-up word. Also, English- speaking volunteers had to work out what the meaning might be before they could settle on a pronunciation. The Italian subjects, however, were much quicker due to having this sure set of rules to rely on when translating letters into sounds, they did not need to extrapolate the meaning first. If the connection to meaning is key in reading English and there is little activity in the brain that makes this connection in the dyslexic, it is easy to see why dyslexia would be more apparent in English than in transparent languages, such as Italian. Italian dyslexics are not so dependent on this brain function. In fact, Eraldo Paulesu of the University of Milan Bicocca, showed from his studies, that comparisons between Italian dyslexics and English dyslexics revealed greater reading ability in Italians, despite dyslexia.

So, it seems that certain languages are "dyslexia-friendly", so to speak, in the sense that they employ less of the left-hemisphere and more of the right, which is predominant in dyslexics. English requires a great deal of analysis before a conclusion can be drawn and this function is the specialty of the left hemisphere. This links in well with the studies discussed in chapter one.

The problem is not in just the language itself, that is, there are definite neural differences manifest in the dyslexic. However, dyslexia is not just a neural disorder, as we have seen, the language structure can worsen or alleviate the problem.

CONCLUSIONS AND RECOMMENDATIONS

At the outset, it was mentioned that dyslexia could be likened to an engine, with many components working together and not in isolation. For example, an engine needs its oil changing periodically to ensure the engine is operating at optimum levels. Without this, the vehicle may struggle with normal tasks and when presented with a more demanding task, going up hill, for example, problems may become manifest. We have seen the role oil plays in improving the abilities of the dyslexic, Essential Fatty Acids were discussed, but we also saw that these nutritional studies cannot be looked at in isolation to other findings. We saw that the advantages of Essential Fatty Acids could be linked with the Myelin sheath, which can be damaged through an autoimmune response, brought about by an environmental insult. Thus, changing the diet of the dyslexic is not the whole solution and that nutritional factors are not the whole cause of the problem either, just as changing the oil of a car is not all that is required to maintain it. Use of vaccines in genetically predisposed individuals is another factor to consider, for example. A connection between studies discussing the magnocellular system and autoimmune disorders was established, thus, providing a bridge to the studies mentioned above. This then gives us a wider view of the causes of dyslexia, that is, it is not just a visual problem or just a genetic problem, but a combination of many things. However, it was seen clearly that Dyslexia is more apparent in non-transparent language groups, such as English, which wouldn't be the case if dyslexia is just genetically predetermined, for example. However, this does not mean dyslexia should be tackled from just a linguistic point of view, either. Indeed, we saw that dyslexics have a greater dependency on right-hemisphere functions, and it was seen that transparent languages require less use of the left-hemisphere than abstract languages, such as English, do. Thus, reading English is like the car struggling up hill, it is a more demanding task, which makes an existing problem manifest. It is not the hill that is at fault; neither can the fault just be laid at the door of the English language itself. So, Dyslexia has to be looked at as a whole problem with many contributing factors. Then remedial strategies employing knowledge of all the factors involved would be more effective, rather than just tackling dyslexia from one angle.

It was also seen that the dyslexic's disability with regards to reading and writing is by no means a measure of their intelligence. In fact, the opposite is true, in many cases dyslexics have enhanced abilities in certain areas, remember Einstein and Da Vinci, for example. Recognition for their talents and for their unique way of seeing the world should be reflected in our education system. Dyslexics should not be excluded from knowledge until they are capable of accessing it in a way that requires them to be literate. Highly intelligent dyslexic children often have their intellect doubted and whilst they are forced into separate remedial classes, working on reading "cat" and "rat", their contemporaries are dealing with information considered beyond the dyslexic. In addition to this, the education system is not only word-based, but it gives greater emphasis to analytical thinking and subjects, not allowing room for the synthetic, or dyslexic thinker, to grow. Are we not, thus, possibly wasting valuable human resources? Are not potential Einsteins passing us by?

Indeed, dyslexia can be a gift if detected and harnessed early and the burdens of dyslexia can be alleviated with strategies, which combine and utilize knowledge of its many different facets.

References

1- British Dyslexia Association-
http://www.jmk.su.se/global99/access/dyslexia/statdys.html
2- Library of Congress, Online Science Section-
http://lcweb2.loc.gov/cgi-bin/query/D?sctb:1:./temp/~sctb_IcVT::
3- Library of Congress, Online Science Section-
http://lcweb2.loc.gov/cgi-bin/query/D?sctb:1:./temp/~sctb_IcVT::
4- Overcoming the Frustration of Dyslexia- Awake! 8th August, 1996, p 11-14.
5- Tinted View-New Scientist, 30th October, 1999.
6- An Interview with David Harrison, Case Study One.
7- Phenomenal Talent- The Autistic Kind- Lyndall Hendrickson, Visiting Fellow
http://www.nexus.edu.au/teachstud/gat/hendric1.htm
8- The Two Sides of the Brain- The Brain Book, Peter Russell, p 48-53
9- British Dyslexia Association, Dyslexia- A Definition-
http://www.bda-dyslexia.org.uk/d07xtra/x02stats.htm#define
10- When Words Dance- Guardian, 24th April, 1999
11- Phenomenal Talent- The Autistic Kind- Lyndall Hendrickson, Visiting Fellow
http://www.nexus.edu.au/teachstud/gat/hendric1.htm
12- Phenomenal Talent- The Autistic Kind- Lyndall Hendrickson, Visiting Fellow
http://www.nexus.edu.au/teachstud/gat/hendric1.htm
13- Eye Movements in Reading- The Brain Book, Peter Russell, p 191
14- Reading From Behind the Eyes- Reading, Frank Smith, p 12-35
15- Phenomenal Talent- The Autistic Kind-Lyndall Hendrickson, Visiting Fellow
http://www.nexus.edu.au/teachstud/gat/hendric1.htm
16- Hope For Dyslexics- Awake! 8th October, 1981, p 31
17- Dyslexia Linked to Nerve Damage
http://news.bbc.co.uk/hi/english/health/newsid_325000/325537.stm
18- The Sensory Basis of Reading and Dyslexia- http://www.physiol.ox.ac.uk/~jfs/
19- Journal of the American Optometric Association, Volume 70, p 629
20- Eye Patch Improves Reading- Roger Highfield, Telegraph, 13th January, 2000.
21- Current Biology, Volume 8, p 791
22- Neuron, Volume 2, p 505
23- Autism is an Autoimmune Disease- http://members.aol.com/nitrf/autism1.htm
24- Autism- A National Emergency-http://www.garynull.com/Documents/autism_99.htm
25- Journal of Psychiatry and Neuroscience, Volume 24, No. 2, March 1999, p 388-304
26- Journal of Allergy and Clinical Immunology, Volume 101, No.1, January 1998, s 122
27- Fats That Heal, Fats That Kill- Tatler Journal, Jan 2000, Volume 295, No.1
28- Fish Oils Help to Improve Dyslexia- Sunday Telegraph, 15th April 2001.
29- The Human and Scientific Story of Adrenoleukodystrophy-
www.accessexcellence.org/ae/aepc/wwc/1994/adreno.html
30- Why Very Long Chain Fatty Acids are Dangerous-
http://carbon.cudenver.edu/~bstith/loren.htm
31- Dyslexia in Different Languages- http://web.ukonline/wdnf/languages.html
32- TESOL Methodology Manual, 2001- Dr. Harry Cotton, p 31.
33- Blame it on the Written Word- Time Magazine, 2nd April, 2001, p 71.