

2

What Is Dyslexia?

Introduction	20
A historical overview of dyslexia research	20
Definitions of dyslexia	21
Basic learning mechanisms	24
Reading processes and learning to read	28
Behavioural manifestations and cognitive correlates of dyslexia	30
Cognitive and neurological explanations of dyslexia	33
Summary of key points	38
Activities	38
Further Reading	39

Introduction

In this chapter we will discuss what dyslexia is. The reason we devote an entire chapter to this type of SpLD is that, among the various learning differences, it is dyslexia that has the most significant impact on language learning. As pointed out in the introduction of this book, different types of SpLDs are often difficult to distinguish from each other and often co-occur. Therefore, this chapter will not only consider the linguistic manifestations of dyslexia and the cognitive correlates of reading difficulties, but will also provide a broad overview of the strengths and weaknesses of dyslexic students.

Defining dyslexia is not a simple enterprise. If you ask a layman, he/she would tell you that dyslexia is a reading problem children tend to experience. A special education teacher would say that dyslexia is when children fail to learn how to read despite adequate instruction. An educational psychologist would describe dyslexia as a reading difficulty, which is unexpected given the cognitive abilities of the child. These definitions seem to suggest that dyslexic individuals have difficulties in reading, but, as we will see in this chapter, dyslexia might also affect spelling and general information processing skills. In fact, dyslexic adults might not exhibit noticeable problems with literacy skills and might mainly struggle with memory and attention problems. Dyslexia also has different degrees of severity; hence dyslexic students often display different profiles of strengths and weaknesses. Not only is the definition of dyslexia problematic, but, as this chapter will show, the causes of dyslexia are also enigmatic. Mainstream theories of dyslexia consider deficits in phonological processing as major causes of dyslexia, and neurological and genetic factors contributing to the development of dyslexia have also been identified. Recent theorizations of dyslexia, however, have begun to question the widely held belief that dyslexia is a specific learning difficulty that manifests itself only in literacy-related skills. It has been argued that dyslexia might encompass a conglomerate of learning differences, which among others cause problems in motor-control, sustaining attention and in the automatization of knowledge.

A historical overview of dyslexia research

The word dyslexia was invented in 1884 by a German ophthalmologist, Rudolf Berlin, in order to explain a neurological condition in which people lost the ability to read, but where all their other intellectual capabilities remained intact. Such cases had previously been described by Adolph Kussmaul with the term ‘word-blindness’. The terms ‘word-blindness’ and ‘dyslexia’ were used interchangeably until the 1960s, when dyslexia became the general term used for labelling reading difficulties (on the further evolution of terminology see Chapter 1). The first descriptions of cases of dyslexia were concerned

with acquired dyslexia, that is, with conditions when people lost the ability to read as a result of brain damage. Developmental dyslexia, that is, problems in learning to read in childhood and lack of achievement in the development of reading skills, was first studied by the British physician Pringle Morgan, who described the case of a 14-year old boy, who failed to learn to read despite his apparently good intellectual capacities.

Systematic research on dyslexia started in 1917 with the work of a Glasgow eye surgeon, James Hinshelwood, who made the first attempt to describe the symptoms of dyslexia. In the United States, Samuel Orton, a neurologist, studied a large number of patients who exhibited reading difficulties. He argued that the main problems of these people were related to 'symbol twisting' such as mixing up the letters b and d and interchanging letters in words. He concluded that dyslexia is caused by visual processing problems. As the list of researchers mentioned above reveals, in the early stages of the history of the field, dyslexia was perceived to be a medical problem, and most of the work on reading difficulties was carried out by doctors. Public awareness of dyslexia emerged in the beginning of the 1960s in the USA and in the UK, and dyslexia research started to be undertaken by educational psychologists. A major breakthrough in the investigation of the causes of dyslexia occurred when theories of reading were evoked in explaining reading difficulties, and when phonological deficit was identified as the main cause of dyslexia (e.g. the work of Vellutino, 1979). Since the 1980s, the study of dyslexia has been undertaken in a number of disciplines: educational psychology, linguistics, developmental and cognitive psychology, neurolinguistics, neuropsychology and genetics. Although our knowledge of what dyslexia 'is' is far from complete, insights from different fields of scientific inquiry will hopefully help us understand the causes of reading difficulties and find appropriate means to support students with dyslexia.

Definitions of dyslexia

Dyslexia is difficult to define because four different levels need to be considered in its definition: behavioural, cognitive, biological and environmental (Frith, 1999). At the behavioural level there seems to be an agreement that dyslexia manifests itself in reading problems (although we will see below reading difficulties are not the sole symptoms of dyslexia – for a review see Nicolson & Fawcett, 2008). The behavioural definition of dyslexia, however, is insufficient for several reasons. First of all, reading difficulties can be caused by a number of factors and not only by dyslexia; thus poor performance in a reading test is not a sufficient diagnostic criterion for dyslexia (Frith, 1999). Secondly, with age and practise, the reading skills of dyslexics improve, and the severity of reading problems tends to decrease, yet other dyslexic problems such as spelling difficulties might remain (Frith, 1999). Defining dyslexia at the behavioural level with sole reference to reading impairments would also imply that dyslexia is a condition children grow out of, which is obviously not the case.

To define dyslexia in terms of reading test performance is rather like defining measles as an increase in body temperature. Raised temperature, however, is merely a sign of the infection, not the illness itself. Decreasing the temperature is usually a good thing, but it does not cure the illness. All the knowledge accumulated in dyslexia research indicates that dyslexia is not a disease which comes with school and goes away with adulthood. It is not a temporary childhood affliction; it is a life-long burden (Frith, 1999: 209).

The difficulty of definition starts at the cognitive level, where explanations for reading problems need to be offered which are related to the cognitive functioning of dyslexic individuals. These explanations have to account for differences between dyslexia and general learning difficulties, and they have to be able to differentiate dyslexia from other types of SpLD such as ADHD. At the biological level, further explorations into the neurological/genetic causes of differential cognitive functioning need to be carried out in order to understand the fundamental cause of dyslexia and develop effective support tools. This is especially important because for a long time dyslexia was not diagnosed until children failed to learn to read. Waiting until children experience failure might cause serious emotional and social problems and might eventually lead to poor overall academic achievement in school. Remediation and support at a young age is of crucial importance, and valuable time might be wasted if adequate screening methods based on findings in neurology are not developed (Nicolson & Fawcett, 2008). Environmental factors, such as exposure to print, attitudes to literacy in the family, and the effectiveness of reading instruction also need to be considered in order to separate the effect of social, cultural and economic status and inadequate teaching on reading behaviour from the effects of developmental dyslexia (see Figure 2.1. for the illustration of the different levels of dyslexia).

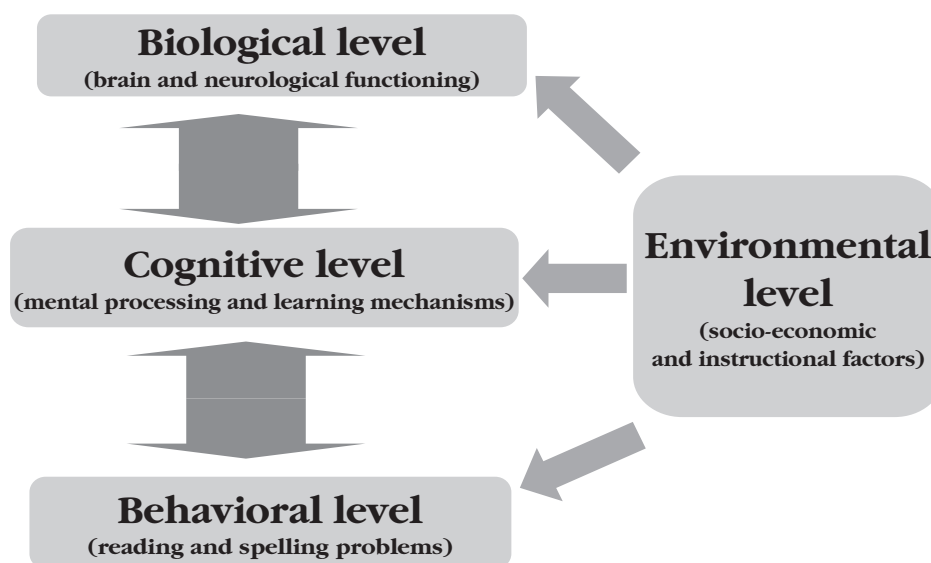


Figure 2.1 Illustration of different levels of dyslexia (based on Frith, 1999)

There is now extremely clear evidence that the earlier one intervenes in helping a child learn to read, the more effective (and cost-effective) the intervention is (with many different interventions apparently being effective). Replacement of the “wait-to-fail” diagnostic method is arguably the central applied issue (Nicolson & Fawcett, 2008: 17).

The first definition of dyslexia that dominated the international field of education up to the 1990s was based on the discrepancy between students’ aptitude primarily measured with the help of IQ tests and tests of achievement. An example for this conceptualization of dyslexia is the definition of the World Federation of Neurology in 1968, which stated that ‘developmental dyslexia is a disorder in children who, despite conventional classroom experience, fail to attain the language skills of reading, writing, and spelling *commensurate with their intellectual abilities*’ (our emphasis). Viewing dyslexia as a disorder was characteristic of the medical discourse in the 1960s, and, as argued in Chapter 1, it implies that dyslexia is an ‘abnormal’ condition. Definitions based on discrepancies between IQ and reading achievement have also come under serious criticism, due to the biased nature of IQ tests towards certain ethnic and social groups, and also because they were found to under-identify students with dyslexia (for a review see Fletcher *et al.*, 2007). An additional problem with this definition was that, in order to diagnose dyslexia reliably, the difference between the IQ test score and the reading test score had to be sufficiently large (Miles & Haslum, 1986). Consequently, students who were dyslexic but whose IQ score was in the lower band of normally developing children might have missed identification.

The main question that arose after the discrepancy-based definitions were discredited was how it was possible to identify reading difficulties without reference to general intellectual abilities. One possible answer was to introduce the concept of unexpectedness, namely that dyslexia might occur despite adequate cognitive skills, appropriate socio-economic circumstances and high quality literacy instruction. A number of conceptualizations of dyslexia in the 1990s viewed unexpectedness as the students’ failure to respond to appropriate and high quality instruction (Response to Intervention Model – Fuchs & Fuchs, 1998). A definition that illustrates this conceptualization is that of the American Psychiatric Association (1994): ‘Developmental dyslexia, or specific reading disability, is defined as an *unexpected*, specific and persistent failure to acquire efficient reading skills despite conventional instruction, adequate intelligence and socio-cultural opportunity’ (our emphasis). Although this definition is more detailed and makes more accurate predictions concerning the diagnosis of dyslexia, it is still a behavioural definition, which does not make reference to the underlying cognitive and neurological characteristics of dyslexic individuals. Another problem with this definition is that it shifts responsibility for reading difficulties from the educational institution to the individual learner.

More recent definitions of dyslexia include specific differences in cognitive and neuro-psychological functioning. One of the most influential definitions of dyslexia today is that of the International Dyslexia Association (IDA) in the United States, which makes an attempt to integrate all four levels of descriptions: biological, cognitive, behavioural and environmental (see Table 2.1). Although this definition is one of the most detailed to date, it does not provide sufficient insight into the nature of the neurological

Table 2.1 *Levels of description in the definition of dyslexia by the IDA*

Dyslexia is a specific learning disability that is neurological in origin.	Biological level
It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities.	Behavioural level
These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities	Cognitive level
and the provision of effective classroom instruction.	Environmental level

characteristics of dyslexic children, and it places a heavy emphasis on the behavioural manifestations of dyslexia. Another issue to consider in relation to this definition is that it is primarily a medical definition, which describes dyslexia as a disability instead of regarding it as a learning difference.

Another related problem of definition is that dyslexia is dimensional and is not an ‘either-or’ condition; hence cut-off points in tests below which children are identified as dyslexic are often arbitrary. People can exhibit symptoms of dyslexia that range from mild to severe, and sometimes symptoms might even be camouflaged (Frith, 1999). The severity of dyslexia might depend on the nature of the underlying cognitive abilities, such as the extent to which phonological processing skills of individual children are impaired. Dyslexia might also have different sub-types: for example, there might be children who are only slow in reading (i.e. have speed differences), and children who decode words in accurately (i.e. have phonological processing problems), and children who have both speed and phonological processing difficulties (Wolf & Bowers, 1999). Other cognitive differences frequently associated with dyslexia, such as attention deficit, might also influence the severity of reading problems. Finally, educational factors, such as high quality remedial instruction, and a supportive home environment where literacy activities are highly valued, might also mitigate the manifestations of dyslexia.

Continuous abilities type theories of dyslexia are based on the assumption that reading ability occurs along a continuum defining levels of reading ability and that there is a gradation of risk for becoming dyslexic, depending on the particular assortment of reading-related cognitive abilities with which the child is endowed and the degree to which that child’s home and school environment capitalize and build on his or cognitive strengths and compensate for his or her cognitive weaknesses. (Vellutino *et al.*, 2004: 4)

Basic learning mechanisms

In order to understand dyslexia and other associated learning differences described in the next chapter, we need to be familiar with the basic cognitive mechanisms involved in learning. In the following we present the structure of memory and the mechanisms involved in acquiring various skills such as reading.

Memory is generally sub-divided into two main components: long-term memory and working memory. Long-term memory, as its name suggests, is the store for the knowledge, skills and habits a person has acquired during his or her lifetime and consists of two main components: declarative and procedural memory (Ullman, 2004). Declarative memory stores knowledge about facts and events, such as the fact that the capital of Italy is Rome, whereas procedural memory is the storage place for motor and cognitive skills and habits. Declarative memory is sub-divided into two further components. Semantic memory contains concepts as well as meaning related memory traces associated with these concepts, such as the concept that the dog is a furry four-legged animal. Episodic memory is the store of temporally organized events or episodes experienced in one's life (Tulving, 1972) – being bitten by a dog, for example.

Working memory is the gateway to long-term memory, through which information passes before being encoded in long-term memory. The most widely accepted conceptualization of working memory today is the model developed by Baddeley and Hitch (1974; Baddeley, 1986), in which working memory is not only seen as a storage device but also as a module where the processing and manipulation of information takes place. Although models of working memory use terms like modules, components and sending and receiving information, we should not think about working memory as a separate compartment of the brain. It should rather be conceptualized as part of the intricate network of long-term memory which is active at a given moment in processing information either based on the input or in preparation for producing output (Cowan, 1999; Craik, 2002; Engle, Kane & Tuholski, 1999). Working memory is limited in capacity and usually maintains information actively for one or two seconds (Baddeley, 1986). When we process incoming information, the memory traces of the information will fade very quickly, but if some elements of the incoming stimuli become integrated and encoded during this time in long-term memory, we can say that learning took place. Consequently, working memory is a key cognitive component in learning, and it has been found to influence a number of skills and abilities. As we will see below, working memory capacity plays a key role in most types of SpLDs.

The working memory model comprises a multi-component memory system consisting of the central executive, which coordinates two modality-specific subsystems, the phonological loop (also called phonological short-term memory) and the visuo-spatial sketchpad. The visuo-spatial sketchpad works with visual and spatial information, while the phonological loop is specialized for the manipulation and retention of speech. The central executive has several functions, including attentional control, directing the flow of information through the system and planning (Gathercole, 1999).

The most widely researched component of working memory is the phonological loop. This subsystem consists of a phonological store, which holds information for a few seconds, and an articulatory rehearsal process, which refreshes decaying information amongst other functions. The rehearsal process is analogous to subvocal speech and takes place in real-time, resulting in a limited span of immediate memory (after a certain number of items, the first one will fade before it can be rehearsed). The best example for the working of the phonological loop is when one wants to remember a telephone

number. In order not to forget the number before we can get a piece of paper and write it down, we keep repeating it to ourselves. Phonological loop capacity is often measured by tasks involving immediate serial recall of numbers (digit span) or words (Baddeley, 2003). One of the most widely used tests of phonological short-term memory capacity is the non-word repetition test, where participants have to repeat non-words of various length. Non-words are words that do not exist in the given language but conform to its phonological rules. We will show below that differences in phonological short-term capacity have important consequences for the acquisition of literacy skills and certain aspects of mathematical abilities.

One of the basic mechanisms in learning involves the development of the automaticity of a particular skill, such as the automatization of word-recognition. Automaticity is necessary for efficient, quick, effortless and accurate performance in a number of skills because our attentional resources are limited, and when carrying out complex activities such as reading a text, we cannot pay attention to all the processes involved at the same time. Most human activity involves a combination of *automatic* and *controlled* performance. For example, when we read in our first language, we automatically decode the words, retrieve the meaning associated with them and process the sentence structure, but in order to interpret the meaning of the text, we need to consciously draw on our background knowledge and remember previously read pieces of information. This latter process is an example of conscious controlled processing. Automatic processes are generally fast, can run parallel, are effortless, capacity-free and unintentional. They are the result of consistent practise and are not prone to interference from processes. On the other hand, controlled processing is often slow and inefficient, is limited by the capacity of the working memory and requires effort (Schneider & Shiffrin, 1977).

There are several theories of automaticity development, and here we will only describe the ones that have direct relevance in understanding the cognitive characteristics associated with SpLDs. There are two main groups of theories of automaticity: rule-based and item-based approaches. Rule-based approaches to automaticity view the development of automaticity as the transformation of factual knowledge into production rules, which are called *procedural knowledge*. To take an example from the field of learning to read in English, when a child is taught that the grapheme combination of 'sh' represents the [ʃ] sound, he/she will first store it as factual or *declarative knowledge*. With practise, this knowledge will be transformed into a production rule, such as: 'if I see two letters s and h together, I should read [ʃ]'. Finally, this rule will be applied automatically, that is, without conscious attention. Rule-based approaches to automaticity attempt to account for how this conversion takes place. Item-based approaches of automaticity development argue that in learning solutions to problems, processing mechanisms become stored as one unit in memory (e.g. one does not add up 4 five times when calculating 4x5 but remembers the solution) and are retrieved from memory as a single item.

The best-known rule-based theory of the development of skilled performance is Anderson's (1983) ACT* (adaptive control of thought) and ACT-R theory (adaptive control of thought – revised) (1995). Anderson proposed that the development of automatic processes does not only involve a quantitative change, that is, speeding-up, but also

qualitative modifications in the nature of processing. Two important processes in the development of automatic performance are *composition* and *proceduralization*. Composition and proceduralization constitute the sub-processes of knowledge compilation, in which the former involves the creation of ‘macro-productions’ from the smaller units of processing, and the latter the removal of declarative knowledge, which results in the retrieval of the production as a whole. In other words, the creation of macro-productions is called chunking, which refers to the psychological process of transforming items into larger units in order to help processing in the working memory. The simplest example of this is remembering telephone numbers. Due to the fact that the working memory can hold between 5-7 items at a time, when trying to remember a phone number, which is a long list of unrelated one-digit numbers, people tend to chunk this list into larger units in order to help keep it in working memory (e.g., 2 4 6 1 9 2 2 3 6 gets chunked as 246-19-22-36). The process of proceduralization has the potential to explain why, once a production has become automatic, the initial declarative knowledge underlying it is often not retrievable any more. For example, L2 learners who were once taught explicitly in which situations to use the present perfect tense in English might not remember the exact rules after the application of these rules becomes automatic. Figure 2.2. gives a graphic illustration of the theory.

Logan’s (1988) instance theory is an example of an item-based model of skill acquisition. Logan was the first to address the issue that not all learning involves the conversion from declarative to procedural learning. Logan assumed that automatic processing equals memory retrieval, that is, the use of an algorithm is substituted by a single step retrieval of the solution from memory. For example, beginning readers decode words letter by letter first, but, with the development of reading expertise, they will be able to automati-

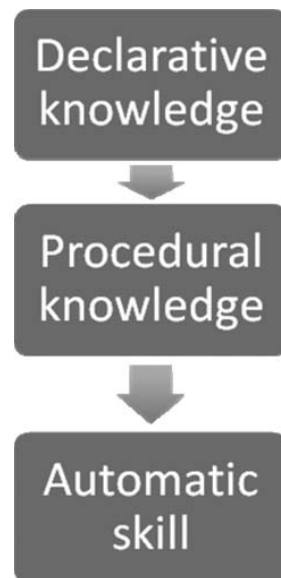


Figure 2.2 An illustration of skill acquisition theory

cally recognize words just by looking at them and without recourse to phonological analysis. In other words, in this theory it is presumed that if a problem is solved repeatedly, the solution becomes stored as one unit and is called upon when encountering the problem. With practise, associations between problems and the memory traces of their solutions become stronger, and retrieval consequently speeds up. Logan (1988) also argued that there is a competition between rule-based processing and memory retrieval, and the speed of the two different processes determines which one will be applied. Logan's instance theory is best illustrated with mathematical operations; when a child first learns to do multiplications, such as 6×3 , s/he will use the algorithm $6+6+6$. With practise, s/he will sooner or later remember the solution (18), and instead of applying the algorithm, will retrieve the solution from memory. Memory-retrieval will take place when its speed exceeds that of the algorithm.

Reading processes and learning to read

In order to understand the difficulties of dyslexic readers, we also need to examine how reading works. Reading is a complex skill in which several processes need to work parallel and automatically to aid the decoding of information. Reading skills are hierarchical in the sense that low-level reading processes such as word recognition and sentence comprehension need to be automatized before readers can be expected to understand the overall informational content of a text. The key component of lower-order reading processes is fast and efficient word-recognition (for a review see Perfetti, 2007). In order to recognize words, the reader needs to combine different processing mechanisms: orthographic processing (recognizing letters), phonological processing (phonological activation of word forms, converting letters to sounds, letter combinations to syllables), accessing the semantic and syntactic information related to the word, and finally morphological processing to understand words with suffixes and prefixes. Higher order reading processes involve creating a text model, that is, processing the informational content of the text, and a situation model, which helps the reader interpret the information presented in the text based on relevant background knowledge (Kintsch, 1998).

The prevailing views about dyslexia suggest that phonological processing problems are at the core of the reading difficulties that dyslexic students experience (see below). As these problems primarily manifest themselves at the stage of word-recognition, we will describe word-recognition processes in detail here. There are two ways in which words can be recognized: the sub-lexical and the lexical routes (for a review see Nicolson & Fawcett, 2008). In the sub-lexical route (route 2b in Figure 2.3.), the written word is decoded letter by letter. The reader accesses the meaning of the word through the conversion of letters into sounds and assembling the sounds to form the phonological (spoken) form of the word. This is the prevalent reading process for beginning readers and for reading unknown words. There is another route for reading, which bypasses the phonological

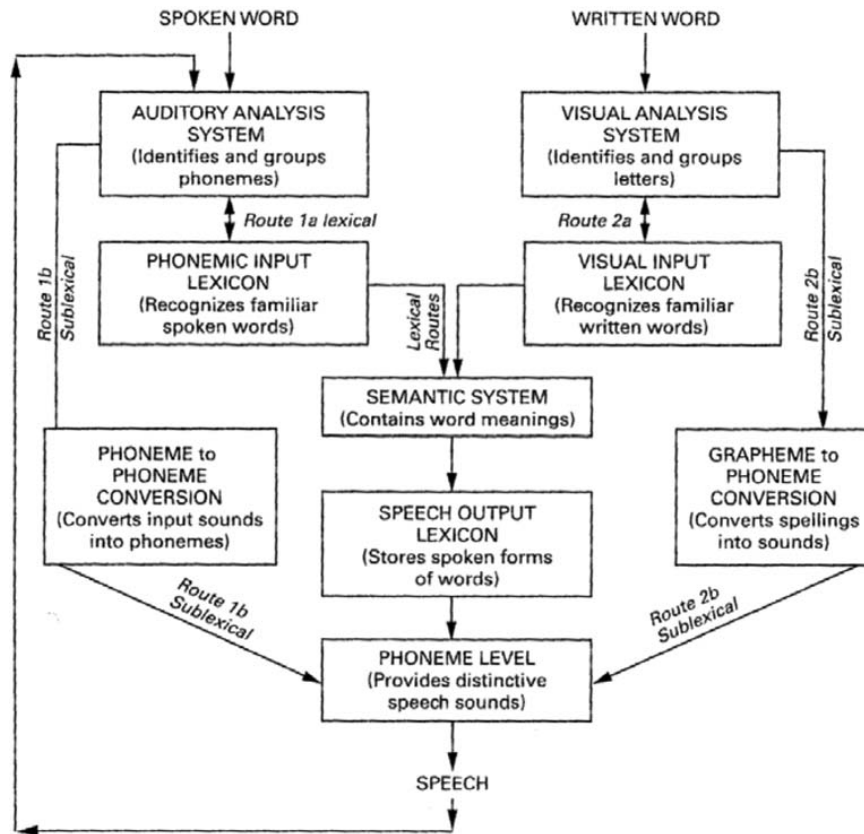


Figure 2.3 Model of word recognition (Figure 3.1. on p. 44 of Nicolson & Fawcett, 2008 reprinted with permission.)

analysis, called the lexical route (route 2a in Figure 2.3.). In the lexical route, readers perceive the visual form of words as a whole unit and recognize the word-form without having to analyse it into segments. Skilled readers often recognize familiar written words in this way.

In order to understand reading difficulties, it is also important to consider how children learn to read. The most influential theory of learning to read was proposed by Frith (1986), who argued that children acquiring reading skills in an alphabetic language proceed through three stages. First, children learn to read a few words as a whole unit, such as their names or the names of supermarkets on the roads they frequently pass. This is called the *logographic stage*, which corresponds to route 2a in Figure 2.3. In this stage, children do not yet know the alphabet and process the words visually as one single unit. In the next stage, the *alphabetic stage*, children learn to segment visually perceived word forms into letters, convert letters into sounds and combine them to form the phonological form of the word (see route 2b in Figure 2.3.). Children need to achieve high levels of automaticity in these processes to be able to proceed to the next stage. If we recall skill acquisition theory, presented above, children will first acquire alphabetic

knowledge in a declarative form through explicit classroom instruction, and with ample practise they will proceduralize their knowledge and will be able to use it automatically. As children with dyslexia experience difficulties in phonological processing, it is this stage of learning to read that is the most challenging for them. They need more exposure to explicit explanation, as well as more practise, to be able to successfully move on to the next stage of reading.

The final stage in Frith's (1986) theory is the *orthographic stage*, in which children do not process words letter by letter anymore but analyse words into bigger units such as letter sequences and convert these into syllables. This is called the orthographic stage because readers have to make use of their knowledge of how written (orthographic) words are constructed from larger chunks such as morphemes, prefixes and suffixes. In Figure 2.2., this involves route 2a and additional phonological analysis from route 1a. Children with dyslexia might also find this phase of learning challenging due to their reduced level of syllabic awareness (see below).

Nicolson and Fawcett (2008) propose another stage in reading acquisition at which words are automatically recognized visually as one unit in a similar fashion as at the logographic stage. This stage of development can be understood as a solely memory-based process based on Logan's (1988) instance theory, which we described above. Instance theory of automaticity development might explain that in skilled word recognition there might be two routes: one based on the proceduralization of phonological encoding processes and one on instant memory based recognition of word forms. Phonological encoding processes might be called on in reading unknown or unfamiliar words, whereas memory-based processes are at work in the case of highly familiar words. This dual processing route explains why dyslexic people may easily recognize familiar words, and why their reading difficulties manifest themselves when faced with unfamiliar words.

Behavioural manifestations and cognitive correlates of dyslexia

The main behavioural manifestations of dyslexia in childhood are reading and spelling difficulties, as well as problems in memory and organization. As pointed out above, manifestations of dyslexia might vary in their severity and not all the symptoms might be present in every individual. Reading difficulties primarily manifest themselves in word-recognition and are assumed to be caused by difficulties in converting letters to sounds. Dyslexic children tend to have problems recognizing existing words as well decoding non-words. Although we will present a more detailed cognitive explanation for this problem below, we give a brief description of the nature of the word-recognition problems here. Every writing system, even Chinese, makes use of information related to speech sounds, or in other words, phonological information (Goswami & Bryant, 1990).

Alphabetic and syllabic writing systems are based on the notion that speech can be represented in units (i.e. phonemes in an alphabetic system and syllables in a syllabic system). Therefore, when children learn to read and write, they first have to be able to do two basic things: segment spoken words into relevant units, and acquire how specific units are represented in writing (orthographically). In the case of alphabetic writing systems, the latter process is called phoneme-to-grapheme mapping, and it is this process which causes the most serious difficulties for dyslexic learners (for a review see Vellutino *et al.*, 2004). These difficulties might result in slow and/or inaccurate word-recognition.

Another important factor influencing the nature of dyslexic difficulties is the language itself in which children learn to read. Some languages, such as Italian, German or Hungarian, have relatively simple sound-letter conversion rules and a predictable writing system, which is called *transparent orthography*. In other languages, such as English and French, the phoneme-to-grapheme mappings are complex and sometimes unpredictable, and acquiring these orthographic systems might cause serious problems for dyslexic children. As a consequence of the differences in writing systems, reading difficulties might manifest themselves differently in different languages. Italian or German dyslexic children might be slow but generally accurate readers, whereas dyslexic children whose first language is English might exhibit differences in reading both in terms of speed and accuracy (Paulesu *et al.*, 2001).

Another major area in which dyslexic children experience difficulties is spelling. In certain cases of dyslexia, spelling difficulties might be the sole signs of literacy problems (Frith & Frith, 1980; Snowling, 2008). Just like word recognition, spelling requires segmenting spoken words into phonemes and converting these phonemes into letters or letter combinations. While visual processing mechanisms such as recognizing the word as a unit by sight and other contextual clues might compensate for a lack of phonological awareness in reading, these compensatory processes are not available in writing. Therefore, spelling problems are frequent correlates of dyslexia and might often be observed in the case of at-risk readers who do not meet the diagnostic criteria for dyslexia based on their reading performance (Snowling, 2008).

We have shown above that learners with dyslexia have difficulties in segmenting words into sounds and learning sound-letter correspondence rules, both of which involve phonological processing. Phonological processing, however, is not only implicated in reading and writing but also in speech perception and speech production. Research evidence suggests that dyslexic individuals show differences both in the accuracy and in the speed with which they can process orally presented information (Bowers & Swanson, 1991; Wolf, 1991). Dyslexic children were found to perform significantly worse in sound-discrimination (Adlard & Hazan, 1998) and in word repetition tests than their non-dyslexic peers (Miles, 1993). Both of these tasks involve phonological short-term memory, which helps maintain verbal information active for further processing. Baddeley (1986) argued that the phonological short-term memory plays a crucial role in the learning of new words by storing unfamiliar sound patterns while long-term representations are built, which presupposes a direct link between short-term memory and the long-term retention of vocabulary. Impairments in phonological short-term

Table 2.2 *Overview of linguistic problems experienced by dyslexics*

Problems in segmenting words into phonological units
Problems with phoneme-grapheme correspondences
Problems in word-recognition
Slow reading speed
Difficulties in spelling
Smaller range of vocabulary
Slow word retrieval
Slow speech
Articulation problems
Problems in keeping verbal material in phonological short-term memory

memory and in phonological processing generally result in speech delay, a slower rate of speech sometimes with indistinctive pronunciation, and a smaller receptive and expressive vocabulary range (Lundberg & Høien, 2001; Scarborough, 1990, 1991; Snowling, 2008). Not only is the size of the vocabulary dyslexic children are familiar with often smaller than that of their non-dyslexic peers, but they might also be slower in retrieving words when they have to name pictures. Table 2.2 gives an overview of the linguistic problems experienced by dyslexic students.

One of the major problems in research on SpLDs, to which we will return towards the end of our discussion of dyslexia, is that most dyslexic individuals do not only exhibit difficulties in literacy-related skills but show other types of differences, though sometimes minor ones, in other areas of cognitive functioning. Research evidence suggests that not dyslexic people also have a shorter working memory span (Jeffries & Everatt, 2004). This might explain, for example, why so many dyslexic children have problems memorizing the multiplication tables and have difficulties with arithmetic and are also considered as having dyscalculia (mathematical learning difficulties) (see Chapter 3). Reduced working memory capacity makes it difficult for dyslexic people to hold several pieces of information in working memory at the same time, which is often required in mathematics as well as in reading and listening to longer pieces of texts. Problems with sustained attention are also frequent in the case of dyslexic children and adults even in the absence of a formal identification of ADHD (e.g. Fletcher *et al.*, 2004; Snowling, 2008). Limited attention span can cause difficulties in general academic contexts and can lead to problems in acquiring general knowledge and skills, not only literacy related ones. Attention to input is a prerequisite for learning new information, and, due to problems in sustaining attention, dyslexic individuals cannot concentrate on new incoming stimuli for a long time, and might need repeated exposure to acquire new knowledge. Attention is also necessary for monitoring output, and thus dyslexic students are prone to making mistakes even if they have acquired the relevant knowledge and skills. Difficulties with

Table 2.3 *Overview of non-linguistic problems experienced by dyslexics*

Smaller span of working memory
Problems with arithmetic and memorizing multiplication tables
Difficulties with handwriting
Gross motor-coordination problems
Problems with sustained attention
Difficulties in time-management and organizing work
Difficulties in automatizing new skills

attention might also be the cause of difficulties in time-management, keeping deadlines and organizing academic work.

Dyslexic children and adults are often perceived to have difficulties with motor skills (for a summary see Nicolson & Fawcett, 2008). Fine motor skills are needed for handwriting, which explains why a large number of dyslexic children's handwriting is often difficult to read (Miles, 1993). Gross motor-coordination problems such as difficulties in bicycle riding and swimming have also been reported among dyslexic children (Augur, 1985). Finally, Nicolson and Fawcett (2008) additionally summarize evidence that dyslexic children tend to be slow in automatization when acquiring new skills.

We have already pointed out above that with adequate instruction, support from the home environment and practise, reading and spelling difficulties might decrease, but dyslexic adolescents and adults frequently continue to struggle with other problems associated with dyslexia, such as problems with working memory, sustained attention and the coordination of motor skills. Consequently, non-literacy related difficulties might be important signs for teachers working with language learners past childhood age, and these difficulties might sometimes need more attention in the classroom than problems with reading and spelling (for an overview of the difficulties see Table 2.3).

Cognitive and neurological explanations of dyslexia

The most well known cognitive theory of the causes of dyslexia, which is based on the models of reading and learning to read presented above, is the Phonological Deficit Hypothesis (Stanovich, 1988; Vellutino, 1979). As its name suggests, the Phonological Deficit Hypothesis assumes that dyslexia is caused by an underlying phonological processing problem, namely impaired phonological awareness. Phonological awareness has two levels: syllabic and phonemic knowledge. Syllabic knowledge entails the ability to segment words into syllables and manipulating syllables in words (e.g. deleting or

adding syllables). Phonemic knowledge involves the ability to divide words into sounds, differentiating sounds from each other and manipulating sounds (e.g. deleting, adding and substituting sounds). The Phonological Deficit Hypothesis has received extensive support through research, which has demonstrated that dyslexic people perform significantly worse in tasks requiring phonological awareness, such as non-word reading and non-word repetition, sound differentiation, letter recognition, deleting and adding letters and syllables to words, than their non-dyslexic peers. Support for decreased phonological awareness in dyslexic people, in particular in phonemic knowledge, has been provided in a number of intervention studies, where significant improvement in reading skills was achieved through training in phonemic awareness (for a review see Vellutino *et al.*, 2004). Difficulties with phonological processing skills can provide a good explanation for why dyslexic people have problems in lower level reading skills, specifically in word recognition, and why they experience spelling and speech perception problems (see Figure 2.4). There seems to be a consensus among dyslexia researchers that the underlying cognitive cause of reading difficulties in people with dyslexia is phonological processing deficit. The question, however, is whether phonological deficit is the only cause of dyslexia and what other underlying neurological problems might explain dyslexic reading difficulties. The Phonological Deficit Hypothesis has been instrumental in setting up remedial programmes for dyslexic children, which gave them support in acquiring sound-letter correspondences and helped to develop their phonological awareness.

A modified version of the Phonological Deficit Hypothesis is the so-called Double-Deficit Hypothesis, which posits that, in addition to phonological processing problems, naming speed deficits also play a role in developmental dyslexia. Research evidence suggests that dyslexic children are significantly slower in word naming tasks than people with no apparent dyslexia (Denckla & Rudel, 1976), which might point to problems with the speed of processing in the case of dyslexic participants. Wolf and Bowers (1999) argued that differences in naming speed and difficulties with phonological processing are two independent sources of dyslexic reading problems (see Figure 2.5). They supported their theory by showing that students who experience reading difficulties can be divided into three groups: those who exhibit speed problems; those with phonological processing problems; and finally the most severely impaired reading performance was associated

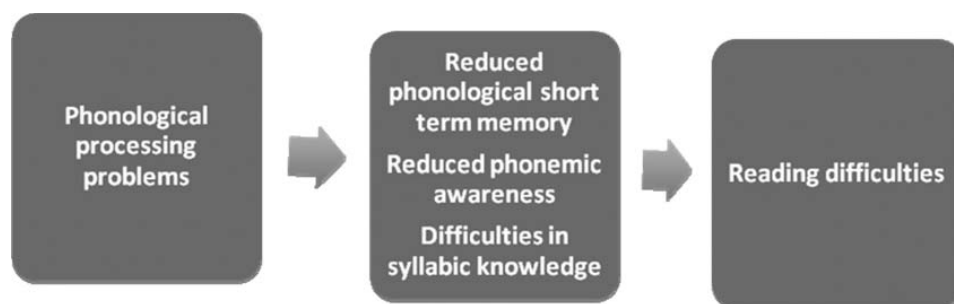


Figure 2.4 An illustration of the Phonological Deficit Hypothesis

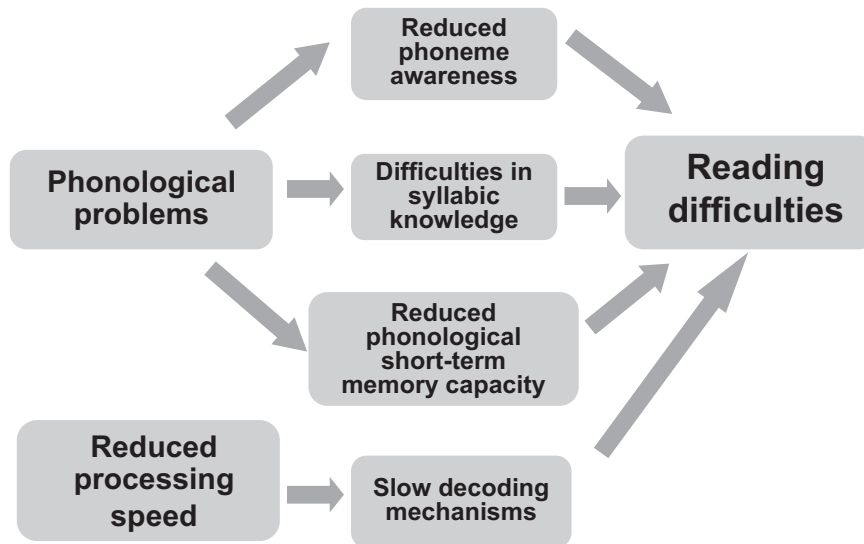


Figure 2.5 An illustration of the Double-Deficit Hypothesis

with both phonological processing and naming speed. It has to be noted that most studies that have tested the Double-Deficit Hypothesis found that the majority of dyslexic people have difficulties both in terms of speed and phonological processing (e.g. Lovett *et al.*, 2000; Pennington *et al.*, 2001). These findings seem to suggest that the Double-Deficit Hypothesis might not be tenable. Nevertheless, the hypothesis had important consequences for reading remediation because in addition to phonics support, children also started to receive training in the fluency of letter and word-recognition.

A competing cognitive theory of dyslexia is based on the observation that dyslexia frequently co-occurs with other types of learning differences such as motor coordination problems (dyspraxia), general language processing difficulties (Specific Language Impairment) and ADHD. Therefore, it might be argued that dyslexia is a manifestation of a learning difference, which is not only restricted to reading. Nicolson and Fawcett (1990) hypothesized that problems in the automatization of new skills are at the core of the difficulties dyslexic children experience in different spheres of life. In their view, 'dyslexic children will suffer problems in fluency for any skill that should become automatic through extensive practice' (Nicolson & Fawcett, 2008: 29). The illustration of their conceptualization of dyslexia can be seen in Figure 2.6. If we consider the theories of automaticity presented above, this hypothesis claims that dyslexic children have problems in the proceduralization of skills in general, and that they find it difficult to reach the stage of automatic skilled performance not only in phonological processing but also in fine and gross motor skills. Nicolson and Fawcett also developed a neurological model that supports their hypothesis. In this model, which is called the Cerebellar Deficit Hypothesis, they argue that a specific part of the brain, the cerebellum, is responsible for procedural learning, and deficits in cerebellar functioning are responsible for the variety of symptoms dyslexic individuals display in acquiring different skills. Although Nicolson

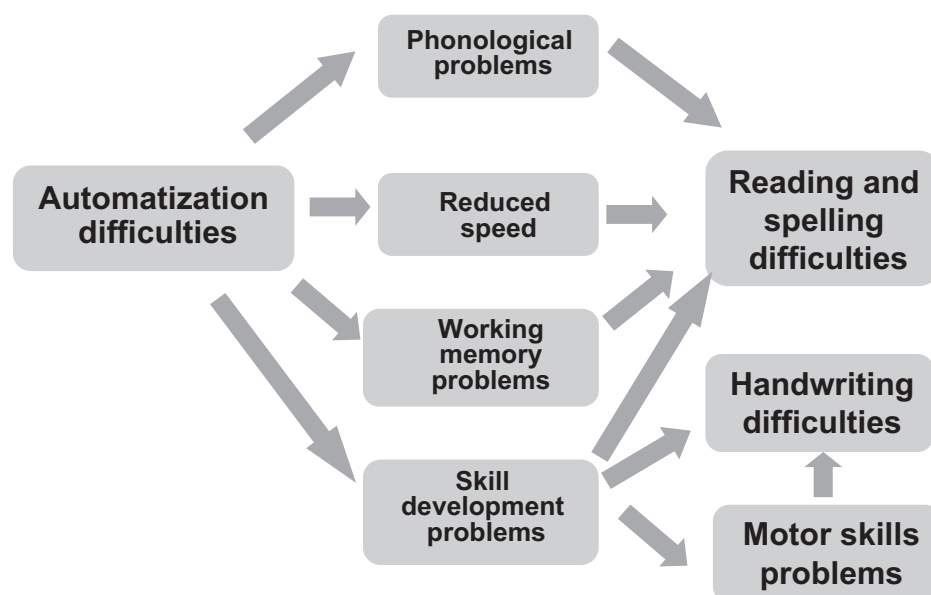


Figure 2.6 Illustration of the automaticity deficit hypothesis

and Fawcett's hypothesis is compatible with the assumption that the cognitive cause of dyslexia is phonological processing deficit, it has been criticized on methodological grounds (for a review see Ramus, *et al.* 2003). Nevertheless, it is worth noting that in a recent article Snowling (2008), who previously unequivocally supported the Phonological Deficit Hypothesis, acknowledges that 'phonological deficits alone are insufficient to explain literacy difficulties, and it is children with multiple deficits (including language problems) that are more likely to succumb to reading failure' (p. 142). Recent research in the field of behavioural genetics also suggests that learning differences do not only have specific effects on cognitive functioning but also on general functioning, and that learning differences restricted to one single module of cognitive processing are rare (Plomin & Kovas, 2005).

The present data suggest that it is not appropriate to question whether phonological deficit is necessary or sufficient to account for dyslexia – this kind of question depends on adopting arbitrary cut-offs for defining deficits. If instead dyslexia is viewed as a continuously distributed dimension, then those who fall at the lower end are more likely to have poor phonology. But they are more likely to have other cognitive deficits as well. This is not to deny that specific disorders exist; indeed individuals with pure disorders are more likely to be recruited to laboratory samples as the findings of our study make clear. (Snowling, 2008: 153)

Another neurological theory of dyslexia relates the causes of literacy problems to difficulties in processing visual and auditory stimuli in the cerebral cortex, which is the part of brain involved in understanding incoming speech. It was discovered that one of the pathways in the brain that transmits auditory and visual signals, called the magnocellular pathway, might be impaired in dyslexic people (Livingstone *et al.*, 1991).

Due to the fact that magnocellular pathways are responsible for processing both visual and auditory stimuli, two different theories of dyslexia were developed: one in which the visual pathway is affected (the Visual Magnocellular Hypothesis) and another in which the auditory pathway shows differential functioning (the Auditory Magnocellular Hypothesis). The Visual Magnocellular Hypothesis is based on Lovegrove's experiments, in which it was found that dyslexic people have difficulties in reading black print against a white background (Martin & Lovegrove, 1987). The Auditory Magnocellular Hypothesis claims that dyslexic children are slow in processing auditory stimuli. Neither of these theories has received sufficient empirical support (for a review see Nicolson & Fawcett, 2008).

Finally, we need to mention that dyslexia might have genetic origins. Research evidence suggests that male children who have either a dyslexic parent or a dyslexic sibling have a 50% chance of being dyslexic (Gayán & Olson, 1999). Advances in genetic research have also been made in terms of identifying the potential genes that might be responsible for dyslexia. Although the familial risk of dyslexia is very important in the diagnosis of dyslexia, environmental factors often override the role of genetics. Thus, a home environment in which literacy activities are supported and which creates optimal conditions for the cognitive development of the child might reduce the severity of reading difficulties associated with dyslexia. On the other hand, it is also worth noting that the effects of dyslexia in a family might be cumulative. It might often be the case that dyslexic parents cannot provide the necessary literacy and academic support to their children, which might predispose them to reading problems. Moreover, dyslexia is often the cause of reduced employability (see Chapter 9), and this might adversely affect the social and economic status of the family, which again might contribute to the development of reading problems in at-risk children.

In this chapter we provided an overview of the history of dyslexia research and outlined several definitions of dyslexia. We discussed the possible cognitive causes of dyslexia and related these to general theories of learning and models of reading development. The behavioural manifestations of dyslexia were also outlined in detail. We pointed out that although dyslexia is primarily associated with problems related to literacy skills, it is rare that dyslexia only manifests itself in the form of reading and spelling difficulties. Therefore, teachers also need to be aware of the challenges these learners face in other aspects of academic performance and in their private lives. The next chapter will acquaint readers with other types of learning differences that frequently co-occur with dyslexia.

Summary of key points

- The best available definition of dyslexia today is that of the International Dyslexia Association, according to which 'dyslexia is a specific learning disability that is neurological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction.'
- The mainstream position in dyslexia research is that, at the cognitive level, the cause of dyslexia is reduced phonological awareness.
- Dyslexia is a type of learning difference which is not only limited to reading and spelling. Literacy problems are frequently associated with other areas of cognitive functioning such as lack of sustained attention, difficulties in proceduralization and automatization of knowledge and problems with gross and fine motor skills. Even if dyslexic students have managed to overcome their literacy problems, their overall learning difference is not likely to disappear and it will affect them throughout their lives.
- Dyslexia is dimensional and not an 'all or nothing' state. Dyslexic difficulties might be of different degrees of severity and dyslexia might be associated with a variety of other learning differences, which means that dyslexic individuals might display very different strengths and weaknesses.
- Dyslexia needs to be considered in the context of education, the family and the socio-economic setting. Early identification and remediation of literacy problems is of key importance for dyslexic children not only to ensure their academic success but also to avoid the negative emotional experiences of failure. Family support in literacy activities and in creating a supportive atmosphere for the child's emotional and cognitive development plays an important role in reducing the effect of dyslexia on the child's future life and academic success. Children who are at-risk of dyslexia in disadvantageous social settings need additional support from the relevant educational institutions. Great care must also be taken not to over-diagnose dyslexia in specific social and cultural groups.

Activities

1. What definition of dyslexia is used in your country? Discuss the implications of this definition for diagnosis and teaching an L2.
2. What are the signs on the basis of which a language teacher might suspect that a student has dyslexia?
3. Discuss the different theories of dyslexia presented in this chapter in terms of their explanatory power with regard to the symptoms of dyslexia. Which symptoms can these theories account for and which ones remain unexplained by them?
4. Interview a parent who has a dyslexic child. What difficulties does the parent give account of concerning the child's experience in everyday life and in school?
5. Interview a dyslexic adult about the difficulties s/he experienced as a child in school and in everyday life and about the problems that persist in adulthood.

Further reading

Frith, U. (1999). Paradoxes in the definition of dyslexia. *Dyslexia*, 5, 192–214.

Shaywitz, S. (2003). *Overcoming Dyslexia: A New and Complete Science-based Program for Reading Problems at any Level*. New York: Alfred Knopf.

Vellutino, F.R., Fletcher, J.M., Snowling, M.J. & Scanlon, D.M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry*, 45, 2–40.