Cambridgeshire County Council

CAMBRIDGESHIRE DYSLEXIA GUIDANCE

Research Basis

"No matter where they live or what their background, every single child in this country deserves the opportunity to read, to read widely, and to read well - it's a simple matter of social justice."

Child Literacy Campaign 2015

Introduction and Rationale

Scope of this document

The aim of this document is to provide a transparent rationale and basis for the Cambridgeshire Dyslexia Offer by sharing the evidence-basis which underpins key positions and decisions. Evidence presented draws from academic research to practice research in education, psychology and educational psychology. It is hoped that, in addition, this document may prove useful to a range of stakeholders in developing as clear (as far as that is possible within this field) and as comprehensive as possible an understanding of current key issues and factors relating to dyslexia and, crucially, how to go about addressing the needs of dyslexic individuals who they support. A complete meta-analysis of the research related to all aspects of dyslexia is not possible within the scope of this review (arguably within any single review given the vastness of the field). Nonetheless, as far as possible, the evidence from research presented reflects peer-reviewed publications that are either as recent as possible or which reflect relatively recent meta-analyses and seminal papers (which may be older). The contents of this Research Basis are reflected within Cambridgeshire SEND Service 0-25's three Tier Dyslexia Training Programme for schools.

Living with dyslexia

Human experience

A discussion around dyslexia is ultimately a discussion about people. The potential social and emotional impacts of reading failure have long been recognised, and are often referred to briefly in published reports on dyslexia (although less so by academic researchers) (e.g. Rose, 2009; Goswami, 2008; Reason, 2001; Snowling, 2008). However, there has as yet been relatively little systematic research into the personal experiences of dyslexic individuals (see Glazzard, 2012; Humphrey, 2002).

Pollack (2005), Riddick (2010) and Edwards (1996) have carried out extensive interviews with dyslexic individuals, adults and children, as well as their families. Pollack (2008) found that many dyslexic students in higher education reported thinking that many of the significant adults in their lives (parents and teachers) considered them to be incompetent and unintelligent. Their respective findings have repeatedly revealed dyslexic individuals' feelings of distress and low self-esteem. Humphreys and Mullen (2002) also found that dyslexic individuals tended to attribute success to external (rather than internal) factors, which left them prone to a sense of 'learned helplessness'.

Riddick (1996; 2010) notes the risk of children and young people with reading difficulties developing behavioural difficulties, either as a response to the frustration or to distract others from their reading difficulties. She further states that, *"it is important that the behavioural difficulties are not seen as the primary cause of the reading difficulties, although by now they may also be a strong contributory factor"* (Riddick, 1996, p.48). Chiappe (2013) provides an overview of the experiences of dyslexic individuals in further education (FE) and concludes that many of the barriers faced represent a lack of flexibility within systems in FE as well as the limited awareness of and understanding around dyslexia of many staff working in FE.

More recently, Cameron (2016) and Cameron & Billington (2015a) have explored the impact of ambiguity and variation in what is meant by dyslexia on the personal experiences of young adults who are identified as dyslexic, and have concluded that understanding personal experience of dyslexia is as important as understanding its cognitive and instructional bases and implications.

The cost of dyslexia

In 1952, Kellmer-Pringle wrote of dyslexic children that:

"...their under functioning means a loss of efficiency and a waste of ability now and in the future which the country can ill-afford. More important still, the children themselves suffer and if offered no help become sooner or later emotional problems.

The fact that the great majority of juvenile delinquents are educationally retarded[1] *shows how failure to derive emotional satisfaction at school may well be an important factor in directing children's energies into anti-social channels."*

- Kellmer-Pringle, 1952, cited in Newton and Thomson, 1975, p.3

Over 65 years later, there remains an overwhelming indication that there is a significant cost of dyslexia on life chances and outcomes, in particular in relation to unemployment, poverty, self-esteem and offending behaviour (Bennett, 2008; Gyòrfi & Smythe, 2010). Students entering secondary education with very low literacy skills are, according to Gross (2008), five times more likely to be excluded from school than their peers with age-expected levels, and are reported to be four times as likely to truant. According to Bennett (2008), it costs £9,900 per year to provide provision for a child who had been excluded from school and he also reports that 20% of UK prisoners are dyslexic. Bennett further suggests that if all dyslexic children received early identification and effective support, the Crown Prosecution Service would stand to save in excess of £300 million per year[2]. The World Literacy Foundation (2015) estimated that the overall cost of illiteracy to the UK economy is around £82.5 billion each year through economic losses (loss of personal and business earnings) and on social costs to taxpayers (benefits for unemployment associated with illiteracy, prison costs and the impact of health costs including not being able to access and understand health and medicine-related information). As such, dyslexia left unaddressed and unsupported presents an unequivocal risk factor which carries with it significant human and financial cost.

Misperceptions

Understanding, awareness and theory around dyslexia have undergone multiple paradigm shifts since its early inceptions (Hinshelwood, 1917; Orton, 1937; Pringle-Morgan, 1896). The evolving nature of theory and related operationalisation as a

[1] Some of the word choices presented in this quote may appear insensitive. However, it may be worth bearing in mind that this terminology may not have had elicited the same emotional responses when it was written over fifty years ago.

[2]It is worth noting that risk-taking and offending behaviour are not solely accounted for by dyslexia and that there are many other related factors (e.g. Guttmannova, Szanyi & Cali, 2008; Hecht, Inderbitzen & Bukowski, 1998; Laukkanen, Shemmeika, Notkala, Kaivumaa-Honkanen & Nissinen, 2002; Kraatz-Kelly, Bates, Dodge & Petit, 2000).

function of developments in research and understanding is perhaps an inevitable feature of any phenomenon under investigation; educational, social, medical, psychological, or otherwise. This certainly appears to be of particular relevance to the topic of dyslexia which appears to be at present emerging from a paradigm and cultural shift in theory and understanding (e.g. McGeowan, 2015). This has, perhaps inevitably, resulted in a great deal of dissonance among a range of stakeholders (e.g. parents, children and young people, lobby groups, specialist educators, teachers, educational psychologists, politicians) who perceive that their understanding, knowledge and skills around dyslexia are being undermined and challenged (e.g. British Dyslexia Association, 2015). By consequence, a number of perceptions have been shared about the intention and wider implications of this shift in theory and understanding, which have led to anxiety and anger.

For example, Julian Elliott (Elliott, 2005; Elliott and Grigorenko, 2014)'s suggestion that 'dyslexia' in itself is not a useful term because it does not refer to a tangible, concrete or shared understanding of a child's reading needs and cannot, in itself impact on effective intervention, has been repeatedly met with the response that such a position dismisses the needs of and impact of individuals with reading difficulties (specifically those with a formal identification of dyslexia). This may most usefully be considered to be a straw man argument[3] on the basis that Elliott's argument refers to the utility and reliability of a construct and terminology, and does not dispute the real and potential distressing impact of significant reading impairment on children's, young people's and adults' lives (Knight, Day and Patten-Terry, 2009). Much of the discussion is around how to ensure that literacy needs can be best understood and addressed for struggling readers (see Elliott, 2015). Similarly, Brooks (2015) shares feedback that recent changes in understanding and policy around dyslexia are perceived by some to reflect a covert intention to remove resources for those with a formal identification of dyslexia. This, assures Brooks (2015) is not the case, not least because a formal identification of dyslexia does not in itself ensure access to additional resources as it is, and also because in fact the

[3] A straw man argument refers to a situation whereby rather than dismissing a point, argument or position, the opponent actually refutes an argument that was not put forward in the first place.

opposite premise is the case, that all struggling readers require access to the support necessary to address their needs.

Indeed, there is a nascent but growing body of agreement that the term, 'dyslexia' is, of itself amorphous and unhelpful on the grounds that it is so difficult to tightly define (e.g. Barden, 2017; Elliott & Grigorenko, 2014; Reason & Stothard, 2013; Snowling, 2015; Van Daal, 2015). There also appear to be almost as many definitions and understandings of dyslexia as there are stakeholders (Gyòrfi & Smythe, 2010; Reid, 2016). Nonetheless, Snowling (2015) argues that it is better to have a vague and imprecise label and understanding for reading impairment than none at all in order to ensure that children can be supported as best as possible (see also Bishop, 2014 in relation to language disorders). In addition, there is evidence that recourse to the label of 'dyslexia' is valuable for many individuals who are struggling readers (e.g. BDA, 2015; Glazzard, 2010; Snowling, 2015) although there are documented positives and drawbacks to a 'label' (e.g. Elliott & Gibbs, 2008; Elliott & Grigorenko, 2014; Lauchlan & Boyle, 2007).

Pool (2003) provides a succinct response to such theoretical and ideological arguments, suggesting that, *"We urgently need to separate what is an interesting debate for researchers from what is likely to help children with learning difficulties"* (p. 168). It is not in the remit, scope, interest or authority of this document to discontinue the use of the terminology of dyslexia, and regardless , Reason and Stothard (2013) note that whatever the views of current research and theory, terminology around 'dyslexia' is in the public domain. As such, the term 'dyslexia' is referred to throughout this document and the related Guidance Document and, based on the consensus of research and theory in the field as discussed in due course, is used interchangeably with reading and spelling difficulties at the word level difficulties and literacy difficulties at the word level (e.g. National Institute of Child Health and Development, 2007; Pennington & Bishop, 2009; Siegel and Mazabel, 2013; Swanson & Hsieh, 2009). This, in no way, dismisses or undermines the significant difficulties faced by struggling readers who have a formal identification of dyslexia. Indeed, the current guidance will also refer to literacy difficulties that may not solely be at a word level. This is because it aims to support the literacy needs of all struggling readers in Cambridgeshire including those whose difficulties are at the

word level (i.e. those who can be described as dyslexic), as well as those whose needs may reflect difficulties with comprehension or writing but whose word reading and spelling may be accurate and fluent (i.e. those who would not be described as dyslexic according to the Rose definition of Dyslexia but whose needs nonetheless need to be recognised, understood and addressed).

Reading

Reading is not an evolutionary skill with dedicated neural architecture like speaking or walking (e.g. Nicolson, 2005). Rather it is a complex social and cultural activity which draws on existing neural and cognitive architecture (e.g. Bjorklund & Blasi, 2011; Pennington & Olson, 2011; Pollack, Luk & Christodoulou, 2015). The Oxford English Dictionary (2nd Ed.) holds full entries for 171,576 words, each of which are composed of different combinations of the 26 letters of the English alphabet. Upon encountering a piece of text a reader is potentially faced with a vast arena of words composed from the many different possible combinations of letters, yet adult readers are able to identify a familiar word somewhere in the order of 400 – 600milliseconds (e.g. Rayner, Pollatsek & Schotter, 2012). Readers can narrow down the possible words in a text to some extent by using cues such as word frequency and context. Nonetheless, the automaticity of skilled reading is an astounding feat, described by Mason (1975) as “perhaps the most complex and intriguing skill that has evolved in the history of the human race,” (Mason, 1975, p147). Altman (1997) identifies the written word as one of the greatest achievements of humankind alongside the discovery of fire and the invention of the wheel, claiming that without the written word, we may still be in the dark ages because science relies on too much information to have been passed down through word of mouth alone.

Models of reading

Aside from an opportunity to celebrate the enormity and complexity of the achievement of learning to read, consideration of models of skilled reading serve to remind us that reading and learning to read are extremely complex processes which we should perhaps be wary not to oversimplify when considering points at which the process may go awry for those who struggle to learn to read. Indeed, it may be argued that part of the difficulty discussed below about agreeing a definition of

dyslexia that accounts for the needs of all dyslexic individuals is that it is likely that there are multiple points at which individual differences in the reading process may occur, resulting in difficulties with reading (and by extension, spelling) (e.g. Coltheart, 1996; Howard & Best, 1996).

The Simple View of Reading (Gough & Tumner, 1986)

The Simple View of Reading (Gough and Tumner, 1986) provides a neat framework within which to conceptualise the process of reading and the place of dyslexia within it.

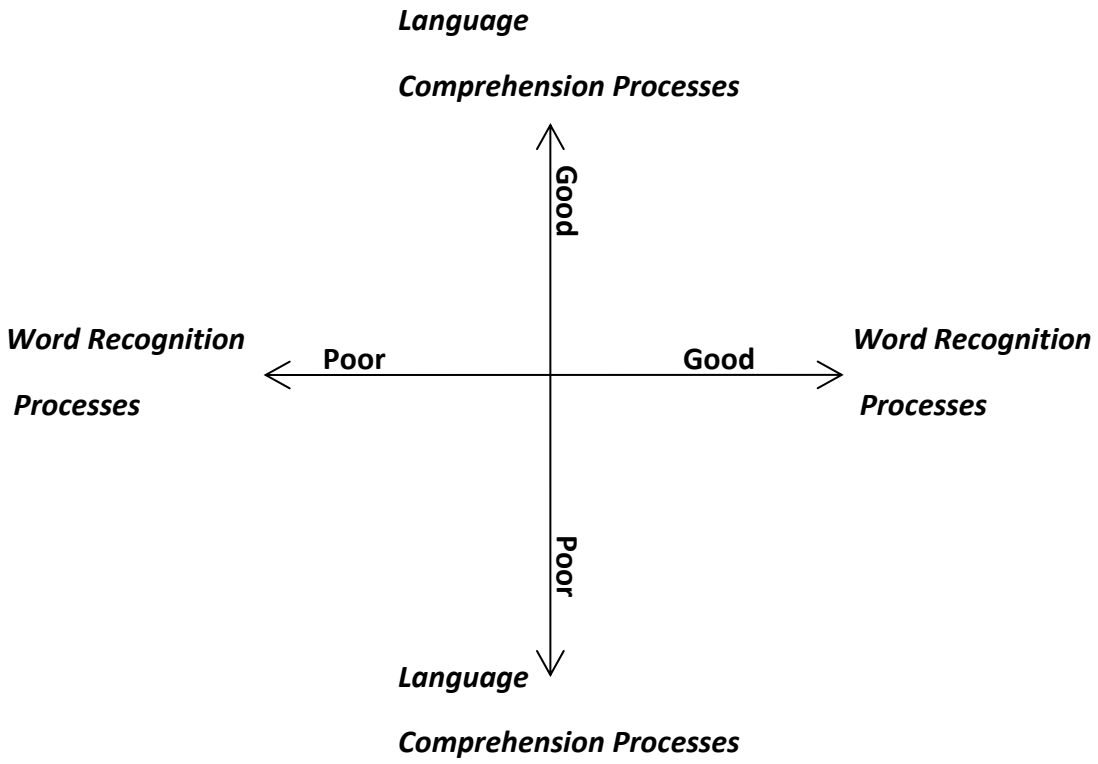

Figure 1. The Simple View of Reading (Gough &Tumner, 1986).

The simple view of reading apportions reading into word recognition processes (decoding words; ascertaining word identity) and language comprehension processes (i.e. lexical understanding; processes by which given word identification, sentences and discussions can be interpreted). Gough and Tumner (1986) propose that word recognition is necessary, but not sufficient for successful reading to take place

because being able to pronounce a word does not guarantee understanding of a text. Conversely, language comprehension is a necessary, but not sufficient condition for successful reading, as being able to identify what words are must precede being able to understand the meaning of a text.

The Simple View of Reading is presented in Figure 1. as a continuum within which word recognition processes may be good or poor, as may language comprehension processes. This may provide a useful framework within which to consider dyslexia, which is by definition a difficulty with word recognition. A dyslexic individual may therefore be expected to have poor word recognition skills, and on account of not being able to decode words successfully may appear to have poor language comprehension skills despite having unimpaired oral language comprehension skills. Conversely, an individual may have excellent word recognition skills, but poor language comprehension skills; they can identify what the words in a sentence are, but they are unable to extract meaning from what they have read.

Although there is good evidence that the 'Simple View' model is able to account for a great deal of the variation in early reading skills (e.g. Lervåg, Hulme & Melby-Lervåg , 2017), the 'Simple View' model is not able to provide a more detailed overview of the more specific mechanics involved in the process of reading. Within cognitive psychology, there exist a number of computational models of reading relating to various aspects of the overall reading process including:

- Identification of individual words (e.g. Coltheart, Coltheart, Rastle, Perry, Langdon & Ziegler, 2001; Seidenberg & McClelland, 1981; Plaut, McClelland, Seidenberg, and Patterson, 1996)
- Encoding of letter position (e.g. Davis & Bowers, 2006; Grainger & van Heuven, 2003; Whitney, 2001; Wagstaffe, 2004; 2005)
- Eye movements (e.g. Reichle, Rayner, & Pollatsek, 2003; McDonald, Carpenter, & Shillcock, 2005)
- Discourse processing (i.e. connecting the meanings of sentences to support sentence comprehension; e.g. see Kintsch,1988,1998;Schmalhofer, McDaniel, & Keefe, 2002)

- Syntactic parsing (i.e. sentence-level processing e.g. Frazier, 1995; McRae, Spivey-Knowlton, & Tanenhaus, 1998; Tabor, Juliano, &Tanenhaus, 1997).

Rayner and Reichle (2010) suggest that an integrated framework of all the elements of the reading process is necessary, in particular in relation to seeking an integrated understanding of dyslexia (Fletcher, 2009). In the meantime, despite the inconsistencies in definitions of dyslexia, what they do all seem to agree on at their base is a difficulty with word reading and spelling (e.g. Gyòrfi & Smythe, 2010; Rose, 2009). As such, of the models of skilled reading available, models of word identification may be considered the most relevant framework within which to consider dyslexia.

Brief summaries of the two main models of word recognition are provided in order to allow for a more detailed overview of what this stage of reading entails. It may be worth noting that these models are somewhat elderly (Coltheart et al, 2001: Plaut et al., 1996). However, there appears to have been little change in the models since their inceptions and they continue to be referred to as the most relevant models of word identification in most contemporary texts (e.g. Boukadi, Potvin, Macoir, Laforce, Poulin, Brambati & Wilson, 2016; Eysenck & Keane, 2013; Pritchard, Coltheart, Marinus & Castles, 2016; Rayner & Reichle, 2010; Welcome, Leonard & Chiarello, 2010).

The Dual Route Cascaded (DRC) Model of Word Recognition (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001)

The essence of the DRC model of word recognition is that there are two potential routes by which the pronunciation of a word may be derived from print; a lexical route and a sub-lexical, grapheme-phoneme correspondences (GPC) route (see Figure 2).

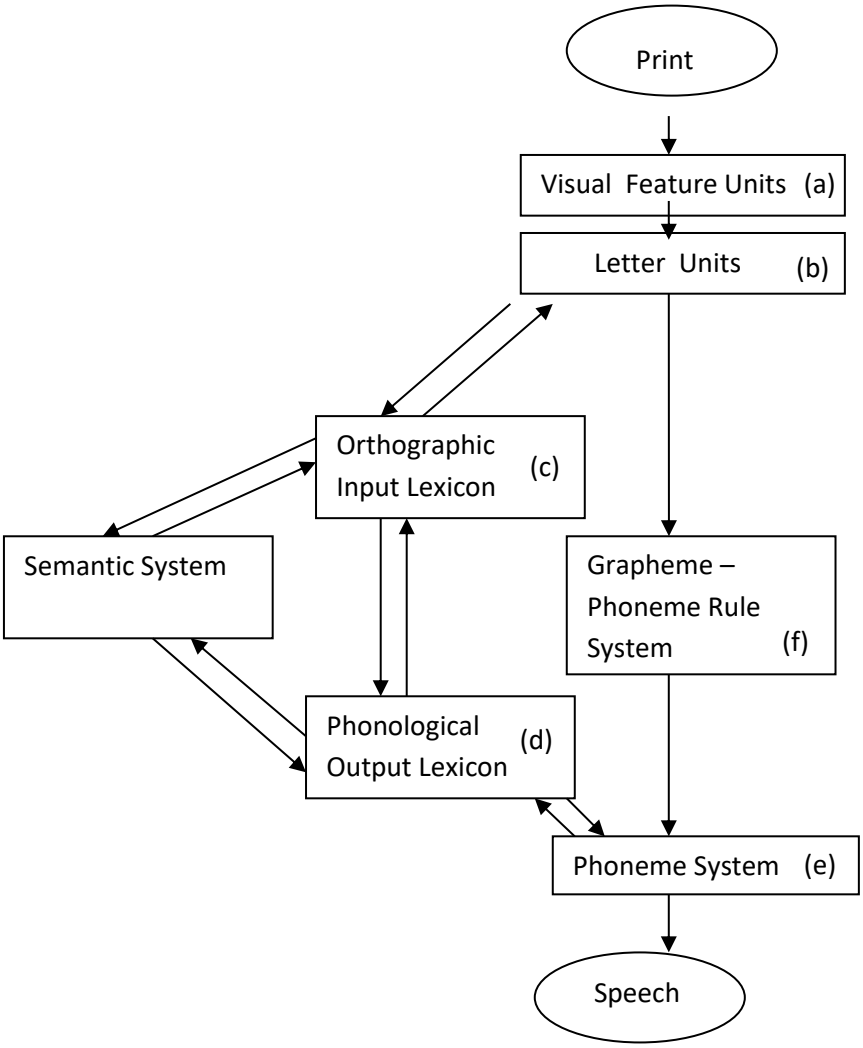

Figure 2. The Dual Rote Cascaded (DRC) Model of Reading (Coltheart et al., 2001)

The lexical[4] route achieves word identification via a process that within education may be referred to as 'sight reading' of whole words or parts of words, as opposed to letter-sound decoding. When a word is presented in print, the visual features of letters are processed at the letter feature level (a). The features then activate the word's letter units at the letter unit stage (b). Having been identified, the letters then activate the corresponding word (or part of a word) entry in the orthographic lexicon[5] (c). They then activate the corresponding word (or part of a word) entry in the phonological lexicon[6] (d), and finally the letters activate the word's phonemes in the phoneme system (e), which allows the reader to pronounce the word. It is by this route that irregular words such as 'yacht' are able to be read.

The grapheme-to-phoneme[7] correspondence (GPC) route identifies the features of letters and the identities of letters via the same mechanisms as the lexical route. Having identified the letters, the grapheme-to-phoneme rule system (f) converts the letters into their phonological representations using GPC rules. The phonemes are assembled into a phoneme string, allowing the word to be pronounced. This route allows unfamiliar regular words (i.e. words with a transparent grapheme to phoneme correspondence) and pronounceable non-words (e.g. 'luftan') to be read.

Parallel Distributed Processing Models of Word Recognition (e.g. Seidenberg & McClelland, 1981; Plaut, McClelland, Seidenberg, and Patterson, 1996).

Parallel Distributed Processing (PDP) models of reading comprise similar processing levels to the DRC model, but all processing operates in parallel via a single route.

[4] Lexical = word-based
[5] The orthographic lexicon is the name given to the stored set of visual representations of words or parts of words.
[6] The phonological lexicon is the name given to the stored set of phonological representations of words or parts of words.
[7] Grapheme to phoneme correspondence refers roughly to the mappings between letters and sounds. For example, the visual representation of the letter, 'p' maps onto the letter sound /p/. In reality, it is somewhat more complex than this, as where letters can be defined as single units of orthographic representation, graphemes are defined as the visual representations of phonemes. This becomes more complicated as in English orthography every letter is a grapheme - as each letter represents a phoneme - but there are additional phonemes that are represented by more than one letter; multi-letter graphemes (e.g. 'ng; is the grapheme representing the phoneme, /ŋ/ in 'bring', and the grapheme, 'th' represents the phoneme /θ/ in 'thanks')

Figure 3 shows Seidenberg and McClelland's (1989) model of lexical processing. PDP models are based on the premise that a processing system consists of a great many processing units, which are connected to each other. The strength of the connections between the units depends on several factors, and crucially, adapts each time the system encounters a new experience. PDP models of visual word recognition (e.g. Seidenberg and McClelland, 1989; Plaut, McClelland, Seidenberg and Patterson, 1996) hold that when a word is presented (i.e. on input), information about its orthography (i.e. constituent letter identities) is received by the processing system, while phonological information about the word is generated at an output level (see Figure 3). The connection between the input and output levels is mediated by hidden units (*). The process is identical regardless of the type of word that is presented to the system (i.e. regular word, irregular word or pronounceable non-word).

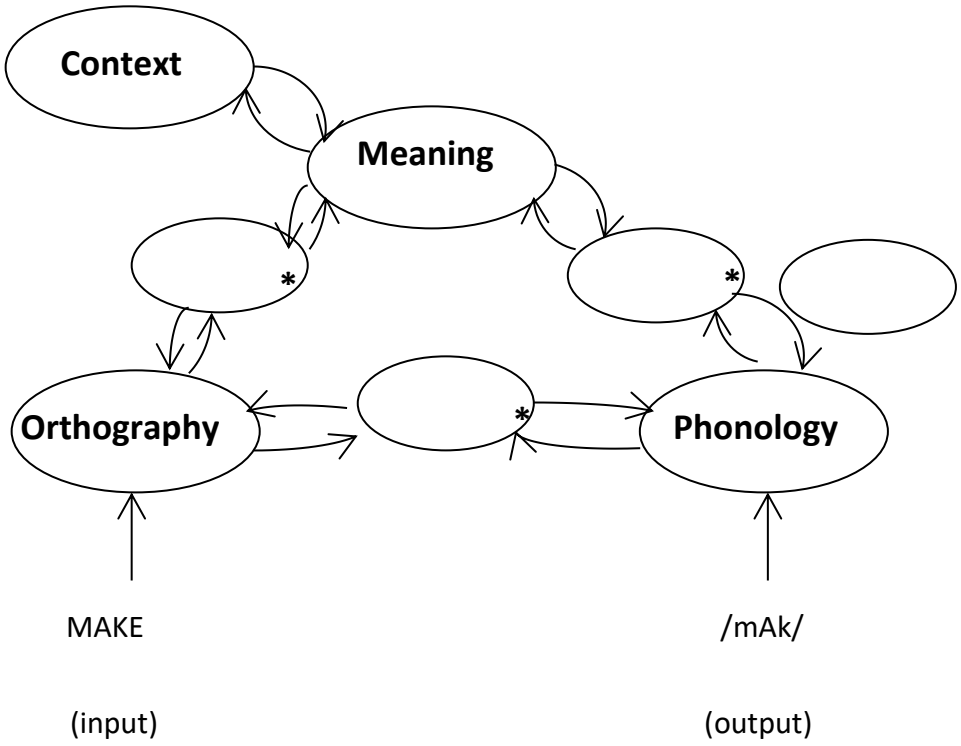

Figure 3. A Parallel Distributed Processing (PDP) model of reading (Seidenberg & McClelland, 1989).

Both DRC and PDP models of reading have successfully simulated dyslexic-type impairments in word recognition in their computational models (e.g. Coltheart et al., 2001; Plaut et al., 1996), although these theoretical accounts of dyslexia have been

rather dismissed within education research[8]. What the two theoretical models of reading outlined above do show is that word recognition is an extraordinarily complicated process, and that there may be several different stages at which it could be dissimilar in dyslexic readers compared to typically-developing readers. Indeed, the Dual Route Cascaded (DRC) model (Coltheart et al, 2001) has slightly more success than the PDP models (Plaut et al, 1996) with accounting for phonological dyslexia[9] (see Eysenck, 2013) and as such the DRC model will be referred to through the remainder of this document when considering models of skilled reading.

Reading development

Models of the way in which children learn to read tend to acknowledge that first phase of word recognition is a pre-alphabetic (e.g. Ehri, 2005) or logographic (e.g. Frith, 1985) stage which reflects that children appear to recognise visual word information at a whole word level from the environment (e.g. their name or shop logos etc.) at the level of shapes and other visual cues. This is consistent with the development of children's awareness of the phonological structures (sounds) of language, which begins with the largest units of language (words). As such, young children tend to be aware of words as whole units but not of the parts that make them up.

It is widely agreed that children's phonological awareness thus begins with whole words and is gradually refined to increasingly smaller units from syllables[10], onset-

[8] The fact that DRC and PDP accounts of dyslexia have not been embraced within applied research and practice, may reflect the underlying motives of the researchers. Coltheart et al. (2001) and Plaut et al. (e.g. 1996) are primarily cognitive researchers of the processing involved in reading from a theoretical point of view. Their models of reading and dyslexia do not necessarily appeal to applied researchers, perhaps because they do not offer direct implications or suggestions for intervention. It may also be the case, more generally, that the language used by academic researchers is less appealing to applied practitioners, who are more likely to take account of social and emotional implications of theory. For example, many academic discussions of dyslexia talk of 'deficits', 'dysfunction' and 'abnormality'; applied discussions of dyslexia are more likely to refer to learning 'differences' and 'relative areas of strength and weaknesses'.

[9] It may be interesting to note that some academic research continues to distinguish between 'phonological', 'surface' and 'deep' dyslexia although the latter two are rarely, if ever, referred to in practice.

[10] A syllable refers to a unit of pronunciation with one vowel sound; it typically reflects the way a word naturally divides into parts when pronounced. For example, syl/la/ble.

rimes[11] and eventually phonemes[12] (e.g. Stanovich, 1992). This gradual process down the hierarchy of the size of units of language tends to be consistent across languages (Anthony, Lonigan, Driscoll, Phillips & Burgess, 2003; Ziegler & Goswami, 2005).

There is a wealth of evidence indicating a strong relationship between children's early phonological awareness skills and their later reading development (e.g. Bradley & Bryant, 1983; Bryant, Maclean, Bradley & Crossland, 1990; Goswami & Bryant, 1990; Share, 1999). However, there remains some debate about the order in which they may develop different phonological skills. What does appear to be generally acknowledged is that development of vocabulary is a strong predictor for skills at the larger units of words (whole words, syllables, onset-rime) and may be a necessary precursor for the impact of awareness of phonemes on later reading (e.g. Byrne, 1998; Muter, 2003). As such, although some phonological skills (e.g. awareness of syllables and onset-rimes) may pre-date the teaching of reading, some rely on exposure to print and explicit teaching (e.g. Goswami and Bryant, 1990). The relevance of this to the current discussion is that there is a general consensus that the two most important factors in beginning to learn to read are phonological awareness and knowledge of letter sounds, but that the combined impact of these may be mediated by a number of other factors and are both likely to develop atypically for (many or most) dyslexic readers (e.g. g. Bradley and Bryant, 1983; Goswami and Bryant, 1990; Lundberg and Hoien, 2005; Snowling, 2000; Swan and Goswami, 1997).

Defining Dyslexia

Definitions

Defining dyslexia is 'somewhat paradoxically' both very easy and very difficult because the definition needs to be wide enough to capture the range of needs that

[11] Onset-rimes refer to dividing a word into the part before the first vowel (onset) and the part of the word which includes the vowel onwards. For example, ex (onset) - ample (rime); v (onset) - owel (rime).

[12] A phoneme refers to the smallest units of speech sounds, i.e. the sounds of letters (graphemes) or groups of letters. E.g. sound has 4 phonemes: s/ou/n/d and 5 letters, and sand has 4 phonemes and 4 letters (s/a/n/d).

dyslexia reflects, while being specific enough to refer a distinct group of individuals who it represents (Elliott & Grigorenko, 2014).

Critchley (1970) *was* among the first to posit a definition of dyslexia, as:

"A disorder manifested by difficulty with learning to read, despite conventional instruction, adequate intelligence and sociocultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin"

As research and understanding of dyslexia continued to develop, the need for a refined definition saw Critchley's increasingly replaced on the grounds that its emphasis was too exclusionary (i.e. it said more about what dyslexia is not rather than what it is, see Rutter, 1982). Over time, a number of updated definitions have emerged, including:

International Dyslexia Association (2003), defining dyslexia as:
"Difficulties with accurate and 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 areas and the providing of effective classroom instruction"

The IDA definition moves away from a 'discrepancy model' (see below) by removing any reference to intelligence, but does emphasise that reading difficulties may otherwise be unexpected for a child or young person with dyslexia. It is helpful in that it narrows down the elements of reading that may be impacted. However, part of the problem in applying this definition operationally is in determining in a consistent way which may be considered to be unexpected so that this can be applied in a helpful or meaningful diagnostic sense (e.g. Elliott & Grigorenko, 2014; Wagner, 2008). Shaywitz (2005) suggests that unexpectedness can be determined by a cognitive

profile whereby decoding is an isolated difficulty within 'a sea of strengths'. Although this profile may reasonably apply to many dyslexic individuals, it is difficult to generalise because reading development and vocabulary development are so closely linked, which means that there are many dyslexic individuals who would not necessarily have good language skills (e.g. Tumner & Greaney, 2010) or good general knowledge (e.g. Vargo, Grossner & Spafford, 1995) which is further compounded by not being able to effectively access text. As such, there is no clear logical or theoretical grounds on which to apply a different criteria or understanding for children whose cognitive profiles are 'relatively flat', reflecting needs in one or more area than just a difficulty with decoding (Fletcher, Morris & Lyon, 2003. Fletcher, Stuebing, Morris & Lyon, 2013).

The European Dyslexia Association (2007) defines dyslexia as:
"A difference in acquiring reading, spelling and writing skills, that is neurological in origin. The cognitive difficulties that cause these differences can also affect organisational skills, calculation abilities, etc. It may be caused by a combination of difficulties in phonological processing, working memory, rapid naming, sequencing and the automaticity of basic skills. Alongside these issues is the ongoing challenge for people with dyslexia navigating through life in a largely non-dyslexia friendly world. Researchers acknowledge that there are many possible causes of dyslexia including genetics. There is no relationship between a person's levels of intelligence, individual socioeconomic position and the presence of dyslexia. Furthermore, across Europe the diversity of languages and the multilingual demands, sociocultural backgrounds as well as educational opportunity, have a significant impact on the life-chances for dyslexic children and adults" (from Gyòrfi & Smythe, 2010, p. 89).

This provides a good example of an inclusionary model of dyslexia in that it provides guidance about what may be involved for an individual with dyslexia and what their experiences may include, as well as acknowledging the significant real-life impacts of long-term reading impairment. Note an explicit statement refuting 'intelligence' as a mediating factor. However, there are theoretical and operational difficulties with using such a definition in any sort of helpful diagnostic sense. Firstly, as discussed in

due course, the overwhelming consensus from research within the UK currently recognises phonological processing difficulties as causal in dyslexia, with the other accounts mentioned here (working memory, rapid naming) being accounted for as epiphenomena (i.e. by-products) of phonological processing difficulties (e.g. Hulme & Roodenrys, 1999) or as not sufficiently reliable to account for the needs of dyslexic individuals (e.g. Snowling, 2000). Note that this discussion is based on the consensus of research evidence, and as discussed in more detail below, it is likely to be helpful to at the least acknowledge a wide range of theoretical models when considering individual needs in dyslexia. However, in guiding a definition to be used in a clear, consistent and operational sense, based on the weight of evidence from research, the European Dyslexia Association definition is not sufficiently reliable.

In addition, both the European Dyslexia Association (2007) and Snowling (2008) suggest that a defining feature of dyslexia is a 'neurological origin' for the deficits experienced. Although there is undisputable evidence for neurological and genetic substrates of reading difficulties (see below), there is not currently any mechanism whereby these can be used in any diagnostic sense (e.g. Grigorenko & Naples, 2009; Leonard & Eckhert, 2008; Rutter, Kim-Cohen and Maughan, 2006; Stein, 2018; Ramus, Altarelli, Jednoróg, Zhao & Di Covella, 2017; Van Daal, 2015), nor at present are they able to guide intervention in any meaningful way (e.g. Barden, 2017; Elliott & Grigorenko, 2014; Lopes, 2012; McCardle & Miller, 2012). As such, reference to a causal neurological component as a determining feature of dyslexia is not at present operationally relevant or practical, although it remains an important theoretical question and ideally a future paradigm shift in dyslexia may involve being able to usefully and meaningfully apply this crucial body of research (e.g. Everatt & Reid, 2009; Fletcher, 2009).

Health Council of the Netherlands (1997)

Perhaps unsurprisingly, the implication of such difficulties with reaching a clear, reflective, usable and meaningful definition of dyslexia has resulted in increasing reduction of the definition. Indeed, the Health Council of the Netherlands (1997)

identified criteria by which the acceptability of a definition of dyslexia could be approved. These included that it should be:

- descriptive with no explanatory elements
- specific enough to identify dyslexia within reading and spelling problems
- general enough to allow for various scientific models and any developments they may undergo
- operationalizable for the purpose of research into people and groups
- directive for statements concerning the need for intervention
- applicable to the various groups involved.

This led to the resulting definition of dyslexia:
"*Dyslexia is present when the automatization of word identification (reading) and/or spelling does not develop or does so very incompletely or with great difficulty"* (from Gyòrfi & Smythe, 2010, p. 88).

British Psychological Society (1999; 2005)

A trend towards increasingly inclusive (i.e. reflecting agreement of what dyslexia is, rather than what it is not) definitions has followed in the UK, with the British Psychological Society's (1999, re-issued in 2005) definition:

"Dyslexia is evident when accurate and fluent reading and /or spelling develops very incompletely or with great difficulty. This focuses on literacy learning at the 'word level' and implies that the problem is severe and persistent despite appropriate learning opportunities. It provides the basis for a staged process of assessment through teaching".

Rose (2009)

The 2009 Rose Review, Identifying and Teaching Young People with Dyslexia and Literacy Difficulties, although not without its critics, built largely on the BPS model, added to its definition a crucial sentence that moved identification of dyslexia into a new era.

"Dyslexia is a learning difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling.'

- *Characteristic features of dyslexia are difficulties in phonological awareness, verbal memory and verbal processing speed.*
- *Dyslexia occurs across the range of intellectual abilities.*
- *It is best thought of as a continuum, not a distinct category, and there are no clear cut-off points.*
- *Co-occurring difficulties may be seen in aspects of language, motor co-ordination, mental calculation, concentration and personal organisation, but these are not, by themselves, markers of dyslexia.*
- *A good indication of the severity and persistence of dyslexia difficulties can be gained by examining how the individual responds or has responded to well-founded intervention."*

It is worth noting that Scotland has a separate education system to the rest of the U.K and The Scottish Government and Dyslexia Scotland have agreed on a slightly different definition:

Dyslexia can be described as a continuum of difficulties in learning to read, write and/or spell, which persist despite the provision of appropriate learning opportunities. These difficulties often do not reflect an individual's cognitive abilities and may not be typical of performance in other areas.

The impact of dyslexia as a barrier to learning varies in degree according to the learning and teaching environment, as there are often associated difficulties such as:

- *auditory and /or visual processing of language-based information*
- *phonological awareness*
- *oral language skills and reading fluency*
- *short-term and working memory*
- *sequencing and directionality*
- *number skills*
- *organisational ability*

- *motor skills and co-ordination may also be affected*.

Dyslexia as a Continuum

The 2009 Rose definition of dyslexia has not been superseded to date and is widely considered to provide a 'best-fit' framework for understanding dyslexia, in a way which impacts on assessment through a Response to Intervention approach, rather than a 'wait to fail' approach, and which acknowledges frequently-arising co-occurring difficulties in a reliable way which doesn't require them to be a 'marker' for identification. It accounts for the difficulties of a heterogeneous group of dyslexic individuals and is inclusive enough to recognise characteristic features without applying them as exclusionary criteria. It is for these reasons that the 2009 Rose definition of dyslexia has been adopted by Cambridgeshire County Council as well a majority of other Local Authorities nationally.

The crucial sentence in the Rose definition, according to Reason and Stothard (2013) was that referring to dyslexia as a *"continuum, not a distinct category, and there are no cut-off points"* (p. 10). This, according to Reason and Stothard (2013) moved understanding of dyslexia firmly from a question of 'dyslexia or not' to a question of 'what is the nature of the dyslexia and how severe is it?' In fact, reference to dyslexia as a continuum without clear cut-off points reflects a view that has been prevailing in dyslexia research and theory for some time and appears to now be largely uncontested (e.g. Snowling, 2015; Fletcher, Lyon, Fuchs and Barnes, 2007; Rice and Brooks, 2004; Pennington, 2009; Elliott, 2008; Van Daal, 2015).

Identification (note distinction to diagnosis) of dyslexia on a continuum has engendered debate over whether there is any qualitative difference between the reading difficulties of children who are specifically dyslexic and those whose difficulties with reading and writing are due to more general or pervasive developmental difficulties (e.g. Elliott, 2005). Indeed, there is little evidence of any meaningful distinction of a dyslexic subgroup within the wider group of struggling readers in terms of causality, assessment, neurology or intervention (e.g. Barden,

2017; Knight, Day & Patten-Terry, 2009; Rice & Brooks, 2004; Elliott & Grigorenko, 2014; McCardle & Miller, 2012; Pennington, 2009) [13]. It is important to note that this reflects developments in evidence and theory and does not in any way detract from the very real, distressing and ongoing difficulties of dyslexic individuals. Indeed, perhaps there is reason to be optimistic that the reading needs of a wider group of dyslexic individuals are increasingly better understood and can be addressed.

The demise of the discrepancy model

The first reported case of what we now refer to as 'dyslexia' was of a fourteen-year old boy named Percy who had been unable to learn to read. Pringle-Morgan, the doctor who reported this case noted that it was surprising because *"the school master who taught him for some years says that he would be the smartest lad in the school if the instruction were entirely oral"* (Pringle-Morgan, 1896, cited in Miles and Miles (1990, p.vii). Such reported difficulties with reading took on many different names over the years, from 'congenital word blindness' (Hinshelwood, 1917), to

[13] Discussion of the Rose definition of dyslexia by the House of Commons Science and Technology Committee concluded that *"The [Rose] definition is so broad and blurred at the edges that it is difficult to see how it could be useful in any diagnostic sense"* (71; 2009). Brooks (2015) responded that, *"it wasn't meant to be 'useful in any diagnostic sense' because no definition could ever be precise enough to deliver the sort of dichotomous 'is it/isn't it dyslexia judgement…"* (p. 17). The House of Commons Science and Technology Committee appear eventually to have come to the same conclusion, noting that: *"The answer we reached was that it is not useful from an educational point of view. There is no convincing evidence that if a child with dyslexia is not labelled as dyslexic, but receives full support for his or her reading difficulty, that the child will do any worse than a child who is labelled as dyslexic and then receives specialist help. That is because the techniques to teach a child diagnosed with dyslexia to read are exactly the same as the techniques used to teach any other struggling reader. There is a further danger that an overemphasis on dyslexia may disadvantage other children with profound reading difficulties.* ***We conclude that 'specialist dyslexia teachers' could be renamed 'specialist literacy difficulty teachers'. There are a range of reasons why people may struggle to learn to read and the Government's focus on dyslexia risks obscuring the broader problem. The Government's support for training teachers to become better at helping poor readers is welcome and to be supported, but its specific focus on 'specialist dyslexia teachers' is not evidence-based"*** (77; 2009 emphasis in original). And, *finally "This is an interesting admission: that the Government decided to spend time and money looking specifically at dyslexia because of the strength of the dyslexia lobby, rather than because of any pre-existing, well researched, well defined problem. We have demonstrated the range of difficulties in this area: that dyslexia is so broadly defined that it encompasses a continuum of reading difficulties that have little if any relation to specific literacy interventions; and that the research in this area is not of the highest quality. The Minister's admission explains why teachers who are being trained to help all children with reading difficulties are labelled 'specialist dyslexia teachers'.* ***We recommend that the Government be more independently minded: it should prioritise its efforts on the basis of research, rather than commissioning research on the basis of the priorities of lobby groups"*** (House of Commons Science and Technology Committee, 2009; 84).

'strephosymbolia' (which literally translates as 'twisting of symbols'; Orton, 1937). One factor that remained constant throughout these early inceptions of dyslexia is that the difficulties that underlay reading and writing acquisition for such individuals were surprising given their general abilities and 'intelligence'. Thus was born the discrepancy model, which is inherent in early definitions of dyslexia (see Critchley, 1970 definition above). Snowling (2000) notes several issues with the Critchley definition of dyslexia, including the vagueness of terms such as 'conventional instruction' and 'adequate intelligence'. It is perhaps the latter that has formed the focus of the most ardent objections to the discrepancy model; the reliability of IQ measures of intelligence has come under considerable scrutiny. Therefore, to identify individuals as dyslexic as opposed to generally 'backward[14]' (Snowling, 2000), on the basis of such a poorly defined and ethereal construct, is considered by many to be neither valid nor useful (e.g. Stanovitch, 2005; Stanovitch and Siegel, 1994; Stuebing, Fletcher, Le Doux, Shaywitz and Shaywitz, 2002). A lack of relevance or usefulness of IQ in dyslexia has been replicated in research in many other languages including Finnish (e.g. Korttenein, Närhi & Ahonen, 2009) and Spanish (e.g. Jiminéz & Garcia de la Cadena, 2007). Nonetheless, as noted by Elbheri and Everatt (2009*), "IQ and dyslexia have been associated in such a way that it is often impossible to disconnect the two in social/political discourse"* (p.24). As such, despite an almost unanimous agreement that IQ is not a meaningful or relevant factor in identifying or responding to dyslexia (although see Herrington Hunter-Carsh, 2001; Thomson, 2002), there appears to be a prevailing public view that has outlived the paradigm shift in research and understanding and it is often still referred to as an indicator in guidance around assessing reading difficulties (e.g. Anderson & Meier-Hedde, 2017; Muter, 2018). That dyslexia occurs across a range of learning needs (including otherwise high achievers or able learners as well as learners who are struggling across many areas of learning and development) does not detract from the very real and difficult experiences that dyslexic learners face.

It may be worth noting that acknowledging that IQ scores in themselves are not helpful or relevant in identifying and addressing dyslexia, this does not mean that

[14] Original terminology (Snowling, 2000)

cognitive assessments are never useful for understanding the needs of struggling readers. As outlined later, there may be some children who, following a carefully planned and monitored Response to Intervention approach, continue to find their reading and spelling development resistant to intervention. In such situations, a cognitive or learning assessment aimed to explore their relative areas of strength and need and how these link with their reading difficulties can be helpful in guiding intervention. Nonetheless, even in this scenario the overall IQ score remains irrelevant to understanding the nature of the need or to guiding intervention.

The discrepancy model in academic research

One particular area in which a discrepancy identification of dyslexia often continues to be applied is in academic research studies (e.g. Berringer, Raskind, Richards, Abott & Stock, 2008; Goswami, Huss, Mead, Fosker & Verney, 2013; Gooch, Snowling & Hulme, 2012; Snowling, 2000; Stein, Talcott & Witton, 2001) despite acknowledgement that a discrepancy model is no longer considered to be a valid marker of dyslexia in practice (e.g. Van Daal, 2015). The continued use of this model reflects a difference in the perspective and purposes of the different professional groups working around dyslexia. Academic researchers need to refine participant groups so that they are as homogenous as possible in order to allow reproducibility of findings and to allow consistency and specificity to support the development of theory (e.g. Reid, 2016; Singleton, 2009; Stanovich, 1992; Van Daal, 2015).

Prevalence

Perhaps unsurprisingly given the wide and ever evolving definitions of dyslexia outlined above, there is little consistency in reported prevalence rates of dyslexia. The US National Institute of Health (cited in Elliott & Grigorenko, 2015) reports a rate of 20%, consistent with Shaywitz (2005). Gyòrfi & Smythe (2010) cite a prevalence for dyslexia in Europe affecting 10% of the population, as does van Bergen, de Jong, Plakas, Massen and van der Leij (2012) in the Dutch population and the Dyslexia Foundation of New Zealand (2008). More locally, Crisfield (1990) wrote on behalf of the British Dyslexia Association that there was prevalence in the UK of 10% for mild dyslexia and 4% for severe dyslexia. Goswami (2008) also identifies a rate of 4 – 10%, whereas Nicolson (2005) works on a rate of 5% of the population. Butterworth

and Kovas (2013) refer to a prevalence rate of 4 – 8% of dyslexic individuals in the general population, as does Snowling (2008), although Snowling (2013) later refers to a rate of 3 – 10%.

Indeed, Fletcher (2009) notes reported rates of dyslexia in the population varying from 3 – 17% and concludes, that, "*Deciding where on a continuum a disability resides is inherently arbitrary, which is why prevalence estimates vary"* (p 3; see also Pennington, 2009).

In practice, it may be a helpful heuristic for teachers to assume a prevalence rate of 20% in order that they are prepared or expecting at least one in every five children in their class to struggle with reading and to be prepared to make adaptations to support in line with a Response to Intervention approach at that level.

Biological Factors: Neurology and Genetics

There is incontrovertible evidence that dyslexia (as defined by the Rose model) has genetic and neurological substrates (e.g. Hoskyn, 2008; Galaburda, 1993; Masland, 1990; Leonard & Eckhart, 2008; Nicolson, 2005; Grigorenko, 2004; Elliott & Grigorenko, 2014; Ramus et al, 2017; Stein, 2018).

Research in genetics has identified a number of genes linked with reading impairment (e.g. Grigorenko & Naples, 2010) and an interaction between genetic factors and access to education which has implications for early intervention (e.g. Samuelson, Byrne, Olson, Hulslander, Wadsworth, Corley et al, 2008). Indeed, Leavitt, Nash and Snowling (2014) have reported that many parents of children identified as dyslexic also have reading difficulties. However, no clear causal model and specific genetic aetiology for dyslexia has yet been identified (e.g. Grigorenko & Naples, 2010; Pennington, 2009).

Similarly, research in neuroscience has identified a number of key regions of the brain that differ for dyslexic and typically-developing readers (e.g. Pollack, Luk & Christodoulou, 2015; Leonard & Eckhart, 2008; Galaburda, 1993; Berringer et al, 2008). Hoskyn (2008) notes that, "*the general assumption that guides much of this* [neuropsychological] *research is that once identified, a neurobiological signature for*

developmental dyslexia has important implications for early detection and for the design for intervention efforts" (p. 659). Fletcher (2009) notes that as theoretical models of reading impairment become more specific, so will the biological correlates become more apparent and more applicable to support dyslexic children in practice. However, as noted by Pollack et al (2015), although there are many and increasing brain regions involved in impaired reading, "*…the mechanism underlying this functional disruption and how it relates to behaviour requires further investigation"* (p.8; see also Leonard and Eckhert, 2008). This is perhaps unsurprising when taking into account the multiple points in the cognitive processes underlying reading at which difficulties may arise (see Figure 2), many of which reflect differing neurological architecture. Furthermore, there are not yet any clear implications for intervention, at least not beyond general principles around overlearning and pacing learning (Everatt & Reid, 2009).

Developments in genetics and neuroscience thus indicate a clear link between biological factors and dyslexia, and show how these interact with environmental experiences. This does not yet have any clear practical implications for identifying or supporting dyslexic individuals but neuroscience is a rapidly developing field so there may be reason to be optimistic that such practical applications may become more apparent over time (e.g. Fletcher, 2009; Hoskyns, 2009; Stein, 2018).

Causal models of Dyslexia

The Phonological Deficit Hypothesis

Early accounts of dyslexia assumed that its associated reading difficulties were visual in origin, as reflected in some of its early terminology ('word blindness'; 'strephosymbolia'). One of the major paradigm shifts in thinking about dyslexia was that it may not reflect a problem purely of visual processing, but also (or indeed primarily) of processing language (Vellutino, 1979). The Phonological Deficit Hypothesis (e.g. Snowling, 2000; Swan and Goswami, 1997) proposes that the core deficit within dyslexia that results in poor word reading arises as a consequence of

poor phonological representations[15] (e.g. Boada and Pennington (2006; Bradley and Bryant, 1983; Goswami and Bryant, 1990; Thomson, Richardson, & Goswami, 2005). Lundberg and Hoien (2005) outline the way in which some of the main features of phonological difficulties (at a cognitive level) in reading may manifest as the following difficulties at a behavioural level. These include: difficulty segmenting words into phonemes, difficulty retaining letter strings (presented either as visual or auditory stimuli) in short term memory, and difficulty with manipulating phonological information (e.g. spoonerisms). It is widely thought to be accounted for by difficulties in temporal processing which interrupt sequencing of the order of sounds in spoken words and letters in written words (e.g. Francisco, Jesse & Groen, 2017; Goswami, Power, Lollier & Fawcett, 2014; Stein, 1993) The Phonological Deficit Hypothesis is currently the most widely accepted account of dyslexia (see Rose, 2009), and is supported by a multitude of research in English, (e.g. Hulme and Snowling, 1994) as well as in other languages including Dutch (e.g. de Jong and van der Leij, 1999), French (Courcy, Beland and Pitchford, 2000) and Chinese (Perfetti, Tan and Siok, 1996). There is also some evidence that a paucity of exposure to a rich language and literature in the early years can impact on later phonological development, thus suggesting a link between early home experiences and later reading development (e.g. Corriveau, Goswami & Thomson, 2010; Hamiton, Hayiou-Thomas, Hulme & Snowling, 2017).

A large majority of published interventions for dyslexic children and young people are designed to promote phonological awareness and ability (see later section on interventions); indeed the importance of explicitly teaching synthetic phonics in to all children in primary schools has become increasingly embraced in recent years (e.g. DfES, 2007; Johnston and Watson, 2014; Rose, 2006).

It may be tempting to conclude from this that all dyslexic children must by definition have a difficulty with phonological processing skills as the basis of their reading difficulties and that any intervention for any dyslexic child must take the form of additional, intense phonics intervention. Indeed, this has been the gist of the proposed government response to dyslexia (Rose, 2009). There are also a range of accounts

[15] Phonological representations refer to information that is stored in the brain about the sounds of words and individual letters or graphemes, in the form of phonemes.

for the origins of phonological processing difficulties (e.g. Corriveau ate al, 2010; Goswami et al, 2013; Perrachione, Del Tufo & Gabrieli, 2011). However, there are some dyslexic children for whom phonics interventions are not successful in helping them to progress with their word reading skills (e.g. Rose, 2009; Snowling, 2008; Torgesen, Wagner and Rashotte, 1994). While there is general agreement in research and applied psychology communities that phonological deficits are a core feature of dyslexia, they do not necessarily account for all of the subtle features of all dyslexic children, even within the narrow focus of word recognition (e.g. Byrne, 2011; Ramus & Szenkovits, 2008). Indeed, Peterson, Pennington, Shiberg & Boada (2009) refer to the 'tyranny of the phoneme' (p. 1997) as an overrepresented linguistic unit in studies of reading and reading impairment. As has been discussed previously, dyslexia is not straightforward or neat; not all dyslexic children have the same profile of strengths and weaknesses, and as shown in Figure 2 and Figure 4 there are many possible stages in the reading process at which difficulties may become apparent. There are a number of additional theories which aim to account for some of these variations, but which are often overlooked outside of academic research, perhaps because they do not fit neatly within a 'one-size-fits-all' approach (e.g. Bell & McLean, 2016; Reynolds & Shaywitz, 2009). If all dyslexic children are to receive support that specifically meets their needs, we may need to consider the possibility that a phonological deficit is certainly one, but not necessarily the only cause of dyslexia (e.g. Nicolson and Fawcett, 2008).

The Double Deficit Hypothesis

The Double-Deficit Hypothesis proposes that there is a second core deficit in dyslexia, in addition to the phonological deficit outlined above. This second core deficit is apparent in naming speed (e.g. Geschwind, 1974), which is thought to manifest in dyslexia as processing rates that are not sufficiently rapid to support fluent reading (Wolf and O'Brien, 2001; Wolf, Bowers and Biddle, 2000). Results of studies using Rapid Automatized Naming[16] (RAN) tasks (e.g. Denckla and Rudel, 1974) suggest that the speed (but not the accuracy) with which the names of test items are recovered are significantly slower for dyslexic readers than for average

[16] During Rapid Automatized Naming (RAN) tasks, participants are asked to name a series of stimuli as quickly as they can. These stimuli can be alphanumerical (letters or numbers), categorical (e.g. colours) or nominal (e.g. pictures).

readers. There is thus a large and growing body of evidence to suggest that dyslexic readers in general have a significant difficulty in the rapid retrieval of item names from memory, particularly when the items are alphanumerical in nature.

The Double-Deficit Hypothesis proposes that there are some dyslexics whose reading difficulties are purely phonological, a small number whose difficulties relate purely to speed of processing (as evidenced by speed of naming) and some dyslexics who have a double-deficit of both phonological and naming-speed difficulties (Lovett, Steinbach and Frijters, 2000). These individuals, according to Wolf and Bowers (2000) are the most impaired dyslexics, perhaps because their double deficit limits their potential to use compensatory routes to word recognition and reading. Part of the reason why this theory has received relatively little attention within educational publications of dyslexia is that naming speed has been assumed by many proponents of the Phonological Deficit Hypothesis, to fall under the category of a phonological deficit (e.g. Snowling, 2000) However, there is also a growing body of research to suggest that the phonological and speed of processing deficits implied in this account of dyslexia are mutually independent (e.g. Wolf and Bowers, 2000; Kirby, Georgiou, Martinussen, Parrila, Bowers & Landerl, 2010 but see also Ziegler, Bertrand, Tóth, Csépe, Reis, Faísca et al, 2010).

Working Memory

Issues of whether naming-speed deficits are subsumed by phonological deficits in general, reflect a somewhat broader debate about the role of working memory in dyslexia. There is increasing agreement among researchers and educationalists that some dyslexic difficulties may be related to difficulties in working memory. Again, proponents of the core Phonological Deficit Hypothesis have argued that working memory deficits in dyslexia are reflective of difficulties in retrieval and manipulations of phonological items within the phonological loop (e.g. Hulme and Roodenrys, 1995). Pickering (2006) however, suggests that some dyslexic reading difficulties reflect functionally separate working memory difficulties, at the level of visual working memory, and at the level of the central executive. Research into the role of working memory in dyslexia is prolific (e.g. Menghini, Finzi, Carlesimo & Vicari, 2011;

Gathercole, Pickering, Knight & Stegman, 2004) and yet tends to be relatively dismissed (e.g. Ricketts, 2011) in the crucial process of applying theory to classroom practice, at least through the route of government-endorsed education policy and practice[17]. Interestingly, however, many independent resource guides and books on classroom practice include advice and tips on how to effectively address the needs of dyslexic children whose speed of processing is not as rapid as that of their peers, or who find it difficult to carry out several instructions at once (perhaps reflecting a working memory deficit, (e.g. Pollack and Waller, 1990; Mackay, 2005). There is a developing body of interventions aimed to support the development of working memory in the classroom, but these have not yet indicated consistently promising results in relation to classroom performance or generalisation (e.g. Dunning, Holmes & Gathercole, 2013; Elliot, Gathercole, Alloway, Kirkwood & Holmes, 2010; Melby-Lervåg & Hulme, 2013 although see Egeland, Aarlien & Saunes, 2013). Indeed, more recently, an emphasis on 'teaching for neurodoversity' (e.g. Armstorng, 2010; Department of Education, undated; see section later on) draws attention to working memory as a common factor in many neurodevelopmental differences (incluing dyslexia, ADHD, Autism, speech and lanagueg diffiulcties etc) and there is therefore an increased drive to mediate classroom teaching in line with strategies that are effective for young people struggling with working memory (see also Cooper, 2017) to help a diverse range of presentations and needs.

Low-Level Visual Processing Deficits

In a return to more visual accounts of dyslexia, Lovegrove, Martin, Blackwood and Badcock (1980) found results suggesting that there were functional differences in the visual processing systems of dyslexic and non-dyslexic readers. Specifically, they found that many dyslexics have lower contrast sensitivity[18] than skilled readers, particularly at low temporal and high spatial frequencies,[19] which are processed by magno cells (Stein, 2003). A large body of subsequent studies have found similar

[17] This tendency may be reflected in the fact that many of the members of the expert advisory group called upon by Jim Rose in his most recent review of the current research evidence in dyslexia were themselves proponents of the Phonological Deficit Hypothesis.
[18] Contrast sensitivity refers to measurement of how well details can be seen at low contrast; i.e. the degree to which an image can be faded without becoming indistinguishable from its surroundings or background.
[19] Spatial frequency refers to the width of the bands in a sine-wave grating.

differential qualities in the physical structures (e.g. Livingstone, Rosen, Drislane, & Galaburda, 1991) and functional responses (e.g. Lehmkuhle and Williams, 1993) of the magnocellular system of dyslexic and non-dyslexic readers. Magnocellular deficits have also been found to affect visual motion sensitivity in dyslexic readers (Stein, 2003) as well as visual instability which may cause dyslexic readers' eyes to 'wobble' during fixations (e.g. Eden, Stein, Wood and Wood, 1994). The conclusion that dyslexic readers may have reduced sensitivity in their magnocellular processing (e.g. Pammer, 2012; Vidyasagar, 2012) has been criticised on account of a degree of inconsistency in findings; the proportion of dyslexic readers found in studies to have a magnocellular deficit is relatively small (e.g. Skottun, 2000). Accounts of causal connections between low-level visual processing deficits and reading difficulties have also been dismissed as mere epiphenomena of the phonological deficits thought to be implicit in dyslexia (e.g. Hulme, 1988). However, Talcott, Witton, McClean, Hansen, Rees, Green and Stein (2000) found that features of low-level visual processing such as motion sensitivity could account for orthographic (visual) reading ability, when phonological ability was controlled for, suggesting that such psychophysical characteristics of dyslexia may be more than mere epiphenomena. "*From a neuropsychological perspective, development dyslexia has multiple causes. One may be a M*[magnocellular]*-deficit subtype*." (Chase, Ashourzadeh and Kelly, 2005, p.135).

A further account of a link between low level visual processing difficulties and dyslexia is provided by theories of scotopic sensitivity (Meares-Irlen Syndrome) (e.g. Singleton, 2009a; Irlen, 1997). This refers to visual discomfort experienced during reading due to increased sensitivity to glare, resulting in a number of visual distortions (Singleton, 2009a). Mearles-Irlen Syndrome has been largely dismissed as a causal factor in dyslexia (e.g. American Academy of Paediatrics, 2009; Wilkins, 1995; Whit, Milne, Rosen, Hansen, Swettenham, Frith et al. 2006), there is equally acknowledgement that visual stress may make reading unpleasant and therefore lead to avoidance (e.g. Singleton, 2009a). This may account for the high number of dyslexic readers who anecdotally report that they find coloured overlays helpful (e.g. Wilkins 1995; 2003).

Automaticity

The Dyslexic Automatization Deficit Hypothesis (DAD; Nicolson and Fawcett, 1990) proposes that dyslexic individuals have difficulty with developing automaticity in cognitive as well as motor skills. This view is supported by the observation that even once dyslexic children have mastered word reading skills in terms of accuracy, their performance remains relatively slow and less fluent than non-dyslexic readers (e.g. Snowling, 2000). It is suggested that such difficulties in acquiring automatization in reading, as well as a wide range of other skills, originates from differential functioning of the cerebellum[20] in dyslexic compared to non-dyslexic individuals (e.g. Frank and Levinson, 1973; Fawcett, Nicolson and Dean, 1996; Nicolson and Fawcett, 2008). This account of dyslexia appears to have been entirely overlooked in educational spheres and has come up against significant criticism as far as concerns its reliability as a causal factor in reading (e.g. Chaix et al, 2007; Stoodly & Stein, 2011; 2013; Rochelle & Talcott, 2006). One of the original proponents of this model, Nicolson (2005), himself acknowledges that it is perhaps of limited interest in education as its implications for intervention for dyslexic learners are not readily appreciated (Elliott & Grigorenko, 2014).

Neurodiversity and co-occurring difficulties

Neurodiversity is a term first coined by campaigners for Autistic indiviuduals who did not identify as having a ‘disability’ but simply as being ‘different’ and, importantly that their differences include strengths. The term appears consistent with a Social Model of Disability (Oliver, 1983) which purports that disabilities are created and maintained by the barriers that societal norms and structures create, rather than necessarily always by a medicalised need. In relation to social, behavioural and learning difficulties, Armstrong (2010) notes that there is not a benchmark of a ‘typical’ brain and set of behaviours against which to measure differences and therefore that it may

[20] The cerebellum (‘little brain’) sits towards the back of the brain and overlays the brain stem. Information about sensory inputs that convey body position, as well as motor outputs are inputted into the cerebellum. Further inputs to the cerebellum include visual, auditory and balance information. The outputs of the cerebellum are to motor and premotor cortex; the role of the cerebellum is crucial in the coordination of movement. It may be worth noting that it is not the cerebellum itself that controls movement; its key role is to integrate information in order to allow coordinated and fluent movement (GazzanOliga, Ivry and Mangun, 2002).

be unhelpful to identify divergences as ‘disabilities’ but rather as differences. In this way, the concept of neurodiversity has extended beyong autistic spectrum conditions and come to refer to a wider range of needs (e.g. OECD, 2017) incluing Dyslexia, Attention Deficit Hyperactivity Disorder (ADHD) and so on (see Figure 4, below). This approach aims to promote the potential strengths that people with such differences may have in order that they can be employed effectively to help them (e.g. Armstrong, 2010). It also emphasises the responsibility of society and wider societal instititions for creating environments which are inaccessible to some individuals.

Cooper (2017) and the Department of Education in collaboration with the British Dyslexia Association (undated) draw attention to a number of overlapping factors in a range of developmental areas of difference (dyslexia, ADHD, ASD, dyspraxia, specific language impairment, dyscalculia) which may include diffilties with working memory and attention (among others). Griffiths, Kelly and Horobin (2018) have developed a training programme for teachers in the UK to teach in a way which meets the needs of a diverse range of needs rather than focussing too much on what the specific label may be. The approaches as set out within the PATOSS Teaching for Neurodiversity training materials for primary and secondary schools (https://www.patoss-dyslexia.org/Resources/2016-09-12/Teaching-for-Neurodiversity-Resources/) are largely consistent with the approaches as set out within Dyslexia Friendly Classrooms.

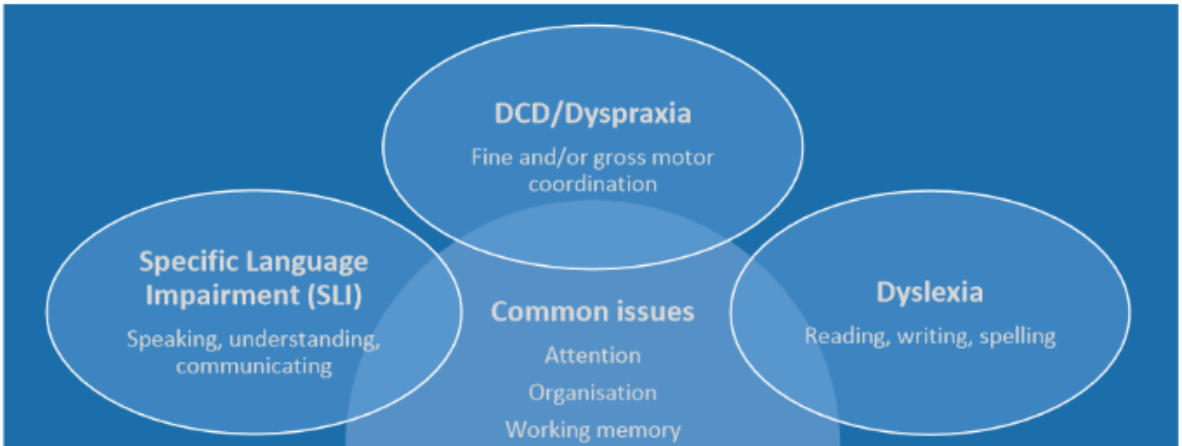

Figure 4. Graphical representation of how neurodiversity may account for a wide range of developmental differences and some of the factors which may be common to several areas of need. (from Teaching for Neurodiversity: A Guide to Specific Learning Difficulties).

Although it is helpful to maintain an awareness of the range of needs that a given young person may be experiencing, it is important to note that emphasis on neurodiversity does not mean that most or all children with dyslexia will necessarily have another area of significant need. However, the Rose (2006) definition of dyslexia notes that "*Co-occurring difficulties may be seen in aspects of language, motor co-ordination, mental calculation, concentration and personal organisation, but these are not, by themselves, markers of dyslexia".*

Indeed, there is reported comorbidity between dyslexia and ADHD, with prevalence rates varying between 5 – 7 % (e.g. Polanczyk, Silva de Lima, Horta, Biederman & Rohde, 2007) and 15-35% (e.g. Willcutt & Pennington, 2000). Similarly, dyslexic children frequently have associated motor coordination difficulties, with comorbidity rates reported between 5 – 18 % (e.g. Geuze, Jongmans, Schoemaker& Smits-Englesman, 2001) and 50% (Kaplan et al., 1998). Dyslexia has also been found to be a common additional need for children with Specific Language Impairment (e.g. Catts, Adolf, Hogan and Weismer, 2005) and as noted above, is frequently associated with difficulties in working memory (e.g. Jeffries and Everatt, 2004).
As such, it is important for school staff working with dyslexic children to be aware that they may have associated needs and to ensure that they are accounted for in

planning, support and monitoring approaches. However, it is important to note that these co-occurring difficulties are not in themselves markers of dyslexia in the absence of other reading or writing difficulties.

Operationalising Dyslexia

Identification

There is no dispute that early identification of dyslexia (note that this is used interchangeably with reading difficulties) is key to providing effective intervention and preventing escalation of more entrenched difficulties (e.g. Crombie & Reid, 2009; Elliott & Grigorenko, 2014; Muter, 2003; Ott, 2007; Gyòrfi & Smythe, 2010; Knight et al, 2009; Rose, 2009). Changes in understanding around dyslexia in relation to its heterogeneous nature, as well as its status as a continuous rather than a distinct category, suggest that a 'diagnosis' of dyslexia is no longer a meaningful, relevant or accurate terminology, and that focus needs instead to be on 'identification' and response.

One model of identification and assessment used widely and increasingly in the United States is a Response to Intervention (RTI) approach (e.g. Fuchs & Fuchs, 2009; Fuchs, Fuchs & Compton, 2012). This approach stands in contrast to a 'wait-to-fail' approach whereby assessment and identification of needs would traditionally have come following a period of not making progress and falling further behind peers (e.g. Knight et al., 2009; Elliott & Grigorenko, 2015).

Models of RTI operate through simultaneous identification of need and intervention to support need with a built-in mechanism for monitoring impact and progress (Fuchs, Fuchs and Compton, 2012). They tend to

include the following levels:

1. **A relevant process of universal screening:**
   This can be carried out using authentic and effective measures that predict later reading development, from early visuo-perceptual skills to early

vocabulary, early phonological awareness skills and so on as relevant. There are a number of packages available but 'soft' measures available to school staff can also be used (Knight et al, 2009). Of paramount importance is that the measures used are valid and authentic and that they know how and what they are measuring and how it links to literacy development (Bryan, Ergul & Berstein, 2008). Crombie and Reid (2009) suggest screening of skills relating to rhyming, alliteration, difficulties with recall and coordination and ideally this sort of screening should occur in the Foundation Stage (Knight et al, 2009).

2. **Progress monitoring:**

   This approach uses curriculum based and other available measures to determine whether progress is being made in relation to previous performance and intervention effectiveness. There is debate about how frequent monitoring updates need to be. Stecker, Fuchs and Fuchs (2005) suggest weekly checks, but Speece and Walker (2007) note that this may not be practicable and that monitoring every three weeks is perfectly appropriate. Built in decision points mean that if an intervention or approach is not impacting on measure of progress, it can be adjusted and through this progress, theories about the factors causing difficulty can be refined and interventions adjusted accordingly (see Figure 5).

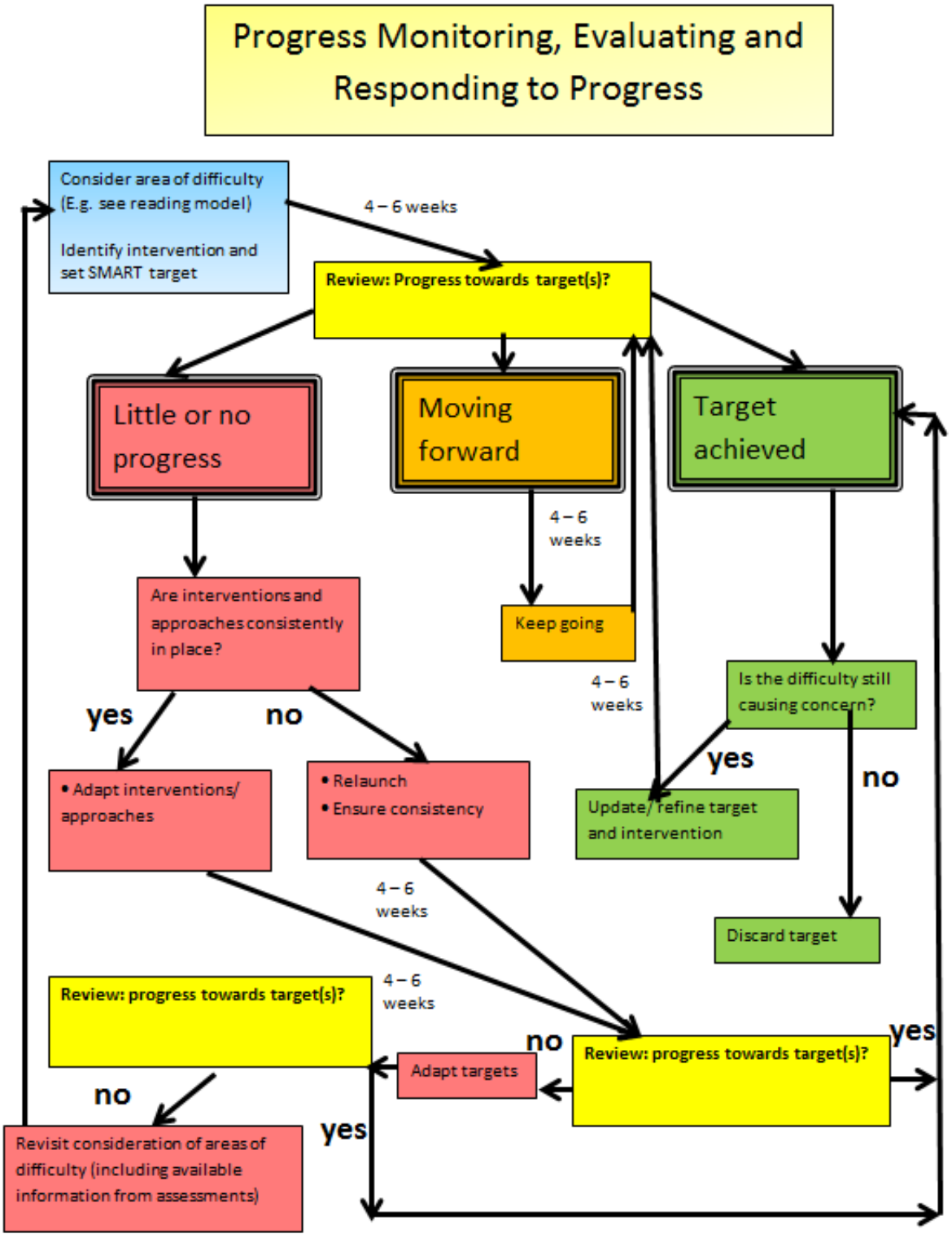

Figure 5. Graphical representation of an approach to progress monitoring including decision points about continuing, adapting or revisiting targets and associated interventions.

3. **High quality, evidence-based instruction for all pupils in the classroom**
   In the UK context, this would include recourse to strategies and approaches suggested within Dyslexia Friendly Classrooms in all lessons. It would also reflect teachers with confidence, understanding and skills in responding to reading difficulties which is a factor consistently noted as a key factor in success for struggling readers (European Commission, 2011). It may be worth noting at this point that in a 2008 study by Elliott and Gibb, class teachers reported that they were relatively confident in supporting struggling readers but that they were less confident in response to struggling readers with a formal identification of dyslexia (see also Brackley, 2015). It is important that class teachers feel that they can confidently apply their skills for all struggling readers, especially as there is no clear evidence that there are different interventions necessary for struggling readers and those identified as dyslexic (Elliott, 2008; Elliott & Grigorenko, 2015; Ramus, 2014).

4. **Tiers of intervention targeting specific pupils who are not making progress in response to screening or progress monitoring measures (e.g. Mellard & Johnson, 2008).**
   Tiers at this level refer, in the UK, to the levels of support as identified by the Special Educational Needs Code of Practice (2013), using a graduated approach. This reflects increasingly bespoke intervention according to the level of need and access to more specific assessment and advice from specialist practitioners for children with the most severe and pervasive needs.

As such, the question is not about ‘is the child dyslexic or not’, but ‘what is the nature and severity of their dyslexia’ and crucially, ‘what do they need to support them’? (Gyòrfi & Smythe, 2010; Reason & Stothard, 2013; Brackley, 2015; Snowling, 2015; Pool, 2003).

Assessment and Intervention

The purpose of assessment must be to identify relative strengths and areas of difficulty so that they can be addressed. As outlined above, there is not a 'test for dyslexia', and given how complex and convoluted the reading process is, how many neural areas are involved and how wide the definition of dyslexia is, the lack of a single test is perhaps not surprising. However, there are a number of materials that can be used effectively by schools and, for the most severe and persistent difficulties, by specialist practitioners, that can be used to generate an accurate understanding of the nature of a dyslexic individual's reading needs (Muter, 2018). From the point of view of an educationalist, theories of reading and dyslexia are only as useful as their implications for intervention and interventions should therefore be selected which address understanding of an individual child's needs. At the most basic level this may reflect consideration of whether the difficulty is around word identification, comprehension or both (see Figure 1; Gough and Tumner, 1986). At a more targeted level, this will reflect consideration of some of the more specific components of the reading progress which may be causing difficulties for an individual and how best to address them (see Figure 6 for an example).

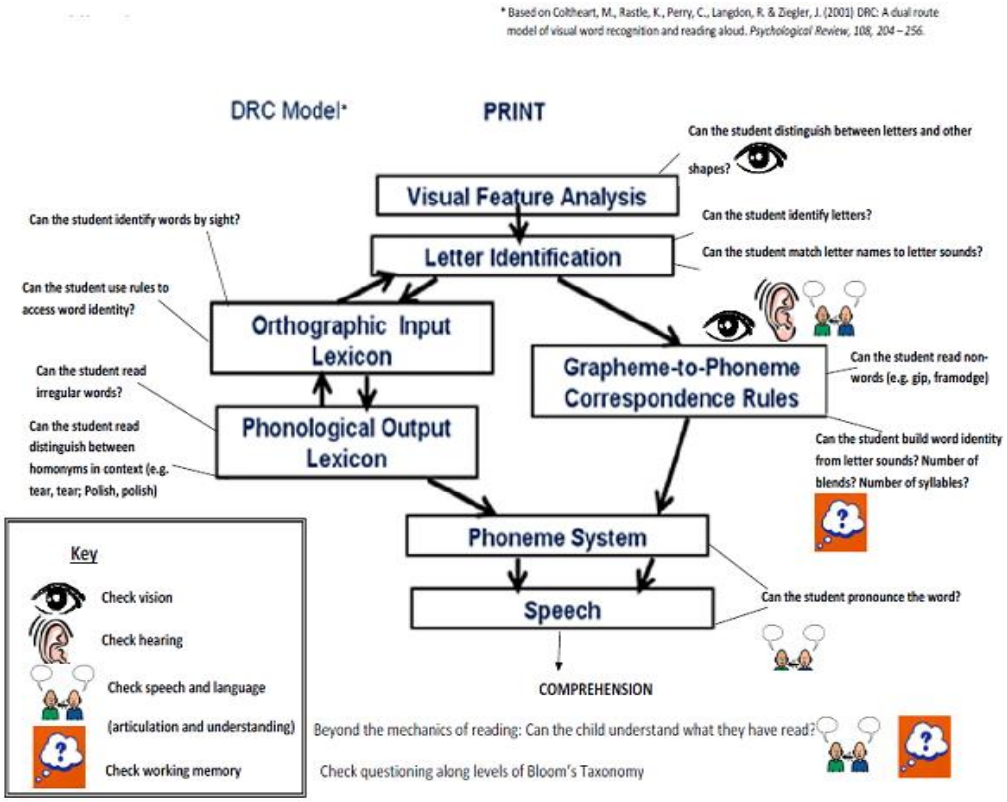

Figure 6. Example of how particular elements of the process may be considered in relation to an individual's reading difficulties so that they can guide specific intervention approaches.

Assessment

There a number of areas which could be assessed in realtion to reading difficulties which have been resistant to universal approaches (including Dyslexia Friendly Classrooms), depending on the level of concern and identified areas of difficulty which are presenting. The top two should always be intergrated into any literacy assessment. Areas to assess may include:

- **The young person's strengths**
- **The young person's views about reading/writing and their emotional response to it**
- Word reading accuracy
- Word reading fluency (single words)
- Word reading fluency (in text)
- Reading comprehension skills
- Phonological awareness skills
- Working memory

- Processing speed
- Oral langage skills
- Listening comprehension skills
- Spelling accuracy
- Spelling fluency
- Handwriting speed

Interventions

There exists an almost incalculable number of available interventions to support reading and writing development. Some of these have evidence-bases backed by research including demonstration that they are statisictally more likely to have an impact on reading and wriing than no intervention. This is not the case for all marketed interventions and schools should therefore be very mindful of ensuring that investments that they make within scant resources available have the best possible chance of impact.

Hattie (2009) carried out meta-analyses of over 800 research articles in relation to effective approaches in education and provides helpful indication of the sorts of approaches that may be considered to have a strong evidence-base. In relation to reading intervention, Hattie found that the most effective approaches were based on extended vocabulary[21] (effect size: 0.66) instruction and repeated reading (effect size: 0.67). It is likely that this reflects evidence that the factors which can mediate successful reading and development of phonological awareness is vocabulary (e.g. Muter, 2003; Solity, 2015) and that development of fluency reduces cognitive load thus allowing capacity for comprehension. Phonic instruction was also found to be highly effective (effect size: 0.6), but note that this encompassed different types of phonic instruction including synthetic and analytic phonics as well as other phonological awareness skills. This is of particular relevance as for some dyslexic individuals, synthetic phonics instruction alone is unlikely to be effective, particularly if they have poor letter-sound representations (e.g. due to early glue ear and/or early speech articulation difficulties) or if their dyslexia is characterised by difficulties with working memory. Indeed, Van Daal (2015), Rose (2009) and Solity (2015) among others, note that an overreliance on synthetic phonics, as currently characterises

[21] Effect size refers to a measure of a quantitative difference between two groups. For example some measure of a variable in an experimental group who receive an intervention may be compared to the same variable in a matched control group.

reading instruction in the UK, may be unhelpful for some dyslexic individuals. Hattie (2009) found that comprehension programmes were relatively effective (effect size: 0.58) in supporting progress, as were programmes such as Reading Recovery (0.5).

There are a number of sources that school can access to find out what evidence-based assessments are available. It is beyond the capacity of this document and the associated Guidance document to provide an exhaustive list of evidence-based literacy interventions available. However, useful sources to access include:

Greg Brooks(2016) : http://www.dyslexiaaction.org.uk/files/dyslexiaaction/what-works-5th-edition.pdf

http://evidence4impact.org.uk/programme.php?Index=4#programme_details).

http://www.sendgateway.org.uk/resources.sen-support-research-evidence-on-effective-approaches-and-examples-of-current-practice-in-good-and-outstanding-schools-and-colleges.html

https://educationendowmentfoundation.org.uk/

https://ies.ed.gov/ncee/wwc/ (From USA)

Key factors in the effectiveness of interventions depend on:

- Interventions being selected which address specific areas of need. As outlined above, not all dyslexic/struggling readers' difficulties have a single cause. As such, interventions should be identified based on assessment which are aimed to address relevant areas, for example:
    - Letter sound accuracy
    - Letter sound fluency
    - Word identification accuracy
    - Word identification fluency
    - Phonological awarenss skills
    - Skills in applicarion of phonic knowledge
    - Alternatiave approaches to word identification
    - Reading comprehension skills
    - Inference skills

- Reasoning skills
- Vocabulary deveoopment
- General knowledge
- Spelling accuracy
- Spelling fluency
- Applying phonic knowledge to spelling
- Alternative approaches to spelling
- Skills in planning ideas for writing
- Study skills
- Etc.

- Where evidence-based interventions are used, they **must** be implemented according to the way the programme was designed. Strategies for maintaining effectiveness of an intervention or programme include:
  - **Ensuring that all staff are committed to the fidelity of the programme or intervention.**
    Everyone must commit to delivering the programme as agreed. Consistency of approach and delivery are critical to ensuring good outcomes for the child or young person.
  - **Taking account of cultural adaptation.**
    Keep in mind that culture is reflected both in the materials used in the programme and in the aims of what it is trying to achieve. These should be clearly communicated to all concerned, including parents, to ensure joint understanding of the purpose of the programme and the materials to be used,
  - **Considering the language used in the programme or intervention.**
    Ensure that written and verbal instructions and guidance are understood by the child or young person and that materials used are developmental age appropriate and are of a high level of interest.
  - **Staying true to the duration and intensity of the programme or intervention.**
    A programme designed to be delivered in six weekly sessions is unlikely to have the same effect if it is delivered in three half days, even if all the content is covered. It is important, therefore, to follow the guidelines for the frequency and duration of the programme or intervention, and the length of each session.

- **Taking steps to avoid programme drift**
  Regular monitoring and review of the implementation will help address any unintentional variation from the original programme design.
- **Staying up-to-date with programme revisions and new materials.**
  Evidence based programmes are regularly revised and updated to incorporate new research on the programme's effectiveness.
- **Risky adaptations;** The following are likely to reduce the effectiveness of some of the interventions or programmes:
  - reducing the number or length of the group or individual sessions;
  - lowering the level of participant engagement, for example by reducing the time for completion of activities from 20 minutes to 10 minutes; or by the supporting adult completing some of the activities for the child or young person;
  - removing topics from the programme or intervention, perhaps because of a lack of confidence of the supporting adult, or because an assumption is made that the child or young person already knows the topic well enough;
  - using staff or volunteers who are not adequately trained or qualified;
  - changing the theoretical approach and incorporating other information that is derived from another theoretical perspective;
  - using fewer staff members to deliver the programme or intervention than recommended.

(from O'Connor, Small & Cooney, 2007)

Non-standard approaches to intervention

As long as they are closely matched to a child's identified needs (e.g. see Figure 6) and are regularly monitored in terms of their impact on a child's progress (e.g. see Figure 5), most of the interventions outlined above (as well as many others not mentioned above) should be expected to meet the needs of most dyslexic children. Indeed, Duff and Clarke (2011) note that *"a good understanding has been reached*

regarding how to ameliorate word-level weaknesses in children with dyslexic difficulties…" (p. 5). However, there remain some children for whom barriers to their literacy remain significant and resistant to most interventions, *"Notwithstanding this, there is a growing appreciation that even interventions that honour best practice are not effective for all children…. Ongoing work is needed in order to understand the profiles of non-responders and how interventions can be adapted to suit their needs"* (Duff & Clarke, 2011, p.5). Shaywitz, Morris and Shaywitz (2008) also note that there is no single approach to, or programme of, intervention that will meet the needs of all struggling readers, or even any tightly defined group of struggling readers. There is an ongoing debate about whether standardized intervention programmes are more or less effective than individualised approaches in meeting the needs of struggling readers (e.g. Vaughn, Fletcher, Francis, Denton, Wanzek, Wexler et al, 2008; Wanzek and Vaughn, 2007 but see also Denton, Tolar, Fletcher, Barth, Vaughn and Francis, 2013). As such, for some children with the most severe and persistent needs that are most resistant to standard packages of intervention it may be more appropriate for them to access a bespoke package of interventions and approaches designed to reflect their individual needs including their motivation, self-esteem, self-efficacy). In drawing on implications from academic reading research there is a wider pool of evidence for interventions than may be reflected in educational practice. For example, reading interventions based on struggling learners accessing larger (and arguably more phonologically consistent units) of sound such as onset-rimes so that readers can learn using rhyme analogies (e.g. Goswami and Bryant, 1990) have been gaining ground and a growing evidence-base. For example, Graphogame-Rime, a computer-based intervention aimed to support struggling readers in developing phonological awareness at the level of rhyme analogy as well as through phoneme identification and blending have been shown to support progress for struggling readers more effectively than the same intervention using phoneme identification and blending alone (Kyle, Kujala, Richardson, Lyytinen, & Goswami, , 2013). There is currently local research underway exploring the effectiveness of Graphogame Rime for struggling readers in Cambridgeshire.

Similarly, there is a growing local body of research around the effectiveness of an approach called the Expanded Rehearsal Technique which aims to support the

development of children's automaticity and fluency in their phonic knowledge as well as their whole word recognition.

There are a number of interventions that have not been embraced as widely in education, for many of the same reasons as their associated theories have not been (see earlier sections on models of dyslexia). However, there are nascent pools of evidence implying that some of these interventions have been successful in helping some dyslexic individuals with their reading. These theories (and presumably therefore, their consequent interventions) are presented as complements to (and not competitors of) core Phonological Deficit theory (e.g. Snowling, 2000) and its associated phonological interventions. In considering that there remain dyslexic children who do not respond to phonological intervention alone, it may be remiss to disregard evidence of the effectiveness of the following interventions altogether.

Ray, Fowler and Stein (2005) present evidence that using yellow filters for three months when reading significantly increased dyslexic children's reading ages compared to those who had worn a placebo filter. This may provide a long-sought-after scientific basis for oft-cited anecdotal evidence that coloured overlays can be helpful for struggling readers. Lovett, Steinbach and Frijters (2000) found that a metacognitive phonics program that incorporated phonological interventions as well as interventions designed to increase naming speed, was more effective than a phonological reading program alone. Finally, as a result of the DAD-cerebellar model of dyslexia (e.g. Nicolson and Fawcett, 1990) an exercise-based intervention program was devised to accentuate the efficiency of cerebellar processing; Dyslexia, Dyspraxia and Attention-Deficit Treatment (DDAT). Following a six-month exercise-based intervention, Reynolds, Nicolson and Hambley (2003) found significant gains in children's reading ability (as measured by reading age). Furthermore, Reynolds and Nicolson (2007) found that these gains were maintained following an eighteen month interval.

Summary

Interventions should be targeted and based on assessment of individual struggling reader's needs. There are a huge number of reading interventions in existence. This section has aimed to provide some information about the general characteristics of reading interventions that tend to support struggling readers (e.g. vocabulary development, reappeared reading, development of phonological skills etc) and then to consider some of the evidence-based interventions as reported by Brooks (2013) following a meta-analysis of intervention evaluations for children in primary school, Key Stage 3 and those with the most persistent needs. The value of individualised approaches as opposed to standardised packages of interventions was discussed for some children with the highest levels of need and some further links between academic reading research and implications for interventions in practice were reviewed. Throughout all of this, the importance of matching interventions to needs and closely monitoring effectiveness and impact are emphasised.

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