



Reading disorders

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Abstract

There are two major types of reading disorder; developmental dyslexia and reading comprehension impairment. The primary difficulty in dyslexia is with the accurate and fluent reading of single words, whilst in reading comprehension impairment words can be read accurately but there is no or little understanding of what is read. Using the causal modelling framework, the underlying causes of the two disorders are reviewed together with the co-occurrence of reading and language disorders. The rationale for viewing reading as a dimensional disorder, where the difficulties experienced are on a continuum rather than using cut-off points to identify disorders is also reviewed.

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Introduction

Reading involves mapping the written symbols (i.e. letters or characters) on a page to their corresponding sounds in a given language in order to form words and to attach meaning to those individual words. Reading extended text also includes understanding the wider meaning of the text of which the individual words are part. The process of reading is complex, involving a number of cognitive and linguistic processes: the decoding and recognition of letters and words; retrieving the meaning of these words; understanding the syntactic structure of what is read; linking the meaning of sentences to each other whilst remembering and monitoring what is being read and integrating this with existing knowledge. Successful acquisition and mastery of these skills and the ease with which children learn to read can be affected by environmental factors such as the orthography of a language, the way in which reading is taught, the home environment, motivation to read and a family risk of language or literacy difficulties. Learning to read does take time but most children learning to read in an opaque orthography like English will have acquired reading skills by the age of ten. However, for a small number of children learning to read is difficult and these difficulties with reading can manifest themselves in different ways and with differing rates of severity. Furthermore, for some of these children their difficulties with reading continue into adulthood and can seriously affect their future academic and vocational prospects.

The majority of research investigating reading disorders has been carried out in languages such as English which use an alphabetic script. Difficulties with reading acquisition were first recognised in the late nineteenth century. The most notable case was that of a case study of a fourteen-year-old boy who had difficulties in reading and spelling words (Pringle-Morgan, 1896). Pringle-Morton used the term “congenital word-blindness” to describe these difficulties. However, subsequent research (see Vellutino, 1979) proposed that the difficulties encountered in children learning to read were not visual (i.e. a type of word-blindness) but instead were characterised by an underlying difficulty in language, primarily in phonological processing.

Phonological processing refers to the ability to use the sounds of a language to understand the letters used in written language. It includes the ability to identify and manipulate the individual sounds (phonemes), as well as larger phonological segments such as syllables and sub-syllabic units (for example, the onset and rime) within words. The ability to do this requires the use of memory to retrieve the pronunciation and meaning of the phonological units and this needs to be done quickly and efficiently. Thus, three key skills have been found to be associated with reading at the single word level: firstly, alphabetic or letter knowledge (i.e. the ability to map sounds to letters) and the ability to identify and manipulate phonological segments (i.e. phonological awareness), secondly the ability to retrieve these units (i.e. from memory) and thirdly, to do so quickly and efficiently.

However, reading involves more than just the decoding and recognition of words and the Simple View of Reading (SVoR) framework (Gough & Tunmer, 1986) identified two key skills required for successful comprehension of written text; firstly the decoding and recognition of words and, secondly, language comprehension skills. Whilst the relative contribution of each varies in different stages of reading acquisition both skills are essential. The SVoR model predicts four different profiles for reading; skilled readers who are able to read words accurately and understand what they are reading; and three different profiles of reading disorders where the reader has difficulties in one or both of these key skills. Firstly, those readers who have poor decoding and word recognition skills but good comprehension

skills (developmental dyslexia), secondly, those with the opposite profile: good decoding and word recognition skills but poor comprehension (reading comprehension impairment) and lastly generally poor readers who have difficulty in both word reading and comprehension.

Characteristics of reading disorders

The difficulties with reading first described by Pringle-Morton (1896) are similar to the developmental dyslexic reading profile identified in the SVoR. There have been many attempts over the years to define the difficulties with reading that are characteristic of those with the poor decoding or word recognition skills identified in the SVoR. This has resulted in definitions of dyslexia changing over the years. However, it is now widely accepted that the core difficulty in dyslexia is with the accurate and fluent decoding of words and that this difficulty can also extend, not surprisingly to spelling. Indeed, in some cases where interventions have been successful in teaching strategies for decoding, it is often difficulties with reading fluency and spelling that persist and continue to cause difficulty in adulthood. The characteristic difficulties seen in dyslexia are slow, laboured and inaccurate reading. This is principally for single words and whilst reading extended text may be slow and lack fluency, understanding can often be achieved by using context and meaning. Reading unfamiliar words that have a regular letter to sound mapping will be particularly difficult as this requires the use of decoding skills. In addition to spelling mistakes, slow and laboured writing are often found in dyslexia. There are also some other difficulties that are characteristic of dyslexia and these are evident in tasks that involve phonological processing skills: phonological awareness, verbal short-term memory and naming or verbal processing.

Phonological awareness is the ability to identify and manipulate the phonological units that make up words i.e. syllables, sub-syllabic units and individual phonemes (sounds). It includes, for example, the ability to identify the sounds and syllables within words, identify words that rhyme with each other and identify and delete the initial and final sounds from words. Difficulties with verbal short-term memory can be seen in tasks where there is a need to retain and repeat information, for example sequences of digits that increase in length and repeating sequences of words or nonwords that increase in number and/or syllable complexity. Difficulties can also be found in naming tasks which require the ability to quickly name pictures of letters, digits, colours and objects. These are known as Rapid Automated Naming (RAN) tasks and require several cognitive skills (for example, retrieval of phonological codes, speed of processing and executive function). The type and number of difficulties experienced in dyslexia and their severity does vary but there is general agreement that the difficulties with reading in dyslexia appear to be caused by an underlying difficulty in phonological processing.

The difficulties found in individuals with reading comprehension impairments are very different to those seen in dyslexia. Phonological processing skills are generally good which results in fewer difficulties in the accurate and fluent reading of words. However, successful understanding of what we read is a complex skill that goes beyond accurate and fluent word decoding and recognition. We need to understand the individual words and generate meanings for sentences and make links between these sentences in order to build a coherent representation of their combined meaning. Reading text may also require inferencing skills and the retrieval and integration of existing knowledge to allow the reader to go beyond the literal meaning of what is read. This may also require executive control

processes to monitor ongoing comprehension as a text is being read to identify when and where it may be necessary to re-read part of the text. There may also be a need to inhibit or suppress information in the text that may be irrelevant or more peripheral to understanding.

In contrast to dyslexia, children with a reading comprehension impairment do not have difficulties with phonological processing but instead can have a range of difficulties with language and meta-cognitive skills. Difficulties with language include poor vocabulary and semantic knowledge; poor knowledge of grammar and in particular morphology and syntax; difficulties with spoken language and the ability to understand and produce spoken narratives and discourse. Difficulties with meta-cognitive strategies have also been found. For example, difficulty in making links between sentences (i.e. local and global cohesion); using inferencing skills to allow the integration of existing knowledge with what they are reading; understanding the structure of what is read and plot and story conventions in fictional writing and lastly being able to monitor and comprehend what they are reading. In addition to underlying language weaknesses a number of other skills have also been found to be affected, such as working memory and the executive control processes which are required for text monitoring. Unlike dyslexia, where the primary cause of the reading problems is a difficulty with phonological processing, it is not possible to identify one primary cause for reading comprehension impairments and the specific difficulties experienced are likely to vary in both their nature and severity. It is therefore likely that a number of factors interact to cause the particular difficulties with reading that are found in reading comprehension impairments.

Diagnosing reading disorders

Identification of the type of reading difficulties experienced is important for children to receive appropriate support and targeted interventions and a diagnosis of the particular type of reading disorder they are experiencing will be required. A reading disorder will be diagnosed where there is a failure to acquire reading skills despite having had adequate opportunity to do so. Reading skills will also be substantially and quantifiably below those expected for the individual's age and cause difficulties in academic, occupational, or everyday activities. Furthermore, the reading difficulties experienced cannot be explained by a general medical condition or cognitive impairment. In the latest edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013) "reading disorder" is no longer a separate category, and instead included under an umbrella term: "Specific Learning Disorder" along with difficulties with maths and written expression. DSM-5 does however recognise the following reading and spelling difficulties:

- Inaccurate or slow and effortful reading;
- Inadequate understanding the meaning of what is read;
- Poor spelling.

In addition, DSM-5 also notes that "the word 'dyslexia' is an alternative term that can be used to refer to a pattern of learning difficulties characterised by problems with accurate or fluent word recognition, poor decoding and poor spelling abilities" (DSM-5, 2013, p67). The publication of DSM-5 saw two key changes with respect to reading disorders. Firstly, the recognition of the different types of reading difficulties that can arise, separating out decoding and word recognition from comprehension. Secondly, there was a move away from the previous problematic discrepancy definition used to diagnose dyslexia whereby the

level of reading skill had to be below what would be expected given the individual's intelligence and age.

Estimates of the prevalence of children with reading disorders vary according to the definition adopted, the cut-off points, the assessment tasks and whether the data originated from clinical or subclinical and large population samples. For dyslexia, estimates range from between 3–6% for dyslexia with more boys than girls affected (Hulme & Snowling, 2009), whilst estimates of prevalence for reading comprehension difficulties appear to be higher at around 7–10% (Clarke, Snowling, Truelove, & Hulme, 2010; Nation, Cocksey, Taylor, & Bishop, 2010).

The underlying causes of reading disorders

The improved clarity in the definitions of reading disorders is helpful for accurate diagnosis. However, understanding the causal origins of the observed difficulties is important for the design and delivery of appropriate interventions and the design and use of appropriate assessment tools for identification of both those with reading difficulties and those who may be at risk of developing reading difficulties. Morton and Frith's (1995) causal model has provided a useful framework for understanding reading disorders by considering three levels of description which are necessary to explain disorders: biological, cognitive and behavioural. In causal models a distinction is made between the observed behaviours (for example, the difficulties experienced with decoding and performance on phonological processing and language tasks) found in reading disorders and the underlying cognitive processes and biological and genetic factors that are involved. They also look at the interaction of environmental factors with each of the three levels (biological, cognitive and behavioural). Causal models can, therefore, provide a framework for understanding and evaluating the multiple factors that can interact and cause the reading disorders observed in children, the severity of these difficulties and how they can co-occur with other developmental disorders in language, attention and motor control.

Dyslexia

The causal modelling framework has been used successfully in dyslexia to inform understanding of the underlying causes (see Hulme & Snowling, 2009; Frith 1999). Starting with the biological level, there is evidence to support dyslexia as having a genetic origin and that it is hereditary. However, in common with other neurodevelopmental disorders, no one gene has been identified for dyslexia, although several candidate genes have been identified as affecting the development of some of the language systems in the left hemisphere (see Peterson & Pennington, 2012 for review). Further support for the role that genetic factors may play in an explanation of dyslexia is provided by results from studies of twins sharing the same environment (for example, the Colorado Twin Study, DeFries, Fulker, & LaBuda 1987) where dyslexia was found to be higher in monozygotic (identical) twins than in dizygotic (fraternal) twins. In addition to twin studies, the heritability of dyslexia has also been studied in longitudinal studies that follow the development of children who have a family history of dyslexia, with one or both parents having dyslexia. Snowling and Melby-Lervag's (2016) meta-analysis of 21 samples from 95 studies found that the mean prevalence of dyslexia in children with a family risk of dyslexia was 45%.

Within causal models, environmental factors play an important role at each level and interact with genes and cognitive skills which can lead to difficulties in acquiring the skills involved in learning to read. One important environmental factor is that of the home

literacy environment and children in families where one or both of their parents have literacy difficulties may have less opportunities to learn to read in terms of the availability of books at home, parental encouragement of reading as an activity, the availability of shared reading opportunities and help with school reading assignments. Furthermore, children who are struggling with reading are also less likely to be motivated to seek out opportunities for reading than good readers, even if books are available and reading encouraged in the home environment. Socio-economic factors have also been found to have an impact with dyslexia being more prevalent in disadvantaged groups.

At the cognitive level of explanation, the dominant theory of dyslexia is that the difficulties seen at the behavioural level with reading and with phonological processing tasks are caused by a phonological deficit in the way speech sounds are represented, manipulated and retrieved. This is known as the Phonological Representations theory (Snowling, 2000). A phonological deficit is recognised as being a central difficulty in dyslexia but alternative theories have been proposed based on auditory deficits (Tallal, 1980) or sensorimotor deficits in vision and motor domains (for example, Stein's (2001) magnocellular theory). These theories have proposed that the phonological deficit is secondary to auditory processing, visual processing and/or the motor control deficits that are sometimes found in individuals with dyslexia. However, whilst some difficulties such as visual stress may disrupt reading acquisition, sensory and motor deficits are not able to explain the underlying cause of dyslexia although they may co-occur with phonological deficits in individuals with dyslexia. (For a review of alternative theories using a causal modelling framework see Ramus, 2003)

Although the difficulties seen in dyslexia are varied, there is general agreement that most children with dyslexia have some form of phonological deficit and that this is the cause of their reading difficulties. Support for this comes from a number of longitudinal studies with both typically developing children and children with dyslexia. For example, phonological skills were found to predict later reading ability in typically developing children (Muter, Hulme, Snowling, & Stevenson, 2004). Further support for a causal role between poor phonological skills and dyslexia comes from studies that have found children with dyslexia to have poorer phonological skills than both chronologically age matched typically developing children and younger reading aged matched children. These longitudinal studies show that not only do phonological skills at pre-school predict later reading ability but that the deficits in phonological processing skills were present before the children started to read. The success of interventions for dyslexia, following the pioneering work by Bradley and Bryant (1983) and Hatcher, Hulme, and Ellis (1994), that target decoding skills, by combining phonological awareness with letter-sound knowledge and reinforcing them with reading practice also provide support for the causal role of phonological processing in successful decoding.

However, the precise nature of the phonological deficit is still under investigation. The phonological skills that are essential in word reading vary in terms of the complexity of processing required and a distinction can be made between those that are implicit, where phonological processing is automatic and those that are explicit, where phonological units need to be identified and manipulated. Measures of explicit phonological processing skills are those tasks that involve access to phonological representations and involve phonological awareness at the phoneme, syllabic and sub-syllabic levels. These include syllable and phoneme detection tasks, phoneme identification and isolation tasks, rhyming tasks and elision. These explicit phonological processing skills are more directly involved in decoding

in word reading. However, accessing phonological representations is involved in other tasks that do not directly influence word reading but for which children with dyslexia are also found to perform poorly on. These implicit phonological processing skills require access to phonological codes and involve verbal recall but do not require the manipulation of phonological units such as letters, syllables and words. These tasks include RAN tasks, phonological short term memory tasks such as forward digit or word span tasks and tasks that require the repetition of nonwords. These processes involve phonological representations but do not directly influence word reading in the same ways as phonological awareness. This has led to the suggestion that the observed difficulties in phonological tasks seen in dyslexia are due to difficulties in the phonological skills required to access phonological representations (Ramus & Szenkovits, 2008; Ramus, Marshall, Rosen, & van der Lely, 2009).

The ease with which children learn to read can depend on another environmental factor, the orthographic depth of their native language. In English there is an inconsistent and irregular mapping between letters and sound and in typically developing children learning to read takes longer than in languages where a more consistent mapping between letter and sound is found. (Seymour, Aro, & Erskine, 2003). However, in terms of the predictors of decoding skills, cross-linguistic studies of reading in alphabetic languages have found the predictors to be consistent, despite the transparency of the orthography; namely letter knowledge, phoneme awareness, and RAN (Ziegler et al., 2010; Caravolas et al., 2012).

Reading Comprehension Impairment

In children with reading comprehension impairments, the reading difficulties experienced show the opposite pattern to dyslexia, with relatively good decoding and word recognition skills but difficulties with the non-phonological aspects of language. Although less researched, the role of genetics at the biological level has been studied and similar heritability estimates to dyslexia have been noted (Keenan, Betjemann, Wadsworth, DeFries, & Olson, 2006). However, the observed difficulties at the behavioural level make it unlikely that there is a single cause of reading comprehension difficulties. Typically, difficulties in vocabulary, morpho-syntax, and receptive and expressive language skills are found but with relatively good performance reported on tasks tapping phonological processing and phonological awareness (Nation, Clarke, Marshall, & Durand, 2004). However, other studies have found evidence that difficulties extend beyond the literal interpretation of the text to higher levels of processing and meta-cognitive strategies such as making inferences and monitoring comprehension (Cain, 2010).

In typical language acquisition Muter et al. (2004) found that vocabulary knowledge and grammatical skills were predictors of later reading comprehension difficulties and there is evidence from longitudinal studies with children with reading comprehension impairments that their difficulties with comprehension may originate in semantic, grammatical and lexical processes outside of phonology. For example, Catts, Adolf, and Weismer (2006) found that 14-year old children with a reading comprehension impairment also had deficits in language (receptive vocabulary, grammatical understanding and discourse skills) but had typical phonological processing abilities. They also found these language difficulties were present at previous testing points when the children were much younger, with about one third meeting the diagnostic criteria for a language impairment in kindergarten. Another longitudinal study by Nation et al. (2010) of children aged 5-to 8-years found similar results with 8-year old children identified as having reading

comprehension impairments also having had difficulties with non-phonological aspects of oral language at 5-years of age. These studies support the view that the oral language weaknesses found in children with reading comprehension impairment in mid-childhood are not a simple consequence of their reading difficulties.

Two main hypotheses have been proposed to explain the causes of reading comprehension impairments. The first proposes that the difficulties are caused by oral language difficulties (Nation, 2005). The alternative hypothesis is that the difficulties are caused by deficits in meta-cognitive skills such as inferencing skills, comprehension monitoring and with executive processes such as working memory and inhibition (see Cain, 2010). Clarke et al. (2010) tested these two alternative hypotheses in an intervention study for 8- to 9-year old children identified as having a relative weakness in reading comprehension compared to reading accuracy. Three interventions were included. The first, oral language training involved no reading or writing and targeted oral language skills (i.e. vocabulary, listening comprehension, figurative language, and spoken narrative). The second was text comprehension training and involved meta-cognitive strategies (i.e. reading comprehension, inferencing from text and written narrative) and the third intervention consisted of a combined oral language and text comprehension training. The study also included a fourth waiting control group. Whilst all three groups showed improvements post training, at the follow up 11 months later only the oral language training group showed significant improvements over the other two groups and the untreated group and this appeared to be driven by an increase in vocabulary knowledge. Clarke et al.'s (2010) study provides support for the proposal that the language weaknesses that characterise poor comprehension play a central role in the difficulties reported and can be ameliorated by suitable teaching interventions.

The role of language in reading disorders

Language skills are important in reading and in individuals with reading disorders co-occurring difficulties with language are frequently found. This is perhaps not a surprising, since reading builds on spoken language processing and children with spoken language difficulties may also be at risk for reading disorders. In dyslexia the primary cause of the difficulties is in phonological processing skills, a difficulty which is also found in some children with Developmental Language Disorder (DLD). In reading comprehension impairment, oral language weakness is emerging as a risk factor, particularly in vocabulary, semantic, morphological and syntactic knowledge, which are often areas of difficulty in children with DLD. Studies investigating the co-occurrence of reading and language disorders have found considerable overlap (McArthur, Hogben, Edwards, Heath, & Mengler, 2000; Catts, Adolf, Hogan & Weismer, 2005). For example, McArthur et al. (2000) found that 55% children diagnosed with a reading disorder also met the criteria for language impairment and furthermore that 51% of the children diagnosed with a language impairment could also be diagnosed as having difficulties in reading at the word level. In studies of children with reading comprehension impairments, many of the children have also been found to meet the criteria for DLD (Catts et al., 2006; Nation et al., 2004). There are clearly similarities between children with dyslexia and children with DLD who have phonological difficulties and also between children with reading impairments and children with DLD who do not have phonological difficulties. This co-occurrence of literacy and language disorders and the overlap in some of the difficulties experienced, has led to a debate as to whether dyslexia, DLD and reading comprehension impairment are separate

and distinct disorders. This has resulted in different models being proposed to explain the relationship between the disorders (Bishop & Snowling, 2004; Catts et al., 2005) with Bishop and Snowling's (2004) review concluding that these disorders are different but overlapping. The phonological deficits seen in DLD cannot be responsible for all of the language difficulties found in DLD, particularly those found in syntax. Indeed, not all children with DLD do have difficulties with phonology and where children with DLD do have difficulties with phonology, their difficulties have been found to be different to children with Dyslexia (see Ramus et al., 2013).

Further evidence for the role that language difficulties play in reading acquisition can be seen in the results of longitudinal studies that have followed children with and without early language delays. For example, Catts, Fey, Tomblin and Zhang (2002) found that the presence of a language impairment in kindergarten was a risk factor for later reading difficulties in second and fourth grade and that those children with language impairment performed poorly on not just decoding but also in reading comprehension. Longitudinal studies have found that in addition to early language difficulties, the presence of a family risk for language or literacy difficulties is also an important predictor of reading ability (see for example the Jyväskylä longitudinal study of dyslexia in Finland: Lyytinen, Eklund, & Lyytinen, 2005). The conclusions drawn from Snowling and Melby-Lervåg's (2016) meta-analysis of longitudinal studies following the development of children from families at risk of dyslexia were that early language difficulties are a risk factor for reading disorders and that a phonological processing deficit is still the main cause of reading difficulties but that it is not sufficient on its own to cause dyslexia. Therefore, early language difficulties affecting vocabulary and morpho-syntax as well as phonology, appear to increase the likelihood of later diagnoses of dyslexia. Whilst fewer in number, longitudinal studies have found a similar pattern in reading comprehension impairment. For example, Duff, Reen, Plunkett, and Nation's (2015) intervention study with 300 British children found that 2-year old children with delayed vocabularies and a family history of language/literacy difficulties have a higher risk of developing later reading difficulties, both in reading accuracy and in reading comprehension.

Reading as a dimensional disorder

The above studies suggest that there are shared risk factors between reading disorders (i.e. dyslexia and reading comprehension impairment) and language disorders (i.e. DLD) and that there is some overlap between the type of difficulties and the severity of these difficulties. Bishop and Snowling (2004) proposed that rather than viewing reading disorders as distinct categories and using cut-off points to identify difficulties, a dimensional approach should be taken. In adopting a dimensional approach, reading disorders are viewed as being on a continuum that has a phonological dimension and a broader oral language dimension. The difficulties experienced on this continuum can range from severe to mild and the extent to which co-occurring difficulties are present can also be assessed. Thus, a difficulty with phonological processing places a child at risk of dyslexia, whereas wider oral language difficulties place a child at risk of reading comprehension impairment. This approach recognises that different risk factors can interact and at different stages and that different risk factors can both protect or increase the possibility of a reading disorder developing. This approach can also allow for subclinical populations in the classroom to be identified and appropriate and targeted interventions be provided for all children

experiencing difficulties in learning to read and also those at risk of developing language and literacy difficulties.

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