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Sub-lexical reading intervention in a student with dyslexia and Asperger's Disorder[1]

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ABSTRACT

Dyslexia is a common presenting condition in clinic and educational settings. Unlike the homogenous groups used in randomised trials, educators typically manage children who have multiple developmental problems. Investigations are required into how these complex cases respond to treatment identified as efficacious by controlled trials. This study reports on a sub-lexical intervention in a student with dyslexia and Asperger's Disorder. Substantial and clinically significant gains were obtained on multiple measures of phonological decoding skill and irregular-word reading. The improvements in word-level skills were accompanied by moderate improvements in text-reading accuracy and reading comprehension. Results are discussed in the context of single-case methodology and the implications for practice and future research are discussed.

INTRODUCTION

Children begin reading by establishing a small bank of written words that they recognise by sight (Frith, 1986; Ehri, 1987; 1991). However, due to the large visual memory load imposed by the number of words in the English language and the similarity that exists between many words (*mess/mass*), beginning readers must develop efficient strategies for word recognition. They must develop knowledge of the alphabetic principle; knowledge that there is a systematic relationship between graphemes (letters/letter groups) and phonemes (speech sounds; Byrne & Fielding-Barnsley, 1989; Snowling, 1996; Snowling, 2000). Alphabetic knowledge is in turn facilitated by the ability to perceive and manipulate the sounds in spoken words (phonological awareness; Byrne & Fielding-Barnsley, 1989).

Children who are aware that the spoken words *pet, pop* and *pen* all begin with the speech sound /p/ find it much easier to map /p/ on to the grapheme 'p'. Knowledge of grapheme-phoneme conversion rules (GPCs) provides the beginning reader with a device that allows them

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to independently decode novel words. For example, the child who understands the GPCs for the letters ‘a’, ‘i’, ‘t’, ‘s’, and ‘p’ cannot only decode the words *sit* and *pat*, but also the words *sat*, *pit*, *tap*, *tip*, *sip, spat, spit* and so on. Accurate decoding leads to the acquisition of lexical knowledge and memory for the visual form of whole words which underlies skilled word recognition (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Shahar-Yames & Share, 2008).

While most children learn to read easily, a substantial minority struggle to develop adequate word-level reading skills such as whole word recognition and phonological decoding, despite having at least average intelligence and oral language skills (Stanovich, 1988; Vellutino et al., 1996). This difficulty occurs in 5-10% of the population and is referred to as developmental dyslexia (Shaywitz, 1998).

The core deficits in dyslexia consist of delays in acquisition of phonological awareness, limitations in knowledge of GPCs, difficulty using GPCs to decode novel words (phonological decoding), and limitations in whole word recognition (Bowey, 2006; Castles & Coltheart, 2004; Hulme, Hatcher, Nation, Brown, Adams, & Stuart, 2002; Snowling, 2000; Vellutino et al., 1996; Scarborough, 1990; Stanovich, 1988). A beginning reader at risk of dyslexia finds it difficult to recognise that the spoken word *pit* comprises three separate phonemes (/p/ /i/ /t/) and therefore finds it more difficult than his peers to map those phonemes onto the graphemes ‘p’, ‘i’ and ‘t’ respectively. These deficits in knowledge of GPCs means they do not have the device that allows them to independently decode the novel words *tip* and *it*. Instead they must rely on an adult or on inefficient text-based cues such as pictures, salient letters within the word, or sentence context. These strategies lead to high error rates in the range of 75-95% and draw the child’s attention away from the data which help form a visual memory for the word; that is, the letter sequence and the logic of the spelling-sound mappings (Dehaene, 2009; Shahar-Yames & Share, 2008). Hence, the word remains novel and it has to be read (or ‘guessed’) with considerable effort the next time it appears in text.

Experimental data (e.g., de Graff, Bosman, Hasselman, & Verhoeven, 2009; Hatcher, Hulme, & Ellis, 1994; Johnson & Watson, 2006; Torgesen, Alexander, Wagner, Rashotte, Voeller, Conway, et al., 2001) and a number of reviews (Bowey, 2006; Bus & Van IJzendoorn, 1999; Castles & Coltheart, 2004; Ehri et al., 2001; NICHHD, 2000; Swanson, 1999) have consistently found treatments that emphasise systematic teaching of synthetic phonics provide the most efficacious treatment for dyslexia. For example, the National Reading Panel (NICHHD, 2000) reported a moderate mean effect size (d = 0.45) for phonics instruction relative to non-phonics approaches, with the strongest effects for improving children’s ability to decode regularly spelled words (d = 0.67) and nonsense words (d = 0.6).

Synthetic phonics explicitly teaches GPCs and encourages the reader to use that knowledge to identify novel words by ‘decoding’ the sounds made by each letter and thereafter blending the sounds into the whole word. For example, a beginning reader who already knows the GPCs for ‘t’ and ‘a’ is taught that the letter ‘s’ makes the phoneme /s/ and then shown the word ‘sat’ to decode.

Synthetic phonics teaching works best when the instruction is both systematic and cumulative. *Systematic* refers to approaches where GPCs are taught in a pre-specified sequence. *Cumulative* implies that new knowledge in the teaching sequence builds on the previous and that practising new skills includes review of previous knowledge (Torgeson, Brooks, & Hall, 2006). Understanding Words (Wright, 2005) is a good example of how systematic and cumulative phonics instruction works. Beginning readers are taught single letter-sounds, consonant digraphs (th, ch, sh, ng, qu), graphemes representing ‘long’ vowel sounds (e.g., ee, oa, oo), r-controlled vowels (e.g., or, ar, ur), and dipthongs (e.g., oi, oy, i-e, ou) in a strict sequence. In the initial lessons, children are taught that the letters ‘t’ and ‘a’ represent the phonemes /t/ and /a/. They are taught that this knowledge will help them identify novel words because they will recognise the word name if they say the sounds the letters make. The word ‘at’ is then presented and the children are asked to decode it. The act of decoding ‘at’ helps consolidate the GPC memories for ‘t’ and ‘a’ and to establish decoding as an effective behaviour. The teaching sequence then introduces the letter 's' representing the phoneme /s/ and the child is confronted with the words 'sat' and 'at'. Introducing letters 'p' and 'i' representing the phonemes /p/ and /i/ allows the child to read *tap, tip, pit, pat, sap, spat* and so on.

Despite the relative success of phonics interventions for dyslexia, current intervention approaches do not produce significant change in a substantial minority of non-responders (e.g., Duff, Fieldsend, Bowyer-Crane, Hulme, Smith, Gibbs, et al., 2008; Torgesen, 2000; Denton, Fletcher, Anthony & Francis, 2006; Vellutino et al., 1996; Wright & Conlon, 2009). The question of what reading treatment works for whom is a topic of debate in the literature and is acknowledged as a research priority (Pugh & McCardle, 2009). One problem faced by clinicians and educators is that the school population or referred patients do not always resemble the samples described in published controlled treatment trials. Such trials have typically included a homogenous treatment group with few, if any, co-morbid weaknesses (e.g., Hatcher et al., 1994; Vellutino et al., 1996).

In contrast, educators manage students who have multiple behavioural and/or developmental problems. The current state of the literature requires practitioners to infer, rightly or wrongly, that co-morbid weaknesses have little influence on treatment selection and treatment response in dyslexia. In the absence of large randomised trials, one approach that can provide useful information is single cases in which multiple disorders exist. This paper reports on response to treatment in an individual with co-morbid dyslexia and Asperger's Syndrome (AS).

AS is a pervasive developmental disorder whose clinical features include difficulty forming friendships, poor social cognition (perspective taking, reciprocal interactions, and social appropriateness and congruence of behaviour), diminished empathy, restricted, repetitive patterns of interests and behaviour, and pervasive and circumscribed interests (American Psychiatric Association, 2000; Volkmar & Klim, 2000). AS differs from high functioning autism in that onset is usually later, social, and communication deficits are less severe, motor mannerisms are typically absent, while intense interests and verbosity are typically more obvious. Cognitive and oral language abilities are usually preserved in AS (Volkmar & Klin, 2000). However, there is controversy about the latter. Diagnostic criteria require that there be "no clinically significant delays in language" (American Psychiatric Association, 2000) and most individuals with AS have intact language *content* (phonology, semantics, and grammar). In contrast, many have pragmatic deficits in the social and contextual *use* of language (Bishop, 2000).

There has been an historic assumption that reading skills in autistic spectrum disorders are a relative strength (Church, Alisanski, & Amanullah, 2000; Frith & Snowling, 1983; Goldberg, 1987; Grigorenko, Klin, Pauls, Senft, Hooper, & Volkmar, 2002; Mayes & Calhoun, 2003; Nation, Clark, Wright, & Williams, 2006; O'Connor & Klein, 2004). However, recent evidence suggests autistic spectrum disorders and dyslexia do co-occur (Nation et al., 2006). One might also then assume that AS and dyslexia co-occur and there seems little reason to assume that dyslexia occurs at a lower rate of prevalence in AS than it does in the wider population. However, there is no published literature of which we are aware to support this statement. Furthermore, we are currently unaware of any published treatment studies of dyslexia and AS and there is limited available evidence upon which clinicians can base decisions about effective reading intervention when AS and dyslexia co-exist in the same child.

Models of reading (e.g., Coltheart et al., 2001; Morton & Patterson, 1980) propose that the skilled reading system involves independent procedures for reading words aloud; one referred to as the lexical route and the other as the sub-lexical route (Castles & Coltheart, 1993). When reading via the lexical route, a printed word is matched to an entry in the orthographic lexicon and the word name is retrieved from the phonological lexicon. Lexical reading requires the reader to have had prior experience with a word and thus the lexical route cannot be used for novel words such as Karamazov or nonsense words such as spoink. In contrast, the sub-lexical route is typically employed for novel words which do not have a lexical entry and involves 'decoding' words via grapheme-phoneme conversion rules. While the sub-lexical system can read nonsense words like spoink, it produces regular, and therefore incorrect, pronunciations for irregular words like yacht and colonel.

Children who have dyslexia can have problems with either route, although they most frequently have difficulty with both procedures. The current study evaluated a sub-lexical treatment approach for JK, a 9-year-old boy diagnosed with both AS and dyslexia. JK had mixed dyslexia; however, the sub-lexical weaknesses were far more substantial and the focus of the program was on treating these weaknesses. The aim of the treatment was to improve the ability to use the sub-lexical reading route for reading novel words. The treatment design allowed investigation of treatment efficacy, generalisation of treatment effects to reading of untreated words (regular-, irregular- and non-words), and generalisation to text-reading performance and comprehension.

METHOD

Participant

JK, a right-handed boy, was born in August 2000 and was 9 years old at the time of initial testing. He was referred to a private developmental psychology clinic for assessment. There was no history of developmental disorders in the immediate family except a maternal uncle who had dyslexia. JK did not have any neurological, ophthalmic or audiological history. He had attended two primary schools and had not received any special education services before the current study. Oral language skills had reportedly developed early and he was reported by his mother to have had “exceptionally advanced conversations since two years of age”.

Failure to develop age appropriate peer relationships, anxiety in response to change in routines, failure to display typical emotion, difficulty engaging in reciprocal communication, and a strong interest in computers which pervaded thought and communication brought JK to the attention of special education staff at his school. The first author was asked to assess for an autism spectrum condition.

A clinical interview based on the Autism Diagnostic Interview – Revised (Rutter, LeCouteur, & Lord, 2003) was conducted with his mother. JK did not meet the ADI-R criteria (Rutter et al., 2003) for autistic disorder; primarily because of late onset and more advanced communication skills than typical in autistic disorder. He did meet DSM-IV (APA, 2000) criteria for Asperger’s Disorder in that he had significant weaknesses in social communication, had difficulty interacting with peers and adults, and had a limited and relatively inflexible behavioural repertoire. The presence of a pervasive developmental disorder was supported by parental responses above the clinical cutoff (raw score = 16) on the Social Communication Questionnaire (Rutter, Bailey, & Lord, 2003).

JK displayed 9/9 DSM-IV (APA, 2000) Attention-Deficit/Hyperactivity Disorder (ADHD) inattentive symptoms. However, as is often the case in children with autism spectrum conditions (Klin, Sparrow, Marans, Carter, & Volkmar, 2000), JK did not have difficulty focusing. Rather, he was hyper-focused on specific activities or topics and adults had difficulty getting him to paying attention to the task at hand. For example, the first author observed one reading lesson in which JK was reading word lists presented on a laptop computer. He kept interrupting the task to show the adults in the room how to use a shortcut function to see how quickly the computer was running. ADHD was not diagnosed because of this apparent hyper-focus, rather than the inattention typically seen in ADHD.

In addition to Asperger’s Disorder, concerns were expressed for JK’s reading and spelling skills. Formal intellectual testing conducted in April 2008 by the school psychologist using the Wechsler Intelligence Scale for Children (WISC-IV; Wechsler, 2003) showed that JK had a Full Scale IQ of 117. The WISC-IV index scores were 124 for Verbal Comprehension, 125 for Perceptual Reasoning, 86 for Working Memory and 106 for Processing Speed. In contrast, an assessment performed by the first investigator in December 2009 revealed a standard score (population mean = 100; SD = 15) for word recognition of 86, 79 for non-word decoding, and 75 for spelling on the Wechsler Individual Achievement Test (WIAT-II; Wechsler, 2001). Representative spelling errors included *apl* for 'apple', *fingr* for 'finger', *unbrel* for 'umbrella', *ges* for 'guess' and *unbr* for 'under'. Reading Comprehension on the WIAT-II (Wechsler, 2001) was in the 50th percentile.

In summary, there was strong evidence for the triad of weaknesses seen in AS and evidence of developmental dyslexia. While he performed relatively better on tests of reading ability assessing whole-word (lexical) knowledge (WIAT-II Word Reading subtest) relative to decoding (sub-lexical skill; WIAT-II Pseudoword Reading subtest), JK was generally a poor word-reader for his age. In addition, his word-level reading and spelling skills were well below the level of his general intellectual ability.

Measures

WIAT-II Word identification: The Word Reading subtest from the WIAT-II (Wechsler, 2001) was used to assess single word recognition skill. The task required JK to pronounce single letters and single words (r_{xx} = .97 for internal consistency; r = .98 for test-retest reliability; maximum raw score = 131).

WIAT-II Pseudoword decoding: The ability to use phonological information to decode words was assessed with the Pseudoword Decoding subtest from the WIAT-II (Wechsler, 2001). Pseudowords or 'non-words' are used to determine how well the individual can decode and pronounce words they have not seen before (Muter, 2006). Nonwords are letter strings that resemble English words and conform to the spelling and sound structure of English, but do not make sense (e.g., leb, ruckid, and unfrodding; r_{xx} = .97 for internal consistency; r = .95 for test-retest reliability; maximum raw score = 55).

Castles & Coltheart word lists: The revised version of the Castles and Coltheart word lists (CC2; Castles, Coltheart, Larsen, Jones, Saunders, & McArthur, 2009) was used to assess word-level reading skills. The CC2 includes three word lists each of 40 words: irregular-, regular- and non-words. The test is available in two formats: a web-based version and a pencil-and-paper PDF version (see http://www.motif.org.au). The pencil-and-paper version was used in the current study. The child is presented with the items for reading aloud, one at a time, until he or she makes five consecutive errors on any single item type. At that point, presentation of that type of word list ceases. Testing proceeds until the child makes 5 consecutive errors on the final item type. A total raw score /40 is obtained and can be converted to z-scores and percentiles within age bands of 5-6 months.

Curriculum-based non-word reading: A curriculum-based non-word reading test (hereafter CBM Non-words) was administered in which JK read 155 nonwords constructed from each of the GPCs shown in Table 1. The GPCs were selected because they matched the curriculum content of the intervention program (Understanding Words; Wright, 2005) that was to be used with JK. The items were presented in the same order each time JK was tested. The items were printed on individual cards printed in 48 point Comic Sans font.

Reading comprehension: The Neale Analysis of Reading Ability (3rd Edition; NARA-III; Neale, 1999) was administered as a measure of reading comprehension. The NARA-III includes two parallel forms with standardised norms. The test required the participants to read a series of up to six graded passages. Word-reading errors are subtracted from a total possible passage score of 16 (e.g., if four errors are made, the participant received a passage score of twelve). The stopping rule applies when the participant makes 12 or more errors in a single passage. When <12 errors are made on a passage, questions about the text are presented orally immediately on completion of each passage. Form 2 was used at Baseline 2, Form 1 at Post-treatment testing and Form 2 at

9-month Maintenance (r_{xx} = .71 for internal consistency for Form 1 and r_{xx} = .81 for Form 2; parallel form reliability r = 0.86; maximum raw score = 44). There are four questions for the first passage and eight for each passage thereafter. Some questions require retention of literal information and others require generation of knowledge-based inferences.

Text reading accuracy: The Neale Analysis of Reading Ability (3rd Edition; Neale, 1999) was used to assess text reading accuracy. The participants read a series of up to six graded passages. Word-reading errors are subtracted from a total possible passage score of 16. The stopping rule applies when the participant makes 12 or more errors in a single passage. Form 2 was used at Baseline 2, Form 1 at Post-treatment testing and Form 2 at 9-month Maintenance (r_{xx} = .95 for internal consistency for Forms 1 and 2; parallel form reliability r = 0.98; maximum raw score = 100).

Procedure

The study was conducted under the auspices of a private clinic and use of the data was authorised via Griffith University Human Research Ethics Committee arrangements. All services were provided gratis after informed written consent was obtained from JK's parents.

A double baseline was established by testing JK at two points prior to intervention. At Baseline 1, he was assessed on the WIAT-II Word Identification and Pseudoword Decoding subtests and the CBM Nonwords. He was reassessed on all three measures after 10-weeks (Baseline 2). At Baseline 2, JK was also assessed on the revised version of the CC2 regular-, irregular-, and non-word reading lists (Castles, et al., 2009), and the accuracy and comprehension components of the third edition of the Neale Analysis of Reading Ability (NARA-III; Neale, 1999). It is important to note that JK saw his learning support teacher 3 sessions/week during the baseline period. The stated aim of these sessions was to improve his reading skills. No specific program was used to achieve this aim and the first author's observations were that the time was spent reading texts and playing memory games and word bingo. Following the baseline period, JK then engaged in a 10-week reading intervention for sub-lexical reading deficits. All measures were administered a third time at Post-treatment (after 10-weeks) and again at 9-month Follow-up. No treatment was provided by the researcher or school between Post-treatment and Follow-up because JK moved schools. All testing was conducted by the first author.

Training items: Training items were selected on the basis of performance on the CBM Non-words. Table 1 shows the grapheme-phoneme conversion rules covered by the CBM Non-word test. JK was able to read no fewer than 4/5 non-words containing the graphemes L, W, J, V, Z, Y, CH and SH. He scored 2/5 for the 'X' grapheme and no higher than 1/5 on any of the other GPCs which, along with X, were selected for training.

Teaching method: Thirty sessions of training were provided. The thirty sessions were equivalent to 30-hours of instruction; however, note that a considerable portion of each session had to be devoted to redirecting JK or allowing him to finish conversations he initiated which were irrelevant to the treatment. The first three lessons were conducted by the first author and thereafter by the school special education teacher. Every fourth session was observed by the first author to ensure treatment fidelity. From the second session on, each session began with a 5-10 minute review of previously taught GPCs. A new GPC was then introduced. For example, the teacher wrote the digraph AI on a whiteboard, pointed and said: "these letters make the sound /ae/; what sound?" When a firm representation had been established, the teacher made a word using the trained GPC and previously known GPCs (e.g., 'raid') and asked: "If these letters make /ae/, what is this word?"

Table 1. The 31 grapheme-phoneme conversion rules assessed in the CBM Non-word test with a word example for each item.

L	lip	X	box	W	wet
J	just	V	vet	Y	yet
Z	jazz	QU	quick	SH	shop
CH	chip	TCH	pitch	IGH	sight
Y	try	TH	with	OA	boat
NG	sing	AR	part	OO	moon
OR	sport	AI	rain	UR	turn
AY	say	OW	cow	EE	seem
OI	coin	AIR	fair	EAR	hear
A_E	take	O_E	note	U_E	dune
I_E	like				

Letters would then be swapped in and out of the word to make a number of new words/non-words (e.g., RAID-RAIN-BRAIN-CHAIN-HAIN).

JK then read word lists comprising words and non-words from the Understanding Words (Wright, 2005) student materials. The materials were presented on a computer as it was felt that this medium matched JK's interests and was more likely than a paper-based medium to generate motivation. The words in the list were constructed using the grapheme taught in that lesson and previously taught or known graphemes (e.g., gain, strain, and laip). None of the non-words featured on the CBM Non-word test. JK then engaged in approximately 15 minutes of spelling and/or letter-sound manipulation activities which were used to assist him in forming a stronger representation of the GPC and in understanding how the new knowledge could be used functionally for word-decoding or spelling. The session ended with JK reading sentences or short stories from the Understanding Words (Wright, 2005) student materials which contained the newly taught GPC. The purpose of this part of the treatment was to help JK recognise that the purpose of the decoding strategies used in the word-level treatment was to teach him how to use the same procedures when faced with unfamiliar words in a text.

RESULTS

JK's reading performance is shown in Table 2. The traditional approach to analysis of single-subject research data involves visual comparison of responding across conditions (Horner, Carr, Halle, McGee, Odom, & Wolery, 2005; Parsonson & Baer, 1978). Demonstration of a functional relationship between independent (treatment) and dependant (reading outcome) variables requires compelling evidence of an effect (Horner et al., 2005). In the case of the current study, a functional relationship between treatment and reading ability required a stable baseline (during which no treatment occurred) followed by substantial growth in reading ability during the period in which treatment was provided. Finally, to ensure that any effect seen during treatment was due to the intervention itself and not to a variable such as increased attention or the parent-student relationship, the treatment effect must be maintained at 9-month follow-up. Remember that JK did not have additional intervention during 9-month follow-up and did not have contact with the special education teacher who ran the intervention because he changed schools. A regression in skills from post-intervention to follow-up would indicate that at least part of any reading gains were due to the teacher-child relationship or to some other psychosocial variable.

Figure 1 shows JK's response on the WIAT-II Word Identification and Pseudoword Decoding measures. It can be seen that no improvement was made during baseline. A sharp improvement in non-word reading then occurred during the treatment period and this gain was maintained 9-months later. Less growth was made on the Word Identification measure during treatment; although there does appear to be a positive trend occurring from onset of treatment to follow-up. The difference between response for non-words and the items on the word identification measure will be addressed in the Discussion. Figure 2 shows JK's response on the CBM Non-word test. His scores were again stable across baseline and a sharp improvement in phonological decoding ability occurred during treatment. This gain was maintained at 9-month follow-up.

Quantitative analysis of reading gains

In order to assess JK's reading gains quantitatively, it was necessary to adopt a rule of thumb against which the clinical significance of changes could be compared (M. Coltheart, personal communication, May 24, 2011). Some studies have used post-treatment status (e.g., a post-test standard score of ≥90) as a benchmark for clinically significant response to intervention (Torgesen, 2000; Torgesen et al., 2001; Wright & Conlon, 2009). However, this method may obscure the amount of reading growth in response to intervention (Fuchs, 2003). To assess the clinical significance of JK's reading growth we obtained the standard deviation (SD) of the relevant raw score distribution for the CC2 word-reading tests (Castles, et al., 2009) and the NARA-III text reading accuracy and reading comprehension tests (Neale, 1999). These data were obtained from the test manuals. The CC2 SD was based on a 9-9.5 years-of-age cohort and the NARA-III SD was based on a grade-level cohort. Raw data were not available for the WIAT-II Word Identification and Pseudoword Reading subtests so the clinical significance of change on these measures could not be calculated using the current method. Our rule of thumb required JK

Table 2: Baseline, post-treatment and follow-up (raw) scores on reading measures.

Test	Baseline 1	Baseline 2	Post-treatment	9-month Follow-up
Word Identification	84	82	87	93
Pseudoword Decoding	15	12	40	38
Text Reading Accuracy	xx	33	40	48
Reading Comprehension	xx	18	20	23
Regular-word accuracy	xx	25	31	33
Irregular-word accuracy	xx	12	16	17
Non-word accuracy	xx	6	26	32
GPC Test	48	41	127	119

Note: xx = task not administered.

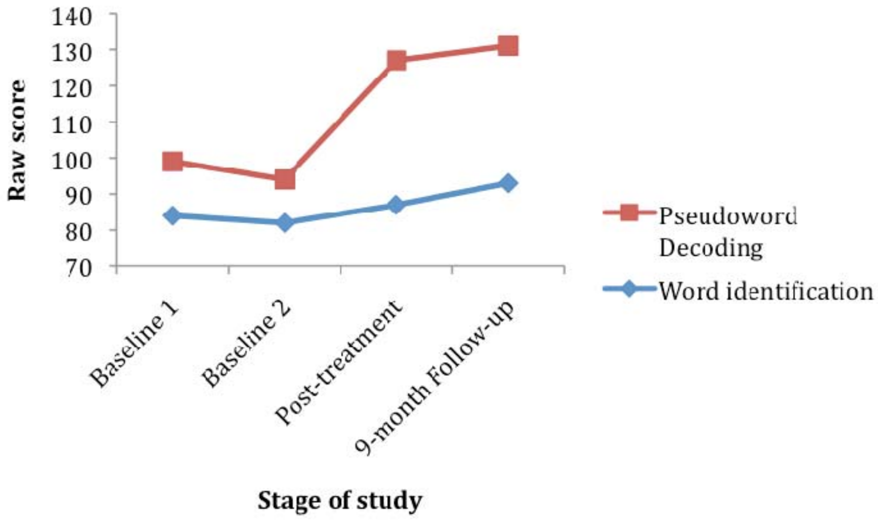

Figure 1. JK's raw scores on the WIAT-II Word Identification and Pseudoword Decoding measures across the different stages of the study.

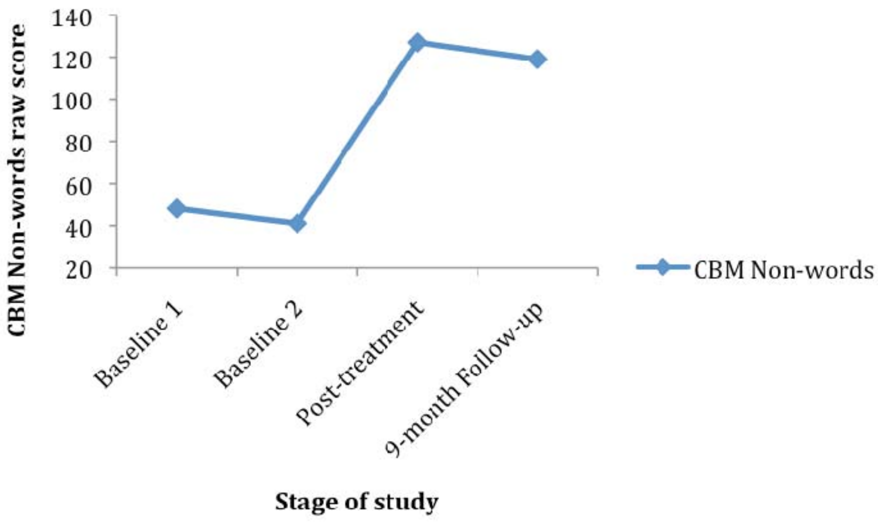

Figure 2. JK's raw scores on the CBM Non-word test across the different stages of the study.

to make change of ≥0.8 of a standard deviation from Baseline 2 to 9-month Follow-up. The ≥0.8 standard deviations rule of thumb was selected because it represents a large effect size (Cohen, 1992).

JK made >0.8 of a standard deviation change from Baseline 2 to 9-month Follow-up on the CC2 (Castles, et al., 2009) regular-, irregular and non-word reading measures. The amount of change was equivalent to a strong effect (Cohen, 1992). The benchmarks for the NARA-III reading accuracy and comprehension measures were 17.28 and 6.8 raw score points respectively. JK just failed to meet these benchmarks, making gains of 15 and 5 raw scores points on the reading accuracy and comprehension measures respectively. The ≥0.8 standard deviations rule of thumb is a conservative criterion that makes it difficult to achieve the benchmark for clinically significant change in a short-term intervention. It should therefore be noted that JK's gains on these latter two measures were far from insubstantial. The gain in text reading accuracy was equivalent to 0.69 of a standard deviation based on the grade-level normative distribution and the gain in reading comprehension was 0.58 of a standard deviation.

Treatment satisfaction

JK's mother and special education teacher both indicated being satisfied with his response during the treatment. JK's teacher reported that she felt that he was more willing to read curriculum materials within the classroom and that she had observed him using the decoding strategies taught in the intervention to help decipher classroom texts. The teacher reported that she believed the intervention methods could be delivered to other students with relative ease and that there was intent to continue using the intervention method within her special education unit.

DISCUSSION

Where previously it had been assumed that word-level reading skills in autism spectrum disorders were typical, there is now recognition that autism spectrum disorders and dyslexia can overlap (Nation, et al., 2006). The purpose of this study was to investigate whether or not a reading intervention method previously shown effective in dyslexia could be effective in a single case of Asperger's Disorder (AS) and dyslexia. The participant, JK, displayed a mixed dyslexia profile with mild weaknesses in lexical processes and more severe weaknesses in phonological decoding. Response to an intervention had not been studied previously in this population.

The results indicated the following.

1. Sub-lexical reading intervention produced substantial and clinically significant improvements in phonological decoding skills.
2. There were substantial improvements in irregular-word reading despite the fact that the treatment focused on sub-lexical reading skills.
3. The improvements in word-level skills were accompanied by moderate improvements in text reading accuracy and reading comprehension.

Treatment effects

Provided sufficient experimental controls are employed, single-case research allows conclusions to be drawn about treatment effectiveness. Indeed, single-case research is considered a rigorous scientific method that can form part of the process of establishing evidence-based practices (Horner et al., 2005). In single-case research an independent variable (e.g., reading intervention) is systematically varied to document a functional relationship between independent and dependent variables. Performance during treatment is contrasted with performance during, preferably, multiple baselines and untreated periods. An experimental effect is demonstrated when predicted change in a dependent variable (e.g., improvements in reading) covaries with manipulation of the independent variable (onset and/or cessation of intervention; Horner, et al., 2005).

In the current study, it was demonstrated that JK made no gains on measures of word identification and non-word reading across a 10-week baseline. Importantly, he was receiving the same amount of contact with his special education teacher during this period as he received during the treatment period. The teaching aims were also generally the same during these two periods; to improve reading skills. Introduction of a sub-lexical reading intervention covaried with substantial growth in sub-lexical reading skills (i.e., the ability to apply phonological decoding strategies to novel words). That sharp improvement was seen on the reading sub-skill upon which the intervention focused is partial evidence of a treatment effect. More importantly, the gains made during the treatment far exceeded those made during baseline despite JK receiving the same amount of teaching from the same teacher. While not conclusive, these data are evidence against the effect being purely the result of the teacher-student relationship. They also demonstrate that the improvements were not the result of increased attention (i.e., a Hawthorne effect) because JK received the same amount of attention during baseline and treatment periods. Finally, removal of treatment seems to have resulted in reading levels stabilising but without evidence of further gains. This is further evidence of treatment effects rather than gains being due some other psychosocial variable.

Irregular-word reading

Gains were made on WIAT-II Word Identification subtest despite this task consisting of mostly irregular words that have to be read via the lexical route (Castles & Coltheart, 1993; Coltheart, et al., 2001). Strong gains (≥0.8 of a standard deviation unit) were also seen from baseline to follow-up on the CC2 irregular-word reading measure. These lexical gains were made despite the fact that the intervention focused exclusively on sub-lexical skills. The current data do not permit conclusions as to why this effect occurred. Authors have previously speculated that gains occur for words for which individuals have partial orthographic representations pre-treatment and that the additional activation of the orthographic lexicon during treatment helped these representations to become better specified (Brunsdon, Hannan, Coltheart, & Nickels, 2002; Wright, Conlon, & Wright, 2011). Identifying how and why generalisation occurs is an important avenue for future research because time is such a precious commodity in school-based intervention and if skills can be acquired without direct teaching it will save considerable time and money.

Text reading and comprehension

Gains were seen in text reading and comprehension that were equivalent to the size of a moderate effect (Cohen, 1992). Because a baseline was not established for these measures there was not sufficient experimental manipulation to allow conclusions to be drawn about these gains being the result of the treatment (Horner, et al., 2005). Future research should investigate the transfer of reading sub-skill interventions to these measures as they are the reading skills that have the most direct relevance for the curriculum.

Social validity

The social validity of interventions is enhanced by several factors, including: (a) selection of dependent variables with high social value, (b) demonstration that the intervention method can be applied with fidelity in real-world settings and, (c) demonstration that intervention agents report satisfaction with the method, that they report the method feasible and that they report intent to use the method after formal support is withdrawn (Horner et al., 2005). A conclusion of this study is that the intervention method has considerable social validity. Gains were seen in behaviours with high social value (reading). The intervention method was implemented with fidelity and the teacher reported that it was highly likely that the method would be used again within the special education setting. Finally, both parents and teachers reported satisfaction with progress during the study.

Limitations

Both dyslexia and AS are heterogeneous disorders. We must therefore be careful about extrapolating the conclusions to other children with the same diagnoses. Further single-case research with appropriate experimental controls and/or controlled group studies will be required before broader generalisations can be made about the response of children with co-existing dyslexia and AS.

The client-therapist relationship is important in any form of therapy; however, it is arguably even more vital when working with students who have an autism spectrum disorder. The importance of the relationship between JK and his teacher can therefore not be overstated. That no gains were made across the baseline period suggests that the improvements seen in this study were most likely due to the intervention rather than to the student-teacher relationship. However, this does not mean that any teacher or paraprofessional will be able to use the same intervention method with the same success for a child with AS. It would be much more realistic to suggest that a sound understanding of AS and a strong student-teacher bond are pre-requisites for being able to deliver reading intervention for those with co-existing dyslexia and AS. Future research will need to investigate knowledge and personality factors within teachers that contribute to response to intervention in this population.

Finally, the reading outcome measures used in the current study could have been collected more regularly to allow better visual inspection of growth trends. Future research would do well to use curriculum-based measures such as the CBM Non-word test used in the current study to obtain data at weekly or even bi-weekly intervals.

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