As modern civilization started teaching most of its citizens how to read, it became evident that there is a tremendous amount of variability in how people acquire and practice reading. This chapter focuses on the lower tail of the distribution of this variability, i.e. reading disability (RD).

What is reading disability?

Much debate in the literature surrounding issues concerning reading difficulties is a result of a degree of conceptual confusion, whereby a variety of terms are employed to describe the same, or closely related, literacy problems. These include such terms as learning disability, (specific) learning difficulty, (specific) reading difficulties, reading disorder, (specific) reading disorder, (specific) reading retardation and dyslexia. Some writers use these terms interchangeably, while others consider them as describing different conditions, a situation that often leads to no little confusion. This differing use of terminology partly reflects the differing focus and interests of various academic disciplines, professions and lobby groups. For the purposes of this chapter, the term reading disability (RD) will be used as synonymous with these other terms. Thus, it will depart from the position of those who contend that RD should be differentiated from dyslexia, this latter term sometimes being employed to describe a smaller subset of reading-disabled individuals with particular profiles of underlying difficulty (Elliott and Gibbs, 2008; Elliott and Grigorenko, in press).

A further complication concerns which aspects of reading should be considered to be covered by the term reading disability. For some, the term should be reserved to describe those with severe difficulties of single-word-processing accuracy (i.e. decoding and/or recognition). Others, however, argue that, while some with RD can overcome their decoding/ recognition problems, they may continue to experience problems of word processing fluency. This position is particularly evident in relation to transparent languages such as Finnish, German or Italian, where accuracy difficulties are rare, but problems are manifested by slow and laborious reading. While those experiencing problems of accurate and fluent word processing are very likely to encounter difficulties in taking meaning from text, comprehension problems are not considered to be markers of RD.

A key element of RD has been the notion that it is a condition that is often found in children with sound abilities in other cognitive and academic domains. In line with such thinking, a distinction has been made between those with general reading backwardness (where reading performance is at a level that would be expected on the basis of the individual’s IQ) and a more specific disability (e.g. specific
reading retardation, as per Rutter and Yule, 1975) where word-processing skills are much weaker than would be predicted on the basis of IQ. The idea that RD reflected a discrepancy between IQ and reading performance was challenged on the basis of reviews of discrepancy studies (Fletcher, Lyon, Fuchs and Barnes, 2007; Stuebing, Barth, Molfese, Weiss and Fletcher 2009; Stuebing et al., 2002) that have shown that dividing poor readers into IQ-discrepant and non-discrepant groups provides no meaningful information for diagnosis or intervention. Such studies have now resulted in widespread acceptance that IQ tests have little value in diagnosing RD (Vellutino, Fletcher, Snowling and Scanlon, 2004), although resistance to this general consensus continues amongst some researchers and clinicians (Stanovich, 2005).

Incidence, prevalence and prognosis

RD is generally conceived of as a condition that lies along a continuum with no clear-cut distinction between typical and atypical (disabled) readers. This contrasts with a categorical distinction, whereby one either has or does not have a disability. As a result, prevalence estimates can vary substantially depending upon where the cut-off point is applied. Shaywitz (2005) provides a figure of 17.5%. A similar figure is provided by the US National Institutes of Health; RD is thought to affect at least 10 million American children, or approximately 20% of individuals under 21 years of age.

Others argue that it is preferable to talk of a much smaller group with severe reading difficulties that prove tough to overcome. In some instances, this group is described as dyslexic, with prevalence rates typically in the range of 4–8% (Hulme and Snowling, 2009), although others prefer to see dyslexia as synonymous to RD and thus describing a significantly larger proportion of poor readers. Recognising the difficulties involved in arriving at a clear consensus, Fletcher and colleagues (Fletcher et al., 2007) suggest a prevalence of RD of between 6% and 17% of the school age population, depending upon the definitions and cut-off points selected to differentiate individuals with RD on the reading performance distribution curve.

There is some disagreement as to the proportion of males and females with RD, with gender ratios varying according to the differing definitions and measures employed. Generally, it is considered that there is a higher prevalence of males, although earlier estimates of 3 or 4 to 1 have now been seen to be somewhat excessive. It has often been noted that the proportion of boys is higher in clinical than epidemiological samples. This appears to reflect the greater tendency of teachers to refer boys to support services as they are also more likely to display other co-morbid externalising disorders (Pennington, 2009; Shaywitz, 2005). In contrast, girls often demonstrate a comparatively higher proportion of internalising disorders that are less obtrusive in school settings. Most commentators now estimate a true reading-disabled ratio of males to females as approximately between 1.3:1 and 1.5:1 (Fletcher et al., 2007).

For many, RD can last throughout the school years and even have lifetime effects, with as many as 80% of those identified as having RD in childhood continuing to experience significant reading difficulties in adulthood (Rutter, Kim-Cohen, and Maughan, 2006). However, for many individuals, improvements in accuracy can be made as a result of sound instruction, yet difficulties persist in fluency, often coupled with poor spelling and slow writing speed (Bruck, 1990). As is noted below, there appears to be a group of poor readers (sometimes described as treatment resisters) comprising about 2–5% of the general population, for whom best intervention practices appear to be ineffective.

The aetiology of reading disability

From its introduction into the literature in the late nineteenth/early twentieth century, RD has been considered a familial condition, i.e. it was noticed that reading difficulties run in families. This observation triggered research into the environmental and genetic factors clustered in families that seemed to underlie these difficulties.
The investigation of environmental factors has resulted in the identification of so-called ‘risk or protective’ factors for reading difficulties that tend to be associated with RD statistically. Among these factors are socioeconomic status (SES) (Nicholson, 1997), family traditions and values concerning education and literacy (Kamhi and Laing, 2001), exposure to printed material (Cunningham and Stanovich, 1997) and protected time for reading (Carter, Chard and Pool, 2009). When ‘low’ or ‘weak,’ these factors are considered to be risk factors, when ‘high’ and ‘strong’ – protective. None of these factors is considered to be causative, yet they appear to be important modulators of genetic risk factors.

Genetic factors predisposing for RD are studied both at the levels of the genome and the brain. Such a multi-level approach is warranted by the fact that the human genome does not contain specific genes that code for reading. What the human genome contains is the potential for a complex system of reading to arise as a result of the emergence of the so-called reading brain, i.e. the human brain that can read. The emergence of such a brain assumes that the specific brain structures involved in the cognitive processes required for reading are intact, functional and properly connected with each other. The structural development of the brain, its maturation, and its acquisition of connectivity are orchestrated by the human genome. Correspondingly, when genetic bases of RD are investigated, the assumed emergent structure is three-layered, from the genome, to the brain, and then to reading. However, researchers, for reasons of theoretical and experimental simplicity and economic frugality often focus only on two layers, connecting the genome to reading and the brain to reading.

Studies connecting the genome to reading have resulted in the following observations (Grigorenko, 2007; Grigorenko and Naples, 2009; Scerri and Schulte-Körne, 2010). First, the familiality of RD is explained, to a substantial degree, by the fact that reading (i.e. both the ability and disability, as well as the cognitive processes underlying reading) is heritable. Although heritability estimates vary across languages, samples and specific assessment instruments, most of them converge within the range of 40–60% (Grigorenko, 2004), indicating a substantial role of the genome in building the machinery utilized in reading. Yet, the transition from these statistical estimates of the genome’s involvement to the identification of particular genetic mechanisms and the specific genes that are involved in the realization of these mechanisms has been difficult. Currently, the field is considering about a dozen genes that have been nominated as candidates involved in these mechanisms, but the research is still too much in progress to put forward a comprehensive hypothetical model for such a mechanism.

Yet, there are specific hypotheses, which cover the components rather than the whole system of reading mechanisms. These specific hypotheses are directly related to the structure and function of the brains of individuals with RD. For example, it turns out that at least four of the currently studied candidate genes (DCDC2, ROBO1, KIAA0319, and DYX1C1) generate proteins that participate in various stages of neuronal migration (Galaburda, LoTurco, Ramus, Fitch and Rosen, 2006). This hypothesis is supported by the observation (although obtained on a very small number of postmortem brains of individuals with reading difficulties) of heterotopias, which can arise as a result of deficiencies in the process of neuronal migration. Another specific hypothesis connects the candidate genes for reading to specific areas of the brain that seem to substantiate the machinery of reading biologically (Paracchini, Scerri and Monaco, 2007). Thus, based on recent reviews (Price and Mechelli, 2005) implicating specific areas of the brain (i.e. the fusiform gyrus – roughly the ventral portion of Brodmann area (BA) 37; the posterior portion of the middle temporal gyrus – roughly the ventral border of BA 21 with BA 37; the dorsal border of the superior temporal sulcus, the angular gyrus – BA 39; and the posterior portion of the superior temporal gyrus – BA 22) as key in the brain anatomy substantiating reading, researchers are currently investigating which of these candidate genes are expressed in these areas and at what intensity.

**Cognitive processes in reading disability**

Although the earliest accounts of RD in the late nineteenth century assumed that the core problem concerned visual processes, research during the past four decades has increasingly emphasised that the
problem has a linguistic, rather than a visual basis (Vellutino et al., 2004). Since this time, the dominant theory has been the phonological deficit hypothesis (Stanovich and Siegel, 1994). While there is debate about which cognitive processes are most appropriately covered by this term (Nicolson and Fawcett, 2008), the three most commonly identified elements are phonological awareness, verbal short-term/working memory and rapid retrieval of phonological information stored in long-term memory, as exemplified by rapid-naming tasks (Wagner and Torgesen, 1987).

**Phonological awareness**

Phonological decoding is an important process for reading unfamiliar words and involves a process of mapping speech sounds onto patterns of letters. According to the phonological deficit hypothesis, children with RD are hindered by faulty representation of speech sounds and this leads to difficulties of phonological awareness, alphabetic knowledge, letter-sound mapping and associated skills such as orthographic awareness (Vellutino et al., 2004). Phonological awareness, the ability to detect and manipulate the sounds of language, operates at both phoneme and syllable levels within words. Phonemic awareness (the ability to segment spoken words into phonemic elements) is a key factor in reading, for weaknesses in this are likely to result in failure to discover spelling-to-sound relationships and, consequently, the acquisition of adequate alphabetic coding skills.

Recognition of the importance of these processes grew from studies of young children that have demonstrated that phonological awareness, together with letter-sound knowledge, is one of the strongest predictors of early reading development (National Early Literacy Panel, 2008). Poor phonological awareness has consistently been found to be a feature of most RD children, although the predictive ability of phonological measures appears to be stronger for reading ability than disability (Scarborough, 1998).

While findings that phonological interventions for early readers improve subsequent reading ability (Bradley and Bryant, 1985) have strengthened claims for a causal relationship, it appears that the relationship is bidirectional (Castles and Coltheart, 2004). Thus, experience of reading will impact upon children’s phonological skills, and early experiences at home and at school are likely to play an important role (Corriveau, Goswami and Thomson, 2010).

One of the most common criticisms of all cognitive and sensory accounts of RD is that none of these can explain the problems of all children who struggle to learn to read. Not all children with RD experience a phonological deficit (Castles and Coultheart, 1996), and children with poor phonological abilities can nevertheless develop good reading skills. Phonological problems also seem to be less important in respect of other more transparent languages (Pennington, 2006), where reading fluency is often the key outcome measure. Here, rapid naming appears to be a more important predictor, although, for such languages, phonological awareness continues to be seen as key for spelling.

**Rapid naming**

While phonological awareness difficulties appear to be highly significant for many with RD, there appears to be another group for whom rapid naming is particularly problematic (Wolf, 1991). This idea arose from experimental studies that required participants to name, as quickly as possible, a series of familiar items such as letters, colours, or everyday objects placed in front of them. Performance on such tasks has been found to be problematic for both children (Wolf, Bowers and Biddle, 2000) and adults (Pennington, van Orden, Smith, Green and Haith, 1990) with RD, although it should be noted that this problem is more closely associated with reading fluency than single-word decoding (Manis, Doi and Bhadha, 2000). It is for this reason that rapid naming is seen to be particularly relevant for transparent languages, in which the major presenting problem is slow, laborious reading (Torppa, Lyytinen, Erskine, Eklund and Lyytinen, 2010).
According to the double-deficit hypothesis model (Wolf and Bowers, 1999), those with RD can be divided into three groups: those with phonological difficulties, but with average naming-speed ability, those with a rapid-naming deficit, but average phonological skills and those with both phonological and rapid-naming difficulties. This last group typically experiences the greatest difficulty in learning to read.

It is important to emphasise that, for Wolf and her colleagues, the study of rapid naming is primarily a means to help gain an understanding of underlying processes. Fluent reading, she contends, requires the ability to integrate a range of perceptual, attentional and naming mechanisms that enable the matching of visual representations to phonological codes, precisely, and at speed. Thus, problems of rapid naming do not concern a single isolated problem, but rather a number of difficulties involving several high- and low-level processes. This difficulty points to the need for intervention targeted at multiple levels of language.

While the presence of rapid-naming problems in RD is widely accepted, the double-deficit hypothesis has been criticised for being insufficiently explicit to enable experimental evaluation of the theory (Vellutino et al., 2004) and there continues to be considerable uncertainty about the cognitive processes that underpin naming speed and its relationship to reading. Debate has also concerned whether naming speed should be considered as an aspect of phonological processing, with some holding this position (Snowling and Hulme, 1994; Wagner and Torgesen, 1987) and others (Jones, Branigan, Hatzidaki, and Obregon, 2010; Wolf and Bowers, 1999; Wolf et al., 2002) arguing that these should be considered as independent processes.

**Short-term and working memory**

When one considers the various demands of the reading process it is hardly surprising that memory is often identified as a problem for those with RD. While there has been some interest in long-term memory processes (Menghini et al., 2010), most research has focused on short-term or working memory, processes that have been consistently demonstrated as poor for many with reading disabilities. Both types of memory involve holding information for brief periods of time; however, working memory involves both storage and processing.

Much earlier research focused upon verbal short-term memory and, although a relationship with RD was sometimes found (Wagner and Torgesen, 1987), other studies did not find strong effects (Savage, Lavers and Pillay, 2007). More recently, interest has shifted towards the more complex tasks that are seen as tapping working memory. Studies have now accumulated a strong body of evidence demonstrating that working memory is an important factor in RD (Alloway, Gathercole, Kirkwood and Elliott, 2009), with this and short-term memory both showing independent variance when comparisons are made with normally achieving children (Swanson and Hsieh, 2009).

As is the case for rapid naming, there is some debate as to whether short-term verbal memory should be incorporated within a broader phonological deficit model, or should instead be seen as a separate element within a broader working memory model. Studies comparing verbal and visual-spatial forms of short-term or working memory have tended to indicate that it is the former domain that is most problematic for poor readers. Such findings are unsurprising, given that RD is largely conceived of as a language-based disorder. However, research studies have provided a mixed picture, with some reporting normal visual-spatial functioning in reading-disabled individuals (Schuchardt et al., 2008) and others citing weaknesses (Menghini, Finzi, Carlesimo and Vicari, 2011). In part, this discrepancy is explained by differences in the nature of the samples, measures and methods employed. Recent meta-analyses of reading-disabled groups (e.g. Johnson et al., 2010) have, however, supported the suggestion that visual working memory is related to reading difficulty, albeit not as strongly related as verbal working memory.

It is important to note that, while memory problems are a feature of many who experience reading difficulties, there remain a significant proportion of this group who appear to have no memory-related...
problems. Others have also pointed to the less powerful predictive aspects of working memory when compared with measures of phonological processing (Savage et al., 2007). Working memory has been seen to play an important role in reading comprehension (Swanson, Howard and Sáez, 2006). However, difficulties in taking meaning from text are generally differentiated from the decoding and fluency problems that are seen to lie at the heart of RD.

Auditory and visual processes

In recent years, there has been a resurgence of interest in the role of auditory and visual processing in RD, with some evidence found of a relationship between these and reading difficulties. Estimates suggest that an auditory processing difficulty can be found in approximately one-third of reading-disabled samples (Boets et al., 2007), although the variation across studies is considerable. Several studies have also indicated a variety of visual-processing problems in those with reading disabilities, although, as is the case for auditory processing, difficulties are not found in all those with RD and it is possible that such problems co-occur, rather than play a causal role (Pennington, 2009).

A further visual explanation for reading difficulty is that of visual stress, a condition where reading can become physically discomforting, with reports of sore eyes and headaches or visual distortions and illusions (Singleton, 2009). This may render extensive examination of text unpleasant and result in a disinclination to read. The condition is variously known as visual discomfort (Conlon et al., 1999), scotopic sensitivity, or Meares-Irlen syndrome (Irlen, 1991), with claims that it may affect as many as one in five of the general population (Jeans et al., 1997). While the condition may impair reading fluency to some degree, it would not appear to explain the problems of those who present with the complex decoding difficulties of those with a RD (Wilkins, 1995).

Intervention

Despite the vast numbers of studies, across many disciplines, that have sought to examine the underlying biological and cognitive bases of RD, our understanding as to how to overcome this problem in its most severe form is still rudimentary, and there remains a small group of poor readers (sometimes known as treatment resisters) whose progress in reading and spelling is still highly problematic.

Perhaps one of the most important lessons from scientific research has been that, unlike speech, reading is not naturally acquired (Liberman, 1999) and, for those with RD, highly explicit instruction is required. Eschewing the notion that children with RD can discover letter-sound knowledge as a result of reading, Torgesen (2004: 363) stressed the importance of explicit instruction:

that does not leave anything to chance and does not make assumptions about skills and knowledge that children will acquire on their own.

Hitherto, many children with RD were ill-served by the widespread employment of the whole-language model of the teaching of reading that enjoyed fluctuating ascendancy in many English-speaking countries during the latter half of the twentieth century. This approach led to a widespread belief on the part of teachers that structured approaches involving the systematic teaching of phonics was sterile, unmotivating and ignored the importance of context in reading (Elliott and Grigorenko, in press). However, the growth of rigorous scientific investigations during the 1990s established that it was those who experienced greatest difficulties in learning to read who most needed explicit instruction in letter–sound relationships. While the systematic teaching of phonics was seen as an important component of a balanced approach for all readers (National Reading Panel (NRP), 2000), the need for heavily structured approaches may, however, be less important for young children with strong early reading skills.
In general, children with RD do not require very significantly different reading instruction from other children. All beginning readers require input on print-related concepts, phonological awareness, phonics, the development of reading fluency, vocabulary, spelling, comprehension, and writing that is weighted according to their individual needs and will maximise their interest and motivation. However, in comparison with their peers, children who struggle to acquire reading skills will typically require more individualised, more structured, more explicit, more systematic and more intense inputs.

There is now a large body of research showing the powerful benefits of interventions with young children deemed to be at risk of reading failure (Scanlon et al., 2005). The introduction in many countries of a response to intervention (RTI) model, in which children receive additional, highly structured support in small groups, or even individually, as soon as difficulties are noted, has helped to ensure that appropriate intervention is not delayed unduly. This approach is not without its critics, who argue that knowledge of RTI procedures is still rudimentary and contend that its focus upon intervention at the level of academic content can result in an unhelpful neglect of underlying cognitive processes (Reynolds and Shaywitz, 2009). In response to such critiques, proponents of RTI argue that there is little evidence that cognitive profiling can inform individualised reading interventions (Fletcher and Vaughn, 2009).

While appropriate interventions in the early years can resolve the word reading problems of most children (Torgesen, 2005), there remains a small proportion who continue to fail to make adequate progress, or who drop back when they reach the age of eight or nine, a time when reading demands increase significantly (Vellutino et al., 2008). Estimates of these ‘treatment resisters’ vary but, in the USA, these tend to be around 2–6% of the school population (Vaughn and Roberts, 2007). Unfortunately, research evidence for the effectiveness of interventions for older students identified as having a RD is weaker than that for younger children considered to be at risk (Elliott and Grigorenko, in press), and interventions with older primary school children often result in only modest gains (Wanzek and Vaughn, 2007).

In adolescence, the picture becomes even more complex, as the precise nature of students’ problems becomes more diffuse. Some students will continue to require help at the letter-sound level and others will have few problems with single-syllable words but encounter difficulties when words are multisyllabic. Some will have made significant gains in basic word decoding but continue to struggle to read fluently. These students can be greatly hindered by the consequences of years of struggle, often resulting in limited vocabulary and concept knowledge, problems with reading comprehension and reduced motivation (Biancarosa and Snow, 2006). Attempts to help those with the greatest difficulties to read with greater accuracy and fluency have largely proved to be disappointing (Scammacca et al., 2007) and, beyond calling for more intense and individualised approaches, it appears that researchers continue to struggle to find effective forms of interventions.

Looking to the future

Despite the significant gains made in genetics, neuroscience, cognitive science and education, reading-related problems continue to present a major barrier to learning and blight the lives of a significant number of people. Notwithstanding our best efforts, we continue to struggle to find interventions that can fully overcome the problems of those with the most severe forms of RD. It is to be hoped that advances in each of these disciplines, together with the deployment of increasingly sophisticated forms of assistive technology that enable electronic reading of text and input via speech recognition software, will help those who struggle with reading to fulfil their learning potential and ultimately lead more enriched and fulfilled lives.

References


