

“A computer supported intervention for children
with persistent word reading impairment”
28 March 2017

1. BRIEF ABSTRACT

The thesis research designed, developed, trialled, and evaluated a reading intervention targeting phonological recoding and orthographic processing for children with persistent reading impairment. Eight otherwise typically developing Year 2 participants with reading delay despite previous intervention, were randomly assigned to two groups in a single subject multiple-treatment cross-over design study. The results of group and individual analyses indicated that all participants made significant gains on measures of nonword reading with trends for gains in word reading.

2. THE THESIS RESEARCH

PLAIN ENGLISH SUMMARY OF THESIS RESEARCH

The thesis research aimed to improve word reading skills in children with persistent reading impairment (those who continue to have reading delay despite previous reading intervention). Accurate word reading has been shown to predict later literacy and language skills yet is delayed in most children with reading impairment. Though the effectiveness of interventions targeting phonemic awareness and the alphabetic principle is well established, about 25% of children fail to demonstrate an adequate response: their main area of difficulty being word reading, specifically decoding. Hence the focus of the thesis research was to improve word decoding skills for this population of children.

A single component intervention (the *Decoding Intervention*) was developed, trialled (in a pilot study with three participants), and evaluated because most intervention studies involve multi-component interventions which makes it difficult to determine the active ingredient(s).

The Decoding Intervention was delivered on an iPad (as were all other intervention materials). Its aim was to:

- Target phonological recoding (sounding out and blending to read a word - *decoding*) and orthographic processing (taking note of all letters in the word) because research has shown that:
 - a) Accurate decoding optimises formation of clear mental images of words (a requirement for sight word development).
 - b) Orthographic processing makes a unique contribution to word reading development.
 - c) The decoding component of other multi-component interventions seems to be the active ingredient.
- Match targets to participant decoding skill level.
- Target 2- to 6-letter items with 1:1 letter sound correspondence because children of this age with word reading impairment fail to accurately decode 3-letter words even though they have mastered orthographic knowledge of letter-sound correspondences required for this level of decoding.
- Provide corrective feedback (by the researcher) about decoding accuracy.

Participants were eight otherwise typically developing children with persistent reading impairment who were randomly allocated to two groups of four. Each group received a sequence of five intervention phases. The sequence for the first group was: an initial baseline (to establish pre-intervention decoding skills), the Decoding Intervention, a second baseline, a Language Intervention, and a third baseline (to examine skill maintenance). The sequence for the second group was the same except the Language Intervention occurred first and the Decoding Intervention second. This research design allowed both group and individual analyses, controlled for the individual time spent with each participant, and enabled examination of maintenance (Group 1) and delayed onset of the Decoding Intervention (Group 2).

A range of outcome measures were used to assess the effectiveness of the Decoding Intervention. These included:

- Lists of nonwords which were developed by the researcher – to assess changes in decoding skills.
- Standardised tests of nonword reading accuracy, nonword and word reading efficiency, text reading and reading comprehension; and a detailed examination of changes in nonword spelling – to assess if any changes in decoding accuracy generalised to other reading and spelling outcome measures.

The results of group and individual analyses showed that all participants made significant gains in decoding accuracy on the researcher-developed lists of nonwords following the Decoding Intervention but no change following the Language Intervention. Group 1

maintained these gains for two months following the Decoding Intervention (i.e., during and following the Language Intervention), while Group 2 made no gains in decoding accuracy until after commencement of the Decoding Intervention. These results suggested that the gains in decoding skills were due to the Decoding Intervention.

Group analyses of the standardised tests showed that significant gains were made by both groups on measures of nonword reading efficiency and nonword reading accuracy with no gains in word reading efficiency, text reading, and reading comprehension. However, individual analyses suggested (a) that clinically significant gains were made on measures of word reading efficiency, text reading, and reading comprehension for about half of the participants, and (b) that the lack of generalisation to word and text reading may have been due to severe delays in letter-sound knowledge for vowel spelling patterns (e.g., ee, ow, oy). No significant changes in nonword spelling were demonstrated on the group and individual analyses.

It was concluded that the Decoding Intervention resulted in significant gains in decoding skills – a key factor in word reading development. The results suggested that the Decoding Intervention has the potential to be an effective method of boosting decoding skills in children with persistent word reading disorders.

Some of the key limitations and pointers for future research were that:

- The thesis research design involved a small number of participants. Though this enabled detailed individual analyses, there is a need to replicate this research in typical school settings.
- Some of the outcome measures (e.g., the timed measure of word reading efficiency) may not have been sensitive to gains in word reading.
- The delays in letter-sound knowledge for vowel spelling patterns which was detected in the pre-intervention assessments of all participants may require specific teaching. It is possible that this population may require a specific and intense approach to teach knowledge of vowel spelling patterns.

DETAILED SUMMARY OF THESIS RESEARCH

The aim of the thesis research was to improve word reading accuracy for children with persistent reading impairment. Word reading skills predict reading comprehension in the general population (García & Cain, 2014); later literacy, language, and general knowledge in typically developing children (Sparks, Patton, & Murdoch, 2014); and later literacy development in children with language impairment (Botting, Simkin, & Conti-Ramsden, 2006). However, word reading skills are delayed in most children with reading disorders

(Catts, Hogan, & Fey, 2003; Torppa et al., 2007). Furthermore, most children with reading disorders have problems with word reading, specifically with decoding - use of grapheme-phoneme rules (sounding out and blending) to read unfamiliar words (Castles & Coltheart, 1993; Herrmann, Matyas, & Pratt, 2006).

In recent years the Response to Intervention approach has been used as a framework to guide initial reading instruction (Tier 1) and reading interventions (Tiers 2 and 3). There is well substantiated evidence supporting effective early reading instruction at Tier 1 (Department of Education, 2005; National Reading Panel, 2000) in which research-validated instruction is provided to all students; and many studies have demonstrated that interventions targeting phonemic awareness combined with letter-sound knowledge is effective for Tier 2 small group instructions for children who require additional support in learning to read (Berninger, Vermeulen, Abbott, & McCutchen, 2003; Bus & van Ijzendoorn, 1999; Gillon, 2002; Hatcher et al., 2006; Torgerson, Brooks, & Hall, 2006; Wheldall & Beaman, 1999). However, fewer studies have examined the outcomes for children requiring intensive Tier 3 intervention (Denton et al., 2013) for children who have not made adequate progress in Tier 2 interventions. Hence, this research focused on the development of word reading skills, specifically decoding, for children with persistent reading impairment, that is, those children who continue to have reading impairment despite previous reading intervention.

The Decoding Intervention

The computer supported intervention materials developed for this research (referred to as *The Decoding Intervention*) were presented on an iPad using a computer program best described as a web app, that is, the app required internet connection to load each module but once the module was loaded it no longer required continuous internet connection. Use of an iPad within the intervention provided participants with a motivating activity and enabled automatic logging of data. The Decoding Intervention design incorporated a number of evidence based features.

- It targeted phonological recoding and orthographic processing. This was supported by three areas of research.

First, orthographic processing has been shown to make a unique and significant contribution to word reading development (Badian, 2001; Cunningham, Perry, & Stanovich, 2001; Deacon, 2012). Orthographic processing refers to the ability to acquire, store, and use orthographic knowledge, that is, the mental orthographic representations of words and word parts as well as orthographic pattern knowledge – the knowledge of the alphabetic principle (how letters represent speech sounds) and the “legal” combinations of letters in a given language.

Second, a number of studies have demonstrated that that accurate phonological recoding (sounding out and blending to read a word) optimises development of orthographic representations (Cunningham, Perry, Stanovich, & Share, 2002; Kyte & Johnson, 2006; Share, 1999) which are an essential component for accurate word reading.

Third, intervention studies have shown that interventions targeting phonemic awareness and grapheme-phoneme knowledge within a range of evidence based components (e.g., automatic recognition of sight words, connected text reading, auditory awareness, repeated reading) result in significant and positive gains on a range of literacy measures (Buckingham, Wheldall, & Beaman, 2012; Hatcher et al., 2006; Torgesen, 2001; Wheldall & Beaman, 1999). However about 25% of participants fail to demonstrate adequate gains. This suggests that there are aspects of reading impairment that are not being addressed for a substantial number of children, and/or the mix of components within these interventions are not matched to the individual needs of the child. Furthermore, analyses of the outcomes of other multi-component studies which included tasks focusing on orthographic processing have suggested that the orthographic processing tasks were the key element (Lane, Pullen, Hudson, & Konold, 2009; Pullen & Lane, 2014). These results provided support for an intervention which included a specific focus on phonological recoding to support development of orthographic processing.

- It was a single component intervention, that is, it involved a single task: the child was presented with an item (a word or a nonword displayed on the iPad), performed phonological recoding (sounding out and blending) to support orthographic processing (paying attention to each letter). After the researcher provided corrective feedback to ensure that accurate phonological recoding occurred the child put the words into a book and the nonwords into a bin (i.e., graphic depictions on the iPad). Most previous research interventions incorporate a number of evidence based components which has made it difficult to identify which aspect/s of the intervention are responsible for specific gains. Thus, there is a lack of evidence to support selection of specific intervention components to match individual need. Hence the single component intervention developed for this research enabled unambiguous evaluation of its impact on a range of reading and spelling measures.
- It targeted items with 1:1 letter-sound correspondence as research has shown that this population (8 – 9 year old children with reading impairment) are unable to accurately decode 3- and 4-letter items (McCandliss, Beck, Sandak, & Perfetti, 2003). These children, though they have mastered letter-sound knowledge for consonants and short

vowels, are unable to attend to each letter in an unknown word which suggests that they lack skills which are required to develop orthographic knowledge.

- The items in the intervention were presented without context. This was supported by research which showed that there was no significant difference in orthographic learning (development of mental orthographic images of words) between conditions in which novel items (nonwords) were presented by themselves or within a story context (Cunningham, 2006; Nation, Angell, & Castles, 2007).

Thesis research aims

The thesis research aimed to add to the existing literature in three ways. First, it focused on Tier 3 intervention for word reading impairment. Second, it aimed to design, develop, trial, and evaluate a single component intervention targeting two key skills (phonological recoding and orthographic processing) which have been shown to contribute to decoding accuracy (a skill which is delayed for most children with reading impairment). The single component intervention enabled unambiguous examination of effectiveness on a range of reading outcome measures. The third aim was to examine the characteristics of responsiveness to intervention, as a number of previous studies showed that about 25 percent of participants failed to demonstrate an adequate response. To achieve this aim, a single subject design was employed.

Thesis research questions

Three research questions were investigated:

1. Does an intervention that targets phonological recoding and orthographic processing increase nonword reading skills in Year 2 children with persistent reading impairment?
2. Does this intervention result in gains on standardised measures of a range of reading related skills (nonword reading accuracy, word and nonword reading efficiency, text reading and reading comprehension) and spelling, in Year 2 children with persistent word reading impairment?
3. Do pre-intervention scores on language, intellectual, and phonological processing skills influence outcome measures of nonword reading, text reading, reading comprehension, and nonword spelling?

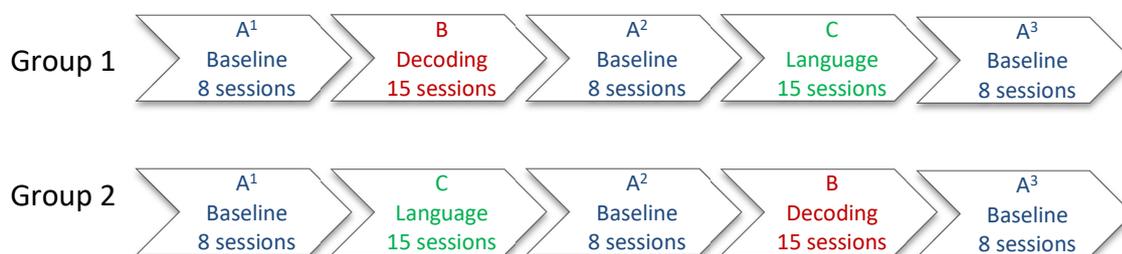
Thesis research design

Two studies were completed. Study 1 (Seiler, Leitão, & Blosfelds, 2013) used a single subject design with three phases (baseline-intervention-baseline) to trial the newly developed intervention with three participants. The outcomes of this study provided preliminary evidence that the Decoding Intervention resulted in significant gains in nonword reading measured by reading accuracy on researcher developed lists of nonwords (the dependent variable). Additionally, observation of participant use of the intervention materials guided minor modifications to the intervention materials and procedure.

Study 2 used a single subject cross-over design with multiple treatments to address the three research questions. There were two treatments: the Decoding Intervention, and the Language Intervention which formed a comparison to the Decoding Intervention, thus controlling for the effect of individual therapy time with the researcher.

Participants were eight otherwise typically developing children in their third year of school (aged 7 – 10 years) with persistent reading impairment.

Two groups of four participants were randomly assigned to the Decoding or Language Intervention regime as follows:



All materials were delivered on an iPad. The Decoding Intervention taught phonological recoding, matched targets to participant decoding skill level, and targeted 2- to 6-letter items with 1:1 letter-sound correspondence. The Language Intervention used a similarly interactive App to target language weaknesses (non-decoding) identified in pre-intervention language assessment.

There were two types of measures. The dependent variable addressing the first research question was accuracy of response on researcher-developed nonword lists; and for the second research question, pre- post-intervention standardised assessments of nonword reading accuracy, word and nonword reading efficiency, and text reading accuracy and comprehension - The decoding subtests of the Phonological Awareness Test-2 (PhAT-2), the Test of Word Reading Efficiency-2 (TOWRE-2), The Neale Analysis of Reading Ability-3 (Neale).

The third research question examined whether pre-intervention scores on standardised assessments of language, phonological awareness, and intellectual skills (The Clinical Evaluation of Language Fundamentals-4; CELF-4, The Comprehensive Test of Phonological Processing-2; CTOPP-2, and the WISC-IV) influenced the responses to the intervention.

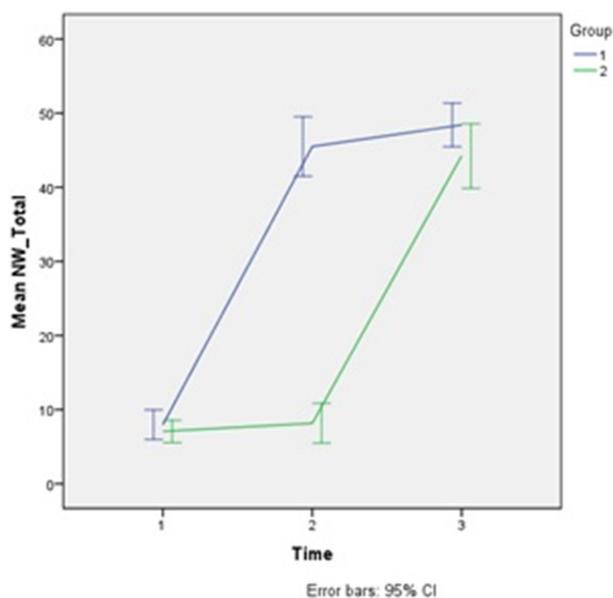
Results and discussion

Effectiveness of the Decoding Intervention on the dependent variable (Question 1), and other standardised measures of word and text reading (Question 2) was examined using group (GLMM) and individual analyses appropriate to a single subject research design. The analysis for the third research question involved a comparison of the number of pre-intervention scores which fell below 1SD to the magnitude of gain in outcome measures.

Question 1

The first question investigated whether the Decoding Intervention resulted in significant gains in nonword reading assessed by participant scores on the researcher-developed Assessment NW Lists. Figure 1 shows the results of the group analysis of for Group 1 (blue line) and Group 2 (green line).

Figure 1: GLMM nonword accuracy



Group 1 (represented by the blue line) demonstrated significant gains in nonword reading following Decoding Intervention and maintained skills during Language Intervention, while

Group 2 (the green line) made no gains following the Language Intervention and significant gains following the Decoding Intervention.

Figures 2 and 3 display examples of the individual analyses of the responses on the researcher-developed nonword lists. Participant 1 was in Group 1 and Participant 7 in Group 2. Using the 2 SD band method, all participants made significant gains in nonword reading following the Decoding Intervention.

Figure 2: 2SD band analysis of nonword reading accuracy for P1 (Group 1)

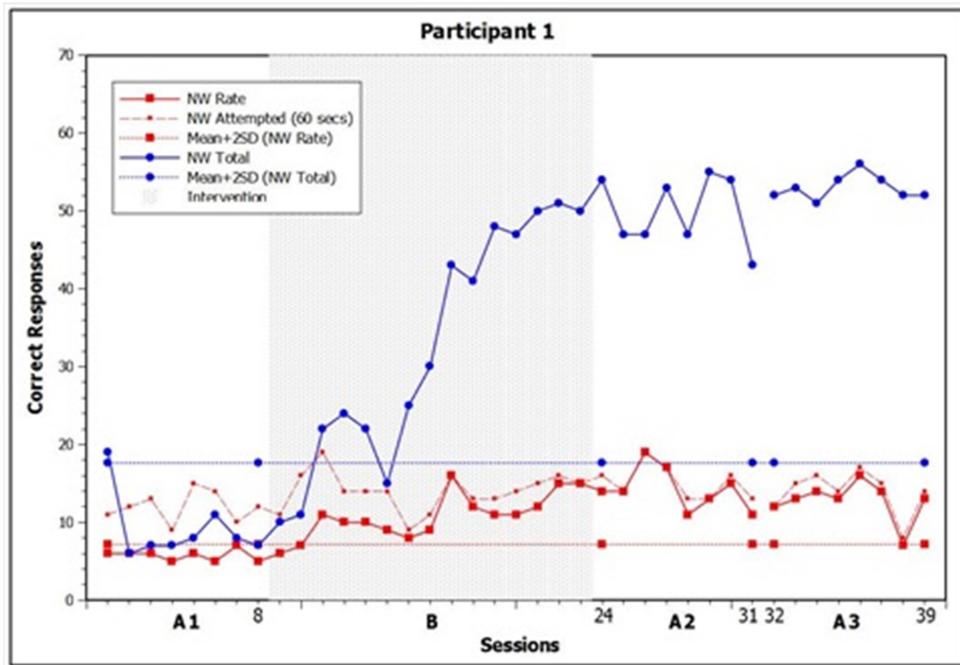
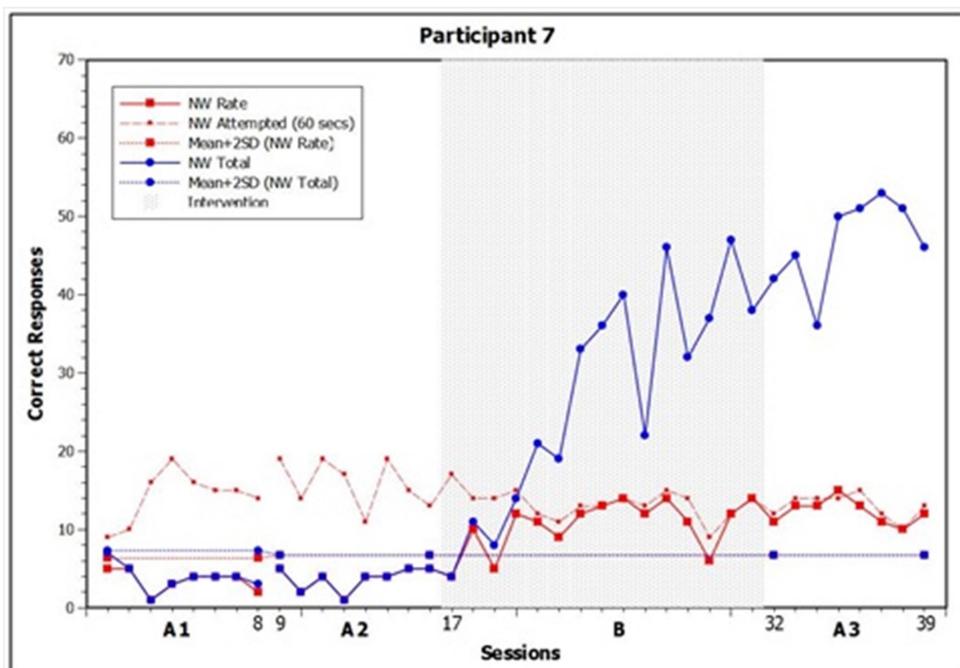


Figure 3: 2SD band analysis of nonword reading accuracy for P7 (Group 2)



These results show that the Decoding Intervention resulted in significant gains on the dependent variable (nonword reading) for both groups; neither group made significant gains following the Language Intervention; and the gains were maintained for two months following The Decoding Intervention.

Question 2

This question addressed the issue of generalisation – would the gains in nonword reading on the dependent variable be reflected in gains on standardised measures of nonword, word, and text reading.

Figure 4 shows the results of group analyses (Group 1 blue line, Group 2 green line) on a standardised measure of nonword reading efficiency.

Figure 4: GLMM nonword reading efficiency

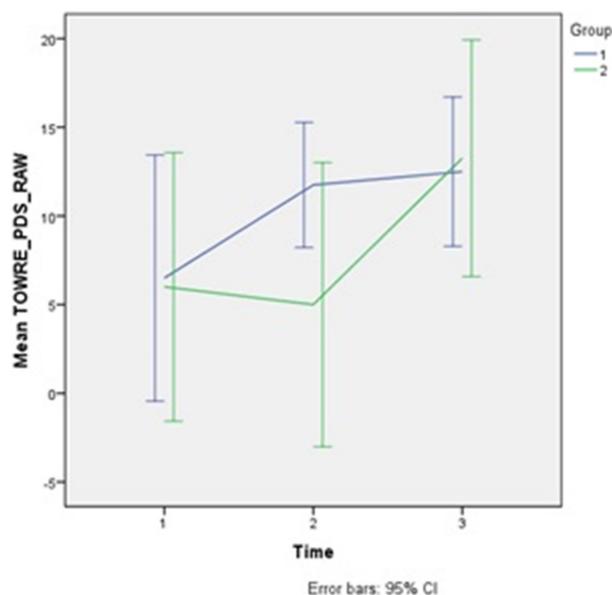


Figure 4 shows that both groups made significant gains in nonword reading efficiency (TOWRE-2) following the Decoding Intervention. A similar result was demonstrated on a standardised measure of nonword reading accuracy (PhAT-2). There were no significant intervention effects on group analyses of measures of word reading efficiency, text reading accuracy and comprehension.

Individual analyses of the responses on pre- post-intervention scores on the standardised measures of nonword, word, and text reading indicated that clinically significant gains were demonstrated by five participants on the measure of word reading fluency (TOWRE-2), four participants on text reading accuracy (Neale Accuracy), and five participants on reading comprehension (Neale Comprehension). Additionally, while six of the eight participants

generalised to a non-targeted area (nonword items with consonant digraphs), no generalisation to vowel digraphs was demonstrated. Examination of responses on the standardised measure of nonword reading accuracy (PhAT-2) showed that though all participants had mastered orthographic knowledge of consonant digraphs prior to intervention, no participant demonstrated orthographic knowledge for vowel digraphs.

These results suggested that the lack of orthographic knowledge for vowel digraphs may have reduced generalisation of decoding skills to measures of word reading. This delay in development of orthographic knowledge is consistent with the results of previous studies (Apel, Thomas-Tate, Wilson-Fowler, & Brimo, 2012; Wolter & Apel, 2010) which have shown that children at risk of reading delay and those with language impairment have reduced skills in orthographic learning. It suggests that these children may require a specific approach to teaching orthographic knowledge.

Question 3

This question investigated whether pre-intervention profiles of language, intellectual, and phonological processing skills influenced response to intervention. The informal analyses showed that most participants had six to seven pre-intervention profile areas that were below average. However, there was no clear pattern of the influence of these weaknesses on responses to intervention. For example, the three participants with the smallest gain on the dependent variable included the two children with the strongest pre-intervention profiles and the child with the weakest pre-intervention profile. It was concluded that though Study 2 involved a small number of participants, the individual analyses suggested that the relationship between pre-intervention profile and response to intervention is a complex one with no clearly predictive pre-intervention pattern, and further suggests that reading interventions for this population need to be specifically targeted to the individual needs of each child.

Thesis research conclusions

The thesis research aimed to add to the evidence-base for Tier 3 reading interventions by addressing the three issues that were highlighted in the literature review: few studies have examined Tier 3 reading interventions, a large proportion of children demonstrate an inadequate response to intervention, and to date, there is not an evidence base regarding the specific role of each component in multi-component interventions.

There were four main outcomes of this research. The first was that the Decoding Intervention was effective in increasing decoding skills for (Year 2 children who required Tier 3 intervention). Accurate decoding skills (sounding out and blending to read words) have been shown to optimise orthographic learning yet are delayed in most children with reading

impairment. This intervention, therefore, has the potential to boost this essential skill for this population.

The second outcome was that while there were trends for gains in word reading, the individual analyses suggested that the reduced generalisation to word and text reading may have been due to impaired orthographic knowledge, particularly of vowel digraphs.

The third outcome was that the analyses of the influence of pre-intervention profile on response to intervention highlighted the individual variability that exists in this population. However, it showed that, irrespective of the pre-intervention profile of strengths and weaknesses, the Decoding Intervention was effective for all participants.

The fourth outcome relates to one of the additional analyses (Mean Intervention Time) which was conducted as part of the evaluation of the effectiveness of The Decoding Intervention. The intervention time of the Decoding Intervention was compared to analogous decoding tasks that were described in other multi-component Tier 3 interventions (Denton et al., 2013; Torgesen, 2001) and interventions with a similar focus on orthographic processing (Lane et al., 2009; McCandliss et al., 2003; Pullen & Lane, 2014). It was found that the mean intervention time of the single component Tier 3 Decoding Intervention in Study 2 of seven minutes per session (2 hours total) was substantially shorter than the decoding component of the other studies which were examined.

These outcomes suggested that The Decoding Intervention has the potential to be an efficient evidence-based component of reading interventions for children with severe and persistent reading delay.

Limitations of the thesis research

The research presented in this thesis had a number of limitations. The first was that Study 1 and Study 2 represent the first two stages in research evaluating the effectiveness of new interventions. Portney and Watkins (2009) suggest that in addition to demonstrating effectiveness during an experimental study, evidence of external validity is also required, that is, that the intervention effects generalise to other individuals with similar characteristics and other conditions that differ from the experimental conditions, and that the effects are sustained after the intervention has ended. They proposed the following sequence of research phases:

- Direct replication involves repeating the same research study across at least three participants.
- Systematic replication occurs after direct replication, and involves changing the variables in the original study to see if the target behaviour generalises to other similar, but not identical, situations.

- Clinical replication is a stage of field testing where the intervention is evaluated in more realistic settings, for example, with patients who have multiple behaviours (or disorders) that tend to cluster together. It can only occur after direct and systematic replications have supplied the researcher with well-defined relationships between treatment components and patient characteristics.
- Social validation extends beyond the question of external validity, and is based on an evaluation of the significance of the goals of intervention, the acceptability of the procedures and the importance of treatment effects.

Using this framework, Study 1 was a direct replication over three participants and Study 2 was a systematic replication which involved introduction of other variables such as a comparison intervention. Future research needs to provide clinical replication in more realistic school settings.

A second limitation within the design of the thesis research relates to the measures of word reading that were employed. The timed measure (word reading efficiency assessed by the TOWRE-2) may have been less sensitive to gains in word reading. Also, inclusion of a reading measure that comprises separate assessments of regular and irregular word reading would have enabled categorisation into subtypes of word reading disability.

A third limitation was that it may have been useful to have gathered information about the type of previous reading intervention, as this may provide valuable insights into the effectiveness of The Decoding Intervention for different groups of children.

Future research

The outcomes of the thesis research combined with the limitations discussed above suggest two lines of future research:

- Clinical replication of Study 2, and
- Research investigating the effectiveness of the Decoding Intervention on orthographic learning

Conclusions

This research addressed the need for evidence about the key component of reading interventions for children with persistent reading impairment. A single component intervention which enables unambiguous interpretation of its impact on reading skills was developed and evaluated. The results provide preliminary evidence that an intervention which specifically targeted phonological recoding and orthographic processing resulted in significant gains in measures of decoding for children with persistent word reading impairment. Its success in significantly increasing decoding skills for all participants suggests that it may form a useful component within Tier 3 reading interventions, and further, that subsequent

expanded versions of WordDriver-1 may provide an efficient mechanism to support orthographic learning in this population.

REFERENCES

- Apel, Kenn, Thomas-Tate, Shurita, Wilson-Fowler, Elizabeth B., & Brimo, Danielle. (2012). Acquisition of initial mental graphemic representations by children at risk for literacy development. *Applied Psycholinguistics*, 33(2), 365-391. doi: 10.1017/s0142716411000403
- Badian, Nathalie, A. (2001). Phonological and orthographic processing: Their roles in reading prediction. *Annals of Dyslexia*, 51, 179-202. doi: 10.1007/s11881-001-0010-5
- Berninger, Virginia W, Vermeulen, Karin, Abbott, Robert D, & McCutchen, Deborah. (2003). Comparison of three approaches to supplementary reading instruction for low-achieving second-grade readers. *Language, Speech & Hearing Services in Schools*, 34(2).
- Botting, N., Simkin, Z., & Conti-Ramsden, G. (2006). Associated reading skills in children with a history of Specific Language Impairment (SLI). *Reading and Writing*, 19, 77 - 98. doi: 10.1007/s11145-005-4322-4
- Buckingham, Jennifer, Wheldall, Kevin, & Beaman, Robyn. (2012). A randomised control trial of a Tier-2 small-group intervention ('MiniLit') for young struggling readers1. *Australian Journal of Learning Difficulties*, 17(2), 79-99. doi: 10.1080/19404158.2012.717537
- Bus, Adriana G., & van Ijzendoorn, Marinus H. (1999). Phonological Awareness and Early Reading: A Meta-Analysis of Experimental Training Studies. *Journal of Educational Psychology*, 91(3), 403 - 414.
- Castles, Anne, & Coltheart, Max. (1993). Varieties of developmental dyslexia. *Cognition*, 47(2), 149-180. doi: [http://dx.doi.org/10.1016/0010-0277\(93\)90003-E](http://dx.doi.org/10.1016/0010-0277(93)90003-E)
- Catts, H. W., Hogan, T.P., & Fey, M.E. (2003). Subgrouping poor readers on the basis of individual differences in reading-related abilities. *Journal of Learning Disabilities*, 36, 151 - 164.
- Cunningham, Anne E. (2006). Accounting for children's orthographic learning while reading text: Do children self-teach? *Journal of Experimental Child Psychology*, 95(1), 56-77. doi: 10.1016/j.jecp.2006.03.008
- Cunningham, Anne E., Perry, Kathryn E., & Stanovich, Keith E. (2001). Converging evidence for the concept of orthographic processing. *Reading and Writing*, 14, 549-568. doi: 10.1023/A:1011100226798
- Cunningham, Anne E., Perry, Kathryn E., Stanovich, Keith E., & Share, David L. (2002). Orthographic learning during reading: examining the role of self-teaching. *Journal of Experimental Child Psychology*, 82(3), 185-199. doi: 10.1016/S0022-0965(02)00008-5
- Deacon, S. Hélène. (2012). Sounds, letters and meanings: the independent influences of phonological, morphological and orthographic skills on early word reading accuracy. *Journal of Research in Reading*, 35(4), 456-475. doi: 10.1111/j.1467-9817.2010.01496.x
- Denton, Carolyn A., Tolar, Tammy D., Fletcher, Jack M., Barth, Amy E., Vaughn, Sharon, & Francis, David J. (2013). Effects of Tier 3 Intervention for Students With Persistent Reading Difficulties and Characteristics of Inadequate Responders. *Journal of Educational Psychology*, 105(3), 633-648.
- Department of Education, Science and Training. (2005). *Teaching Reading: Report and Recommendations*. Melbourne: Australian Government.

- García, J. Ricardo, & Cain, Kate. (2014). Decoding and Reading Comprehension: A Meta-Analysis to Identify Which Reader and Assessment Characteristics Influence the Strength of the Relationship in English. *Review of Educational Research, 84*(1), 74-111. doi: 10.3102/0034654313499616
- Gillon, G. T. (2002). Follow-up study investigating the benefits of phonological awareness intervention for children with spoken language impairment. *Int J Lang Commun Disord, 37*(4), 381-400. doi: 10.1080/1368282021000007776
- Hatcher, Peter J., Hulme, Charles, Miles, Jeremy N., Carroll, Julia M., Hatcher, Janet, Gibbs, Simon, . . . Snowling, Margaret J. (2006). Efficacy of small group reading intervention for beginning readers with reading-delay: A randomised controlled trial. *Journal of Child Psychology and Psychiatry, 47*(8), 820-827.
- Herrmann, J. A., Matyas, T., & Pratt, C. (2006). Meta-analysis of the nonword reading deficit in specific reading disorder. *Dyslexia, 12*(3), 195-221.
- Kyte, Christiane S., & Johnson, Carla J. (2006). The Role of Phonological Recoding in Orthographic Learning. *Journal of Experimental Child Psychology, 93*(2), 166-185. doi: 10.1016/j.jecp.2005.09.003
- Lane, Holly B., Pullen, Paige C., Hudson, Roxanne F., & Konold, Timothy R. (2009). Identifying Essential Instructional Components of Literacy Tutoring for Struggling Beginning Readers. *Literacy Research and Instruction, 48*(4), 277 - 297. doi: 10.1080/19388070902875173
- McCandliss, Bruce, Beck, Isabel L., Sandak, Rebecca, & Perfetti, Charles. (2003). Focusing attention on decoding for children with poor reading skills: Design and preliminary tests of the word building intervention. *Scientific Studies of Reading, 7*(1), 75-104. doi: 10.1207/S1532799XSSR0701_05
- Nation, Kate, Angell, Philip, & Castles, Anne. (2007). Orthographic learning via self-teaching in children learning to read English: Effects of exposure, durability, and context. *Journal of Experimental Child Psychology, 96*(1), 71-84. doi: 10.1016/j.jecp.2006.06.004
- National Reading Panel. (2000). Teaching Children to Read. An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction: U.S. National Institute of Child Health and Human Development.
- Neale, Marie D. (1999). *Neale Analysis of Reading Ability*. Melbourne, Australia: Australian Council for Educational Research.
- Pullen, Paige C., & Lane, Holly B. (2014). Teacher-Directed Decoding Practice with Manipulative Letters and Word Reading Skill Development of Struggling First Grade Students. *Exceptionality, 22*(1), 1-16. doi: 10.1080/09362835.2014.865952
- Robertson, Carolyn, & Salter, Wanda. (2007). *The Phonological Awareness Test 2*. East Moline, IL: LinguiSystems, Inc.
- Seiler, Antonette Mary. (2015). The effectiveness of a computer-supported intervention targeting phonological recoding and orthographic processing for children with word reading impairment: Curtin University.
- Seiler, T., Leitão, S., & Blosfelds, M. (2013). The effectiveness of a computer-supported intervention targeting orthographic processing and phonological recoding for children with impaired word identification. *Journal of Clinical Practice in Speech-Language Pathology, 15*(1), 13-18.
- Semel, Eleanor, Wiig, Elisabeth H., & Secord, Wayne A. (2003). *CELF4 Australian*. Marrickville, Australia: Harcourt Assessment.
- Share, David L. (1999). Phonological Recoding and Orthographic Learning: A Direct Test of the Self-Teaching Hypothesis. *Journal of Experimental Child Psychology, 72*(2), 95-129. doi: 10.1006/jecp.1998.2481
- Sparks, RichardL, Patton, Jon, & Murdoch, Amy. (2014). Early reading success and its relationship to reading achievement and reading volume: replication of '10 years later'. *Reading and Writing, 27*(1), 189-211. doi: 10.1007/s11145-013-9439-2

- Torgerson, Carole J., Brooks, Greg, & Hall, Jill. (2006). A Systematic Review of the Research Literature on the Use of Phonics in the Teaching of Reading and Spelling (Report No. 711). Annesley, Nottingham: Department for Education and Skills.
- Torgesen, J. K. (2001). Intensive remedial instruction for children with severe reading disabilities: Immediate and long-term outcomes from two instructional approaches. *Journal of Learning Disabilities, 34*(1), 33-58.
- Torgesen, J. K., Wagner, Richard K., & Rashotte, Carol A. (1999). *Test of Word Reading Efficiency*. Austin: Pro Ed.
- Torppa, M., Tolvanen, A., Poikkeus, A. M., Eklund, K., Lerkkanen, M. K., Leskinen, E., & Lyytinen, H. (2007). Reading development subtypes and their early characteristics. *Annals of Dyslexia, 57*(1), 3-32. doi: 10.1007/s11881-007-0003-0
- Wechsler, D. (1991). *The Wechsler Intelligence Scale for Children - third edition*. San Antonio, TX: The Psychological Corporation.
- Wheldall, Kevin, & Beaman, Robyn. (1999). An Evaluation of MULTILIT - Making Up Lost Time In Literacy. Executive Summary (T. a. Y. A. Department of Education, Trans.). Sydney, Australia: Macquarie University Special Education Centre, Macquarie University.
- Wolter, Julie A., & Apel, Kenn. (2010). Initial Acquisition of Mental Graphemic Representations in Children with Language Impairment. *Journal of Speech, Language & Hearing Research, 53*(February), 179 - 195.