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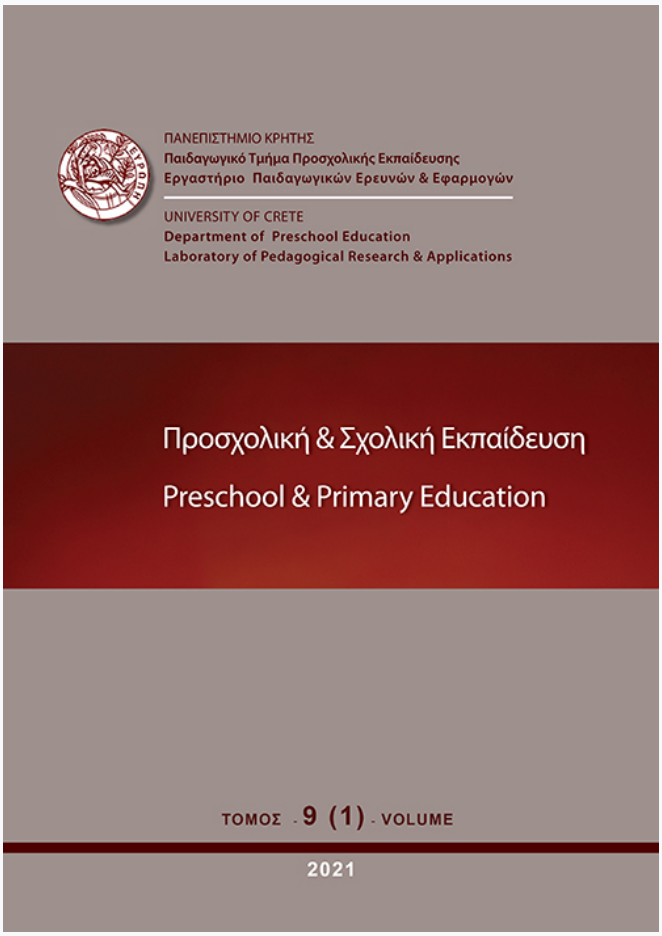

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A linguistic awareness intervention targeting spelling and written expression in a 10-year-old dyslexic child

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Abstract. We report the case of a monolingual English-speaking boy (AM) aged 10, and the intervention targeting AM's spelling and written expression difficulties. AM's performance was contrasted in all experimental measures to a group of 13 typically developing spellers attending the same class. Literacy and cognitive assessments revealed for AM pseudoword reading difficulties, and deficits in spelling, written expression, phonological ability, verbal memory and rapid automatised naming. AM took part in nine sessions of linguistic awareness intervention that focused on promoting simultaneous attention to phonology, orthography, morphology, semantics and syntax. Results revealed a substantial improvement in spelling, pseudoword reading, writing and handwriting. The results indicate that raising linguistic awareness can have a robust impact on spelling and written expression.

Keywords: Phonological dyslexia; intervention; linguistic awareness

Introduction

Only a handful of studies have looked into the effectiveness of linguistic awareness intervention (such as phonemic awareness, morphological awareness, and orthographic knowledge, but also syntax and semantics (Bourassa & Treiman, 2001; Ehri, 2000)) for written expression deficits, and these are mainly group studies predominantly targeting spelling ability (Kirk & Gillon, 2009). In the field of dyslexia research, group studies might not always be the optimal approach to identifying the cognitive processes involved in reading, spelling and writing as they do not take into account individual differences and the fact that dyslexic difficulties can exist on a continuum of severity (Rose, 2009). Single-subject longitudinal experimental designs can control effectively for mediating variables, thus enabling identification of associations and dissociations between cognitive processes (Graham &

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Harris, 2014; Nickels, Rapp, & Kohnen, 2015). Therefore, single-subject designs can supplement group studies, as such a case study approach was used in the current investigation. The study aimed to determine the effectiveness of an intervention programme targeting spelling and written expression in a child with phonological dyslexia. The focus of the intervention was to make the child simultaneously and explicitly aware of the subcomponents of linguistic awareness, using direct instruction techniques (i.e., Apel & Masterson, 2001; Bourassa & Treiman, 2001; Ehri, 2000). The intervention also focused on mitigating the child's written expression difficulties by explicitly teaching proactive strategies, such as drafting (creating conceptual maps and spider diagrams to overcome memory difficulties), and being aware of the intended audience and the different genres (Mallet, 1992; Riley & Reedy, 2005; Wray & Lewis, 1997).

Prior to the intervention, we aimed to identify the specific locus of AM's impairment in order to develop a programme that would target his difficulties effectively. To do this, we used models of written expression (Berninger et al., 2002) and single word spelling and reading which posit phonological and lexical/semantic processes (Castles & Coltheart, 1993; Coltheart & Leahy, 1996; Griffiths & Snowling, 2002). In the first section of the paper, we present the theoretical framework used to profile AM's strengths and weaknesses. The second section comprises a case study of AM and description of the intervention. Then follows analysis of AM's performance before and after the intervention and discussion of the findings.

The Theoretical Framework

For reading and spelling, the Dual Route (DR) model (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001) has been successfully used to identify subtypes of dyslexia based upon processes that are impaired and/or intact (Broom & Doctor, 1995a,b; Brunsdon, Coltheart, & Nickels, 2005). According to the DR model, developing readers use two different routes when reading and spelling: lexical and sublexical. The former is used for reading of all words; regular words (e.g., <*mat*>) that follow the grapheme-phoneme correspondences (GPCs) of the language, and exception words (e.g., <*yacht*>) that deviate from the GPCs. The sublexical route is used for nonword reading, that is pronounceable letter sequences that do not exist in the children's aural vocabulary (e.g., <*brofet*>). Exception word reading is considered to be a measure of lexical processes and pseudoword reading a measure of sublexical processes (Bosse, 2015; Hagiliassis, Pratt, & Johnston, 2006). Identifying whether the child relies on lexical or sublexical processes can help the specialist dyslexia teacher tailor an appropriate intervention according to the child's profile (a lexical, sublexical or mixed profile, see single case studies by Niolaki, Terzopoulos & Masterson, 2014; Niolaki, et al., 2017; Broom & Doctor, 1995,a,b; Brunsdon, Hannan, Coltheart, & Nickels, 2002; Kohnen, Nickels, Brunsdon, & Coltheart, 2008; Rowse & Wilshire, 2007).

According to Treiman and Kessler (2014), some word patterns are difficult to remember, and require rote learning, whereas others are learned through phonological, orthographic and morphological patterns. Treiman and Kessler's (2014) Integration of Multiple Patterns (IMP) theory suggests children spell using graphotactics (the way the letters are arranged in a word), phonology and morphology, but also suggests that the probabilistic patterns of the language (triggering statistical learning skills) have a role to play. The current study used a teaching programme to support a child with literacy difficulties, simultaneously targeting the linguistic components incorporated in the IPM theory and statistical learning skills. Only a handful of studies have tried to look at the different linguistic components (linguistic awareness) and improve spelling using an integrated intervention approach (i.e., Apel & Masterson, 2001; Kirk & Gillon, 2009), but these did not target written expression. Also in these studies individuals (age 13-years for the first study and age range 8;07 to 11;01 for the

second study) with spelling difficulties were assessed whereas in ours AM had a diagnosis of dyslexia and he was 10 years old when the study commenced. In addition, studies frequently targeted only subskills of the linguistic awareness component. For example, Apel and Werfel (2014) suggested that, although some positive outcomes have come from studies promoting morphological awareness, morphological awareness is only one component of linguistic awareness.

To gain an in-depth picture of the child's spelling skill, we conducted a variety of assessments, combining spelling-to-dictation and prose writing, and criterion-referenced and norm-referenced tests of spelling (i.e., Moats, 1993). The aim was to investigate orthographic, morphological and phonological errors our participant could potentially make and to target potential problematic strategies for intervention. Poor spelling is a bottleneck to written expression as has been well-documented in the past (for example, see, Graham, Harris, & Chorzempa, 2002). A child who remembers the accurate spelling of a word will be able to dedicate less time and resources to writing (Berninger et al., 2002; Connelly, Gee, & Walsh, 2007; Graham & Harris, 2014). The Simple View of Writing (SVW) (Berninger et al., 2002; Juel, 1988; Juel, Griffith, & Gough, 1986) suggests that writing consists of low-level skills such as spelling and handwriting and higher level ones such as ideation (planning, translating and reviewing, Connelly et al., 2007) and these are regulated by long- and short-term memory, for composition and revision, respectively.

Graham et al. (2002) conducted a spelling intervention study with 25 Grade 2 poor spellers for 48 20-minute sessions and found a substantial improvement in spelling, written fluency and nonword reading. The result was sustained for spelling and sentence writing at the delayed post-intervention assessment, but not for written composition and fluency. This result does not support the view that higher level writing skills are partially dependent on lower level ones such as spelling. Graham et al. (2002) suggested that other techniques such as handwriting instruction, and self-regulatory features of writing such as planning, revising and editing might have a more pronounced impact on written composition and fluency. Thus, we included in our intervention explicit instruction in these components of written expression (i.e., Berninger et al., 2002; Connelly et al., 2007; Riley & Reedy, 2005).

For reading, spelling and written expression, the past 50 years of research has indicated that a number of cognitive processes including phonological ability, phonological memory, rapid automatised naming (RAN), visual memory and visual attention span (VAS) differentiate good from poor achievers (see, Niolaki et al., 2014, 2017; Berninger et al., 2002; Bosse, Tainturier, & Valdois, 2007; Castles & Coltheart, 1993; Ehri, Nunes, Stahl, & Willows, 2001; Georgiou, Torppa, Manolitsis, Lyytinen, & Parrila, 2012; Giles & Terrell, 1997; Goulandris & Snowling, 1991; Landerl et al., 2013; Savage & Frederickson, 2005; Snowling, 2000; Stainthorp, Powell, & Stuart, 2013; Valdois et al., 2003; Wolf & Bowers, 1999). We utilised assessments of these processes to explore whether, for AM, we might identify, for example, a selective phonological deficit, as suggested by the *core phonological deficit hypothesis* of dyslexia (Hulme & Snowling, 2009; Snowling, 2000), or a lexical deficit, found to be associated in the past with deficient Visual Attention Span (VAS), *the visual attention span hypothesis* (Bosse et al., 2007; Valdois et al., 2003), or impaired visual memory (Goulandris & Snowling, 1991). We also aimed to explore whether AM may have a selective phonological or RAN weakness, or else a *double deficit* in RAN and phonological ability, which has been identified in previous studies with dyslexic participants (Pennington, Cardoso-Martins, Green, & Lefly, 2001; Stainthorp et al., 2013; Wolf & Bowers, 1999).

Next, we review two studies which informed our linguistic awareness programme. Apel and Masterson (2001) carried out an integrated intervention using reading and spelling instruction and simultaneously targeting phonological, orthographic and morphological rules

with an adolescent (13-year-old). The intervention lasted 23 hours in total and targeted phonological and morphological awareness, and orthographic knowledge, as well as single-word reading and spelling. It was administered to small groups of four participants matched for literacy difficulties. The intervention included the following teaching practices, direct instruction with the tutor modelling the skills to be learned, development of metacognitive skills and scaffolding the student's responses, aiming to make her explicitly aware of the reading and spelling strategies, and self-regulatory strategies to improve academic self-confidence. Significant improvement in all skills targeted was observed; however, training did not generalise to written expression, and a delayed follow-up assessment was not conducted. In the current study, we extended Apel and Masterson's intervention by targeting written expression and including an immediate as well as a delayed post-intervention assessment. In addition, our participant was younger, 10 years old when the intervention began and had a formal diagnosis of dyslexia.

In a more recent study, Kirk and Gillon (2009) focused on reading and spelling ability in a group of sixteen poor spellers. The children were randomly assigned to a control and an experimental group. The intervention focused primarily on morphological awareness but also trained other types of linguistic awareness (phonology, orthography, syntax and semantics). The participants, aged 8;07 to 11;01, received on average 19.4 sessions. The experimental group improved in both reading and spelling at the end of the intervention, and the improvement was maintained six months later when the delayed post-test assessment took place. The children were able to generalise their knowledge to untrained words. In this study, the researchers used poor spellers but not children with a diagnosis of dyslexia and the children's age range was wide but included individuals who were the same age as AM.

Aim of the current investigation. Apel and Masterson (2001) proposed that an integrated intervention using multiple linguistic factors can be a successful way to support children with reading and spelling difficulties. We decided to utilise an integrated intervention based on difficulties experienced by AM in a number of different linguistic components (phonology, morphology, orthography, spelling, handwriting, written expression and reading). We extended previous studies by including treatment in handwriting and written expression. The overall aims were:

- to identify cognitive limitations contributing to literacy difficulties via detailed pre-testing
- to evaluate whether an intervention targeting phonology, morphology, orthography, spelling, handwriting, written expression and reading might result in improved standardised scores of reading, spelling and written expression
- to explore if AM's academic self-concept improved over the course of intervention.

Method

Design

We conducted a longitudinal single-case study which included two baseline assessments prior to the intervention, and two follow up assessments (Post-intervention 1 and 2) (Howard, Best, & Nickels, 2015). The study, apart from AM, included two different control groups matched in age. This enabled us to make robust comparisons when experimental tasks were used. All the control group children came from AM's classroom in order to control for teaching experience. The first control group consisted of 13 typically developing children matched to AM for age (mean: 10.03, SD: .8, p=1). This group formed the comparison group for the VAS tasks (presented in the baseline assessments). The second control group consisted of six typical spellers from the same class as AM (mean age: 9.6, *SD:* .54, p=.49) who were

assessed for spelling the criterion referenced words. The same children (control group 2) were also assessed at the post-intervention Time 2 as a comparison group.

Modified t-tests were used to determine whether AM's performance differed significantly from that of the comparison groups' in experimental tasks (Crawford & Garthwaite, 2002). For single case designs appropriate methodology is highly recommended, as such one can claim that the change is due to the intervention and not due to measurement error or variability in performance (Howard et al., 2015). Modified t-tests have been specifically developed to overcome this obstacle by giving the researcher the opportunity to compare an individual's scores against a comparison group when normative data are not available (Crawford & Garthwaite, 2002). This is considered to be a reliable technique for comparing the score of an individual with that of a group. Crawford and Garthwaite (2002, p. 1197) '*utilised a formula developed by Sokal and Rohlf (1995) in this the statistics of the comparison group are treated as statistics rather than as population parameters, and they use the t-distribution (with N − 1 degrees of freedom (d.f.)), rather than the standard normal distribution, to evaluate the abnormality of the individual's scores. This method is called a modified independent samples t-test in which the individual is treated as a sample of M = 1, and therefore does not contribute to the estimate of the within group variance*'.The formula used for the calculation of the signicance and effect sizes is:

$$t = \frac{\mathrm{X1} - \mathrm{X2}}{S2\sqrt{(N2+1)/N2}}$$

Note: X_1= the case's score, X_2= the mean score of the normative sample, S_2= is the SD of the normative sample and N_2= is sample size.

Next, we present AM and information collated by his parents, teachers, and himself.

Case Study

AM is a monolingual English-speaking boy, aged 10;03 at the start of the study. AM's parents and teachers had concerns related to his difficulties with reading, spelling and writing and referred to the first author for diagnostic assessment. When the assessments began, he was in the middle of Year 5, and he lived in an inner-city area in the UK. Prior to literacy and cognitive assessments, an in-depth interview was conducted with AM, his parents and teacher to gain information on AM's history and behavioural profile which could help shed light on his strengths and difficulties (Frith, 1999; Reid & Came, 2009). AM had a normal birth, and all developmental milestones (motor, social, emotional, language) were attained at the appropriate ages. AM had an older sister in secondary school and a twin brother with a diagnosis of autism. AM's father had a diagnosis of dyslexia. AM's teacher said that he struggled to memorise words for spelling, that he found reading comprehension challenging, and struggled with written compositions. Regarding attention, the teacher reported that he did things too quickly, and was often overactive or fidgety. To help him, at the time of the study, AM attended precision spelling sessions three times every week. AM reported that he was falling further behind his classmates. He liked reading for pleasure at home, but only read easy books (with pictures and familiar words). He reported no comprehension difficulties but mentioned that he was not confident with story writing and that others could not easily understand what he had written.

Initial Assessments

Literacy Assessments (Baseline 1). AM was assessed in reading comprehension, reading, spelling and written expression using the Wechsler Individual Achievement Test (2nd Edition) (WIAT II). The WIAT-II test provides UK norms, and the total reliability coefficients are above α=.83 (Wechsler, 2005). We also used the Diagnostic Test of Word Reading Processes (DTWRP, FRLL, 2009-2012) test of regular and exception word and pseudoword reading to assess further lexical and sublexical processes. The test consists of 30 irregular words, 30 regular words and 30 pseudowords. The DTWRP is an individually administered single word and pseudoword reading test appropriate for assessing the academic achievement of children and young adolescents who are aged between 5 and 12 years 11 months (Year 1 to Year 7 in England and P2-S1/Y8 in Scotland and Northern Ireland). All reliabilities were very high, (composite score .99, nonwords .96, exception .97 and regular .97). To assess sublexical processes for spelling a pseudoword spelling task was administered. Such a test with UK norms for children does not exist, so we used the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA, Kay, Lesser, & Coltheart, 1996) nonword spelling subtask.

Criterion Referenced Assessment (Baseline 1 and 2). For spelling assessment, we also used a criterion referenced assessment of 167 words selected from The National Curriculum in English, Key stages 1 and 2 framework (Department for Education, DfE, 2013, p. 49-73). Please also see Appendix A. The 167 words included items with a variety of orthographic and morphological elements (short and long vowels, consonant digraphs, mono-morphemic and multimorphemic words with inflectional and derivational morphemes). The words also varied in frequency (0-3,959 per million), length (3-11 letters) and number of orthographic neighbours (0-17 Nsize). AM was assessed on the list of 167 items in two different baseline assessments (one month apart). The testing was completed in three separate sessions to avoid fatigue.

General ability (Baseline 1). Underlying ability was assessed using the Wide Range Intelligence Test (WRIT, Glutting, Adams, & Sheslow, 2000). This test measures two different domains, an individual's underlying verbal ability and underlying visual/non-verbal ability. When these scores are similar, the combination of verbal and non-verbal ability can provide the individual's general ability. WRIT has high internal consistency which ranges from α = .84 - .95

Cognitive assessments (Baseline 1). The Comprehensive Test of Phonological Processing 2 (CTOPP II) was used (Wagner, Torgesen, Rashotte, & Pearson, 2013). The CTOPP II assesses phonological awareness (the ability to manipulate the sounds of language), phonological short-term memory (the ability to hold in memory phonological information) and rapid naming (the ability to retrieve fast phonological information from long-term memory). For all subtasks, reliability was reported to be high α>.80 apart from pseudoword repetition which has a coefficient α=.77.

In order to explore a possible attention/concentration difficulty, phonological working memory and visual memory we administered the Wide Range Assessment of Memory and Learning 2nd Edition (WRAML II, Sheslow & Adams, 2003). For all core indexes, reliability of WRAML II was reported to be high (α>.86). Finally, visual attention span was assessed by the task developed by Bosse et al. (2007) (please see Bosse et al. (2007) for a description of the task). We aimed to explore if AM had a visual attention span deficit in addition to phonological difficulties. Visual attention span assessment can provide an index of a difficulty in multicharacter item recognition in a single fixation.

Social/Emotional assessment (Baseline 1). AM was also assessed before the intervention on the Piers-Harris Self-concept scale (Piers & Herzberg, 2002), which measures six domain subscales, Behavioural Adjustment, Intellectual and School Status, Physical

Appearance and Attributes, Freedom from Anxiety, Popularity, and Happiness and Satisfaction. For all core indexes, reliability was reported to be good α>.74.

Procedure

All information presented was collated in AM's school after ethical clearance was obtained, and informed consent and assent were signed by the participants and their guardians. In order to estimate the measurement error, we report the confidence interval (CI, how close is the sample mean to the population mean, calculated as '1' for 68% CI and '1.96' for 95% CI). All CIs reported are 95%. The test results below are reported as standardised scores (SS). A standardised score allows the student's performance to be compared to the typical performance of students of the same chronological age. All scores reported are based on a distribution of 85-115, which is the typical range. When SS are not available, we recruited a comparison same age group from AM's classroom (please see Section *Design* for more detail). In addition to the Baseline 1 and 2 data to monitor the effectiveness of the intervention, AM participated in follow-up assessments at the end (Post-test 1), and five months after the conclusion of the programme (Post-test 2). Data at both follow-up assessments were collected by a trained research assistant blind to the purposes of the intervention. Standardised literacy results were also collected. Next, we present the intervention study AM took part in.

Intervention Study. We developed an intervention grounded in the suggested best dyslexia teaching strategies (i.e., Apel & Masterson, 2001; Gillingham & Stillman, 1997; Kirk & Gillon, 2009; Reid & Came, 2009; Tse & Nicholson, 2014). These include explicit teaching in a one-to-one session, direct instruction techniques, development of metacognitive strategies, using scaffolds to help the learner create a new schema or assimilate information to pre-existing schemata, multisensory strategies, structured, cumulative and sequential teaching, positive feedback. A pragmatic reason for tailoring a linguistic awareness intervention was the number of difficulties that AM had (with phonology, morphology, orthography, spelling and reading, handwriting and written expression), based on the initial assessments. The intervention was conducted over nine sessions at AM's school, each session lasting approximately an hour.

The intervention overall aimed to support the following skills:

Phonological ability (PA) was targeted by using Hatcher's (1999) Sound Linkage programme. We included segmentation ('talking like a robot' activities), blending (*The turtle talk*, by Tse and Nicholson (2014)- or *continuous voicing* by Apel and Swank (1999), e.g., /ccaaattt/ instead of /c/, /a/, /t/, he used these activities during both reading and spelling), deletion (search for the little words in big words 'mat->at', which can help in observing the constituent parts of the word (Apel & Masterson, 2001), substitution, transposition and spoonerism activities. For the last three sessions, we used the phonics programme from the computerised Nessy.com programme (Carbol, 2015). The decision to target phonological ability was due to AM's core difficulties in this skill.

The teaching of spelling included direct instruction of morphological/orthographic rules (i.e., Kirk & Gillon, 2009). The activities aimed to target the actual errors made during baseline spelling assessments (e.g., spelling of suffixes -ing, -y, -ies, -er,-est, -tion, -sion, -ssion, -cian and -ation, -ly and -ed, and apostrophy and possesives). To teach spelling rules, we used 70 items in total, and approximately eight items were given at the end of each session for AM to practice at home with his parents. Of these 70 words used, only 22 were included in the 167 criterion test, as we aimed to investigate whether teaching the spelling rules would improve words not directly trained by the practice items in class and at home. Direct instruction using the misspelled words from baseline assessments used the following steps: presentation of a card which included the misspelled part in a different colour. The instructor explained the

error made, provided the correct spelling and stated the rule. The rule was also presented on a card with a visual depiction, e.g., *When there is a consonant before the y, change the y to i and add the -ed Why?... because the –y likes changes like the butterfly does (a semantically related picture with a caterpillar changing into a butterfly was provided).* Next, the instructor asked AM to repeat the rule (as in Kirk & Gillon, 2009) and write the word or complete activities like the ones presented next. If the misspelling was due to incomplete representation of the derived word, then direct links were provided between the root word and its derived form (e.g., <electric> -> <electrician>). Strategies such as, find the word hidden in the derived word (<music>-<musician>) were also used. AM was also encouraged to use visual aids to support his learning and memory (Brunsdon et al., 2005; Partz, Seron, & Van Der Linden, 1992; Niolaki & Masterson, 2015) (see Figure 1). To teach spelling games were included, such as hangman, matching games between root words and derived ones, (i.e., <magic>-<magician>), games with plastic letters, cutting the words into single phonemes and assembling the phonemes to create the words, and look-cover-spell activities on the spellzone.com (Spellzone: Retrieved from https://www.spellzone.com/group_teacher.cfm).

To support syntactic and semantic awareness, AM was always directed to put the taught words into a sentence following the instructor's demonstration on how this should be done.

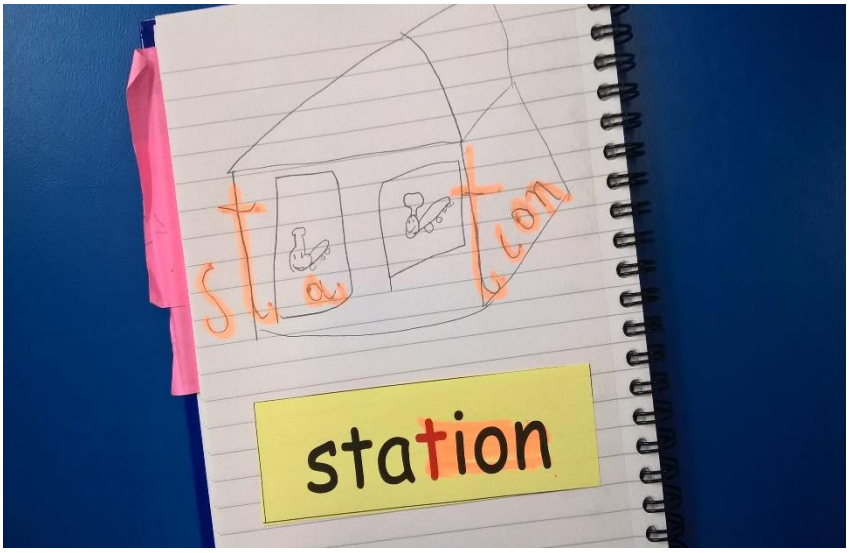

Figure 1 The visual imagery technique by AM

In relation to written expression, we followed the Extending Interactions with the non-fiction texts (EXIT) model by Wray and Lewis (1997). We used Mallet's (1992) and Wray and Lewis's (1997) reading and writing instructions for writing non-fiction: activating previous knowledge (brainstorming techniques and spider diagrams, making predictions and asking questions), establishing purposes, discussing and planning, interacting with the text and communicating information. Some of the activities included were to provide a framework for extended writing, e.g., support in how to develop writing frames (Wray & Lewis, 1997) which provide a series of prompts to support the child's writing and also function as a method to ease cognitive demands (Riley & Reedy, 2005). Other strategies, such as text marking, summarising, numbering text to show a sequence of events, were taught to help identify important information in a given text. Finally, at session nine AM wrote a letter to the local zoo. The aim of this activity was to help AM explicitly realise the importance of writing.

The intervention also aimed to support sentence construction, correct punctuation, use sophisticated vocabulary to enhance the text and use of legible handwriting (correct formation

of lowercase and uppercase letters) and correct pencil grip. Thus, our focus was to evaluate whether teaching AM strategies for planning and improving sentence structure could enhance writing performance (Graham & Harris, 2014). All reading and writing materials were devised by the first author and can be provided upon request. The intervention was also administered by the first author in order to make sure that the intervention targeted the skills in a consistent way during the nine sessions.

Interactive technology (IT) was also used to support teaching; specifically, the freely accessible spelling activities on spellzone.com and the BBC Bitesize activities for Key Stage 2 written expression were used in combination with pencil and paper activities. AM's parents were also provided with a letter with PA activities and instructions on how to teach the spelling of the misspelled words at the end of each session.

In summary, the intervention included:

- Phonological ability training (Hatcher's Soundlinkage programme) (90mins: 10mins x 9 sessions) - Nessy.com phonics training;
- Spelling (focusing on phonemic and morphological awareness and orthographic knowledge) and handwriting skills (based on words AM had misspelled, words are taken from The National Curriculum in England KS1 and KS2) (180 mins: 20mins x 9 sessions);
- Writing ability and vocabulary skills (180mins: 20 mins x 9 sessions);
- Improving reading skill and speed (use of speedreading strategies, such as improvement of reading speed by the use of a stopwatch, 90mins: 10 mins x 9 sessions).

Results

Baseline 1 assessments

AM demonstrated strengths in general ability, with a standardised score of 95 (95%CI, 89-101) on the WRIT (WRIT, Glutting et al., 2005), and in reading comprehension (WIAT-II, Wechsler, 2005), with a standardised score of 102 (CI 95% 96-108)). However, he did not read at a speed commensurate with his reading age and reading comprehension ability. AM often substituted a real word with a visually similar real word (approximately 40% of errors). He mainly produced disphonetic errors (for example, *change*->'charge'). This indicates that he did not effectively use phonological strategies. Similarly, in pseudoword reading using the WIAT II subtest he read at a slow pace, making mainly lexicalization errors but also nonword errors (*infrections* -> 'infrotection', *caft*-> 'craft' and *clotch*-> 'cloth'). This outcome was further supported by the assessment of regular words, irregular words and pseudowords, AM achieved in DTWRP (FRLL, 2009-2012), achieving standardised ranges of 74-81 for pseudoword reading, of 81-89 for regular word reading, and 90-96 for exception word reading. AM demonstrated a phonological profile, with pseudoword reading difficulties but strengths in lexical-semantic reading (Broom & Doctor, 1999a; Hulme & Snowling, 2009; Snowling, 2000). In Table 1, scores in each subtask are given.

Table 1 Scores in background assessments Standardised scores and confidence intervals for AM are reported (scores in bold are composite scores)

Measures	**Task description**	**Skill assessed**	**Standardised Score (mean 100)**	**95% CI**
Verbal Analogies[a]	The Wide Range Intelligence Test (WRIT, Glutting et al., 2000) was used to assess verbal and non-verbal ability.	*Verbal Intelligence*	104	
Vocabulary[a]			94	
Verbal Composite Score[a]			**99**	**92-106**
Matrices[a]		*Non-verbal Intelligence*	94	
Diamonds[a]			103	
Visual Composite Score[a]			**92**	**85-100**
General Ability[a]		*General Intelligence*	**95**	**89-101**
Attention/Concentration Composite score[b]	Wide Range Assessment of Memory and Learning 2nd Edition (WRAML II) (Sheslow & Adams, 2003): finger windows and number letter subtasks.	*Attention & Concentration*	**79**	**71-90**
Phonological Working Memory[b]	WRAML II (Sheslow & Adams, 2003): Tests phonological and symbolic memory in the latter no verbal recall was involved	*Working memory assessment*	**60**	**54-70[1]**

Reading Attainments				
Reading comprehension[c]	The Wechsler Individual Achievement Test-Second UK Edition (WIAT-II UK, Wechsler, 2005). AM read each passage aloud and was allowed to look at each passage before answering questions. The time needed to read each passage was recorded.	*Measures types of classroom and everyday life reading comprehension.*	102	96-108
Reading words in context[c]		*Lexical reading*	0-90	
Reading speed [c]		*Lexical reading*	0-90	
Single word reading[c]	Reading of single words in isolation and without the support of textual context.	*Lexical reading*	85	81-89
Pseudoword Decoding[c]	Reading aloud of single pseudowords (e.g., *brafe*)	*Sub-lexical reading*	81	77-85
Reading Composite Score (WIAT II)[c]			**87**	**84-90**
Fine-grained assessments in reading				
Pseudoword reading[d]	Diagnostic Test of Word Reading Processes (DTWRP, FRLL, 2009-2012): can provide a profile of strengths and weaknesses on whole word recognition (lexical-semantic processes) and pseudoword decoding (sublexical processes).	*Sub-lexical reading*	74-81	
Regular word reading[d]		*Lexical reading*	81-89	
Exception word reading[d]		*Lexical reading*	90-96	
Reading Composite score (DTWRP)[d]			**83**	**78-89**
Spelling Attainments				
Spelling[c]	(WIAT-II UK, Wechsler, 2005) 53-word test graded in difficulty. Each word appears in the context of a meaningful sentence to avoid ambiguity.	*Lexical spelling*	70	63-77
Written Expression[c]	(WIAT-II UK, Wechsler, 2005) A test of fluency, sentences and paragraph.		64	51-77
Written Word Fluency [c]			91-100	
Written Word count [c]			≥111	

Spelling Attainments				
Spelling[c]	(WIAT-II UK, Wechsler, 2005) 53-word test graded in difficulty. Each word appears in the context of a meaningful sentence to avoid ambiguity.	*Lexical spelling*	70	63-77
Written Expression[c]	(WIAT-II UK, Wechsler, 2005) A test of fluency, sentences and paragraph.		64	51-77
Written Word Fluency [c]			91-100	
Written Word count [c]			≥111	
Written Language Composite Score (WIAT-II)			**62**	**48-76**
Fine-grained assessments in spelling				
Pseudoword spelling [e]	PALPA (Kay et al., 1996), the test has 24 items, 3 to 6 letters long.	*Sub-lexical spelling*	8.3[2]	
Cognitive Assessments				
Elision	Comprehensive Test of Phonological Processing 2 (CTOPP II, Wagner et al., 2013) was used to assess phonological awareness (PA), RAN and phonological short-term memory. *PA assessed with words*	*Phonological ability*	95-100	
Blending Words			80-84	
Phoneme Isolation			80-84	

PA Composite Score [f]			**82**	**74-90**
Blending pseudowords	*PA assessed with pseudowords*	*Phonological ability*	70-74	
Segmenting pseudowords			85-89	
PA Composite Score (using pseudowords) [f]			**73**	**65-81**
Rapid Naming Digits	Ability to name with speed single digits or letters. The time taken to name is recorded as well as the accuracy of naming.	*Rapid naming*	90-94	
Rapid Naming Letters			70-74	
Rapid Naming Composite Score [f]			**76**	**68-84**
Memory for Digits	The tasks assess the ability to repeat a series of single digits and pseudowords.	*Phonological short-term memory*	70-74	
Pseudoword Repetition			75-79	
Phonological Memory Composite Score [f]			**67**	**55-79**
Visual Memory Subtest [g]	Assesses visual memory for abstract designs and delayed design memory recognition.	*Visual memory*	90-94	
Design Memory Recognition [g]			85-89	

Note :[1] 90% CI, [a]WRIT, (Glutting et al., 2000), [b]WRAML II, (Sheslow & Adams, 2003), [c]WIAT-II UK, (Wechsler, 2005), [d] DTWRP, (FRLL, 2009-2012), [e]PALPA (Kay et al., 1996), [2]% correct, [f]CTOPP II, (Wagner et al., 2013), [g]WRAML II, (Sheslow & Adams, 2003)

AM's spelling profile was not dissimilar to his reading profile. In real word spelling (WIAT-II) AM produced letter omissions (57% of errors), as well as substitutions and additions, and only 50% of his errors were phonologically appropriate. To calculate the similarity of errors and targets we used Bruck and Water's (1988) visual accuracy measure, which is the percentage of bigrams and individual letters that the spelled word shared with the target word. The overlap between the errors and targets was 59% (*SD*: 21). AM also made a number of morphological (35.7%) and orthographic awareness errors (64.3%) in spelling. In an orthographic choice test where AM had to decide which of two items was spelled correctly (e.g., rume vs room) (after Olson, Forsberg, Wise & Rack, 1994), he scored 51 (63.7%) out of 80 correct. A comparison group of six typically performing children from AM's class (mean age: 9.6, *SD:* .54) were assessed with the task. The mean score was 94.5% (*SD:* 5.3) correct, the modified *t-test* results was $t(6)=5.3$, $p=.001$, Z-CC (plus 95% CI) = -5.81 (-9.38 to -2.26).

In the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA, Kay et al., 1996) nonword spelling subtask, AM was able to spell only 2 out of 24 items. His error responses were only 50% (*SD*: .22) visually similar to the target pseudoword. Some of the errors did not follow phoneme-grapheme correspondence rules (e.g., *birl* -> GIDE, cug -> CATHEAD), indicating that he was not using phonological encoding skills efficiently. His errors included mainly grapheme additions (on average he wrote 5.1 letters (*SD:*1.04) when the mean target letter length was 4.4 letters (*SD:*1.1)) and substitutions.

In written expression (WIAT-II, subtask), AM demonstrated good overall word fluency (standardised score range 91-100). In the sentences subtask, AM achieved a low score as he frequently failed to produce grammatically correct sentences (for example, MARK HAS A AMAZING SISTER WHO IS 6 YEAR'S OLD CALLD ANNA). AM also made many morphological errors (for example CALLD for *called*) and punctuation errors (couldn't -> COULDENT). The paragraph produced by AM was not rich in vocabulary. The sentences were mainly simple, and there were not many conjunctions. AM's writing was not always legible. In addition, strokes in letters were wobbly and shaky. These are key indications of developmental coordination difficulties in handwriting (Montgomery, 2006).

Based on the cognitive assessments, AM seemed to have a core phonological deficit according to the CTOPP II test (Wagner et al., 2013), but also dificulties in attention/concentration based on the WRAML II (Sheslow & Adams, 2003). The overall composite score for Attention/Concentration gave a standardised score of 79, indicating that AM had difficulties in this domain as well (see Table 1). This finding agrees with the teacher's earlier observation but also with literature that supports co-morbidity between Attention/concentration difficulties and Dyslexia (Carroll, Maughan, Goodman, & Meltzer, 2005; Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2005). Assessments of visual memory (WRAML II) and VAS (experimental task developed by Bosse et al., 2007) did not indicate a major difficulty (see Table 1, and 2 for the VAS scores). The VAS is an experimental task, therefore, a control group of 13 individuals was used to detect any substantial differences to the comparison group (please see *Design* section). AM's score did not differ substantially from that of the comparison group for simultaneous or sequential presentation in the global report VAS task. In the partial report version of the task, AM's score was marginally less accurate than the mean for the comparison group, modified *t-test* outcome: $t(13)= 1.83$, $p=.046$, effect size (Z-CC) for difference between case and controls (plus 95% CI) = -1.9 (-2.81 to -0.96).

Selective impairment in phonological ability and memory and RAN is characteristic of children with phonological dyslexia (Melby-Lervåg, Lyster, & Hulme, 2012; Snowling, 2000). AM falls in the double deficit subcategory of dyslexia with substantial difficulties in both phonological ability and rapid naming (see Table 1) (Wolf & Bowers, 1999). According to these researchers, children in this category exhibit the most severe literacy difficulties due to the limited compensatory strategies they have at their disposal. Finally, concerning the self-concept scale (Piers & Herzberg, 2002), AM gained an overall standardised score of 70, he had

strengths in the behavioural adjustment and happiness sub-domain; however, he scored low in popularity. He gained below average scores on the physical appearance domain and the intellectual and school status domains.

Table 2 Results for AM and the comparison group in the VAS tasks

Measures	*AM*	*Comparison group mean*	*t-test*
Global report task simultaneous presentation, arrays correct (max. correct: 20)	4	7.84 (5.77)	p=.26
Global report task simultaneous presentation, letters correct (max. correct: 100)	64	81.46 (10.6)	p=.07
Global report task sequential presentation, arrays correct (max. correct: 20)	4	5.75 (4.02)	p=.34
Global report task sequential presentation, letters correct (max. correct: 100)	70	68 (25.2)	p=.47
Partial Report (max. correct: 50)	32*	40.15 (4.37)	$t(13)$= 1.83, p=.046,

Note: *p<.05

Baseline 1 and 2 assessments

In the criterion referenced assessment AM's performance was contrasted with that of a comparison group (N=6). The comparison group's mean score of 153.83 (out of total 167) correct (*SD:* 9.84) was substantially better than AM's score at Baseline 1 and 2 assessments, $t(6)$= 6.28, p< .001, r=.93 and $t(6)$= 6.01, p< .001, r=.92, respectively. AM spelled 87/167 items correctly at Baseline 1, and 90/167 items correctly at Baseline 2. The McNemar test indicated no substantial difference χ^2 (1) = 1.33, p=.25. During both baseline assessments, he made predominantly non-phonologically appropriate errors [B1= 55% and B2=53.2%].

Results of Intervention Programme (Post-test 1 and 2)

Next, we present AM's performance in the follow-up assessments at the end (Post-test 1), and five months after the conclusion of the programme (Post-test 2). To re-cap, during the Pre-intervention (T1) assessment AM struggled with reading, spelling, and written expression. His scores in all assessments were below average. AM also had below average poor phonological awareness and short-term memory scores.

Criterion referenced assessment. ***i. All items.*** AM was re-assessed on the 167 words three days after the end of the intervention (Post-test 1) and five months later (Post-test 2). The items in each assessment were administered in a randomised order, over three different sessions. At Post-test 1, he spelled 139 words correctly, a gain of 50 words, and at Post-test 2 he spelt 125 items correctly. We conducted analyses to determine whether the intervention produced a substantial change in AM's spelling. Inspection of Table 3 shows that following the intervention AM achieved above the maximum expected gain of 22 trained words over his baseline score of 87 (109 words)(pre-test 87/167 + 22 = 109/167). We also used McNemar's test to investigate improvement. This involved comparison of performance at Baseline 1

versus Post-test 1 versus Post-test 2. The results showed that between Baseline 1 and Post-test 1 there was a substantial increase in accuracy ($\chi 2(1)=46.44$, $p<.0001$), whereas between Post-test 1 and Post-test 2 there was a decrease in performance ($\chi 2(1)=7.04$, $p=.008$). However, the difference Baseline 1 and Post-test 2 was substantial ($\chi 2(1)=29.8$, $p<.001$).

We also used a bi-gram analysis which is considered to be a more sensitive measure of spelling performance (Apel & Masterson, 2001; Vaughn, Schumm, & Gordon, 1993). According to the analysis conducted by Apel and Masterson a bi-gram correct score is the number of letter-pairs spelled correctly plus the first and last grapheme, for example in the word <*WERK*> for <work> AM gained a bi-gram correct count of 3 out of 5 (initial W – 1; final K – 1; bigram WE – 0; bigram ER – 0; bigram RK – 1). Kromrey and Foster-Johnson (1996) recommended that effect size calculation can complement the interpretation of single-subject data. The same analysis was also used by Apel and Masterson (2001) to calculate the effectiveness of their spelling intervention. The formula to calculate the standardised mean difference was:

$$\text{a.}\ \frac{\text{X Post-test 1} - \text{X Baseline 1}}{\text{SD Baseline 1}} = d$$

$$\text{b.}\ \frac{\text{X Post-test 2} - \text{X Baseline 1}}{\text{SD Baseline 1}} = d$$

Note: X is the mean bi-gram correct score for the 167 words, and SD is calculated based on the bi-gram correct score.

The equation gave us in both contrasts medium effect sizes of $d=.69$ and $d=.53$, respectively. These indicate an improvement in the spellings of the 167 words and that this improvement was sustained.

Table 3 Accuracy in spelling the 167 items for AM and the comparison group (standard deviations are in parentheses)

		Pre-intervention		Post-intervention	
		Baseline 1	*Baseline 2*	*Post-test 1*	*Post-test 2*
AM	Total set/167	87	90	139	125
	Trained subtest/22	2	3	18	13
	Untrained subtest/58	0	0	36	29
Comparison group mean	*total set/167*	*153.83 (9.84)*	-	-	*153.83 (8.68)*

In order to exclude the possibility of general maturation effects which could have caused improvement in spelling, the comparison group children, who were tested prior to the intervention (at Baseline 1), were re-assessed in spelling the 167 words at the same time AM was given the final post-intervention assessment (at Post-test 2). The outcome for the comparison children is given in Table 3. The scores were analysed using paired t-tests and demonstrated no significant difference in accuracy across time for the comparison group ($t(166)=.00$, $p=.1$ (two-tailed)).

ii. Untrained items. Regression to the mean is a statistical phenomenon observed when performance on its first assessment is extreme (i.e., selection of items based on misspellings made at baseline) and as a result, at the next measurement, it will tend to move towards the average. In order to make sure that AM's performance was a true improvement

and not an artefact due to regression to the mean, we followed the procedure suggested by Brunsdon et al. (2005) in their single case study. We calculated the improvement in accuracy comparing the spelling outcome between Baseline 1 - Baseline 2 for all the items in the 167-word list. Next, we compared this with the improvement in the untrained items from Baseline 2 to Post-test 1. There was indeed an improvement in accuracy between Baseline 1 and Baseline 2 of 1.7% for the total number of items in the 167-word list. However, the increase in the untrained items from Baseline 2 to Post-test 1 was 62%, and this change was significantly larger in contrast to the increase observed for all the items between the two baselines ($\chi^2(1)=79.18$, $p<.001$).

iii. Phonologically appropriate errors. Before the intervention, AM predominantly made non-phonologically appropriate errors (B1: 55%, B2: 53.24%) while the comparison group children made far fewer (mean=17.5%, *SD*:5.34). At Post-test 1 and 2, the rate of non-phonologically appropriate errors for AM decreased to 25% and 38.1%, respectively.

iv. ***Morphological errors.*** At the baseline assessments, 19.2% and 20.3% of AM's errors were morphological errors whilst the control group made 3.2% (*SD:* 4) morphological errors at baseline 1 and 3.2% (*SD:* 2.3) at Post-test 2. The rate of morphological errors decreased at post-test assessments for AM (Post-test 1 - 1.2%; Post-test 2 - 12.6%).

v. Orthographic errors. AM made errors due to poor orthographic knowledge at Baseline 1 and 2 at a rate of 25.7% whilst the control group made 4.3% (*SD:* 2.1) at baseline 1 and 3.3% (*SD:* 1.4) at post-test 2. This type of error decreased for AM at Post-test 1 to 15.6%, and at Post-test 2 to 12.6%.

Additional assessment of literacy and cognitive skills post-intervention. In the baseline testing, standardised reading, spelling, and written expression assessments scores were below average (see Table 4). AM's reading improved, and the 95% confidence interval (CI) for standardised scores were well above the scores he got at the pre-intervention assessment (pre-intervention 81-89 vs Post-test 2 91-99). Even higher gains were observed in pseudoword decoding (as assessed by the WIAT-II, Wecshler, 2005) (95%CI pre-intervention 77-85 vs Post-test 2 102-110), indicating the positive effect of the phonics orientated training. The findings in the WIAT-II reading test were corroborated by the DTWRP (FRLL, 2009-2012) where we also found a reliable improvement and the results were within those obtained for same age typically developing readers. Although the intervention mainly targeted spelling and written expression we observed positive transfer to reading skills. In addition, the inclusion of speeded reading with a stopwatch showed a positive impact on the reading speed standardised scores during the post-intervention assessment; AM's scores were now in the average range.

In spelling, substantial gains were found, and at Post-test 2, AM's performance was within the average range (95% CI pre-intervention 63-77 vs Post-test 2 90-104). Substantial improvements were observed in written expression (95%CI pre-intervention 51-77vs. Post-test 2 98-114). In the pseudoword spelling test, AM improved by approximately 50% in comparison to his pre-intervention score. On average AM used less letters to spell the pseudowords [Pre-intervention T1 5.1 (*SD*: 1.04) vs Post-intervention T2 4.6 (*SD*: 1.24)]. In addition, we calculated the visual similarity to the target pseudoword and this increase at the Post-test 2 (Pre-intervention T1 50% (*SD*: .22) vs Post-test 2 64% (*SD*: .16), the improvement approached significance, $t(30)=1.8$, (two-tailed) $p=.08$, r=.31. This indicates that the misspellings are closer graphotactically to the target (for example at Pre –intervention T1 he spelled *hoach*-> HSATEH, but at Post-test 2 AM produced HOCH).

AM also improved in phonological ability where he gained an average composite score at Post-test 2 of 90 and his post-intervention true score was higher than the one gained at the Pre-intervention T1 assessment [78-86 vs 86-94]. The gains were even more substantial for the phonological awareness assessment using pseudowords [CI: Pre-intervention T1: 69-

77 vs Post –test 2 94-102]. Improvements were also observed in the RAN letters assessment [Pre-intervention T1: 70-74 vs Post –test 1 95-99]. Improvement in short-term memory was not observed, but this was expected as the intervention did not focus on this skill.

Finally, AM was also re-assessed in the Piers-Harris 2 (Piers & Herzberg, 2002), our measure of self-esteem. AM gained an overall standardised score of 70, which indicates that his self-esteem was still below average. This indicated that AM continues to have doubts about his self-worth. This suggests that the intervention was not enough to boost his self-confidence.

General Discussion

Associated deficits

We first discuss the outcome of the detailed assessment and focus next on the results derived from the intervention. The results obtained for phonological and lexical/semantic strengths and weaknesses (Castles & Coltheart, 1993; Coltheart & Leahy, 1996; FRLL, 2009-2012; Griffiths & Snowling, 2002) indicate that AM had literacy difficulties stemming from phonological processing deficiencies. His performance was below average in PA, RAN and phonological memory as assessed with the CTOPP II (Wagner et al., 2013). Assessments conducted with regular word, irregular word and pseudoword reading indicated strength in lexical processes (Castles & Coltheart, 1993; Coltheart & Leahy, 1996; FRLL, 2009-2012; Griffiths & Snowling, 2002).

The co-occurrence of difficulties in PA, RAN and phonological working memory suggest that the etiology/ies of dyslexia can be better captured by modules that do not focus on a single deficit (Pennington, 2006; van Bergen, van der Leij, & de Jong, 2014). We aimed to provide an intervention which captured the range of difficulties AM displayed. For spelling skill, we had to rely on a pseudoword spelling test used for adults with acquired disorders (see for a discussion, Niolaki, Vousden, Terzopoulos, Taylor, Debney, Shepherd & Masterson, 2019). AM had a clear difficulty in this test, indicating difficulties with phonological encoding. However, as we did not assess exception-word spelling, we can not suggest a single phonological or lexical/semantic profile in spelling as is suggested for his reading. For spelling evaluation, the IPA theory proposed by Treiman and Kessler (2014) helped us effectively design the linguistic awareness intervention (Apel & Masterson, 2001; Kirk & Gillon, 2009) which seemed to work effectively (as discussed next) for AM. The IPA framework acknowledges the importance of morphology and the child's ability to easily learn spelling patterns that frequently occur to a greater extent, in comparison to past theories of spelling development (phase and stage theories, DR models). The inclusion of morphological and orthographic training simultaneously with activities tapping phonology could more reliably support spelling improvement, as spelling is a multi-faceted skill involving all three processes (Treiman, 2017). Our findings support the Simple View of Writing (SVW) (Berninger et al., 2002; Juel, 1988; Juel et al., 1986). To develop operational writing skills a child like AM, should develop an awareness (implicit or explicit) of language phonology, morphology, syntax and semantics. It is likely that once the foundation skills are established, the higher skills can be developed.

Table 4 Pre- (T1) and Post-test (T1 & T2) Standardised scores in literacy and cognitive assessments for AM *(95% CI are in parentheses)*

	Pre-Intervention T1	*Post-test1*	*Post-test 2*
Word Reading[a]	85 (81-89)	99 (95-103)	95 (91-99)
Pseudoword Decoding[a]	81 (77-85)	93 (89-97)	106 (102-110)
Spelling[a]	70 (63-77)	98 (91-105)	97 (90-104)
Written expression[a]	64 (51-77)	114 (101-127)	111 (98-114)
Reading speed[a]	0-90	101-110	101-110
Pseudoword spelling[b]	**8.3**[1]	-[2]	**58.3**
Pseudoword reading[c]	74-81	90-96	90-96
Regular word reading[c]	81-89	90-96	97-103
Exception word reading[c]	90-96	90-96	104-111
PA Composite Score[d]	82 (74-90)	96 (88-104)	90 (82-98)
PA Composite Score (using pseudowords)[d]	73 (65-81)	-	98 (90-106)
Rapid Naming Letters[d]	70-74	95-99	-
Memory for Digits[d]	70-74	70-74	70-74

Note: [a]WIAT-II UK (Wechsler, 2005), [b]PALPA (Kay et al., 1996), [c]DTWRP (FRLL, 2009-2012), [d]CTOPP-II (Wagner et al., 2013), [1]% correct, [2]data were not collected

Intervention

Overall, the results indicated that a sequential, cumulative, structured and multisensory approach could be effective. The effect size outcomes for spelling, especially (*d*=.69 and *d*=.53) argue against suggestions that specialist teaching does not work effectively for dyslexic individuals (Elliot, 2015). Similar positive results in relation to specialist dyslexia teaching approaches were also reported by Apel and Masterson (2001) (*d*=.84), for a participant older in age and without a diagnosis of dyslexia. But also it is important that the intervention can help the student become explicitly aware of the rules that govern the language (Apel & Werfel, 2014; Graham & Harris, 2014; Kirk & Gillon, 2009). The training can indicate that a linguistic intervention simultaneously targeting more than one literacy skill can have a highly substantial impact on a student with dyslexia like AM. In relation to reading and spelling processes, we can see that this holistic intervention (which lasted only nine sessions) had an extremely beneficial impact on both phonology and orthography and significantly strengthened his morphological awareness. Therefore, for spelling, an intervention must have a large number of criterion-referenced items as in that way, we can have more confidence in the results (Howard et al., 2015).

Apel and Masterson (2001) were not able to find generalised improvement in written expression. However, we were able to, as the intervention also targeted writing skills such as drafting and writing for different purposes and audiences. This finding is in agreement with Graham et al.'s (2002) suggestion that handwriting instruction and self-regulatory features of writing can have a more positive influence on writing treatment. In addition, we were able to find that raising awareness of spelling patterns and rules and combining this with phonological training can have a substantial positive impact on spelling and reading (Apel & Masterson, 2001; Treiman & Kessler, 2014; Treiman, 2017). Other researchers in the past, have suggested that training in spelling can generalise to reading (Niolaki et al., 2017; Kohnen et al., 2008) and we were also able to confirm that through our intervention. However, it is also interesting to note the Georgiou, Torppa, Landerl, Desrochers, Manolitsis, de Jong, and Parrila (2020) in a cross-linguistic longitudinal study exploring the bidirectional links between spelling and reading performance in Grade 1 and 2 children did not find a predicted link from spelling to reading, whereas the opposite was observed in our study. This difference to our findings, spelling to be supporting reading skill, could be due to the composition of the population. Georgiou et al. utilised younger typically performing children, thus, for children who have already developed good reading and spelling skills, this direction from spelling to reading might not be on a par to the significance of the direction for children who struggle with reading and spelling, like AM. Children with dyslexia will use any support given to strengthen the links between phonology and orthography and vice versa and especially when this is coupled with explicit teaching or morphological rules and orthographic patterns (see for similar results Conrad 2008; Niolaki et al., 2017; Kohnen et al., 2008).

Delayed post-intervention results demonstrate that AM improved not only in pseudoword reading (indicating the positive influence of the phonics programmes used) but also in exception word reading. For exception word reading the margins of the confidence interval were now above average [95%CI= 104-111]. We can suggest that as spelling training targeted orthography, morphology and word-specific training, these skills could have generalised to exception word reading. Although exception words are considered to be pure measures of lexical processing, exception words contain parts that can be read via the phonological route. Indeed, several studies have demonstrated that phonological decoding skills predict exception word reading (Vousden & Ellefson, 2016; Ricketts Davies, Masterson, Stuart, & Duff, 2016). Researchers have argued in the past that although reading and spelling are not mirror-image processes, skills targeted during spelling training can generalise to reading (Niolaki, et al., 2017; Kohnen et al., 2008). However, we must also acknowledge that

our training included reading of a text linked to AM's interests and practice in speedreading of continuous text at home using a stopwatch (although the main focus of the intervention was on spelling and written composition). This exposure to reading could have brought the positive outcome in reading, and also supported his improved exception word reading skill. Nevertheless, we should not overlook the possible positive influence of phonics and also morphological and orthographic training on exception word reading.

Limitations and further suggestions. The aim was to help the student achieve a set of predetermined learning objectives set by the National Curriculum in England. The outcome was extremely positive, but support should be continuous as words included for the intervention went up to Year 4. Thus, next support steps should include further work on the spelling word list Year 3 and 4 and the statutory objectives set on spelling and writing for Year 5 and 6. Our intervention did not improve AM's social and emotional difficulties, indicating that over time the accumulated effect of being a poor reader was not lessened as a result of the positive feedback and improvement in literacy skills. Therefore, to overcome the social and emotional barriers, an intervention tailored towards these specific needs might be designed, or a positive result might have been observed if the support was for longer. Finally, more studies, not only single case ones, but also group studies testing the effectiveness of linguistic intervention should be conducted.

Conclusion

The study aimed to use an integrated framework for identification and remediation of literacy difficulties using a single case study design. Findings support the notion that a detailed assessment and evaluation of strengths and weaknesses should be conducted in order to tailor intervention taking into account the individual's needs. This detailed assessment goes against the philosophy of one-size-fits-all strategy in teaching children with literacy difficulties. It also supports an integrational multiple deficit model and drives us away from the single deficit cognitive model adopted in the past (Pennington, 2006; van Bergen et al., 2014).

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Endnotes

[1] The WIAT II manual provides details on how to calculate the significant difference value when comparing performance in subcomponents of reading.

Appendix A

Table A1 Words used in the Criterion Referenced Assessment

back	flies	Third	expression	each
bank	tries	Church	discussion	head
rabbit	happier	Burst	musician	read
catch	cried	Boat	electrician	verb
fetch	copying	Coat	league	person
rocks	crying	Toe	tongue	summer
thanks	hiking	Goes	weigh	winter
hunting	hiked	Out	eight	first
hunted	hiker	Sound	boys'	preparation
hunter	nicer	Now	babies'	sadly
jumping	nicest	How	mice's	usually
jumped	shiny	Lie	accident	finally
jumper	patting	Tie	actual	division
fresher	patted	Field	address	television
freshest	humming	Thief	answer	invention
quicker	hummed	High	appear	
quickest	dropping	Night	arrive	
rain	dropped	More	believe	
wait	sadder	Before	bicycle	
oil	saddest	Saw	breath	
join	fatter	Draw	breathe	
day	fattest	Dinosaur	build	
play	runner	Astronaut	Busy	
boy	runny	Hair	Calendar	
enjoy	work	Chair	Caught	
made	worm	Dear	Center	
came	can’t	Bear	Century	
these	didn't	Pear	Certain	
complete	girls'	Dare	Circle	
five	child's	Care	Know	
side	station	Party	Knee	
home	fiction	Family	Write	
hope	motion	When	Written	
June	there	Where	Table	
rule	their	Magic	Apple	
week	here	Giraffe	Hospital	
see	hear	Race	Animal	
sea	information	Ice	completion	

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