Developmental Dyspraxia

Identification and Intervention

A Manual for Parents and Professionals

Second Edition

Madeleine Portwood

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Illustrations by John O'Neill for Max Baker (1992–1998)

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Foreword

Madeleine Portwood's first edition of D*evelopmental Dyspraxia* has been a major source of information and help to parents, carers and all those involved in the education and treatment of children with dyspraxia.

In this, her second edition, the author has built on her well researched, evidence-based practice to refine and develop intervention programmes which can be used by parents and teachers alike. Madeleine Portwood possesses a unique gift - the ability to impart knowledge and information in the kind of straightforward language which neither patronises professionals nor 'blinds with science' parents and carers.

Developmental Dyspraxia spans all ages from the early years through to primary and secondary education. A welcome addition is the chapter on "Information for adults with dyspraxia". Many adults, undiagnosed and untreated in childhood, now have difficulty obtaining relevant information and help. Provision for adults with dyspraxia is sketchy but professionals such as Madeleine Portwood and voluntary groups such as the Dyspraxia Foundation are working towards raising awareness of the condition and an achievement of adequate, appropriate resources.

Madeleine Portwood has been working in a professional and voluntary capacity, helping children and young adults with dyspraxia for some ten years. The Dyspraxia Foundation is privileged to have her as a Trustee and Chair of the Education Committee. Her warmth, humour and no-nonsense attitude make her a popular and valuable committee member.

I wholeheartedly recommend this book, as an indispensable resource, to all who are involved with the development and education of children and young adults with dyspraxia be they teachers, therapists, family or friends.

Tricia Pullen
Dyspraxia Foundation
January 1999

Foreword

'Clumsy' is a miserable label to live with, and 'clumsy kids' suffer from an accumulating social handicap throughout their schooldays, the later toll of which has not even been estimated in terms of adult disadvantage and despair. Disappointment and humiliation associated with everyday drawing, writing, gym or team sports can be compounded if attentional disorders, language problems or learning difficulties are also associated with *developmental dyspraxia* (or 'developmental co-ordination disorder'). In our experience a constellation of problems is often associated with more severe cases of dyspraxia.

It is these severely affected children who are probably first noted in checks by primary health care nurses and then assessed systematically during screening by the school medical service that are most likely to benefit from this book. Those who care for them, in the family, the school or the clinic, should find it a spur to developing better and better practice for their *effective* rehabilitation.

Past practice left a great deal to be desired. A 'clinical audit' by community paediatricians established a need to improve the recognition, referral and treatment of dyspraxia. Above all, there was a need for a better understanding of the condition among health service and education professionals and especially parents struggling in a maze of contradictory advice or changing fashions in treatment.

These concerns were not restricted to Cambridge. When I submitted a short note on dyspraxia to the journal *Physiotherapy* in 1994, I was astonished by the subsequent flood of mail from professionals all over the world. Most of this was along the lines of, '*Are you really seeing children like ours? What works? How soon can you let us know?*'. In 1995 the Child Development Centre presented a very preliminary picture of our randomised controlled trial of treatment at an Anglia & Oxford Regional Health Authority conference: there was standing room only. We were also able to study patterns of handwriting thanks to a small grant from the Nuffield Foundation for a psychology student project. Well, when it came time to outline that modest project at a regional dyspraxia study day, we had to turn people away who wanted to squeeze into that session. Undaunted, we just kept booking bigger venues – often with two or three of us presenting the results in turn.

The Cambridge conference, Changing Perceptions, has just reviewed the growing body of evidence which indicates that providing therapy can make a real difference. The College of Occupational Therapists has even suggested that treating dyspraxia could become their key contribution to the government's new initiative for *Our Healthier Nation:* Healthy Schools. Two crucial themes emerging from this are 1) the *participation* of families as equal partners in determining both policy and practice and 2) *reducing social exclusion*, that is creating imaginative opportunities for disadvantaged children to play a full part all through their schooldays and later on in life. The good news is already beginning to emerge, in the following chapters based on extensive practical experience in Durham. Children with severe dyspraxia have specific needs. In observable, measurable ways, they do respond to specific treatments. 'Clumsiness' is not an indelible label.

Dr. Woody Caan
Head of Research and Development
Lifespan Healthcare, Cambridge
November 1998

Preface

The first edition of *Developmental Dyspraxia* was produced to offer parents strategies to help their children. Some parents had known, almost from birth, that their child was having difficulty achieving expected developmental milestones. My experience suggested that access to 'professionals' who would 'diagnose' dyspraxia was problematic and therapy in many instances unavailable. The way forward had to be to provide intervention programmes for parents.

Since publication in 1996, more than 10,000 copies have been sold, not only in the UK, but in many other countries including the US, South Africa, Australia, Iceland, Greece, China and Singapore. More than half have been purchased by professionals, mainly teachers who have designed and implemented school-based programmes to develop the skills of their pupils.

As more research information becomes available we are able to achieve a greater understanding of the nature of the condition and refine and implement more successful interventions. This new edition details the experiences of parents and professionals who have been involved during the past few years in developing these programmes, and discovering which strategies are most effective.

In a perfect world every child and adult would have access to the appropriate professionals, including paediatricians, psychologists, physio- and occupational therapists and speech therapists, but resources are limited. This manual is for those involved in working with the children on a daily basis – parents, teachers and friends – and it is through their commitment that youngsters who in the past have been undiagnosed, and labelled behaviourally difficult or poor achievers, can begin to reach their potential.

Such involvement must come sooner rather than later to prevent the frustration, disaffection and distress that the condition can generate.

Madeleine Portwood
Durham
January 1999

Acknowledgements

I would like to thank all of the children, parents and professional colleagues who provided the information discussed in this manual.

I have benefited from the continuing support of the Educational Psychologists in the Durham Service and the Director of Education, Keith Mitchell.

In this second edition I would like to acknowledge the additional contributions made by school staff throughout the country who have embarked upon school-based intervention programmes.

Finally, I thank those directly involved with the production of this material:

Peter Chislett for his sensitive editing
Margaret Clay for preparing the manuscript
John O'Neill for his illustrations
John Portwood for producing computerised images
Chris Ridley for extending intervention programmes
Peter Withnall for his examination of content

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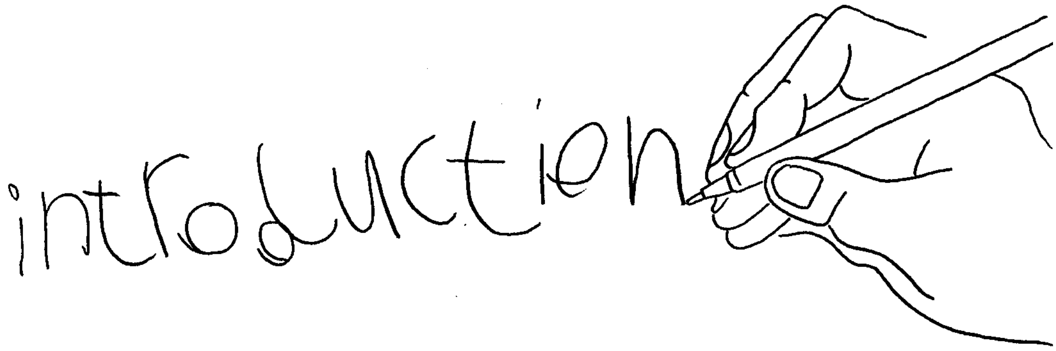


Since the publication of my first manual in June 1996 a great deal of research has focused on external factors such as nutrition and the effect of the environment on the developing child. My own studies during the past two years provided access to a greater sample population of children and young adults and have clarified my thinking about the condition termed *dyspraxia*. This second edition encompasses much of the recent research evidence and its implications for parents and teachers.

I became interested in the subject in 1988 after attending a seminar to discuss the increasing numbers of research papers suggesting that a high proportion of youngsters with emotional and behavioural difficulties showed evidence of significant neurological immaturity.

I was employed then by Durham Local Education Authority as Specialist Senior Educational Psychologist for children with emotional and behavioural difficulties, and screened 107 youngsters aged between 9 and 16 in the county. All had been identified as having special educational needs and allocated day or residential provision for their extreme behavioural difficulties. In that sample, 82 (77 per cent) of the pupils showed symptoms of neurological immaturity.

Research suggests that between 5 and 10 per cent of the general population would expect to have similar immaturities but with this elevated figure of 77 per cent in the sample assessed, it would be reasonable to assume that this factor must be significant in the development of subsequent unacceptable behaviours.

Many of these pupils had experienced failure from an early age. Delayed language development, poor social skills and a lack of co-ordination had forced isolation within their peer group. Many had become the victims of more assertive pupils. For some of the youngsters there were additional problems in their home environment. Some had suffered extreme emotional and material deprivation, others had presented as extremely difficult youngsters from birth with parents resorting to respite care and/or medication to enable them to cope.

There are occasions when environmental factors form the sole basis for explanations about a child's behaviour. It is important to take a more detailed overview and explore factors within the child before reaching any conclusions.

In my original sample of 107 pupils, 12 were selected from the identified 82 for intervention. Their intellectual ability was assessed using the Wechsler Intelligence Scale for Children – RS (WISC-RS) and found to be in the average range despite a number of very low scores in some of these sub-tests. In addition these youngsters had spelling ages of at least three years below their chronological age and their handwriting ranged from barely legible to illegible. In the sample, nine had reading ages, assessed using the Edwards Test, which were at or above their chronological age.

Members of the school staff agreed to supervise individual motor-skills programmes which were provided for each child and followed daily for 20 minutes. Progress was evident by the end of the first month, but within six months there was improvement, not only in language and handwriting skills (see Figure 1.1) but in concentration and behaviour. It was apparent that these youngsters had 'failed' in the educational system because of their inability to perform to expectation. Their frustration had led to displays of uncontrolled emotion which had resulted in significant behavioural difficulties. It seemed certain that, had the 'problem' been diagnosed at a much earlier stage, many of these children would not have been labelled as behaviourally difficult, and they would not have been placed in an educational environment away from their mainstream peers.

The 'symptoms' identified in the previous paragraph characterise the condition defined as *dyspraxia*. My confidence in stating this comes ten years later after being involved with more than 600 children and young adults with similar difficulties.

In 1990, after working extensively with youngsters who had been offered alternative educational provision, my next area of study was to consider approaches to identify and prepare intervention programmes for those within the mainstream sector experiencing similar difficulties, and probable candidates for such provision in the future. Pupils referred for psychological

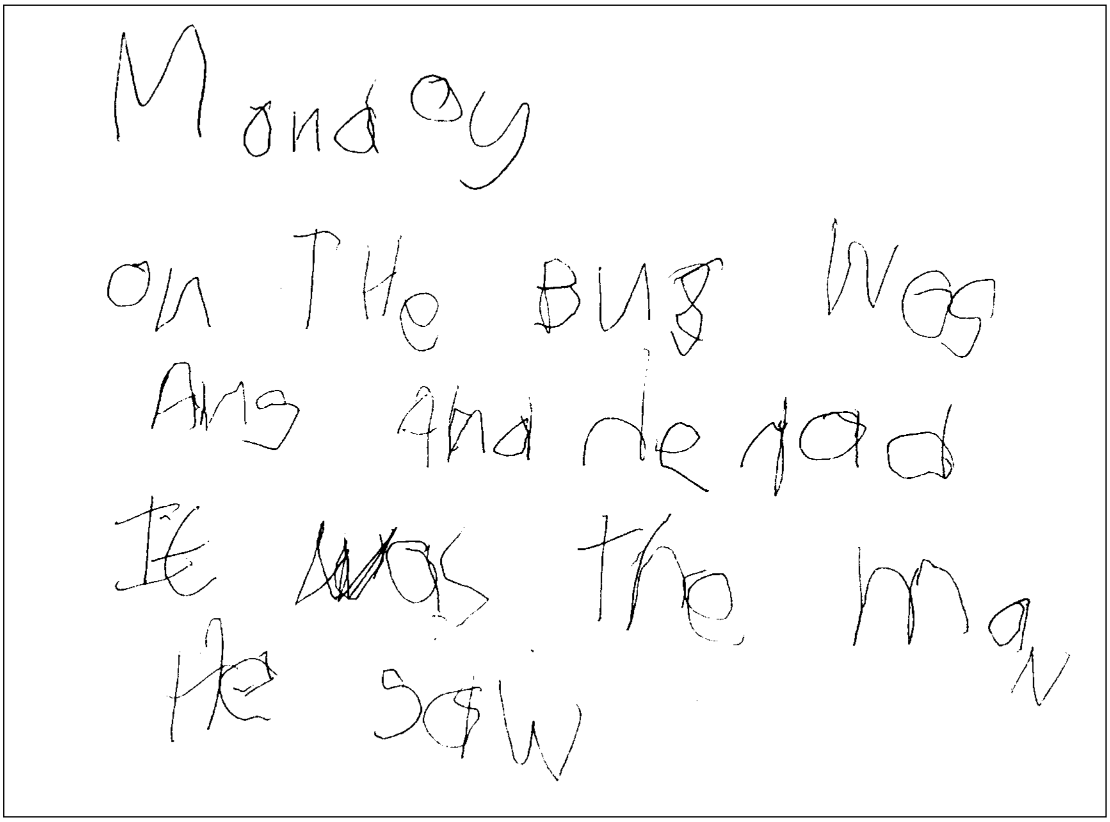


Figure 1.1a Handwriting of Andrew, aged 9, before intervention

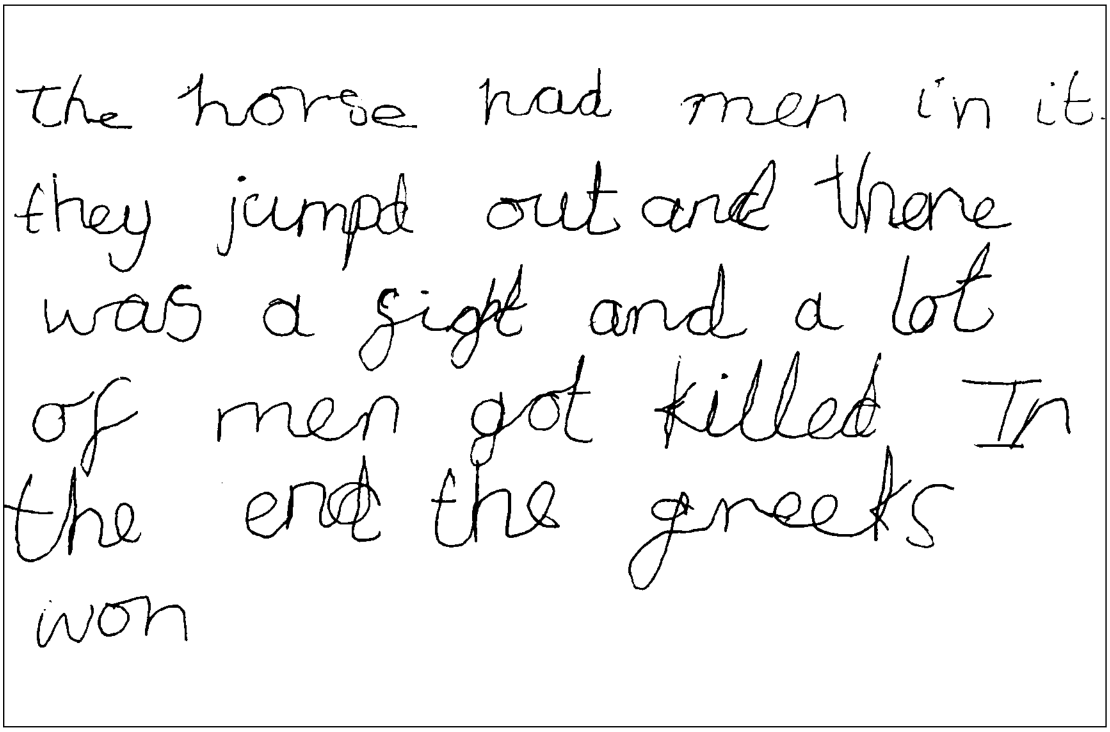


Figure 1.1b Handwriting of Andrew, aged 9, after intervention

assessment usually exhibited recurring displays of unacceptable classroom behaviour, although a minority of the youngsters appeared to be extremely withdrawn. Most of the youngsters were aged between 8 and 11, with the sample heavily skewed to the older end because of the fear that 'although we have managed to "contain" him here, he will never make it in secondary school.' After identification, the youngsters were given access to a series of graded motor-skills activities. Programmes and methods of determining the children's access points are detailed later. Within the primary sector I was given access to data collected by other educational psychologists in Durham and this greatly increased the size of the sample.

The assessment techniques developed for use by teachers to identify dyspraxic youngsters in school were tested between 1988 and September 1993. I embarked then on a control study with children aged between 5 and 7, as research has shown that the earlier the diagnosis, the greater the impact of any intervention programme. This study was undertaken at an infants school in the county and included eight pupils aged between 5 years 3 months and 6 years 8 months. The results of the programme were extremely encouraging.

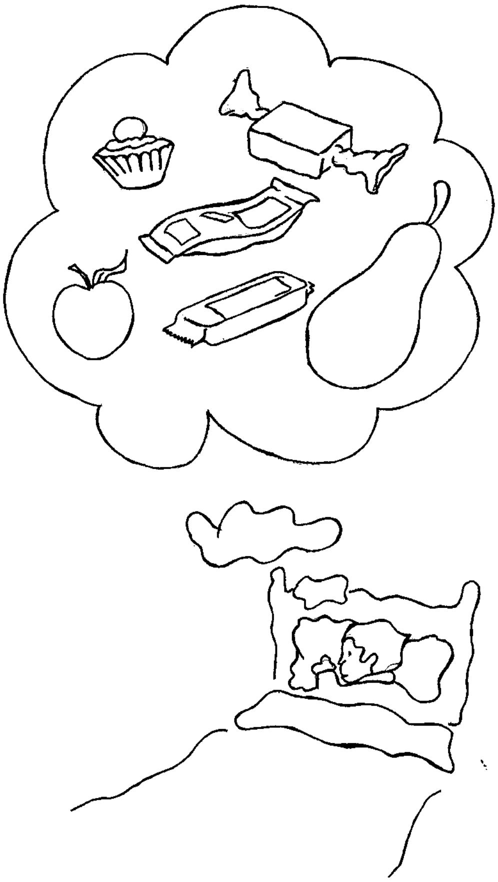
The research was then extended to older pupils as I believed it was important to develop access to programmes in secondary schools. My initial assumption was that, given the differences between the primary and secondary school environment and the age of the pupils, success would be the exception rather than the rule. I had made a total misjudgement: on the whole the pupils themselves were more committed to remediating their difficulties than the younger children.

This research was published in 1996 and attracted a great deal of media attention. I was approached by Sheilagh Matheson, the producer of the BBC2 programme *Close Up North* who was interested in the relationship between dyspraxia and juvenile delinquency. She arranged access to Deerbolt Young Offenders Institution in Barnard Castle and I screened 69 of the youngsters aged between 15 and 17. More than 50 per cent of the youngsters assessed showed varying degrees of dyspraxia.

The programme also followed a youngster who was 4 years of age and due to enter reception class. He had been identified by a speech therapist six months previously as a child who displayed the symptoms of developmental dyspraxia. His progress was filmed over a period of eight weeks to determine the success of the intervention programme. The extent of my research, which is from birth to adulthood, is outlined in later chapters.

As more research evidence becomes available the term *dyspraxia* becomes more complex.

2 Development of the brain and the significance of diet



Dyspraxia results when parts of the brain have failed to mature properly. To understand the complexities of the condition it is important to consider the early development and subsequent functioning of the brain.

Five weeks after conception cells within the developing embryo specialise to form the nervous system. As the brain develops, cells move, cells die, connections are made and broken as the brain assimilates information from sensory input. Eventually the brain develops into a network of 10 billion cells with 1 million billion connections. The brain adapts the body to the environment, through a process of natural selection reinforcing the connections between nerve cells which are most advantageous to the individual.

Esther Thelen, a developmental psychologist at the University of Indiana, has completed an extensive study of babies and produced strong evidence that selection plays an important role in the development of human behaviour. A month-old baby is able to fixate on a suspended object in its line of vision. At 2 months the baby is able to make anticipatory movements towards the object with a closed fist. At this age the child does not know how to co-ordinate movements. In Dr Thelen's study, motion sensors were attached to babies which tracked and recorded their movement in space. This movement was monitored to determine how skills are acquired. By the age of 6 months the child is able to reach and grasp appropriately.

Conventionally, it was believed that skills such as learning to reach are genetically programmed and the brain directs the body to perform certain activities. However, her research discovered that each baby has to solve for himself the sequence of instructions which will result in reaching towards the object. The baby has a range of movements and has to select from these the ones which work. He must locate the place in space to grasp the toy. The baby produces a large repertoire of random movements, making facial grimaces as well as flapping his arms and legs, while grasping at empty space. Occasionally, by chance, he will make contact with the toy. Over time, repeating this variety of movements, the repertoire is narrowed down to enable the action to produce the desired contact. The child is beginning to be able to exert some control over his environment. The next question must be: how does the brain produce this controlled behaviour?

Gerald Edelman, a biologist who won the Nobel Prize in 1972 for his theory that the immune system works by a process of natural selection, has suggested a possible explanation. The source of this information is his book *Neural Darwinism. The Theory of Neuronal Group Selection* (1989). His thoughts are extended in *Bright Air, Brilliant Fire on the Matter of the Mind* (1992).

There are over 200 types of cells in the human body and one of the most specialised is the nerve cell (neurone). It differs from other cells because of its electrical and chemical function and the means by which it is connected to other nerve cells.

The brain is richly supplied with these nerve cells which are interconnected via complex neural systems. There are two kinds of nervous system organisations, which are very different, even though both are made up of neurones.

- *The brain stem and limbic system* have evolved to understand the signals within the body. They respond to feelings such as hunger and anxiety and are connected to a variety of body organs, the endocrine system and the autonomic nervous system. These systems are responsible for regulating heart beat, respiration and digestion. They also determine the body's sleep cycle.
- *The thalamo-cortical system* which consists of the thalamus and the cortex acting together to receive signals external to the body. The cortex is adapted to receive signals from the sensors which respond to sight, touch, taste, smell, hearing and the body's awareness of its position in space.

Within these two systems the greatest area of interest is the cerebral cortex where much of the higher brain function takes place. Thoughts and actions are the result of signals travelling between nerve cells and, if the cortex is magnified, each region shows millions and millions of cells. Thousands of new cells are interconnected to produce a complex network. The cortex contains billions of specialised neurones and their function is to transfer signals from one part of the nervous system to another.

The neurone comprises a cell body, projecting from which are a number of short branches called dendrites (see Figure 2.1). The dendrites receive messages from other neurones and the message is transmitted through the axon, which is a tubular extension of the cell. Nerve impulses can travel only in one direction across the junctions (synapses) between neurones, so the axon of one neurone takes position close to the dendrites of another. A single neurone can receive messages through its dendrites from many other neurones which are transmitting via the axon (Figure 2.2).

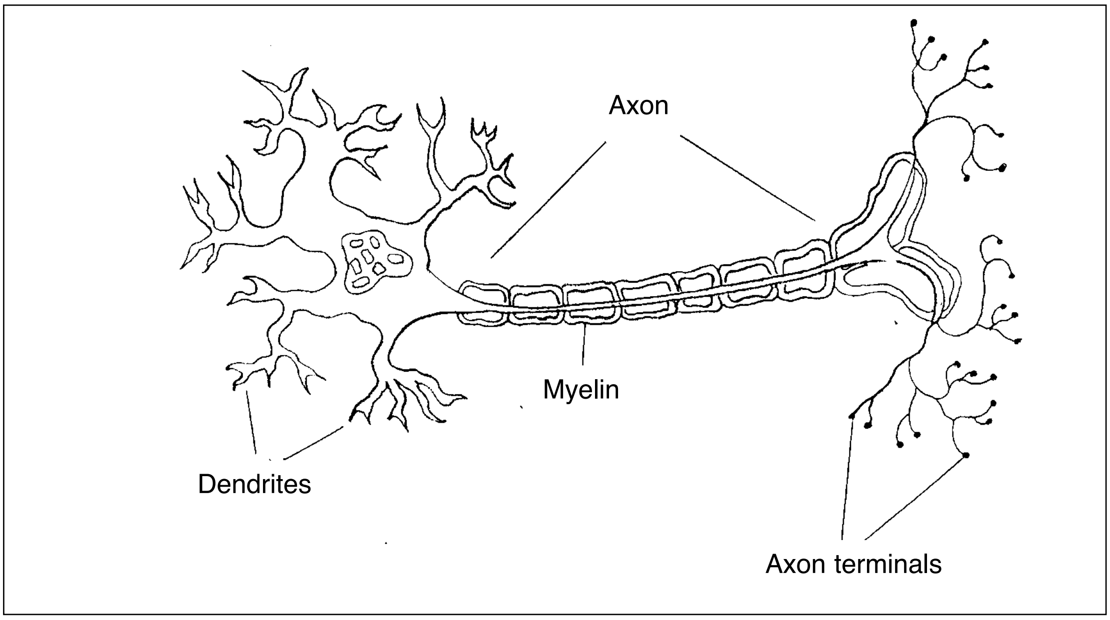


Figure 2.1 Diagrammatic representation of a neurone

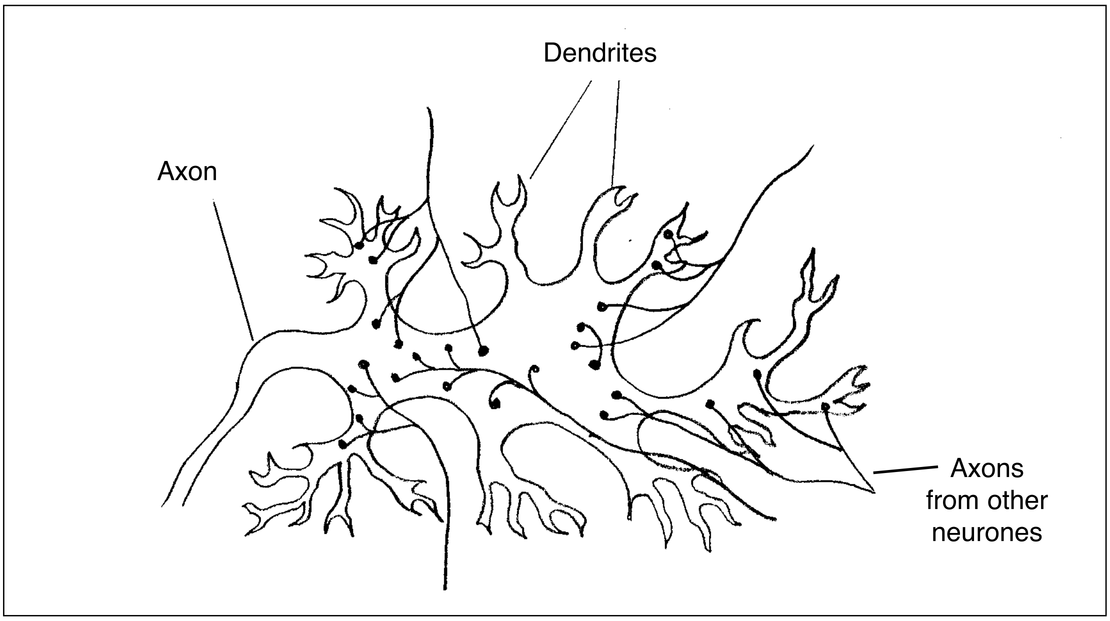


Figure 2.2 The transmission of signals from the axons of closely located neurons

The synapse is the point at which the message is transferred from one cell to the next. It is a specialised structure in which electrical activity passed down the axon of the pre-synaptic neurone leads to the release of a chemical (a neurotransmitter) that in turn induces electrical activity in the post-synaptic neurone (Figure 2.3). As a result, nerve signals in the form of electrical discharges occur at the membranes of the neurones. The synaptic junction is where the signal transfer takes place and the neurone discharges or 'fires' when it is stimulated to a specific threshold. Their sensitivity to stimulation can be altered by a variety of different chemicals, including the neurotransmitters at synapses, and drugs.

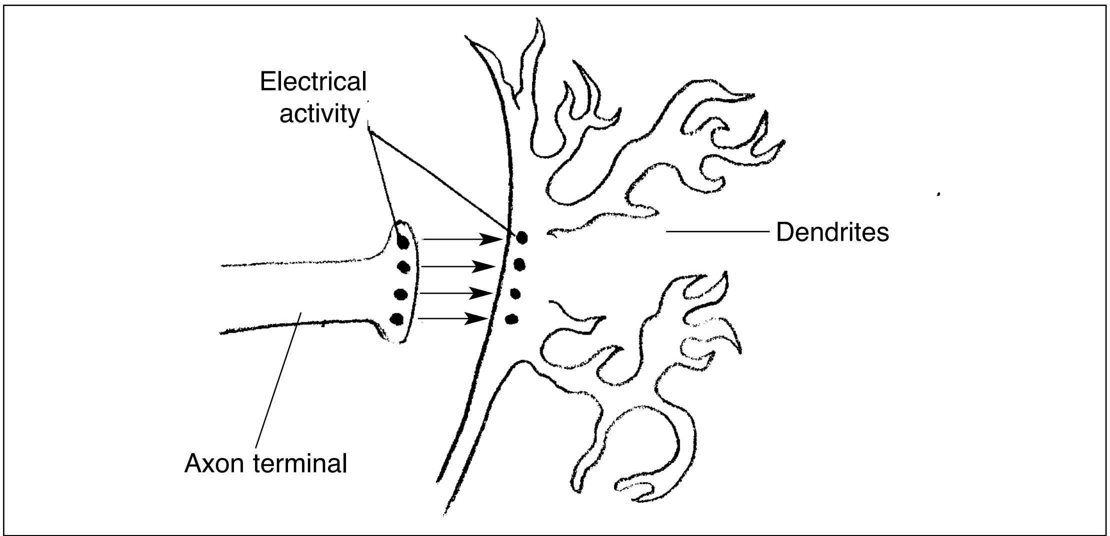


Figure 2.3 Electrical transmission through a neurone

The production of purposeful movement

As mentioned previously, the brain has 10 billion cells and a million billion connections: as many cells as there are transistors in 10,000 Pentium processors and as many connections as the memory capacity (in bytes) of a million hard disks. These connections, in turn, produce a vast number of pathways along which messages can be transmitted. Many of these pathways will serve no useful purpose. By the time the child is 3 years of age a third of these neural pathways will be 'pruned'.

It follows that the brain must have a means of selecting only those pathways which produce useful behaviour. If we look again at the early movements in infants, the grasping response is the result of 'firing patterns' or messages transmitted between nerve cells in the cerebral cortex. When the firing pattern produces a successful outcome, such as grasping a toy, the connections used to achieve that outcome will be reinforced, and other connections which have not been utilised may disappear altogether. The strength of the connection between neurones that are in place rises or falls, increasing the likelihood that the 'stronger' synapses are usually selected. As the infant builds more and more levels of action and thought, each action achieves a satisfying objective.

Implications for the dyspraxic child

The motor movements of the developing infant determine which connections in the cerebral cortex are reinforced. Comparisons can be made between the neural pathways of a 6-week-old child and one who is 6 months (Figure 2.4).

At birth the template for interconnecting neural pathways is present. Observation of a 6-week to 2-month-old child indicates that when a toy is suspended in the line of vision, instinctively all four limbs thrash around wildly as the child seeks to make contact with the desired object. Every so often, just by chance, the child is able to:

- fixate on the object
- extend from the shoulder
- move elbow appropriately
- extend fingers
- touch object.

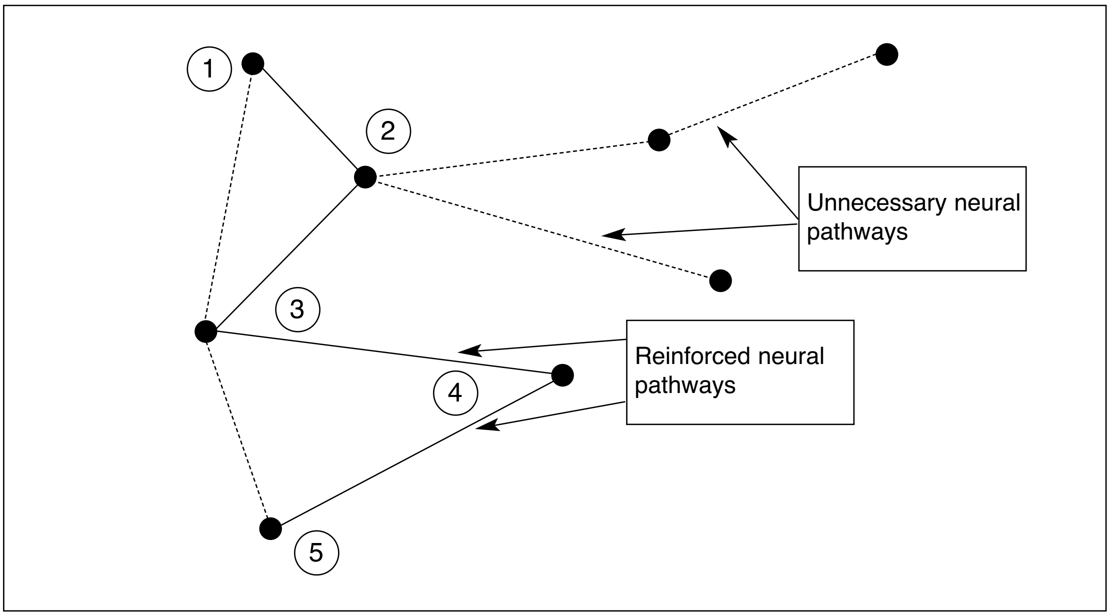


Figure 2.4 Simplified representation of neural pathways at 6 weeks

The track of the simplified message response is outlined in Figure 2.4. Observation of the child, however, shows messages going to all four limbs and this is the result of transmission along unnecessary neural pathways.

By the time the child is 6 months of age he is almost 'reflexively' able to reach and secure a dangling ring, hold small cubes and assist with holding a feeder cup. There has been further reinforcement of appropriate neural pathways, and those which have remained unused are beginning to disappear. In Figure 2.4, the 6-week-old child has to transmit messages between five nerve junctions. In the 6-month-old child (Figure 2.5) this is reduced to three. There are five operations in the younger child compared with three in the older child: therefore not only is the speed of information processing greatly increased but it is much less likely that information will be misdirected.

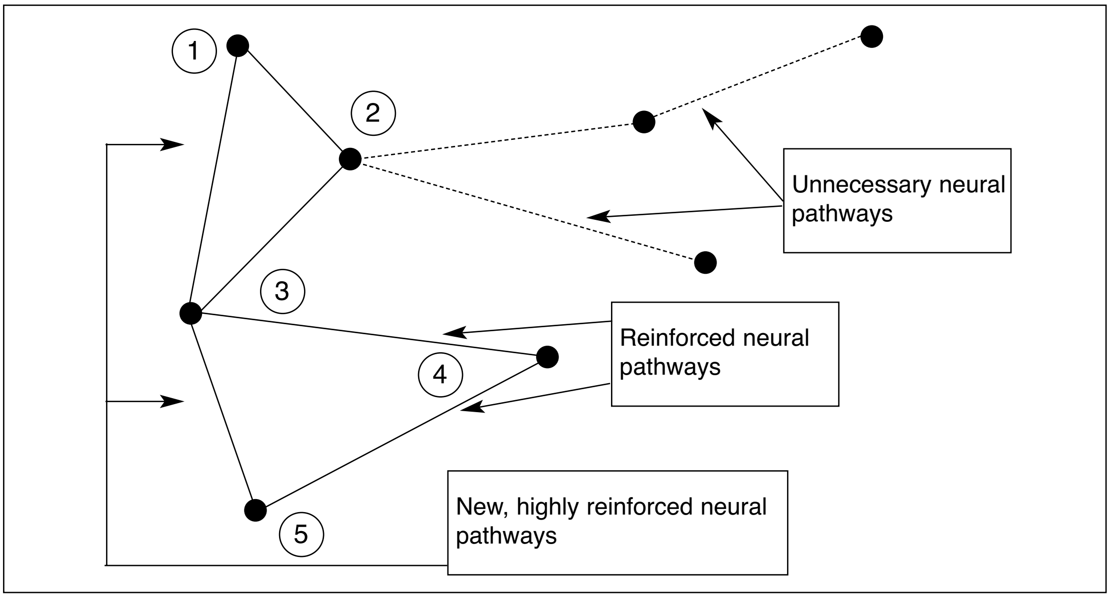


Figure 2.5 Simplified representation of neural pathways at 6 months

Usually, between the ages of 8 and 12 months, the infant has learned to co-ordinate not only his hands but also his feet. The child is able to crawl and can operate hands and feet in opposition. High kneeling follows and soon the child is able to achieve a standing position and walk independently.

There is evidence to suggest that in the case of the dyspraxic child, reinforced interconnections between nerve cells in the cerebral cortex are reduced in number. The cortex persists in a state of immaturity which varies greatly between individuals.

It seems reasonable, therefore, to suggest this is the possible explanation for some of the difficulties encountered by dyspraxic youngsters. Not only do they require additional time to process information, but messages directed towards specific limb function are passed to all four limbs. The vast majority of dyspraxic youngsters do not go through the crawling stage but prefer to bottom-shuffle, and then walk. It is necessary to be able to co-ordinate all four limbs independently to crawl successfully, so it is probably much easier for them to miss out this stage and walk independently as this requires the co-ordination of only two.

If we consider the function of the brain beyond the cerebral cortex, it is possible that there may be other factors which explain some associated behaviours of dyspraxic children. The cortex controls the body's sensory systems, its motor responses and the complex behaviours of thought and language. The cortex surrounds the limbic system, which is the 'instinctive' part of the brain responsible for the automatic responses within the body (Figure 2.6). It is also closely involved in emotional behaviour. The cortex serves to 'dampen' the effect of the limbic system. If this were not the case, the individual would present as highly excitable and over-emotional, with inappropriate responses to differing levels of sensory input. Although the comorbidity of conditions such as dyspraxia, dyslexia, attention deficit and

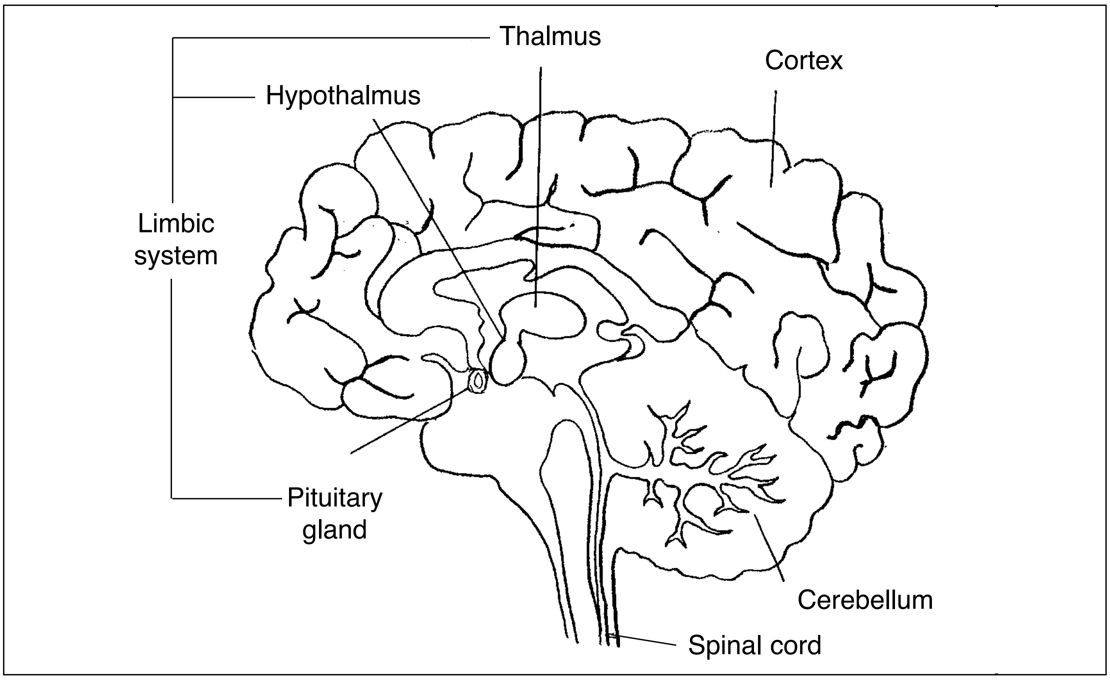


Figure 2.6 The limbic system in relation to the cerebral cortex

hyperactivity disorder (ADHD) and sometimes autism, is high (35–40 per cent), it can be very difficult to obtain a specific diagnosis.

If ADHD results in high levels of excitability, then it is expected that the origin is the limbic system. If this is the case Ritalin (methylphenidate) is extremely effective in 95 per cent of the cases. Ritalin is a stimulant which increases the electrical activity within the cortex, increasing the dampening effect that this has on the limbic system. The excitability of the individual is therefore controlled. In the case of a dyspraxic youngster, it is the cortex with its reduced number of reinforced neural connections that is not sufficiently dampening the limbic system. Although the prescription of Ritalin will increase the electrical activity, this cannot be directed along appropriate neural pathways and therefore the dampening effect on the limbic system appears to be significantly reduced – by perhaps 80 per cent. Although the behaviours of children with dyspraxia and attention deficit and hyperactivity may be similar, i.e. high levels of excitability and poor concentration, the origins of each are very different.

The significance of diet on the effectiveness of neural transmission

My research has led me to believe that dyspraxia is the result of neurological immaturity in the cortex of the brain. However, in my sample of over 600 children and young adults 18 per cent did not appear to have the expected developmental history (to be discussed in later chapters). I was concerned that for such a large group of individuals I could offer no explanation as to the origins of their difficulty. In recent years there has been a great deal of research considering the importance of the maternal diet and its relationship with significant feeding problems in new-born infants. Some of this research has provided a possible explanation.

In the mid-1980s research focused on the production of a specially formulated milk product for babies who were premature or small for dates and could not be breast fed. This pre-term formula milk was higher in protein, carbohydrate and fat content than the readily available formula milk. In 1990 Professor Alan Lucas reported on the results of a study in Glasgow which compared the development of pre-term and small-for-dates babies who were fed either pre-term or the usual formula baby milk. As expected, the results showed that youngsters having access to pre-term formula milk showed a significant IQ advantage at 18 months. Another feature of this intervention highlighted the significance of appropriate feeding up to four weeks after birth. Youngsters who had been fed pre-term formula milk in excess of this four-week period did not show any greater advantage at 18 months than those fed up to four weeks. However, the youngsters who had access to the pre-term formula for less than four weeks after birth did not show the same advantage. The study concluded that pre-term formula milk had significant advantages over the usual formula milk.

In 1992 Lucas reported on a similar study where a comparison had been made between pre-term babies fed either mother's own breast milk, donor breast milk or pre-term formula milk. The youngsters were assessed at the age of 8 and it had been anticipated that those having access to pre-term formula milk would show the greatest advantage. This was not the case. The youngsters who had mother's own breast milk were those who achieved the highest scores in indicators of intellectual ability. It was evident from this study that although there were some advantages with the improved nutritional content of pre-term formula milk, mother's own breast milk offered the best start in life. Further investigation showed that the significant factor was not higher concentration of protein, fat and carbohydrate, but another essential nutrient, docosahexanoic acid or DHA (a long-chain polyunsaturated fat).

The brain is 60 per cent fat, 25 per cent of which is DHA. Further research by Makrides, Neumann and Gibson (1996) highlights the importance of maternal docosahexanoic acid throughout pregnancy and particularly the first four weeks following birth. Some studies have attempted to measure the DHA content in the cerebral cortex from birth through to 2 years of age. They are: Neuringer *et al.* (1988), Makrides *et al.* (1994) and Farquharson *et al.* (1995).

In the fifth week of pregnancy when the cell division of the embryo is most active and again in the last trimester, the DHA content of the cortex increases to between three and five times its normal level. The higher scores on developmental tests achieved by breast-fed infants in comparison with their formula-fed peers prompted an investigation into the relationship between the development of the brain and long-chain polyunsaturated fatty acids in the diet.

The cortex of the brain was analysed by capillary gas chromatography and this determined that breast-fed infants had a greater proportion of DHA in the cortex than those who had been formula-fed. The proportion of DHA increased in breast-fed infants (but not formula-fed infants) with age, and the level continued to be monitored for two years following birth. This higher concentration of DHA in the cortex of breast-fed infants may explain the improved cortical function, as it is possibly integral to neurotransmission.

In the pre-term infant the blood levels of DHA are below what is expected at term (Crawford 1996). Post-natal follow-up suggests that, two weeks after delivery, the DHA level has fallen farther, to a third of the proportion the baby would have had as a foetus. For these youngsters, it is crucial that they have access to appropriate nutrients, high in DHA.

Where breast-feeding is not a possibility or there is a requirement to supplement with formula milk, the nutritional composition, which is detailed on the product, should be checked. One of the well-known brands in the UK states:

> X is a complete food for your baby. It has been specially formulated to be nutritionally close to breast-milk. It contains DHA which is a special blend of long-chain polyunsaturated fatty acids or LCPs, used to help brain and visual development.

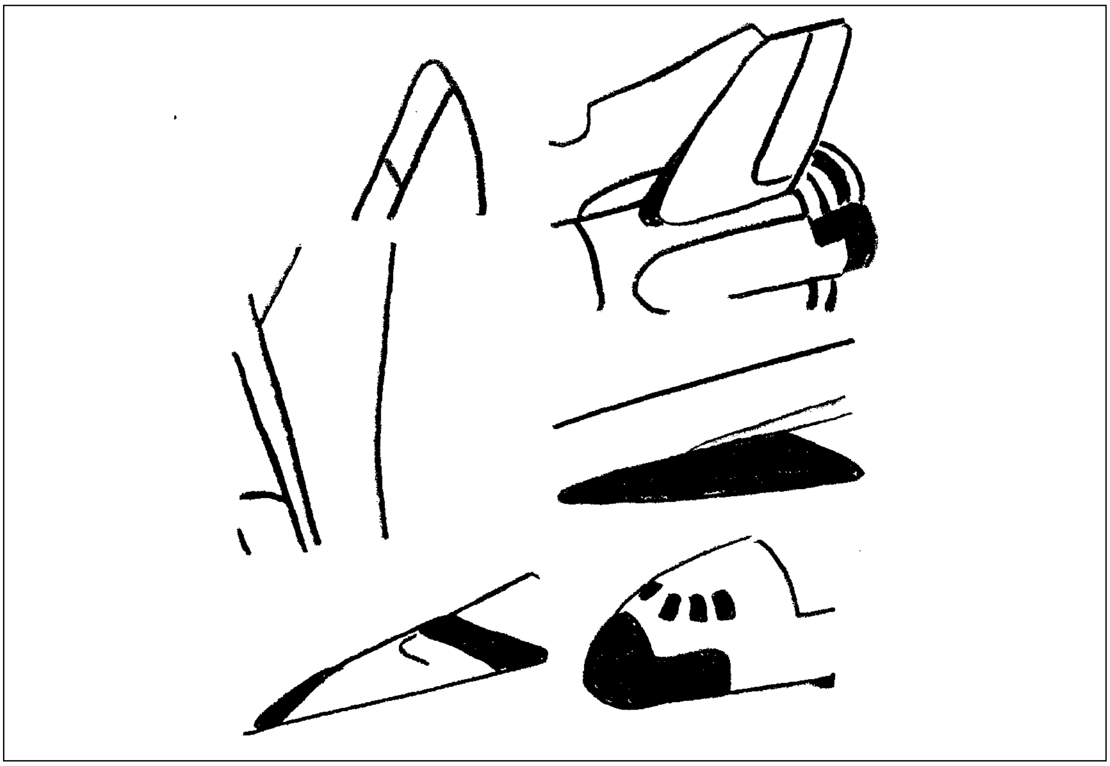
With this information I re-examined the developmental histories of the 18 per cent of youngsters in my original sample of 600 pupils who did not appear to follow the usual pattern of early development. In that group, 70 per cent of the youngsters had significant feeding problems from birth and many mothers reported failure to gain weight appropriately during their pregnancy. It appears from this research that there could be two explanations for the evidence of symptoms of dyspraxia. In the vast majority of cases there is evidence to suggest that there are insufficient reinforced neural pathways in the cortex: there are immaturities. However, for 18 per cent of the youngsters in the sample it may well be that the neural pathways are appropriately placed but there may be a problem transferring the message across the synapse via the neurotransmitter.

Many youngsters and adults in my survey have considered supplementing their diet, and long-chain polyunsaturated fatty acids are readily available in evening primrose oil and fish oil. Some parents have reported immediate improvements in their children's co-ordination and ability to process information. It is important at this stage to include a note of caution: where youngsters and adults have shown elevated levels of electrical activity (diagnosed epilepsy), introducing high concentrations of long-chain polyunsaturated fatty acids into the diet has resulted in an increased number of seizures. Where epilepsy has been controlled, interference with the neurotransmitter is likely to affect the overall electrical activity in the cortex.

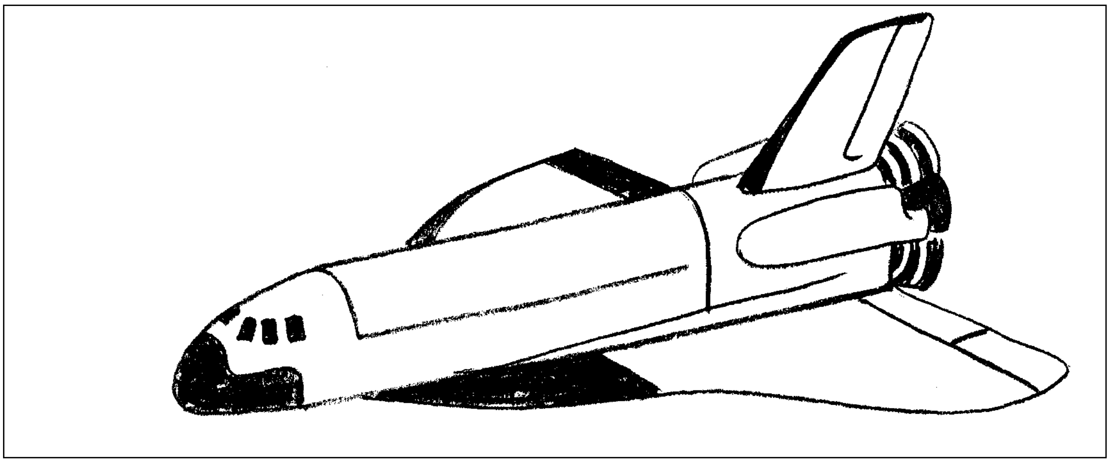
The importance of the left and right hemispheres of the brain

To understand in greater detail the learning difficulties associated with dyspraxia, it is necessary to consider how information is processed in the cortex. The brain comprises a right and left hemisphere, and they function in different ways. The left hemisphere is described as analytical because it processes information sequentially and it specialises in recognising the parts that make up the whole. Although it is most efficient at processing verbal information, language should not be considered to be 'in' the left hemisphere. The motor component of speech is situated in the right hemisphere. The left hemisphere is able to recognise that one stimulus comes before another, and verbal perception and subsequent generation depend on the awareness of the sequence in which sounds occur.

While the left hemisphere separates out the parts which constitute a whole, the right specialises in combining the parts to create a whole (Figure 2.7). Unlike the left hemisphere, which processes information in a linear manner, the right



Left hemisphere



Right hemisphere

Figure 2.7 A visual representation of the functions of the two hemispheres