Chapter 23

Dyslexia and Deafness

Rosalind Herman and Penny Roy

Abstract

Until recently, the dearth of normative literacy data for deaf children and adults has made it difficult to know what was typical for this group, and therefore it has been challenging to determine whether a deaf individual's profile of skills was uneven or discrepant. In this chapter, we present an in-depth case study of a deaf child referred with suspected dyslexia. An approach to assessment is outlined and test findings are presented, comparing the child's test scores with the profile of dyslexia reported for hearing children. The deaf child's pattern of performance is then placed in the context of findings from a large sample of deaf children who were part of a recently completed UK research study investigating reading and dyslexia in deaf children.

Keywords: deaf, dyslexia, reading, sign language, phonological abilities

A recent UK government report (Rose, 2009) entitled "Identifying and Teaching Children and Young People With Dyslexia and Literacy Difficulties" defined dyslexia as a "learning difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling" (p. 10). In contrast to earlier definitions (e.g., Lyon, Shaywitz, & Shaywitz, 2003), no reference was made to the specificity of the learning difficulty. Indeed, drawing on research evidence, the report concluded that dyslexia is best thought of as a continuum that occurs across a range of intellectual abilities, both in terms of the kinds of skills affected (Stanovich & Siegal, 1994) and response to treatment (Vellutino, Scanlon, & Lyon, 2000).

Nevertheless, the issue of cognitive referencing in dyslexia has not entirely gone away. Professionals involved in the identification of dyslexia have cited cognitive measures as the second most frequently used measure to identify dyslexia for exam/resources purposes after reading tests and before spelling, and a significant proportion used a discrepancy criterion as part of their decision process (e.g., Rose, 2009). Similarly, a number of researchers retain the reading versus IQ discrepancy definition of dyslexia, seeing it as a more cautious strategy that maximizes the possibility of identifying the cognitive deficits that underpin the reading problems (Hulme & Snowling, 2009). Further, co-occurring low cognitive abilities increase the risk, if not the nature, of reading difficulties (Catts, Fey, Tomblin, & Zhang, 2002). Lack of agreement about cognitive referencing and different cutoffs and measures adopted may contribute to the range of prevalence reported, with rates of dyslexia varying between 3% and 10% of the population, with boys somewhat more affected than girls, particularly in clinical samples.

As Snowling and Hulme (2012) noted, reading is “a complex skill that depends on a range of cognitive and linguistic factors” (p. 3). A distinction is often made, based on Gough and Tunmer’s (1986) simple model of reading, between decoding skills and language skills, both of which are considered essential for reading with meaning (reading comprehension). Although evidence has challenged the clear demarcation of skills suggested by the simple model, particularly beyond the initial stages of reading acquisition (Ouellette & Beers, 2010), there is general agreement that decoding is an essential first step in the process of becoming literate.

Decoding is the ability to map the sounds of spoken words (phonemes) onto the visual representations of written symbols (graphemes) that constitute printed words and text. Decoding skills rely on exposure to language and the existence of a well-established speech sound (phonological) system, and dyslexia is due to deficits in these skills. However, relations between graphemes and phonemes vary across different languages. In transparent orthographies (e.g., Italian), where graphemes map directly onto phonemes, the serial decoding skills involved in word recognition are essentially the same as those involved in reading unfamiliar nonwords. In contrast, in opaque orthographies such as English, a significant proportion of words are irregular and word recognition draws on word-specific orthographic knowledge and context, in addition to those skills required to decode regular words.

Before turning to consider the nature of these decoding skills in more depth, it is worth noting that the lion's share of research has focused on reading accuracy in dyslexia, even though fluency deficits (Fletcher, Lyon, Fuchs, & Barnes, 2007) and spelling problems (Maughan et al., 2009) may be more severe and persistent and less easy to remediate. Although word recognition can be achieved through partial cues, spelling is more reliant on high-quality lexical representations (Perfetti, 1997).

While other factors may be involved in dyslexia, deficits in phonological abilities known to be key in early reading acquisition are seen to be core (Hulme & Snowling, 2009, 2013; Snowling, 2000). As Hulme and Snowling (2013) noted, three main predictors of early decoding skills in alphabetic languages have been identified: letter knowledge (LK), phonological awareness (PA), and rapid automatized naming (RAN; see Rose, 2009). PA refers to skills involved in the explicit perception, storage, retrieval, and manipulation of speech sounds, and it includes tasks that require the manipulation at the phoneme level (such as phoneme deletion/isolation or spoonerisms) and rhyme ("rime") awareness tasks that involve identifying initial consonant(s) (onsets, e.g., alliteration awareness tasks) or final rhyme (vowel and consonants, e.g., rhyme awareness tasks). Young children's knowledge of letters in their native language, particularly of letter sounds, plays a crucial role in learning the alphabetic principle. Evidence from a large meta-analysis of studies suggested that phonemic awareness is more predictive and discriminating of reading than either rime awareness or verbal short memory (Melby-Lervåg, Halaas Lyster, & Hulme, 2012). RAN tasks measure the naming speed of highly familiar items, including colors, pictures, letters, or digits, and are thought to tap both fluency and automaticity of reading (Norton & Wolf, 2012). RAN tasks, like verbal memory tasks (e.g., digit/word span), are seen as implicit PA tasks, where phonological processing skills are automatically engaged in without conscious awareness or effort.

Interestingly, although intervention studies have underscored the role of PA in reading skills, RAN seems relatively independent of PA and impervious to training, with no obvious benefits found following RAN training for either RAN test scores or reading ability (Hulme & Snowling, 2013). More generally, while a significant proportion of reading difficulties respond to well-founded intensive interventions, some do not (see Duff & Clarke, 2011). The Rose Report argued that these individual differences in response provide a good indication of the severity and persistence of dyslexic difficulties (Rose, 2009), which in turn may relate to the number and nature of underlying deficits. Tilanus, Segers, and Verhoeven (2013), for example, found that the profiles of poor readers were much more varied in terms of the preliteracy measures involved than those of typical Dutch readers.

Many dyslexics have deficits in more than one phonological domain and most researchers agree that the pattern of phonological precursors involved is complex (Ziegler et al., 2008), varies across age and developmental stage (Ouelette & Beers, 2010), and that different developmental trajectories can be implicated (Lyytinen et al., 2006). Correlations between PA and RAN are low and there is some evidence that children with a double deficit have more extensive reading and spelling problems (Torppa et al., 2013). Furthermore, in line with Pennington's (2006) multiple-deficit model of developmental disorders, dyslexia often co-occurs with other disorders, for example attention-deficit/hyperactivity disorder (ADHD), and some problems related to comorbidity, such as inattention, may exacerbate the cognitive deficits associated with dyslexia (Torppa et al., 2013).

It is generally agreed that phonological deficits are constitutional problems and genetically based, particularly in cases where deficits are severe (Bishop & Snowling, 2004). However, environmental factors are significant, too; home literacy backgrounds can contribute or detract from the development of literacy and reading habits, and it follows that some of the heritability of dyslexia is due to an interaction between these factors (Snowling, 2008; Snowling, Muter, & Carroll 2007;). For example, Heath et al. (2014) showed family factors (e.g., socioeconomic status) added to the amount of variance in literacy outcomes explained by within-child factors, including RA, LK, and PA. However, environmental factors were not consistent across domains: family factors (including school socioeconomic status, mother's level of education, parents' phonological awareness, parents' perceived self-efficacy, and family history of reading difficulties) influenced PA and letter knowledge but not naming skills. Children with three (or more) family risk factors had weaker pre- and early literacy skills than those with fewer or none. Thus, compromised early language environments due to deafness or low-socioeconomic-status backgrounds (Roy & Chiat, 2013) may mean children enter school without the necessary phonological and semantic prerequisites for reading, which in turn may exacerbate any individual predisposition for weak PA skills and hence increase the likelihood of dyslexia in these vulnerable children.

Phonological Skills in Deaf Readers

The difficulties experienced by deaf children in learning to read have been widely reported (see Chapter 27, this volume). Some researchers have highlighted the contribution of poorly developed phonological awareness, suggesting that, as with hearing children, phonological skills are predictive of reading in deaf children (Campbell & Wright, 1988; Harris & Beech, 1998; Spencer & Tomblin, 2008) and adolescents (Gravenstede & Roy, 2009; Hanson, Shankweiler, & Fischer, 1983). Others have suggested that reading in deaf individuals may proceed without the development of phonological awareness skills (Dyer, Szczerbinski, MacSweeney, Green, & Campbell, 2003; Waters & Doehring, 1990). Much of the research has been based on mixed samples with a variety of communication preferences, and it is possible that this factor may, to some extent, explain the conflicting findings. Where explicit comparisons have been made between participants who use spoken language and sign language, results indicate that communication mode influences the use of phonological recoding with stronger associations identified among deaf individuals who use spoken language than those who use sign language in reading (Miller, 2002) and in spelling (Wakefield, 2006).

In a meta-analysis of research studies on the relationship between phonological skills and reading in the deaf population, Mayberry, del Giudice, and Lieberman (2011) concluded that phonological skills were only moderately predictive of reading and that other factors, in particular language, played a more significant role. However, the studies reviewed by Mayberry et al. focused almost exclusively on deaf individuals' performance on rhyme tasks, which are strongly influenced by language in deaf children (Herman, Roy, & Kyle, 2014). Although Mayberry et al. suggested that phonemic processing may be a better predictor of reading than rhyme processing, their conclusion that language plays a significant role cannot be disentangled from the limited phonological measures included in the studies that they reviewed. Indeed, in a recent large UK study that included a wide variety of phonological tasks, the predominant influence of phoneme manipulation rather than rhyme tasks was evident among deaf children who use spoken language, once vocabulary was controlled (Herman et al., 2014).

There are also differences in the way that deaf and hearing children develop their phonological representations. Whereas hearing children rely in the main on acoustic information, deaf children augment this with visual information provided by speechreading

(Dodd, 1976; Harris & Moreno, 2006). Indeed, deaf children's speechreading skills have been shown to be associated with reading (Kyle & Harris, 2006; Kyle, MacSweeney, Mohammed, & Campbell, 2009).

Despite findings that deaf children have weaker phonological skills in comparison with hearing peers, both in terms of phonological awareness and phonological coding (e.g., Harris & Beech, 1998; Leybaert & Alegria, 1993; Waters & Doehring, 1990), very little consideration has been given to the possibility that some deaf children may have dyslexic difficulties that either account for or further compromise these phonological difficulties. Given that there is often a genetic component in dyslexia (Pennington & Olson, 2005), it is likely that some deaf children will be dyslexic.

Of the handful of studies that have investigated the co-occurrence of dyslexia and deafness, only one has considered the role of phonological skills, and this study involved children with mild to moderate sensorineural hearing loss rather than severe to profound losses (Park, Lombardino, & Ritter, 2013). This study found word reading and spelling accuracy of the moderately deaf group was poorer than age-matched, typically developing children, but better than children with dyslexia. The authors concluded that children with moderate sensorineural deafness compensated for weak phonological awareness skills with intact rapid naming ability and orthographic recognition.

Samar and colleagues (Samar & Parasnis, 2005, 2007; Samar, Parasnis, & Berent, 2002) examined the contribution of underlying visual deficits to dyslexia in deaf adults. Pointing specifically to the contribution of the magnocellular visual system, Samar et al. (2002, 2005) suggested that all poor deaf readers may be dyslexic on the basis of this marker, and that dyslexia may be the largest secondary disability in the deaf population. However, the role of visual deficits in dyslexia among the hearing population is controversial. Although they frequently co-occur, whether or not they are part of the underlying cause of dyslexia remains unclear (Hulme & Snowling, 2009; Vellutino, Fletcher, Snowling, & Scanlon, 2004).

Identifying Dyslexia in a Deaf Child

To determine whether a deaf child may be dyslexic, it is important to establish initially that reading is problematic. As mentioned earlier, reading level must be considered not only in relation to chronological age but also in relation to cognitive development to investigate any discrepancy between them. Furthermore, in line with the phonological model of dyslexia, it is important to evaluate the contribution of any phonological deficits.

Central to the diagnostic process is the availability of normative data, as this allows comparison of an individual with his or her peer group. Indeed, normative data on reading and dyslexia-related measures have played a key role in the diagnosis and in our improved understanding of dyslexia among hearing children and adults (Snowling, 2000). The lack of equivalent data for the deaf population leads to several problems. Although the use of hearing norms is appropriate for increasing numbers of deaf children who are schooled alongside their hearing peers (Consortium for Research into Deaf Education, 2013; De Raeve, Baerts, Colleye, & Croux, 2012; Uziel, Sillon, & Vieu, 2007), not all measures are equally suitable for deaf children. This may be due to the way that the test is delivered or because the test content disadvantages the deaf child. For example, spelling ability is often assessed by a spelling to dictation task. For a deaf child, performance on this type of task is inextricably bound with the child's speech perception abilities. This means that words that sound similar, or appear the same when speechreading such as sad/sat, are easily confused, with the result that errors are made, but not only because of poor spelling. Some spelling tests include a high number of items with morphological inflections such as /s/ used to mark plural, third-person and possessive or /ed/ to mark past tense in English. Many deaf children find it difficult to distinguish these unstressed endings, and written responses that omit them may be incorrectly scored as misspellings.

Poor speech intelligibility can impact test scores where a spoken response is required. Herman et al. (2014) ensured that testers were familiar with deaf speech patterns when testing deaf children who used spoken language. Nonetheless, tests of reading accuracy still presented challenges to interrater reliability. Poor speech intelligibility can also impair performance on key phonological awareness tasks such as spoonerisms or phoneme deletion, where articulatory precision is needed. For this reason, some researchers have developed measures specifically for deaf children that use picture-pointing responses instead of spoken language (e.g., James, Rajput, Brinton, & Goswami, 2008).

The skills of the person carrying out the assessment may also influence findings. Tests must be delivered by professionals with a high level of skill in communicating clearly and flexibly with deaf children (Herman, 2014). Such skills include the ability to use clear speech patterns, sign language, and/or sign support according to each child’s communication preference. Flexible communication is important to ensure that the deaf child understands what he or she is required to do and for the child to have full access to the individual test items. Even then, deaf children may need additional practice items to understand task demands.

Testers must additionally be aware of the need to check hearing aids or cochlear implants and optimize the test environment, which should be quiet, well lit, free from distractions, and conducive to the needs of a hearing aid or cochlear implant user. Where testers lack the necessary communication skills, or are unable to check amplification that is functioning correctly, identifying and training staff with the appropriate skills to deliver the assessment is an option (Herman, 2014).

When testing a signing deaf child, particular care must be taken when translating tests because a measure developed for one language may not be equivalent in another (Haug &

Mann, 2008; see Chapter 20, this volume). For example, directly translating reading comprehension questions may inadvertently reveal the meaning where the translated sign is iconic, thereby simplifying the task for the child (e.g., “scraps” in British Sign Language).

Due to these challenges, it is unsurprising that many deaf children perform poorly on standardized reading tests. However, there is a dearth of information about the range of typical performance of sizeable groups of deaf children on standardized measures. Such information is essential for professionals in order to be able to confidently diagnose a deaf child with dyslexia. It is notable that the only reported intervention study of (two) deaf individuals with dyslexia is from the United States, where deaf norms are available to facilitate diagnosis (Enns & Lafond, 2007).

In the next section, we introduce Jack, a signing deaf child referred to the clinical facility at City University London with suspected dyslexia. The team’s approach to the selection of appropriate tests and to conducting the assessment sessions are outlined. Jack’s results from a large test battery are presented and the questions that remained unanswered due to the absence of normative data are highlighted. Jack’s test results are then compared with findings from a recently completed UK study that collected normative data from large numbers of deaf children using a battery of similar tests. Data from this study have allowed us to place this single case in the context of his deaf peers in order to better understand his reading difficulties and intervention needs.

Case Study: Jack

Jack was referred to the clinical facility at City University London following teacher concerns that he was not making the expected progress with his reading. Jack was 12 years old and the only deaf child in a hearing family. There was a strong family history of reading difficulties in that both his mother and younger sister were dyslexic. Jack’s teacher of the deaf felt strongly that Jack needed the additional specialist reading support that a diagnosis of dyslexia would bring, support that was available to hearing dyslexic children in his school. However, the school educational psychologist did not feel equipped to make such a diagnosis in a deaf child.

Background

Having passed hearing screening at 7 months, Jack was initially diagnosed with a severe-profound bilateral sensori-neural hearing loss at the age of 3 years. This was subsequently confirmed to be a moderate-severe loss accompanied by auditory neuropathy, characterized by inconsistent auditory responses to pure tones, no brainstem responses at 100 dBHL, and an inability to process complex linguistic information. Although provided with bilateral hearing aids, Jack refused to use them because he did not find them helpful.

Prior to deafness being diagnosed, Jack presented with challenging behavior and delayed language development. Although his behavioral difficulties resolved, he continued to have sleeping problems, which were helped by avoidance of sugary food and drink. Other developmental milestones were within normal limits.

Jack was introduced to British Sign Language (BSL) at the age of 4 years. At the time of referral, parents and teachers described his language environment as consisting of a combination of BSL and sign-supported English (SSE—key word signs accompanying spoken English) at home and at school. Levels of BSL use at home were at a very basic level. At school, a resource unit for deaf children attached to a mainstream school, Jack was one of four deaf children with a range of ages. He spent part of his time in the mainstream class where he was the only deaf child and was supported either by a language support professional or a qualified teacher of the deaf. Jack's school report presented an uneven educational profile with extremely low grades in English, below-average performance in mathematics, yet he was at the level expected for his age in science. He was described as having difficulties maintaining attention in class, behavior that was reduced in 1:1 settings.

Assessment Decisions

Selection and delivery of a suitable test battery was strongly influenced by Jack's preferred mode of communication in sign, with very poor spoken language skills. This meant that classic dyslexia measures such as phoneme manipulation and nonword reading could not be used, although some researchers have shown that these measures are appropriate for deaf children with stronger oral skills (Gravenstede & Roy, 2009; Herman et al., 2014). It was important that tests were presented in BSL; therefore, a deaf researcher who was a native signer delivered all measures under the guidance of the clinical team. Jack was assessed over two sessions using a battery of language, nonverbal, literacy, and phonological measures.

Language

There is a dearth of standardized language measures in sign languages (Haug & Mann, 2008). Fortunately, there were two BSL measures available; however, these did not include a vocabulary measure. This was a limitation of our battery, since vocabulary is known to be strongly associated with literacy (e.g., Kyle & Harris, 2006). The two standardized measures used to obtain a profile of Jack's language attainment in BSL were the BSL Receptive Skills Test (Herman, Holmes, & Woll, 1999) and the BSL Production Test (Herman et al., 2004). The BSL Receptive Skills Test is a video-based test assessing comprehension of BSL sentences of increasing grammatical complexity, with norms derived from deaf children acquiring BSL as a first language. The BSL Production Test uses a language-free video to elicit a narrative sample for analysis of narrative skills and BSL grammar.

No measures of spoken language development were administered since some assessment results were available from the school speech and language therapist. These results are presented alongside the other findings.

Nonverbal and Verbal Performance

Nonverbal subtests from the Wechsler Intelligence Scale for Children (WISC-III UK, Wechsler, 1992 and WISC-IV UK, Wechsler, 2004) were used to evaluate Jack's nonverbal abilities. These included the three core subtests from the WISC-IV UK: Block Design, Picture Concepts, and Matrix Reasoning, plus four supplementary subtests from these test batteries: Picture Completion—visual perception and organization; Picture Arrangement—nonverbal reasoning and sequencing; Symbol Search—processing speed; and Digit Span—working memory, an area known to be affected in dyslexia. A further test of Immediate and Delayed Verbal and Visual Recall from the British Abilities Scales (Elliott, Smith, & McCulloch, 1996) was also used.

Literacy, Phonological Awareness, and Dyslexia-Sensitive Measures

Single-word reading, reading comprehension, and spelling were assessed using the Wechsler Objective Reading Dimensions (WORD, Rust, Golombok, & Trickey, 1993). Letter-sound knowledge was tested informally by going through the fingerspelling alphabet and requesting the sound associated with each letter. Phonological skills were assessed using the Semantic, Alliteration and Rhyme Fluency tasks from the Phonological Assessment Battery (PhAB; Frederickson, Frith, & Reason, 1997).

Finally, Jack's ability to recall familiar sequences (the days of the week and months of the year) was measured because this is a known area of difficulty among hearing dyslexics.

Assessment Findings

Jack's BSL, nonverbal, literacy, and phonological assessment results are presented in Table 23.1.

[INSERT TABLE 23.1 HERE]

The BSL test results indicated average language comprehension abilities for his age but weaker expressive language with his score for BSL grammar in the low-average range. The latter was attributed to his predominant use of SSE and his limited opportunities to communicate with fluent signers at home and at school. Jack's BSL levels on these tests were higher than his observed performance in class, where he was easily distracted by visual stimuli, had pervasive inattention, and was less motivated.

Jack's relatively good communication skills in BSL were contrasted with his more limited spoken language abilities. From his performance on selected subtests from the Clinical Evaluation of Language Fundamentals-III (CELF; Semel, Wiig, & Secord, 1995), Jack's speech and language therapist described his spoken language comprehension and expressive skills as very low for his age. He was able to respond to three-word spoken instructions without sign support, but he would often look away before the instructions had been fully delivered. Spoken instructions needed to be delivered at a slow speaking rate. He struggled to understand question words (e.g. "who," "what," "where"), pronouns, and tenses. His understanding of vocabulary was poor with many gaps evident.

Expressively, Jack's spoken language was more delayed than his receptive language. His speech sound system was reduced with many sounds omitted. At the time we saw Jack, therapy was targeting fricative and velar sounds. Although able to copy two-syllable words correctly, Jack struggled with longer words. His speech was unintelligible unless supported by SSE. Jack's expressive vocabulary was at a very low level and he used short sentences following BSL sentence structure. He was able to correctly use many prepositions, adjectives, and negative forms in BSL.

Results from the six nonverbal WISC subtests showed Jack to have a mixed profile, with four scores in the average and above-average ability range (Block Design, Picture Completion, Symbol Search, and Picture Arrangement) and two scores below average: Picture Concepts and Matrix Reasoning. His score for Picture Arrangement was in the exceptionally high ability range. Along with his score for Picture Completion, Jack's performance on these two subtests is in line with his reported ability to glean information from diagrams and pictures.

Jack's low score for Picture Concepts is likely to have been affected by his poor knowledge of the lexical labels for higher order conceptual categories. His below-average score on Matrix Reasoning is somewhat surprising, especially compared with his much higher score on Block Design, which is a similar task. However, these tasks differ in that Matrix Reasoning demands close attention to detail and unlike Block Design, there is no reference model for checking. The correct answer is arrived at by identifying one of a number of options provided, and Jack may have been less motivated to work through all the logical steps necessary to achieve the right answer, opting instead for a quick and incorrect solution that matched some, but not all of the criteria involved.

Jack's Delayed Verbal Recall and was superior to his Immediate Verbal (signed) Recall, which fell just below the average range. However, his Immediate and Delayed Visual Recall scores were at ceiling: He identified and placed all objects correctly. The Delayed Recall task is based on the same picture of a set of objects used for the Immediate Recall task, and it is likely that his improved performance on the Delayed Verbal Memory Task was supported by his visual recall of the same objects. Taken together, Jack's nonverbal performance on all these measures displays at least average abilities for his age and in some areas he is performing above the average range.

These findings are in stark contrast with Jack's extremely low scores on all literacy measures. The age-equivalent scores indicate that his single-word and reading comprehension scores were substantially below what would be expected for his age and barely above the floor of the test. He was only able to read words within his sight vocabulary and his comprehension of text was extremely poor. It is possible that the accompanying pictures on the WORD reading comprehension measure were a distraction for him, as they may have played into his preference for interpreting pictorial information at the cost of paying attention to the written word. Jack's spelling was also poor, although slightly better than his reading, as has been reported elsewhere for deaf children (e.g., Aaron, Keetay, Boyd, Palmatier, & Wacks, 1998). He was as likely to correctly spell familiar irregular words as regular words. His writing was slow but legible with an immature script. Jack knew the names of the letters of the alphabet and most but not all of the sounds. This was a relatively recent achievement after a considerable amount of training by his support teacher.

Jack's score for Digit Span (forward and backward recall of strings of numbers) was markedly below average for his age. The WISC-III UK (Wechsler, 1992) manual cautions the use of this test for deaf sign users as they argue that it might be approached as a visuospatial task rather than as a measure of auditory/phonological memory, which it is taken to be in the hearing population. It seems unlikely this applied to Jack, whose recall of visual material was good in comparison to his poor recall of written material.

The contrasting scores obtained on the fluency tasks further highlighted Jack's specific difficulty with phonology. Jack found Semantic Fluency the easiest, obtaining a score within the average range. However, his scores on the Alliteration and Rhyme tasks were markedly below average: He was able to produce very few words starting with the same initial letter and none at all that rhymed. Below-average performance on this kind of phonological awareness task is not uncommon in the deaf population (Gravenstede & Roy, 2009). However, in the absence of group data, it was impossible to say to what extent Jack's performance was typical of all deaf children. Furthermore, whether poor performance was due to poor phonology or poor language remained unclear. What was more striking, as far as Jack's literacy was concerned, was that his strong visuospatial skills had not compensated for his specific deficit in phonological representations and recall.

Jack's scores on the Naming Speed task were also revealing. He obtained a below-average score for Naming Speed for Digits and an above-average score for Pictures. Naming Speed performance is significantly correlated with reading difficulties in hearing children

(Bowers & Wolf, 1993; Compton, DeFries, & Olson, 2001; Fawcett & Nicolson, 1994; Kail & Hall, 1994). Typically developing hearing children are better with letters and digits than pictures, since digits constitute a more constrained category and are more readily automatized (Wolf & Bowers, 1999). However, the reverse is true for hearing children with dyslexia (e.g., Bowers et al., 1998; Savage & Frederickson, 2006; Semrud-Clikeman, Guy, & Griffin, 2000), and Jack's profile follows this pattern.

The association between naming speed and poor reading in deaf children has been disputed by Dyer et al. (2003). They used a rapid picture-naming task with a large sample of deaf children but found no relationship between naming speed and reading levels, despite the fact that many of their deaf participants were poor readers. Jack's high score for the Pictures task was in line with the findings of Dyer et al. (2003), reflecting his adequate BSL skills. However, at the time of testing, data from other deaf children were not available for comparison with his substantially lower score for the digits task. In its absence, his pattern of performance appeared to closely fit a dyslexic profile.

The final task used was recall of familiar sequences. Jack spontaneously chose to write down the sequences. This strategy aided his recall, although the words were misspelled and not written in the correct chronological sequence initially. Jack had recently mastered the order of days of the week and this was evident in his performance, but he had considerable problems with the months of the year. Four months were represented by only their first letter or letters, for example "A" for August, "Oc" for October, one was omitted and there were sequencing errors. By the age of 12, this skill should be established in hearing children; at the time of testing, there were no comparable data available for deaf children.

Overall, Jack's profile showed strong nonverbal abilities with some test scores at an exceptionally high level alongside extremely poor scores for literacy and phonological tasks. The disparity between these areas of ability was striking. His excellent visual recall might have been expected to compensate more, such as by using visual orthographic skills, since he used visual strategies where possible to support his learning. However, his literacy and most areas of his academic performance were seriously constrained by his very poor literacy skills, suggesting that Jack's difficulties with written material were very specific. This was despite the fact that Jack was a child who enjoyed books, rather than avoided them.

Jack's selective deficits in verbal fluency, digit span, and naming speed were the same as those reported for hearing children with dyslexia. Indeed, Jack's test profile was almost identical to JM, a hearing child with dyslexia described by Snowling, Stackhouse, and Rack (1986). Jack's strong family history of reading difficulties in two immediate family members plus his limited language exposure further supported a diagnosis of dyslexia.

However, some questions remained unanswered. Without access to group data, it was difficult to know how Jack's performance compared to the wider population of deaf readers, many of whom have phonological difficulties. Furthermore, it is known that a proportion of hearing dyslexic children have comorbid language difficulties. Although this was not the case for Jack in BSL, his spoken language, upon which reading is based, was at a very low level. The contribution of poor spoken language to Jack's reading difficulties was therefore an additional factor to consider, one that forced us to question again how much of Jack's profile was potentially due to deafness.

Placing Jack's Profile in Context

Between 2010 and 2014, our team carried out two major UK studies investigating profiles of good and poor deaf readers to determine whether dyslexia could be reliably identified within the deaf population. The first phase of this research collected data from a representative group of 79 deaf children aged 10–11 years who used spoken language to communicate (Herman et al., 2014). A large battery of language, nonverbal, literacy, and phonological measures was assembled, including many similar to those we had used with Jack.

Deaf participants' test scores were compared with data from a small reference group of hearing dyslexic children. The second phase of the research repeated data collection with a group of 60 deaf signing children (Herman, Roy, & Kyle, 2015.

From these samples, 23 deaf children were identified who matched Jack's profile, that is, children with a communication preference for signing, a hearing family background, and nonverbal abilities within the normal range. The data have not yet been sufficiently analyzed to confirm whether there are other areas of similarity or difference. However, initial findings from this group shed light on some of the questions raised by the assessment of Jack, since they allowed comparison of some of his scores to those of his deaf peers.

In this subgroup, only one other child had nonverbal abilities that were as high as Jack's. This child had literacy scores in line with his nonverbal level; that is, he did not display the same discrepancy as Jack. Using standardized scores from these 23 matched children, despite different measures being used, an important finding was that Jack's literacy scores were at the level of the poorest readers. Similarly, his score for digit span was exceptionally low, even for deaf children. However, Jack's poor rhyme fluency score was in keeping with that of many other deaf children. His difficulty with recall of sequences was also not unusual when compared to his signing peers, over half of whom were unable to recall the months of the year correctly.

Interestingly, the matched deaf subgroup's mean score was slightly higher for picture naming than for digits, as was the case with Jack. In fact, Jack's picture naming score was one of the highest in the deaf group, whereas his score for digit naming was among the lowest. No other child displayed such a wide discrepancy in scores on this measure.

The availability of normative data from other deaf children has allowed us to revisit our original interpretation of Jack's reading difficulties, arrived at several years previously. In Jack's case, the large discrepancy among his nonverbal scores has proved to be a key indicator, alongside unusually low scores for literacy, digit span, and rapid naming for digits. Several of Jack's scores were far lower than would be expected when compared with data from deaf children with similar family backgrounds, communication preferences, and nonverbal abilities. Interestingly, as we have already mentioned, Jack's test profile emerged as being very similar to that reported for hearing dyslexic children, with a number of factors, including family history, that pointed to a diagnosis of dyslexia.

Interventions for Deaf Children With Dyslexia

Once dyslexia has been confirmed, consideration of the individual's profile of strengths and difficulties can lead to the selection and implementation of appropriate interventions. Indeed, Rose (2009) saw response to intervention across time as part of the diagnostic process. Until now, given the difficulties in identifying dyslexia in a deaf child, deaf children have been denied such interventions.

For some deaf children, particularly those with good spoken language skills, interventions known to be successful for hearing children with dyslexia may be effective (see Brooks, 2007, for a review). Indeed, such interventions may be beneficial for other deaf children who are poor readers with weak phonological skills, not only those with dyslexia (Herman et al., 2014). However, their efficacy with deaf children has not to date been investigated.

For a deaf signing child such as Jack, what might appropriate interventions look like? Some research has already reported phonological interventions that take advantage of deaf children's visual strengths to be successful with poor deaf readers, for example the use of Visual Phonics (Trezek & Malmegren, 2005; Trezek & Wang, 2006). In Jack's case, capitalizing on his strengths could involve developing strategies to link new words with pictures or images, providing opportunities for frequent repetition to develop automaticity and reinforcement by writing words down (Vaughn & Roberts, 2007).

Brooks (2007) noted that the use of computerized and multisensory literacy programs can be highly motivating. He recommended structured teaching provided on a "little and often" basis and use of graphic representation, with time allowed for reinforcement and encouraging children to generalize what they have learned. Brooks highlighted the need for intervention to continue throughout secondary education. For Jack, already at secondary school, where reading is expected to be established, highly intensive individualized intervention to address the basics of reading was essential.

Support for Jack, as for many deaf children, was also needed to address his language deficits. Although his BSL skills were mainly at age level, his language skills in English, upon which literacy is based, and particularly vocabulary, were very poor. Jack was socially isolated with limited opportunities to communicate either at home with family members or at school, with few peers who knew BSL. Provision of opportunities to meet other deaf children outside school was therefore important. Deaf children are known to be at risk of mental health problems (Hindley & Kitson, 2000). The same is true of children with literacy difficulties (Rose, 2009). For a child who is both deaf and dyslexic, the dangers to mental health are potentially multiplied; if such consequences are to be avoided, the implementation of appropriate interventions must be a priority.

Conclusions

Case studies such as Jack provide evidence that some deaf children do indeed have dyslexia as defined by the phonological deficit model (Hulme & Snowling, 2009). This contrasts with the claims of Samar and colleagues that dyslexia in deaf individuals may be due to a visual deficit (Samar et al., 2002, 2005). Although diagnosis of dyslexia in a deaf child is complex, it is achievable with careful selection of assessment tools, appropriate tester skills, and an informed interpretation of findings. The availability of deaf norms on a range of literacy and dyslexia-sensitive measures provides an important contribution to the decision-making process and is of use to professionals wishing to investigate dyslexia in deaf children.

Research into dyslexia in deaf individuals is at an early stage. Our recent research has collected normative data from deaf children according to their communication preference. Analysis to date provides further evidence for dyslexia in deaf children who use spoken language (Herman et al., 2014). Analysis of data from signing children will indicate whether reading difficulties exist equally in this group and whether they follow a similar profile.

Diagnosis of dyslexia is important to the individuals concerned and to their families, for whom anxieties about reading achievement can be extremely damaging (Rose, 2009). Diagnosis can pave the way to the implementation of interventions to address the dyslexic symptoms. However, whether existing dyslexia interventions can be used successfully with deaf individuals or whether alternative approaches are needed remain questions for future research.

References

Aaron, P. G., Keetay, V., Boyd, M., Palmatier, S., & Wacks, J. (1998). Spelling without phonology: A study of deaf and hearing children. Reading and Writing, 10, 1–22.

Bishop, D. V. M., & Snowling, M. J. (2004). Developmental dyslexia and specific language impairment: Same or different? Psychological Bulletin, 130, 858–886.

Bowers, P. G., Sunseth, K., & Newby-Clark, E. (1998). Parametric explorations of single and double deficits in rapid naming and phonemic awareness in grade 3. Paper presented at the Annual Meeting of the Society for the Scientific Study of Reading, San Diego, CA.

Bowers, P. G., & Wolf, M. (1993). Theoretical links between naming speed, precise timing mechanisms and orthographic skills in dyslexia. Reading and Writing, 5, 69–85.

Brooks, G. (2007). What works for pupils with literacy difficulties? London, UK: DCFS.

Campbell, R., & Wright, H. (1988). Deafness, spelling and rhyme. Quarterly Journal of Experimental Psychology, 4OA, 771-788.

Catts, H. W., Fey, M. E., Tomblin, J. B., & Zhang, X. (2002). A longitudinal investigation of reading outcomes in children with language impairments. Journal of Speech, Hearing and Language Research, 45, 1142–1157.

Compton, D. L., DeFries, J. C., & Olson, R. K. (2001). Are RAN and phonological awareness-deficits additive in children with reading disabilities? Dyslexia, 7, 125–149.

Consortium for Research into Deaf Education. (2013). CRIDE Report on 2012 survey on educational provision for deaf children: UK wide summary. Retrieved January 2014, from http://www.batod.org.uk/content/resources/survey/CRIDE2013.pdf

De Raeve, L., Baerts, J., Colleye, E., & Croux, E. (2012). Changing schools for the deaf: Updating the educational setting for deaf children in the 21st century, a big challenge. Deafness and Education International, 14(1), 48–59.

Dodd, B. (1976) The phonological systems of deaf children. Journal of Speech and Hearing Disorders, 41, 185–198. doi:10.1044/jshd.4102.185

Duff, F. J., & Clarke, P. J. (2011). Practitioner review: Reading disorders—What are effective interventions and how should they be implemented and evaluated? Journal of Child Psychology and Psychiatry, 52, 3–12.

Dyer, A., MacSweeney, M., Szczerbinski, M., & Green, L. (2003). Predictors of reading delay in deaf adolescents: The relative contributions of rapid automatized naming speed and phonological awareness and decoding. Journal of Deaf Studies and Deaf Education, 8, 215–229.

Elliott, C. D., Smith, P., & McCulloch, K. (1996). British abilities scales (2nd ed). Windsor, UK: NFER-Nelson.

Fawcett, A. J., & Nicolson, R. I. (1994). Naming speed in children with dyslexia. Journal of Learning Disabilities, 27, 641–646.

Fletcher, J. M., Lyon, G. R., Fuchs, L., & Barnes, M. (2007). Learning disabilities: From identification to intervention. New York, NY: Guildford Press.

Frederickson, N., Frith, U., & Reason, R. (1997). Phonological assessment battery. London, UK: GL Assessment.

Frith, U., Landerl, K., & Frith, C. (1995). Dyslexia and verbal fluency: More evidence for a phonological deficit. Dyslexia, 1, 2–11.

Enns, C., & Lafond, L. D. (2007) Reading against all odds: A pilot study of two deaf students with dyslexia. American Annals of the Deaf, 152, 63–72.

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading and reading disability. Remedial and Special Education, 7, 6–10.

Gravenstede, L., & Roy, P. (2009). Phonological awareness and decoding skills in deaf adolescents. Deafness and Education International, 11(4), 171–190.

Hanson, V. L., Shankweiler, D., & Fischer, F. W. (1983). Determinants of spelling ability in deaf and hearing adults: Access to linguistic structure. Cognition, 14, 323-44.

Harris, M., & Beech, J. R. (1998). Implicit phonological awareness and early reading development in prelingually deaf children. Journal of Deaf Studies and Deaf Education, 3, 205–216.

Harris, M., & Moreno, C. (2006). Speech reading and learning to read: A comparison of 8-year-old profoundly deaf children with good and poor reading ability. Journal of Deaf Studies and Deaf Education, 11(2), 189–201.

Haug, T., & Mann, W. (2008) Adapting tests of sign language assessment for other sign languages—A review of linguistic, cultural, and psychometric problems. Journal of Deaf Studies and Deaf Education, 13, 138–147.

Heath, S. M., Bishop, D. V. M., Bloor, K. E., Boyle, G. L., Fletcher, J., Hogben, J. H., … Yeong, S. H. M. (2014). A spotlight on preschool: The influence of family factors on children's early literacy skills. PLoS ONE, 9, e95255.

Herman, R. (2014) Language assessment in deaf learners. In H. Knoors & M. Marschark (Eds.), Educating deaf learners: Creating a global evidence base (pp. 197-212). New York, NY: Oxford University Press.

Herman, R., Grove, N., Holmes, S., Morgan, G., Sutherland, H., & Woll, B. (2004). Assessing *BSL development: Production test (narrative skills)*. London, UK: City University Publication.

Herman, R., Holmes, S., & Woll, B. (1999) Assessing BSL development: Receptive skills test. Coleford, UK: Forest Books.

Herman, R., Roy, P., & Kyle, F. (2014) Reading, dyslexia and oral deaf children: From research to practice. Retrieved January 2014, from http://www.city.ac.uk/__data/assets/pdf_file/0014/212441/Briefing-paper-Reading-and-dyslexia-in-oral-deaf-children-website-final-version-feb-2014.pdf

Herman, R., Roy, P., & Kyle, F. (2015) Phonological skills and reading in deaf children. Paper presented at the 22nd International Congress on the Education of the Deaf, Athens, Greece.

Hindley, P., & Kitson, N. (2000). Mental health and deafness. London: Whurr.

Hulme, C., & Snowling, M. J. (2009). Developmental disorders of language, learning and cognition. Chichester, UK: Wiley-Blackwell.

Hulme, C., & Snowling, M. J. (2013). The interface between spoken and written language: Developmental disorders. Philosophical Transactions of the Royal Society B, 369, 20120395.

James, D., Rajput, K., Brinton, J., & Goswami, U. (2008) Phonological awareness, vocabulary, and word reading in children who use cochlear implants: Does age of implantation explain individual variability in performance outcomes and growth? Journal of Deaf Studies and Deaf Education, 13, 117–137.

Kail, R., & Hall, L. K. (1994). Processing speed, naming speed and reading. Developmental Psychology, 30, 949–954.

Kyle, F., & Harris, M. (2006). Concurrent correlates and predictors of reading and spelling achievement in deaf and hearing children. Journal of Deaf Studies and Deaf Education, 11(3), 273–288.

Kyle, F. E., Campbell, R., Mohammed, T., Coleman, M., & MacSweeney, M. (2013). Speechreading development in deaf and hearing children: introducing the test of child speechreading. Journal of Speech and Hearing Research, 56(2): 416-426. https://doi.org/10.1044/1092-4388(2012/12-0039)

Leybaert, J., & Alegria, J. (1993). Is word processing involuntary in deaf children? British Journal of Developmental Psychology, 11, 1–29.

Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2003). Defining dyslexia, comorbidity, teachers' knowledge of language and reading. Annals of Dyslexia, 53, 1–14.

Lyytinen, H., Erskine, J., Tolvanen, A., Torppa, M., Poikkeus, A. M., & Lyytinen, P. (2006) Trajectories of reading development: A follow-up from birth to school age of children with and without risk for dyslexia. Merrill-Palmer Quarterly, 52(3) 514–546.

Maughan, B., Messer, J., Collishaw, S., Pickles, A., Snowling, M., Yule, W., & Rutter, M. (2009). Persistence of literacy problems: Spelling in adolescence and at mid-life. Journal of Child Psychology and Psychiatry, 50, 893–901.

Mayberry, R. I., del Giudice, A. A., & Lieberman, A. M. (2011) Reading achievement in relation to phonological coding and awareness in deaf readers: A meta-analysis. Journal of Deaf Education and Deaf Studies, 16(2), 164–188. doi: 10.1093/deafed/enq049.

Melby-Lervåg, M., Halaas Lyster, S-A., & Hulme, C. (2012). Phonological skills and their role in learning to read: A meta-analytic review. Psychological Bulletin, 138, 322–352.

Miller, P. (2002). Communication mode and the processing of printed words: Evidence from readers with prelingually acquired deafness. Journal of Deaf Studies and Deaf Education, 7(4), 312–329. doi: 10.1093/deafed/7.4.312.

Norton, E. S., & Wolf, M. (2012). Rapid automatized naming (RAN) and reading fluency: Implications for understanding and treatment of reading disabilities. Annual Review of Psychology, 63, 427–452.

Ouellette, G., & Beers, A. (2010). A not-so-simple view of reading: How oral vocabulary and visual-word recognition complicate the story. Reading and Writing, 23,189–208

Park, J., Lombardino, L. J., & Ritter, M. J. (2013). Phonology matters: A comprehensive investigation of reading and spelling skills of school-age children with mild to moderate sensorineural hearing loss. American Annals of the Deaf, 158, 20–40.

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. Cognition, 101, 385–413.

Pennington, B. F., & Olson, R. K. (2005). Genetics of dyslexia. In M. J. Snowling & C. Hulme (Eds.), The science of reading: A handbook (pp. 379–396). Oxford, UK: Blackwell.

Perfetti, C. A. (1997). The psycholinguistics of spelling and reading. In C. A. Perfetti, L. Rieban, & M. Fayol (Eds.), Learning to spell: Research, practice, and theory across languages (pp. 21–38). Mahwah, NJ: Erlbaum.

Rose, J. (2009). Identifying and teaching children and young people with dyslexia and literacy difficulties: Final report. London, UK: Department for Children Schools and Families. Retrieved August 2014, from http://webarchive.nationalarchives.gov.uk/20130401151715/http://www.education.gov.uk/publications/eOrderingDownload/00659-2009DOM-EN.pdf

Roy, P., & Chiat, S. (2013). Language and socioeconomic disadvantage: Teasing apart delay and deprivation from disorder. In C. Marshall (Ed.), Current issues in developmental disorders (pp. 125-150). Hove, UK: Psychology Press.

Rust, J., Golombok, S., & Trickey, G. (1993). Wechsler Objective Reading Dimensions (WORD). Sidcup, UK: The Psychological Corporation.

Samar, V. J., & Parasnis, I. (2005). Dorsal stream deficits suggest hidden dyslexia among deaf poor readers: Correlated evidence from reduced perceptual speed and elevated coherent motion detection thresholds. Brain and Cognition, 58, 300–311.

Samar, V. J., & Parasnis, I. (2007). Cortical locus of coherent motion deficits in deaf poor readers. Brain and Cognition, 63, 226–239.

Samar, V. J., Parasnis, I., & Berent, G. P. (2002). Deaf poor readers' pattern reversal visual evoked potentials suggest magnocellular system deficits: Implications for diagnostic neuroimaging of dyslexia in deaf individuals. Brain and Language, 80, 21–44.

Savage, R. S., & Frederickson, N. (2006). Beyond phonology: What else is needed to describe the problems of below-average readers and spellers? Journal of Learning Disability, 39, 399. doi: 10.1177/00222194060390050301.

Semel, E., Wiig, E. H., & Secord, W. A. (1995). The Clinical Evaluation of Language Fundamentals—III. San Antonio, TX: The Psychological Corporation.

Semrud-Clikeman, M., Guy, K., & Griffin, J. D. (2000). Rapid naming deficits in children and adolescents with reading disabilities and attention deficit hyperactivity disorder. Brain & Language, 74, 70–83.

Snowling, M. (2000). Dyslexia (2nd ed.). Oxford, UK: Blackwell.

Snowling, M. J. (2008). Dyslexia. A paper prepared as part of the Foresight Review on Mental Capital and Wellbeing. Retrieved January 2014, from http://webarchive.nationalarchives.gov.uk/20140108144555/http://www.bis.gov.uk/assets/foresight/docs/mental-capital/sr-d2_mcw_v2.pdf

Snowling, M. J., & Hulme, C. (2012). Annual research review: The nature and classification of reading disorders- a commentary on proposals for DSM-5. Journal of Child Psychology and Psychiatry, 53, 593–607.

Snowling, M. J., Muter, V., & Carroll, J. (2007). Children at family risk of dyslexia: A follow-up in early adolescence. Journal of Child Psychology and Psychiatry, 48, 609–618.

Snowling, M. J., Stackhouse, J., & Rack, J. P. (1986). Phonological dyslexia and dysgraphia: A developmental analysis. Cognitive Neuropsychology, 3, 309–339.

Spencer, L. J., & Tomblin, J. B. (2008). Evaluating phonological processing skills in children with prelingual deafness who use cochlear implants. Journal of Deaf Studies and Deaf Education. doi: 10.1093/deafed/enn013.

Stanovich, K. E., & Siegel, L. S. (1994). The phenotypic performance profile of reading-disabled children: A regression-based test of the phonological-core variable-difference model. Journal of Educational Psychology, 86, 24–53.

Tilanus, E. A. T., Segers, E., & Verhoeven, L. (2013). Diagnostic profiles of children with developmental dyslexia in a transparent orthography. Research in Developmental Disabilities, 34, 4194–4202.

Torppa, M., Parrila, R., Niemi, P., Lerkkanen, M. K., Poikkeus, A. M., & Nurmi, J. E. (2013). The double deficit hypothesis in the transparent Finnish orthography: A longitudinal study from kindergarten to grade 2. Reading and Writing, 26(8), 1353–1380. doi: 10.1007/s11145-012-9423-2.

Trezek, B. J., & Malmgren, K. W. (2005). The efficacy of utilizing a phonics treatment package with middle school deaf and hard-of-hearing students. Journal of Deaf Studies and Deaf Education, 10, 256–271.

Trezek, B. J., & Wang, Y. (2006). Implications of utilizing a phonic-based reading curriculum with children who are deaf or hard-of-hearing. Journal of Deaf Studies and Deaf Education, 11, 202–213.

Uziel, A. S., Sillon, M., & Vieu, A. (2007). Ten-year follow-up of a consecutive series of children with multichannel cochlear implants. Otology and Neurotology, 28, 615–628.

Vaughn, S., & Roberts, G. (2007). Secondary interventions in reading: Providing additional instruction for students at risk. Teaching Exceptional Children, 39, 40–46.

Vellutino, F. R., Scanlon, D. M., & Lyon, G. R. (2000). Differentiating difficult-to-remediate and readily remediated poor readers: More evidence against the IQ-achievement discrepancy definition of reading disability. Journal of Learning Disabilities, 33, 223–238.

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

Wakefield, P. (2006). Deaf children's approaches to spelling—difficulties, strategies and teaching techniques. Deafness and Education International, 8(4), 174–189. doi: 10.1002/dei.205.

Waters, G. S., & Doehring, D. G. (1990). Reading acquisition in congenitally deaf children who communicate orally: Insights from an analysis of component reading, language, and memory skills. In T. H. Carr & B. A. Levy (Eds.), Reading and its development: Component skills approaches (pp. 323–373). San Diego, CA: Academic Press.

Wechsler, D. (1992). The Wechsler Intelligence Scale for Children (3rd ed.). London, UK: The Psychological Corporation.

Wechsler, D. (2004). The Wechsler Intelligence Scale for Children (4th ed.). London, UK: Pearson Assessment.

Wolf, M., & Bowers, P. G. (1999) The double deficit hypothesis for the developmental dyslexias. Journal of Educational Psychology, 91(3), 415–438.

Ziegler, J. C., Castel, C., Pech-Georgel, C., George, F., Alarion, F-X., & Perry, C. (2008). Developmental dyslexia and the dual route model of reading: Simulating individual differences and subtypes. Cognition, 107, 151–178.

Table 23.1 Jack's Assessment Results

Assessment Target	Measure	Result
Nonverbal skills	WISC-IV^{UK} Block design	Average
	WISC-IV^{UK} Picture completion	Above average
	WISC-IV^{UK} Matrix	Low
	WISC-IV^{UK} Picture concepts	Exceptionally low
	WISC-III^{UK} Picture arrangement	Exceptionally high
	WISC-III^{UK} Symbol search	Above average
	WISC-III^{UK} Digit span	Exceptionally low
Verbal and spatial recall	BAS Immediate verbal recall	Below average
	BAS Immediate spatial recall	Average (at ceiling)
	BAS Delayed verbal recall	Average (at ceiling)
	BAS Delayed spatial recall	Average (at ceiling)
Verbal recall of sequences	Days of the week	Misspellings, correct sequence
	Months of the year	Misspellings and omissions, incorrect sequence
Literacy	WORD Basic reading	Exceptionally low, age equivalent 6;5
	WORD Reading comprehension	Exceptionally low, age equivalent 6;9
	WORD Basic spelling	Exceptionally low, age equivalent <6;0
Letter-sound correspondences	Alphabet and sounds	Fingerspelled alphabet correctly, several sounds incorrect/misarticulated
Phonological skills	PhAB Semantic fluency	Average
	PhAB Alliteration fluency	Exceptionally low
	PhAB Rhyme fluency	Exceptionally low
Language	BSL Receptive skills	Average
	BSLPT Narrative content	Average
	BSLPT Narrative structure	Average
	BSLPT Grammar	Low average
	Naming speed: digits	Low
	Naming speed: words	Above average

Key: Average = within 1 SD of mean, above average ≥ 1 SD ≤ 2 SD, exceptionally high > 2 SD, below average ≤ 1 SD ≥ –1.5 SD, low ≤ 1.5 ≥ –2 SD, exceptionally low ≤ 2 SD.