UNIVERSITY OF SOUTHAMPTON

FACULTY OF SOCIAL, HUMAN SCIENCES AND MATHEMATICAL SCIENCES

School of Psychology

Evaluating the Effectiveness of Phonics as a Method for Teaching Reading to Children and Young People who Experience Learning Difficulties and are Educated in Special School Settings

by

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Thesis for the degree of Doctorate in Educational Psychology

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ABSTRACT

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EVALUATING THE EFFECTIVENESS OF PHONICS AS A METHOD FOR TEACHING READING TO CHILDREN AND YOUNG PEOPLE WHO EXPERIENCE LEARNING DIFFICULTIES AND ARE EDUCATED IN SPECIAL SCHOOL SETTINGS

Emma Holly Victoria Herring

Beginning reading skills are often taught through phonics-based methods. Learning to read is a cognitively demanding task, and for those children who struggle, research has shown that individualised interventions can facilitate the development of reading skills. Although research has demonstrated the effectiveness of phonics as a teaching method with typically developing children, less research has evaluated this method with children who are educated in special school settings. A systematic review was conducted to evaluate research over the past 43 years into the effectiveness of phonics as a method for teaching reading to children who are educated in special school settings. The findings suggested that phonics teaching leads to improvements in phonics skills. However, improvements in phonics skills often did not generalise to whole word reading skills.

The empirical paper evaluated the computerised phonics-based intervention Headsprout Early Reading with eight pupils aged 7 to 19 years, educated in a special school for children and young people who experience severe learning difficulties. The intervention took place over 21 weeks. Three learning conditions were employed, such that four participants completed Headsprout as it was designed with typically developing students, two participants did not complete negation activities, and two non-verbal participants completed Headsprout minus speaking activities. Results indicated that all of the participants improved in initial sound fluency, non-word reading, and word recognition. Participants in the no-negation condition showed improvements despite not completing these activities. The findings suggest that individualised phonics-based reading interventions can be used to support development of early reading skills for students are educated in special school settings.

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DECLARATION OF AUTHORSHIP

I, Emma Holly Victoria Herring, declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

Evaluating the Effectiveness of Phonics as a Method for Teaching Reading to Children and Young People who Experience Learning Difficulties and are Educated in Special School Settings.

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
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Definitions and Abbreviations

APA American Psychiatric Association

ASD Autistic Spectrum Disorder

CCC-S-IV Child Communication Checklist – Short version 4

CTOPP Comprehensive Test of Phonological Processing

DIBELS-VI Dynamic Indicators of Baseline Early Literacy Skills – 6th edition

EPs Educational Psychologists

IOA Inter Observer Agreement

IQ Intelligence Quotient

ISF Initial Sound Fluency

M Mean

NVLA Non-Verbal Literacy Assessment

NWF Non-Word Fluency

PIAT Peabody Individual Achievement Test

PRISMA Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PSF Phonemic Segmentation Test

RAN Rapid Automatized Naming

RCI Reliable Change Index

SD Standard Deviation

SEN Special Educational Needs

SLD Severe Learning Difficulties

TOWRE Test of Word Reading Efficiency

WHO World Health Organisation

WRAPS Word Recognition and Phonics Skills

WUF Word Use Fluency

Chapter 1: Evaluating the Effectiveness of Phonics as a Method for Teaching Reading to Children and Young People who Experience Learning Difficulties and are Educated in Special School Settings: A Systematic Review of the Literature

1.1 Introduction

1.1.1 Learning to Read

Learning to read is considered a key objective of education (Hulme & Snowling, 2013), with Ofsted (2012), the regulatory body for education in the UK, arguing that there is no more important subject than English in the curriculum. Spoken language is acquired naturally by children as they develop in an environment in which they are exposed to it (Chomsky, 1972), in contrast to reading, which is mastered through time and effort (Rose, 2006). Reading requires the skill to decode written language, the ability to actively make sense of what is being read, and needs the reader to be actively engaged with these processes (Graham & Kelly, 2008). Byrne (1998) used the phrase 'cracking the alphabetic code' to refer to the idea that in order to learn to read individuals must understand how written letters map onto spoken sounds. In a meta-analysis (n = 52), the National Reading Panel (2000) concluded that children need to develop five skills to learn to read: (1) spoken vocabulary must extend to become reading vocabulary so children understand that written words mean something; (2) phonemic awareness, recognising that words are formed of separate sounds; (3) phonics skills, the ability to link spoken sounds to written letters and blend these together to decode words; (4) reading fluently with speed and accuracy; and (5) comprehension, an understanding of what is being read.

1.1.2 Teaching Reading Through Phonics

Historically, there has been controversy regarding successful methods for teaching children to read. This has been referred to as the "reading wars" and arguments have focused on whether children should be taught to read individual words, through a whole language approach, or taught grapheme-phoneme correspondences and blending, a phonics-based approach (Connor, Morrison, & Katch, 2004, p. 305). Pogorzelski and Wheldall (2005) argued that the most

significant advance in the scientific study of reading was the identification of the role of phonological processing, and the development of an understanding that word reading requires individuals to be able to convert letters into sounds.

There are different methods of teaching reading through phonics (Rose, 2006). Synthetic phonics is commonly used in education (Finnegan, 2012). This method involves teaching grapheme-phoneme correspondences, the mapping between letters and sounds and developing children's skills in blending sounds together. Children are taught additional word recognition strategies, such as visual spelling patterns, to ensure they have a range of strategies to draw upon when reading (Finnegan, 2012). It has been suggested that the ability to manipulate sounds in oral language, and knowledge about letters, are the foundations on which literacy rests (Treiman, 2000).

However it is important to remember that skilled readers do not use phonics when reading text; instead they read whole words quickly, as single digits, and this automatic recognition of words by sight allows attention to be focused on comprehending what has been read rather than on decoding (Ehri, 2005). Fluent readers not only decode text quickly and accurately, they also alter the pitch and speed of their voice to give meaning to text when reading aloud (Paige, Rasinski, & Magpuri-Lavell, 2012).

Phonics is, therefore, a method for teaching beginning reading skills to children. Through helping individuals develop mastery of grapheme-phoneme correspondences and blending phonemes, they can then learn to apply these skills with greater speed and accuracy until word recognition becomes automatic and the individual decoding of words is unnecessary (Macaruso, Hook, & McCabe, 2006). Teaching reading through phonics may act as a bridge between beginning reading skills and fluent reading for comprehension. Suggate (2010) conducted a meta-analysis of 85 studies to understand whether age and type of intervention were key moderators of effect sizes for typically developing disadvantaged readers, and concluded that between the ages of 5 and 7 years, phonics-based methods had an advantage, after which interventions which had an element of comprehension showed greater effectiveness.

While learning to read phonetically is based on phonemic awareness - the ability to identify and manipulate individual phonemes in spoken language (Lemons et al., 2015) - researchers have also highlighted the importance of foundational phonological awareness skills in young children (Hulme, Bowyer-Crane, Carroll, Duff, & Snowling, 2012). Phonological awareness is the earlier ability to manipulate parts of spoken language (Lemons et al., 2015), for example recognising that the word 'cat' ends with the sounds /at/. Examining the long-term effect of reading interventions, Hulslander, Olson, Willcutt, and Wadsworth (2010) found when they tested 324 pupils' reading

skills at the ages of 10 and 15 years, statistically controlling for phonological awareness improved the prediction of reading development even after initial literacy skills had been accounted for. This suggests that phonological awareness is an important contributor to reading development.

The discussion of the relative effectiveness of phonics-based reading methods is impacted by the differing terms and their definitions used in different studies. Lemons et al. (2015) wrote that phonological awareness is the ability to manipulate spoken sounds in language, whereas phonemic awareness is the skill of manipulating individual phonemes combined with an understanding of grapheme-phoneme correspondences. Suggate (2016) defined phonological awareness as the awareness of sounds, in a similar definition to Lemons et al. (2015) but Suggate (2016) differed in the definition of phonemic awareness, stating this reflected an awareness of the phonemes that compose words and that phonics was when the teaching of associations between graphemes and phonemes took place. An intervention teaching awareness of the sounds of phonemes and their mapping onto written graphemes, would, therefore be defined as a phonemic awareness intervention by Lemons et al. (2015) and a phonics intervention by Suggate (2016). In this literature review I will use the term phonological awareness to refer to an ability to identify and manipulate sounds in language, the term phonemic awareness to refer to the ability to identify individual phonemes in language, and the term phonics to represent how the skill of blending is applied to knowledge of grapheme-phoneme correspondences and existing phonemic awareness to allow an individual to read phonetically. I have chosen to use these definitions, reflecting the understanding of phonemic awareness in Suggate (2016), because this is how the terms are used more widely in the literature (Hulme & Snowling, 2013).

It is important to note that although the majority of researchers have concluded that phonics is a highly effective method for teaching beginning reading skills (Solity & Shapiro, 2008), there is not universal recognition of this teaching method. Hammill and Swanson (2006) addressed the mean effect sizes calculated using Cohen's d reported by the National Reading Panel (2000). They argued that the mean effect correlations should be computed using r and r^2 to estimate the proportion of variance in the outcome variable predicted by the independent variable (Hammill & Swanson, 2006). A reanalysis indicated that the advantages of phonics-based over non-phonics instruction had not been conclusively demonstrated; phonics may help beginning readers learn to decode, but did not conclusively confer an advantage in comprehension or oral text reading.

Despite contention about the effectiveness of phonics compared to other teaching methods, the literature examining the teaching of reading indicates that beginning reading skills are based on phonemic awareness and phonics skills. Some educators and researchers view

Special Educational Needs (SEN) as a continuum without cut-off points, and that teaching methods which are successful for typically developing children could be used with atypically developing children (Long, Wood, Littleton, Passenger, & Sheehy, 2011). This view of SEN supports the idea that all children, regardless of where they are educated, should have access to the same opportunities and access to research-based methods of learning to read. The teaching of reading using phonics-based methods could be available for all children at the beginning stages of learning to read.

1.1.3 Teaching Reading to Children and Young People who Experience Learning Difficulties

1.1.3.1 Definitions of learning difficulties.

According to the World Health Organization (WHO, 2000), a number of terms are used historically and across professions to refer to individuals who experience learning difficulties. Researchers and educational services in England often use the terminology "learning difficulties" to describe children and young people who experience significant difficulties in learning (Frederickson & Cline, 2002, p. 35), however the UK charity Mencap advocate for the term learning disabilities (Mencap, 2016).

Historically, education professionals have used terms such as mental retardation (Polloway, Epstein, Polloway, Patton, & Ball, 1986), which would now be considered inappropriate or stigmatising. Porter (2005) wrote that the differences in terminologies between countries can make it challenging to communicate effectively. In the United States for example, until recently the literature used the term severe mental retardation or intellectual disability for individuals with an Intelligence Quotient (IQ) of between 20 to 40, and moderate mental retardation or intellectual disability for those with an IQ between 40 and 55.

In the Diagnostic and Statistical Manual of Mental Disorders – 5th edition, the term mental retardation was replaced with the term intellectual disability and the diagnostic criteria were also updated (American Psychiatric Association [APA], 2013). The updated criteria stated that the severity of impairment – mild, moderate, severe, or profound - is determined through a consideration of adaptive functioning in the areas of conceptual, social, and practical self-management skills alongside IQ scores (APA, 2013). The WHO has also recognised the need to move to a more complex definition which includes a reduced ability to cope independently alongside a reduced ability to understand complex information, learn new skills, and apply existing skills to new situations or problems (WHO Europe, 2010).

In my own work, I use an interactionist perspective to understand children and young people, considering how internal qualities and environmental factors interact. I, therefore, choose to use the terminology of 'individuals who experience learning difficulties' to reflect this interplay between individuals and their environment. I am aware of the need for original work to reach the appropriate audience in order for it to impact on current understanding and practice. If common terminology is not used, then this increases the challenge for interested researchers and practitioners to identify work in their area of interest. I am also aware of the different terminologies used by different groups which adds to this challenge. For example, the term 'children and young people with learning difficulties' is currently used by the Department for Education, special schools, teachers, and Educational Psychologists (EPs), whereas the research literature uses the term 'children with intellectual disabilities'. In this literature review I will use the term 'children and young people who experience learning difficulties' because this is recognised by stakeholders likely to be interested in and impacted by the research, such as school staff, and will allow my work to have greater impact. I will use this term to refer to all previous synonyms in this area, including mental retardation, educable mentally retarded, mental handicap, developmental disabilities, mild/moderate/severe learning difficulties, and intellectual disabilities. As detailed in the method section, this literature review will specifically focus on phonics as a reading method for children and young people who experience learning difficulties and are educated in special school settings, so this is the terminology that will be used to describe the participants. A wide range of terms were used when searching the literature to ensure that relevant research was captured.

1.1.3.2 Education for children and young people who experience learning difficulties.

Education for children and young people who experience learning difficulties has evolved over the past several decades across the English speaking world (Frederickson & Cline, 2002). Legislation from both the UK and the United States is considered in this review because of the focus on learning to read English, and these countries have had legislation in place for many years to protect the right of all people to education. In the United States, the Education for All Handicapped Children Act of (1975) enshrined the right of all children, including those with SEN, to an education. In the United Kingdom, the Education Act (1944) increased the range of provision, requiring Local Education Authorities to provide special schools for pupils who required such an educational placement.

1.1.3.3 Teaching reading in special schools to children and young people who experience learning difficulties.

In 2016, 42.9% of children and young people, who had either a Statement or an Education Health and Care Plan that recognised their SEN, received their education in maintained special schools rather than mainstream education (Department for Education, 2016). Special schools provide individualised education compared to mainstream education which can provide a set structure that many children are expected to adapt to (Coyne, Kame'enui, & Simmons, 2004).

Literacy education in special schools has often focused on teaching recognition of key, functional words through a sight-word approach rather than phonics-based decoding, which research indicates is effective for learning the beginning skills of reading (Porter, 2005). For example, Sheehy (2009) investigated the handle technique, which uses mnemonic cues, to aid word recognition. Browder, Gibbs, et al. (2009) argued that reading is often de-emphasised with individuals who experience learning difficulties; that it has been assumed that learning to read phonetically is a cognitively complex task which these individuals will struggle to learn, and so a sight word approach was more appropriate. Historically, marginalised groups often suffered from a cultural denial of competence, specifically in this instance that reading skills were linked to IQ (Browder, Gibbs, et al., 2009). It was also assumed that this population would only learn to read functional sight words, and that reading was not appropriate to teach without individuals first having some language and communication skills. Browder, Gibbs, et al. (2009) argued against each of these historical assumptions, proposing a conceptual model which promotes the teaching of literacy skills for children and young people who experience learning difficulties. The authors' model of literacy proposes that every student should receive the opportunity to learn to read, and that reading should be taught to all students based on methods supported through scientific research on reading. The two key outcomes of this model of literacy are for students who experience learning difficulties to have increased access to literature, and increased independence as readers (Browder, Gibbs, et al., 2009).

Teaching reading to pupils who experience learning difficulties has been the focus of previous literature reviews over the past 25 years. Some have chosen to review the different methods used to teach reading to children and young people who experience learning difficulties. An early review conducted by Conners (1992) searched the literature for studies which taught reading to pupils with learning difficulties. The review concluded that sight-word and word analysis instruction were appropriate for use with this population. Browder, Wakeman, Spooner, Ahlgrim-Delzell, and Algozzine (2006) conducted a literature review, searching for 362 terms or combinations of terms, between 1975 and 2003, and focused on all reading instruction methods

for school-aged students with learning difficulties. The authors included 128 studies in their review, only 13 of which focused on phonics instruction. Browder et al. (2006) concluded that the strongest evidence was for teaching sight words using systematic prompting, and that there was some evidence for teaching comprehension using objects as a references. The authors noted that there was least evidence focusing on phonics and phonemic awareness, and that the lack of high-quality research made it difficult to determine the effectiveness of phonics as a teaching tool for this population. Roberts, Leko, and Wilkerson (2013) reviewed the literature between 1975 and 2011 and focused their review on the teaching of reading to adolescents with learning difficulties. The authors chose to specifically examine the literature for adolescents because they argued that adolescents have unique needs, which should be accounted for in teaching. Roberts et al. (2013) reported that vocabulary instruction through sight word teaching was common, and that only one study addressed phonics. The authors concluded that there were few studies specifically including only adolescent participants because research is still focused on attempting to find evidence-based strategies to use with all ages of individuals with learning difficulties.

Only two literature reviews have chosen to focus on phonics as a method of teaching reading to children and young people who experience learning difficulties. Joseph and Seery (2004) searched the literature between 1990 and 2002 and specifically looked for studies which used phonics instruction with this population. The authors retrieved seven studies that focused on teaching grapheme-phoneme correspondences but no studies that examined direct phonics instruction. The review concluded that phonics may be an appropriate teaching method but that further research was needed before any conclusions could be drawn (Joseph & Seery, 2004). Hill (2016) reviewed 11 studies that evaluated phonics as a method of teaching reading to pupils who experienced learning difficulties between the ages of 6 and 21 years. This review searched the literature between 2001 and 2013 to provide an update on the literature since the review by Joseph and Seery (2004). Hill (2016) concluded that children and young people who experience learning difficulties can respond effectively to phonics-based reading interventions.

Other reviews into the teaching of reading with this population have had a narrower focus on specific methods of teaching reading. For example Browder, Ahlgrim-Delzell, Spooner, Mims, and Baker (2009) analysed 30 studies and concluded that time-delay techniques were effective tools for teaching sight word recognition (Browder, Ahlgrim-Delzell, et al., 2009). Hudson and Test (2011) reviewed 13 studies and concluded that there was a moderate level of evidence suggesting that shared story reading promoted listening comprehension and reading independence skills such as vocabulary comprehension.

Past reviews in teaching reading to children and young people who experience learning difficulties have either not specifically looked for phonics-based studies, or have looked in this area but suffered from limitations. The review by Joseph and Seery (2004) was unable to draw conclusions due to a lack of published research available to the authors. The review by Hill (2016) chose to only review the literature since 2001, so did not provide a complete understanding of the evidence, and only included studies that had participants aged 6 and above, despite the fact that phonological awareness develops in the early years. There is a need for an up-to-date review to synthesise both older and more recently published research across a wider range of pupil ages. The aim of this systematic literature review was to collate the research evidence in teaching phonics to children and young people who experience learning difficulties educated in special school settings, and examine the effectiveness of this as a method of teaching reading. In order to search over a wide range of years, capturing the history of the research, I have decided not to compare phonics to other methods of teaching reading but instead to focus solely on the literature using phonics-based methods. However the consequence of this decision is that the review cannot compare the effectiveness of phonics-based methods to other methods of teaching reading in special schools, such as a sight word approach.

1.1.4 Underlying Ontology

My work has been informed and directed by a critical realist ontological approach. A realist account of science was proposed by Bhaskar (1978) as an alternative to the positivist approach. Critical realism assumes that an independent reality exists while acknowledging that any attempts at describing and explaining the world are bound to be fallible and open to critique and replacement by new ways of understanding the world (Scott, 2005). This ontological approach assumes that knowledge can be acquired through experimental design (Tikly, 2015). My ontological view has directly impacted my work in this review in that I have assumed that it is possible to measure word reading and phonics skills, and that experimental design methodology can be used to investigate whether reading interventions lead to an improvement in these skills. My inclusion criteria have therefore been written to reflect these assumptions. I have searched for and included research that has used pre- and post-measures of reading either side of an implemented intervention.

1.2 Method

1.2.1 Search Strategy

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) structure (Moher, Liberati, Tetzlaff, Altman, & Group, 2009). Four databases were searched to identify relevant studies for this review: PsycINFO, Web of Science, ERIC, and Scopus. The search terms used were (*child** OR *young person* OR *young people* OR *adolescen**) AND (*intellectual disabilit**OR *cognitive disabilit** OR *mental retardation* OR *mental handicap* OR *mild learning disabilit** OR *moderate learning disabilit** OR *severe learning disabilit** OR *mild learning difficult** OR *moderate learning difficult** OR *severe learning difficult**) AND (*intervention* OR *teach** OR *instruct** OR *program**) AND (*literacy* OR *read** OR *decod** OR *phon**).

All databases were searched between the years of 1973 and 2016. The year 1975 was originally chosen as the starting year because this is when the Education for All Handicapped Children Act was passed by congress in the United States. This is the earliest legal document enshrining the right of all children, including those with SEN, to education. In Britain it was not until the Education Act (1981) when local educational authorities were required to assess, identify, and describe how they would meet the needs of children with SEN. However an initial search of the database PsycINFO without screening by year found the earliest record of a phonics-based reading intervention with children who experienced learning difficulties was 1973, and therefore this was the start date chosen.

The database results were filtered to identify English language papers that had been published in peer-reviewed journals. This led to 3808 studies being identified: 1482 in PsycINFO, 1178 in Web of Science, 481 in ERIC, and 667 in Scopus. After duplicates were removed, titles and abstracts were screened and 3717 papers were removed, meaning that 47 full-texts were assessed for eligibility based on inclusion and exclusion criteria described below. The reference lists of included papers were searched to identify further studies to include in the review, this led to four additional studies being identified. Studies included in previous reviews in this area were also screened for eligibility (Browder et al., 2006; Conners, 1992; Hill, 2016; Joseph & Seery, 2004; Roberts et al., 2013), and this led to two additional papers being included. A further paper was included after being received by my supervisor. A total of 38 articles were included in this review. Figure 1 displays the number of studies included at each stage of the review. See Appendix E for detailed reasons of the studies rejected after the full text had been retrieved.

1.2.2 Inclusion and Exclusion Criteria

1.2.2.1 Participants.

Studies were included if participants were between the ages of birth to 19, were described as having learning difficulties, were educated in a special school or within a special education classroom in a mainstream school for at least some of their time in school, and were learning to read English. Studies in which English was being taught as an additional language were not included, as were studies that included participants who had a hearing or visual impairment. This was because this review specifically investigated phonics as a method of teaching reading, which involves the matching of visual graphemes with auditory phonemes (Byrne, 1998). Studies that recruited participants with epilepsy were also excluded from this review because this condition has been linked to memory impairments (Menlove & Reilly, 2015), which may affect the learning of these individuals. Participants between the ages of birth to 19 were selected because in special schools in the UK the curriculum is divided up into the stages of early years, primary, secondary, and post-16, which covers the age ranges of 3 to 19 (Department for Children Schools and Families, 2011).

1.2.2.2 Study design.

Studies were included if they had an experimental, quantitative design in which findings were reported from an analysis of data before and after an intervention had been implemented.

1.2.2.3 Intervention.

Studies were included if they taught reading using a method which contained, or was wholly based on, phonics, in which students were taught how language and spoken words consist of separate sounds, how these aural phonemes map onto written graphemes, and were instructed in skills to decode written words (Primary National Strategy, 2007). The definition of an intervention as 'an educational program, product, practice or policy aimed at improving outcomes' from the What Works Clearinghouse (US Department of Education, 2012) was used in this review. Studies were included if they implemented a reading intervention or evaluated classroom practice. Studies also needed to take place in special education settings rather than in mainstream classrooms to ensure that the level of need was similar across participants and findings could be generalised to special education settings.

1.2.2.4 Outcome variables.

Studies included were required to have at least one reading outcome measured pre- and post- intervention, and/or an outcome measure of phonics skills, such as phonemic awareness.

1.2.3 Data Extraction and Synthesis

Details of the study design, sample characteristics, reading intervention, outcome variables, and research findings from the included studies can be viewed in Appendix A. The studies were evaluated using a modified version of the Downs and Black (1998) checklist for assessing the quality of randomised and non-randomised interventions. Modifications to the original Downs and Black criteria were made to ensure that studies using a between groups comparison design and single-subject research could be equally recognised. Twenty articles reporting research conducted in special education settings used single-subject designs and the original Downs and Black checklist did not have criteria that recognised the potential quality of this research. See Appendix B for a full version of the modified checklist used in this review.

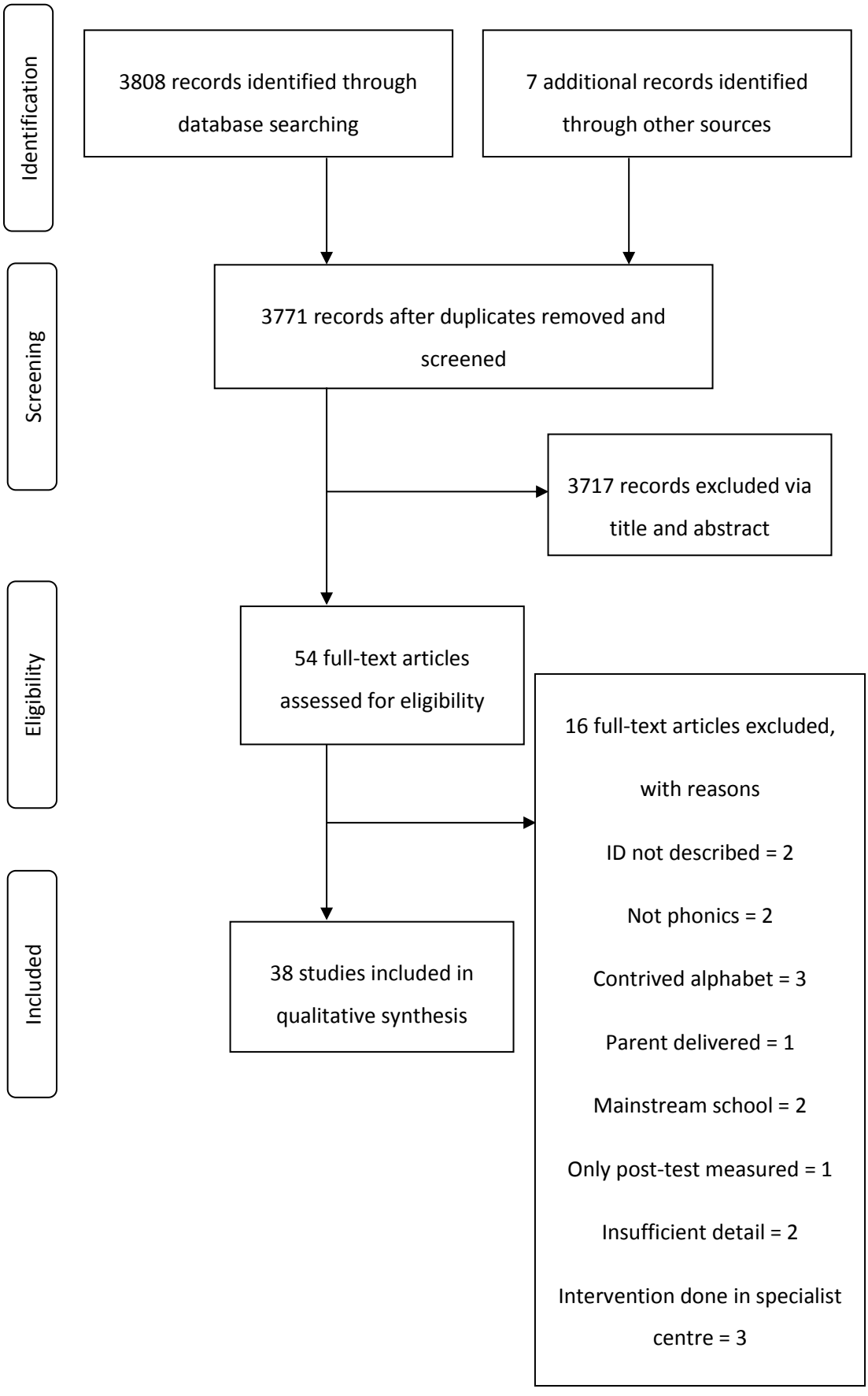

*Figure 1.*Flowchart of the search strategy.

1.3 Results

Thirty-eight studies were included in this systematic review, and have been organised in the following way with the aim of adding an understanding of the effectiveness of phonics-based reading interventions to the current findings in the literature. The studies have been classified into three separate groups by the skills targeted within the reading intervention.

In the first group, *Phonics-Based Interventions,* reading interventions that focused solely on teaching phonics skills were collated (n = 17: 7, 9, 11, 17, 20, 21, 22, 23, 27, 29, 31, 32, 33, 34, 35, 36, and 37). These reading programmes aimed to develop students' skills in blending together phonemes decoded from graphemes to allow them to decode words phonetically (Solity & Vousden, 2009).

The second grouping, *Interventions Embedded in a Wider Context,* was informed by the review published by the National Reading Panel (2000). In this review, five skills were identified as essential components of learning to read: (1) vocabulary comprehension, understanding that written words represent meaning; (2) phonemic awareness, knowing spoken words are made up of individual phonemes; (3) phonics instruction, learning grapheme-phoneme correspondences and how to blend phonemes together to read phonetically; (4) fluency, being able to read with speed and accuracy; and (5) comprehension, understanding what is read. Many of the studies that evaluated phonics skills, grapheme-phoneme correspondences and blending, also included vocabulary, fluency, and comprehension activities. These studies have been grouped and analysed together (n = 18: 2, 4, 6, 8, 10, 12, 13, 14, 15, 16, 18, 19, 24, 25, 26, 28, 30, and 38).

The third group, *Phonemic Awareness and Grapheme-Phoneme Correspondence Interventions,* consists of a smaller number of studies that are focused on evaluating the instruction of phonemic awareness skills - developing students' ability to identify and manipulate the individual phonemes which make up spoken words, and their knowledge of grapheme-phoneme correspondence - learning how these sounds map onto written letters but without teaching skills of blending to read phonetically (Solity & Shapiro, 2008). These studies have been grouped together (n = 3: 1, 3, and 5).

Complete details of the design, intervention, outcomes, reading measures, and quality scores for the studies included in this literature review can be found in Appendix A. Each study in the review has been allocated a reference number that can also be found in this table, and reference numbers will be used in the results section to refer to studies. Of the 38 studies included in this systematic review, 26 of these were conducted in the US (68.42%), and three

were conducted in Australia (7.89%). Seven studies (18.42%) did not report their location. Two studies were conducted in the UK (5.26%).

All studies were evaluated using a modified version of the Downs and Black (1998) checklist, details of the rating for each study can be found in Appendix A. Across all 38 studies, quality scores ranged between 12 and 21, indicating a wide range in the quality of included studies. Of the 17 studies evaluating phonics-based reading interventions, scores ranged between 12 and 19. However of these 17 studies, 6 papers received a rating of 12, and 10 papers were rated 15 or lower. This indicates that a portion of these papers were of less robust quality, and drawing conclusions from their data should be done with caution. The 18 studies evaluating reading interventions embedded in a wider context were generally of higher quality, with scores ranging between 13 and 21. 12 studies were rated 16 or above, with only six rated 15 or below. The phonemic awareness and grapheme-phoneme correspondence interventions had a narrower range of quality scores; they ranged between 16, which two studies received, and 17, which one study received. Studies receiving quality ratings of 15 or below suggest potential methodological weaknesses, and so caution is needed when interpreting these findings.

1.3.1 Phonics-Based Interventions

1.3.1.1 Description.

Seventeen of the studies evaluated interventions that focused specifically on teaching children to read phonetically. Of this group of studies, eight delivered the reading intervention in small groups (20, 22, 23, 27, 29, 31, 32, and 36). Four studies described interventions that used teaching on a one-to-one basis (9, 11, 21, and 37). Three studies used a mixture of individualised and group teaching (7, 17, and 34), and two studies did not report the teaching format used (33 and 35). Of these 17 studies, 12 were published over a decade ago (20, 21, 22, 23, 27, 29, 31, 32, 33, 34, 35, and 36).

A range of different manualised teaching programmes were described. The phonics component of the Integrated Literacy Curriculum (Alberto & Fredrick, 2007) was used by one study (7), the Corrective Reading Program (Engelmann, Becker, Hanner, & Johnson, 1980) was used by three studies (20, 22, and 31), the Distar Reading Program (Booth, 1978) was used by three studies (33, 34, and 36), Rode to Code (Blachman, Ball, Black, & Tangel, 2000) and Rode to Reading (Blachman & Tangel, 2008) were used by one study (11), one study used the ABDs of reading (32), and the Sullivan reading programme (Buchanan, 1968) was evaluated by one study (35). Additionally, seven studies did not report using a specific manualised programme but described the skills taught during the intervention (9, 17, 21, 23, 27, 29, and 37).

1.3.1.2 Intervention intensity.

The studies varied in the frequency with which the intervention took place. Eight studies reported that the intervention took place on a daily basis (7, 17, 23, 31, 33, 34, 36, and 37). Six studies had interventions which took place between two and four times per week (11, 20, 21, 22, 29, and 32). The remaining three studies did not describe how often reading sessions were delivered (9, 27, and 35).

There was also a wide range in the length of time over which the studies took place, with interventions being implemented between 7 weeks (29) and 5 years (33). Three studies did not report the time span of the reading intervention (7, 22, and 35).

Eight studies reported the duration of each teaching sessions with a range of intervals reported: 10 minutes (29), 20 minutes (23 and 34), 15 to 20 minutes (9), 15 to 30 minutes (36), 30 minutes (32), 30 to 50 minutes (27), 40 minutes (37), 45 minutes (31), and 1 hour (20). Seven studies did not report the length of each session (7, 11, 17, 21, 22, 33, and 35).

1.3.1.3 Participants.

The students included in the studies spanned a wide range of ages, from 4 to 18 years. There were also a variety of methods of identifying participants, authors generally began by approaching special schools directly. Nine studies reported the IQs of their participants if they were already known to schools before the study (7, 9, 11, 17, 20, 22, 23, 31, and 36), and three studies measured IQ as part of their research (21, 27, and 35). The other five studies (29, 32, 33, 34, and 37) instead used the labels for this group which were appropriate at the time of writing such as educable mental retardation (32), and used the participants' enrolment in special educational settings as a means of defining their learning difficulties.

Studies varied with regards to their inclusion criteria, specifically the degree of knowledge of reading skills that participants should already have to be eligible to take part in the reading intervention. Eleven studies reported that participants had been selected through teacher recommendation or did not describe any inclusion criteria related to reading skill (7, 9, 17, 20, 22, 23, 31, 32, 33, 34, and 36). The six studies that described reading skills in their inclusion criteria varied in the baseline knowledge required (11, 21, 27, 29, 35, and 37). One study described that participants were only included if they could correctly recognise 80% of letter-sounds from a list of 31 phonemes (27), whilst another study described that all potential participants were given a phonological test and only those who scored less than 30% were included (29).

1.3.1.4 Methodology.

1.3.1.4.1 Design.

The majority of studies used a single-subject design in which each participant acted as their own control with 11 studies describing this methodology (7, 11, 17, 20, 22, 23, 27, 33, 34, 36, and 37). A between-subject design was used in five studies in which participants were allocated to different treatment groups and compared before and after the intervention (9, 21, 29, 32, and 35). Of these five studies, four randomly allocated participants to treatment conditions (9, 21, 29, and 35). One study used a within-subject design (31).

1.3.1.4.2 Outcome measures.

A variety of outcome measures of reading skill were reported, with studies using both standardised tests with known reliability and validity, and curriculum-based measures including probes that directly measured the words being taught in the reading intervention, introducing a potential confound. Seven studies used a mixture of both standardised tests and curriculum-based measures to track reading skills before and after the intervention (7, 9, 11, 27, 32, 33, and 34) whilst eight studies used only curriculum-based measures (17, 20, 21, 22, 29, 35, 36, and 37), and two study solely used standardised measures (23 and 31).

The standardised reading measures used were: the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) used by two studies (7 and 23); the Woodcock Johnson III Diagnostic Reading Battery (Schrank, Mather, & Woodcock, 2004) was used by one study (9); the Stanford Diagnostic Reading Test (Karlsen & Gardner, 1985) used by one study (27); the Wide Ranging Achievement Test (Jastak, Jastak, & Bijou, 1965) used by two studies (32 and 34); the Neale Analysis of Reading Ability (Neale, 1966) used by one study (33); the Peabody Individual Achievement Test (PIAT; Dunn & Markwardt, 1970) used by one study (31); the Dynamic Indicators of Baseline of Early Literacy Skills (DIBELS; Good & Kaminski, 2002) was used by one study (11), and the Woodcock-Johnson Psycho-Education Battery, Tests of Achievement III (Woodcock, McCrew, & Mather, 2000) was used by one study (23).

1.3.1.4.3 Intervention deliverer.

Class teachers or school staff, who had been trained by the researchers, were responsible for delivering the intervention in 10 studies (7, 11, 17, 22, 31, 32, 33, 34, 35, and 36), and in seven studies the intervention was delivered by members of the research team (9, 20, 21, 23, 27, 29, and 37).

1.3.1.5 Outcomes.

Although all of the 17 studies which evaluated phonics-based interventions generally reported improvements in reading skills as measured by the tools chosen, there was variability on the specific gains described. Seven studies (9, 11, 22, 23, 29, 35, and 36) described gains in some areas of reading but not others; these improvements were seen in the areas specifically targeted by the reading intervention. For example, one intervention study that trained participants using blending, segmenting, or rhyming tasks reported that improvements were specific to the targeted area but skills did not generalise to other non-targeted areas (29). Study 22 found that only two of the six participants were able to apply their decoding skills to read untaught words. Indeed another study found that the group which had been taught using a whole-word approach read a greater number of words than the group taught using phonics methods (35). This group of studies found improvements in the skills being taught in the intervention but these often did not result in far-transfer effects such as the ability to read untaught words. The results from this group of studies must be treated with caution due to the variability in quality ratings, 6 papers received a rating of 12, and 10 papers were rated 15 or lower. The number of papers receiving low quality ratings suggests methodological weaknesses affecting the conclusions that can be drawn.

1.3.2 Interventions Embedded in a Wider Context

1.3.2.1 Description.

Eighteen studies taught other reading skills alongside phonics. All 18 studies taught both phonics and comprehension skills (2, 4, 6, 8, 10, 12, 13, 14, 15, 16, 18, 19, 24, 25, 26, 28, 30, and 38). Ten studies also included a fluency element (4, 6, 10, 13, 14, 15, 16, 19, 24, and 38), and vocabulary teaching was included in eight studies (8, 10, 12, 13, 14, 15, 18, and 38). This group of studies had been published more recently, 12 of the 17 took place between 2008 and 2017 (2, 4, 6, 8, 10, 12, 13, 14, 15, 16, 18, and 38).

The intervention took place in small group teaching sessions in seven studies (8, 14, 15, 25, 26, 28, and 30). Individualised teaching was used in seven studies (2, 6, 10, 16, 19, 24, and 38). Three studies used a mixture of one to one teaching and group teaching (4, 13, and 18), and one study did not report how teaching was organised (12).

A range of manualised interventions were reported. The Early Interventions in Reading programme (Allor & Mathes, 2012; Mathes & Torgesen, 2005a, 2005b) was used by five studies (4, 6, 13, 14, and 15); the Early Literacy Skills Builder (Browder, Gibbs, Ahlgrim-Delzell, Courtade, & Lee, 2007) was used by two studies (12 and 18); and the following interventions were used by

one study each: Early Reading Skills Builder (Browder et al., 2007; 2), PCI Reading Program (PCI Educational Publishing, 2007; 8), Literacy by Design (Coyne, Pisha, Dalton, Zeph, & Smith, 2012; 10), Sound Linkage (Hatcher, 1994; 24), Four Blocks Literacy Framework (Cunningham, Hall, & Sigmon, 1999; 25); and Headsprout Early Reading (Layng, Ph, Twyman, & Stikeleather, 2003; 38). Study 30 used Direct Instruction Reading Mastery (Engelmann & Bruner, 1974) and Superkids (Rowland, 1983). Four studies did not use a manualised intervention but rather described the skills taught (16, 19, 26, and 28).

1.3.2.2 Intervention intensity.

There was variation in the frequency with which reading interventions took place. One study implemented the Four Blocks Literacy Framework for four 45-minute sessions per day (25), one study used sessions twice a day (16), and seven studies had daily teaching sessions (4, 6, 10, 13, 14, 15, and 30). One study used between one and three sessions per week (38), one study implemented between three and four sessions per week (19), one used four sessions per week (24), and six studies did not report on the number of weekly sessions (2, 8, 12, 18, 26, and 28).

The total duration of interventions varied by study; one study took place over 6 weeks (16) whilst another study reported over an intervention of 4 years (4).

Fifteen studies reported the duration of each teaching session: 5 to 15 minutes (26 and 28), 15 to 20 minutes (2), 15 to 20 minutes (38), 20 to 30 minutes (10), 30 minutes (16, 19, and 30), 35 minutes (24), 40 to 50 minutes (4, 13, and 15), 45 minutes (6 and 25) and 55 minutes (8). Three studies did not report the length of each session (12, 14, and 18).

1.3.2.3 Participants.

Participants across all the studies ranged between 5 and 16 years of age. Six studies measured participants' IQ as part of the research (2, 4, 12, 13, 14, and 15), and six studies reported the IQs of their participants which were already known to schools before the study (6, 16, 18, 19, 24, and 25). Instead of IQ scores, the remaining six studies used descriptive labels varied with the historical context of when they were written (8, 10, 26, 28, 30, and 38). For example, some used the labels of mild or moderate intellectual disabilities (8) or mild mental retardation (28).

The studies also differed in their inclusion criteria related to participants' existing reading skills. Thirteen studies relied on teacher recommendation and did not describe specific inclusion or exclusion criteria based on reading (4, 6, 10, 13, 14, 15, 19, 24, 25, 26, 28, 30, and 38) whereas the remaining five studies used different criteria. Two studies recruited participants who were

reading below a first grade level (12 and 18), one study specified pupils reading at or below Kindergarten level (8), one study selected pupils who could read at least five words or knew five letter-sounds (2), and one study recruited participants who could read between one and nine non-words or who knew between one and 29 letter-sounds (16).

1.3.2.4 Methodology.

1.3.2.4.1 Design.

Twelve studies used a between-subject design (2, 4, 10, 12, 13, 15, 18, 19, 24, 26, 28, and 30). Of these, participants were randomly allocated by class or teacher in two studies (2 and 12), by school in two studies (4 and 19), by individual in three studies (13, 15, and 18), and matched with a student who had equivalent pre-test scores in one study (24). The remaining studies did not report using random allocation to assign individuals to conditions. Six studies used a single-subject design (6, 8, 14, 16, 25, and 38).

1.3.2.4.2 Outcome measures.

A variety of different outcome measures were used in the research. Eight studies used only standardised reading measures (4, 12, 13, 14, 15, 19, 30, and 38). Nine studies used a mixture of standardised and curriculum-based measures of reading skills (6, 8, 10, 16, 18, 24, 25, 26, and 28). One study used curriculum-based reading measures (2). The standardised reading measures used were: the CTOPP (Wagner et al., 1999) used by three studies (4, 13, and 15); the DIBELS (Good & Kaminski, 2002) used by seven studies (4, 6, 13, 14, 15, 19, and 38); the Non-Verbal Literacy Assessment (NVLA; Ahlgrim-Delzell, Browder, Flowers, & Baker, 2008) used by two studies (12 and 18); the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999) used by three studies (4, 13, and 15); the Woodcock Language Proficiency Battery – Revised (Woodcock, 1991) used by four studies (4, 13, 15, and 18); the Woodcock Reading Mastery Test – Revised (Woodcock, 1998) used by two studies (8 and 16); Woodcock Johnson III Tests of Achievement (Woodcock, McGrew, & Mather, 2001) used by one study (10); the Woodcock Johnson Tests of Achievement (Woodcock & Johnson, 1990) used by two studies (26 and 28). The following tests were each used by one study: the Burt Reading Test (Scottish council for research in Education, 1976; 24); the Test of Early Reading Ability (Reid, Hresko, & Hammill, 1981; 30); the California Achievement Test (*California Achievement Test*, 1985; 30); the PIAT (Dunn & Markwardt, 1970; 30); the Rigby Reading Benchmark Assessments (Nelley & Smith, 2000; 8); the Brigance Diagnostic Comprehensive Inventory of Basic Skills (Brigance, 1983; 25); the Test of Early Reading Ability 2 (Reid, Hresko, & Hammill, 1989; 25); the Analytic Reading Inventory (Woods &

Moe, 1995; 25); the Word Reading and Phonics Skills Test (WRAPS, Carver & Moseley, 1994; 38); and the Woodcock Johnson III Reading Achievement Battery (Mather & Woodcock, 2001; 19).

1.3.2.4.3 Intervention deliverer.

Teachers were recruited to deliver the interventions in 16 studies (2, 4, 6, 8, 10, 12, 13, 14, 15, 18, 24, 25, 26, 28, 30, and 38). The intervention was delivered by research staff in one study (16), and by volunteer mentors in one study (19).

1.3.2.5 Outcomes.

Positive outcomes, defined as increases in reading skill as measured by the chosen measures, were reported for 15 studies (2, 4, 6, 8, 12, 13, 14, 15, 16, 18, 24, 25, 26, 28, and 38). One study examined a phonics programme which focused on blending letter sounds and story reading, and compared it to an alternative teaching intervention which introduced sounds at different positions in the word; this study did not find any significant differences between the two programmes although both successfully taught phonics skills (30). Another study, in which the reading intervention was delivered by volunteer mentors, reported improvements on the oral reading fluency measure of the DIBELS but no improvements on letter-word identification, reading fluency, passage comprehension, or word attack skills (19). Finally one study which was primarily targeting reading comprehension found improvements in comprehension skills but no increases in other areas of letter-word identification, word attack skills, or sound awareness (10).

Additionally, some of the studies which reported improvements as an effect of the reading intervention reported positive outcomes in only some areas (2, 6, 10, 18, 19, and 28). Study 10 reported only improvements in comprehension skills, a key part of the intervention programme, and study 2 found that participants improved in phonemic identification but not blending or segmenting. Similarly to the findings of phonics-based interventions, not all studies reported that improvements in reading showed far-transfer effects beyond the skills targeted by the intervention.

1.3.3 Phonemic Awareness and Grapheme-Phoneme Correspondence Interventions

1.3.3.1 Description.

From the studies included in this review, three specifically focused on individuals' phonemic awareness skills, their ability to hear and manipulate individual sounds that constitute spoken words, as well as teaching pupils to match these phonemes to graphemes but without teaching how to read phonetically by blending phonemes together to read words. Individualised teaching

was used in two studies (3 and 5), and one used small group teaching (1). This appears to be a recent area of research, with all three studies having taken place since 2014.

Different intervention programmes were also investigated. The letter-sound correspondence portion of the Accessible Literacy Learning curriculum (Light & McNaughton, 2009) was used in one study (1), another adapted the Rode to Code intervention (Blachman et al., 2000) by teaching a target word along with each letter (3). One study did not use a specific intervention but aimed to enhance phonemic awareness through child-initiated play activities supported by an adult (5).

1.3.3.2 Intervention intensity.

One study used three sessions per week (1), one used four sessions per week (3), and one study did not report the frequency with which intervention sessions took place (5). Regarding the length of the intervention, one study was conducted over 3 months (1), one over 15 weeks (3), and the third did not report this information (5). The length of the intervention sessions varied between 15 minutes (5), 20 minutes (3), and 45 to 60 minutes (1).

1.3.3.3 Participants.

The age of participants ranged between 5 to 16 years although two studies used students under the age of 8 (3 and 5). One study measured participants' IQ scores (1), whilst the remaining two described their subjects using the labels of Down's syndrome (3) and intellectual disability (5).

One study only required participants to be verbal and did not describe any other inclusion criteria (5), whilst the others asked that participants had pre-kindergarten reading skills (1), or knew fewer than 10 letter-sounds (3).

1.3.3.4 Methodology.

1.3.3.4.1 Design.

All three studies evaluating the effectiveness of phonemic awareness and grapheme-phoneme correspondence interventions used single-subject designs (1, 3, and 5).

1.3.3.4.2 Outcome measures.

Two studies used only curriculum-based measures of reading skills (1 and 5). One study used both standardised and curriculum-based measures (3), the standardised measure being the Woodcock Johnson III (Woodcock, McGrew, Mather, & Schrank, 2001).

1.3.3.4.3 Intervention deliverer.

All three studies targeting phonemic awareness used researchers or specifically hired staff to deliver the intervention rather than class teachers (1, 3, and 5).

1.3.3.5 Outcomes.

As determined by the chosen measures of reading skill, all three studies reported positive impact of their interventions. However only study 1 reported an increase in skills for all participants, the others had a more mixed picture. Study 3 reported improvements in participants' phonological awareness skills but not in the other outcome measures. Study 5 showed that phoneme segmenting fluency increased significantly for all participants but that although sound segmentation and initial sound fluency increased for all children, these changes were not statistically significant for all.

1.4 Discussion

This is the first systematic review which has considered the development of research in this area over the past 43 years, and therefore has important conclusions for children and young people who experience learning difficulties and are educated in a special school setting, the educational practitioners who support them, and researchers in this field. The findings from the 38 reviewed studies suggest that phonics-based interventions may be an appropriate method for supporting beginning reading skills with this population. These interventions have been shown to lead to improvements in phonemic awareness, letter knowledge, and phonics skills. However the finding that none of the reviewed studies reported no benefits from the reading interventions indicates that the literature is affected by the publication bias, and therefore the findings of this review are also affected. The publication bias in psychology means that studies showing significant results are more likely to be published (Ferguson & Heene, 2012). Researchers have noted the tendencies of journals to publish new and innovative research rather than replications of previous findings (Drotar, 2010). As studies showing positive results are more likely to be published, then this review is likely to be biased in that there may be many studies evaluating the effectiveness of phonics with this population showing negative results which have not been published and therefore would not be included in this review. This problem is often referred to as the file-drawer effect (Rosenthal, 1979).

1.4.1 Current State of the Research

Compared to previous reviews that have evaluated this literature, such as Joseph and Seery (2004) and Hill (2016), there were a greater number of studies evaluating phonics-based reading interventions with this population. In the model of literacy proposed by Browder, Gibbs, et al. (2009), the authors stated that all children should have the opportunity to learn to read using teaching methods supported by research. It is promising that so many researchers are actively involved in research in this area, specifically 20 studies have been published over the previous decade.

A trend in the research has been the focus on phonemic awareness with three studies specifically targeting this skill. These studies were published relatively recently, in 2014, 2015, and 2016. This may reflect a trend observed in research with typically developing children that phonemic awareness and letter-sound knowledge are the foundations on which reading is based (Treiman, 2000). It may be that individuals designing reading interventions for children and young people who are educated in special school settings have recognised this finding, and are now incorporating teaching of phonemic awareness and letter knowledge as a precursor to the explicit teaching of skills required to read phonologically such as segmenting and blending.

Nearly one third, 11 of the 38 reviewed studies, described interventions that were delivered by researchers rather than by school staff. Even in the studies in which the interventions were delivered by school staff, it was often researchers who took responsibility for collecting outcome data and monitoring the implementation of the intervention. Previous research has demonstrated that the presence of researchers in an environment can impact upon perceived outcomes, known as the Hawthorne effect (Adair, 1984). This influence in reading interventions should be lessened, as the success of interventions is determined through empirical outcome measures rather than subjective perceptions, but the potential confounding effect does need to be noted. However the alternative, having educational practitioners implement interventions and collect data, would introduce the potential bias that they would want their interventions to have a positive impact on their students and this may also affect data collection.

1.4.2 Key Messages for Practitioners

Educational practitioners working directly with students who experience learning difficulties and are educated in special school settings should be aware that phonics-based reading interventions may lead to improvements in phonics skills. Practitioners such as EPs should be mindful that the literature reviewed has found some positive effects of the skills directly targeted by the intervention, and that the pupils they work with may therefore need

support to generalise their skills to far-transfer tasks. Furthermore, in typically developing populations research has recognised that phonemic awareness is an important skill underpinning the ability to read, and that recent research has reported that interventions targeting the ability to hear and manipulate the spoken units of language is also beneficial for individuals educated in special school settings. EPs may, therefore, want to consider promoting the implementation of phonemic awareness interventions with pupils of a younger age, as a way of promoting skills which will be beneficial to reading later in their development.

1.4.3 Key Messages for Researchers

Reviewing the literature has also highlighted key messages for researchers to take into account when conducting studies in this area. One area of note is the outcome measures used. Curriculum-based measures, which assessed participants' skills on the material being taught in the intervention, were employed as outcome variables in 28 studies. Curriculum-based measures often took the form of probes or reading a list of taught words. Only 10 studies used only standardised measures, defined as measures that have been designed and standardised on a normative population (Kline, 2000), to assess the early reading skills being targeted by the intervention. To complete these tasks, participants are required to generalise the reading skills they have been learning in the intervention tasks to new reading materials. Near-transfer effects refers to the tendency for individuals to become more skilled at completing the intervention tasks and activities similar to these, whereas far-transfer effects refers to the ability to use newly taught skills in dissimilar tasks (Rapport, Orban, Kofler, & Friedman, 2013). The fact that so many studies in this area are choosing to use curriculum-based measures may be confounding the results; the positive outcomes reported may reflect genuine improvement at completing activities similar to the intervention, near-transfer of skills, but does not necessarily reflect a far-transfer effect. Given that the aim of reading interventions is to demonstrate these far-transfer effects, pupils who are unable to use their taught skills to read words in a wide range of different environments may not, in practice, be benefitting from these interventions. Although using standardised measures with children and young people who experience learning difficulties can be problematic as the tools have been standardised on a normative population, research using such tools is preferable as the alternative may be an overly positive description of the intervention due to the near-transfer effects of curriculum-based measures.

Another theme that may lead to the positive findings from phonics interventions being overemphasised is the type and number of skills being tracked through the outcome variables. In sight word interventions, the outcome measures generally consisted of a frequency count of taught words that participants can read (Yaw et al., 2012). However, in phonics-based

interventions, researchers often chose to measure the phonics skills being taught, as well as reading of both taught and untaught words. This method provides greater opportunities to observe a positive intervention effect. Phonics studies are able to look for an increase in the phonics skills, such as blending, but they can also look for an increase in the number of words participants can read. Some studies found an increase in phonics skills which did not generalise to word reading ability (e.g., 22). Studies using phonics-based interventions therefore have greater opportunities to observe positive effects compared to those evaluating sight-word interventions, and this may lead to positive effects of phonics-based interventions being overstated.

The findings from this review suggest that the improvements observed in outcome measures can be specific to particular skills and may not easily generalise to other early reading skills. For example, one study randomly allocated participants to a control group or one of three treatment groups learning skills in blending, segmenting or rhyming. The results indicated that participants improved in the specific area they had received teaching in but that training in one phonological area did not lead to a generalisation of skills and improvement in the other two related areas (29). This theme was observed across a range of studies, with increases in skills reported in the area targeted by the intervention but other areas of reading not showing the same trend. This suggests that for individuals educated in special school settings, it may be necessary to make sure that interventions provide explicit training in different phonological skills and do not make assumptions that skills can be automatically generalised.

Many studies described how often the intervention was intended to be implemented, and this varied from daily to several times per week. However, few studies gave any information about the actual treatment fidelity observed during the course of the study. How often each participant accessed the intervention is an important variable when interpreting the results showing how successful, or not, the programme may have been. Furthermore, research has shown that treatment fidelity can pose difficulties in real-world, educational environments, and that some teachers do not implement interventions with adequate treatment integrity (Sanetti & Kratochwill, 2011).

1.4.4 Future Directions

Several directions for future research have become clear from this review. There are methodological considerations raised by this review which future research could work to address. As previously discussed, many of the outcome measures were curriculum-based, consisting of probes of the material being taught in the intervention, and therefore positive outcomes in studies using these measures are likely to be confounded from near-transfer effects. It is

important that researchers include standardised measures of the underlying skills they expect the intervention to affect so it is possible to examine whether the children and young people can transfer their new learning to read in other contexts, as they will need to do so in order to read phonetically outside of the intervention. Studies should also include discussion of treatment fidelity so that consideration of their findings can take place in the context of understanding of how intervention sessions actually took place. Furthermore only two studies included a follow-up of reading skills after the end of the intervention (26 and 30), and so it is not possible to comment on how these skills were maintained.

An area highlighted by this review has been that many studies reported that participants' reading skills increased in some areas but not others, and that children and young people who are educated in special school settings may find it difficult to generalise reading skills to new areas, such as using decoding skills to read untaught words. Future research could examine how to support these individuals in generalising their skills to far-transfer effect tasks successfully.

Nearly one third of the reviewed studies reported on interventions which were not delivered by school staff and instead relied on researchers or volunteers visiting school settings to deliver the reading programme. Teachers should be empowered to deliver reading interventions themselves rather than relying on others, and future research could also explore teachers' perspectives on reading interventions and how manageable they find it to implement different programmes. As the ease of implementation is likely to have an impact on treatment fidelity, this should be considered in future research.

1.4.5 Limitations

There are several limitations to this systematic literature review that need to be considered when drawing overall conclusions. Firstly, I made the decision to only review studies teaching early reading skills through phonics-based methods. Historically, teaching reading to individuals experiencing learning difficulties has often used recognition of sight words rather than phonics (Browder, Gibbs, et al., 2009). It has been assumed that it is easier for these individuals to learn to recognise a number of functional words than to learn to read phonetically, which involves the more complex task of recalling phonemes from graphemes, holding phonemes in mind, and blending these together into a complete word. The decision to not consider other reading methods, and not to compare phonics-based methods against other reading methods, means that it is not possible to conclude the relative effectiveness of phonics against other methods of teaching reading to pupils educated in special schools.

As previously mentioned, the lack of studies reporting negative effects of phonics-based interventions suggests that this review is impacted by the file-drawer effect (Rosenthal, 1979). The impact of an intervention can only be determined through the consideration of all the research evidence, and if the publication bias in psychology means that only the positive findings are published then this may have led to a false-positive conclusion, that phonics-based interventions are actually not effective but appear to be so because studies which report negative effects are not being considered in this review.

It is also important to bear in mind that this study has only considered the teaching of early reading skills in English to individuals for whom English is their first language. The orthography of a language may have an impact on how individuals learn to read it; previous research has shown that learning to read phonologically is easier in languages with a transparent letter-sound mappings in their orthography (Ziegler, Fidelman, Reutlinger, Vialle, & Stoeger, 2010). Any conclusions drawn from this review therefore apply specifically to learning to read English language only.

1.4.6 Conclusions

Studies spanning the previous 43 years of research show that when children and young people are taught beginning reading skills using phonics-based methods, they can show an improvement in measures of these skills. It is important to be aware that many different measures of differing phonics and reading skills have been used in this research, but the overall message appears to be that these individuals may benefit from phonics-based teaching. Research with typically developing children indicates that phonics can be used to teach beginning reading skills before other word recognition strategies are taught alongside fluency and comprehension. Young people educated in special school settings may take longer to learn these phonics skills, and need support to generalise them, but reading phonetically has the advantage of allowing the decoding of unfamiliar words as compared to learning to read a finite vocabulary of sight words (Grindle, Hughes, Saville, Huxley, & Hastings, 2013).

Chapter 2: The Effectiveness of Headsprout, a Phonics-Based Reading Intervention, at Improving Reading in Pupils Educated in a Special School Setting

2.1 Introduction

2.1.1 Learning to Read

Reading is the process through which individuals decode written words, and actively make sense of text meaning (Woolley, 2010). The National Reading Panel (2000) proposed five component skills of reading: an understanding that written words represent spoken words; recognising that words are made up of separate sounds (phonemic awareness); linking spoken sounds (phonemes) to letters (graphemes) which can be blended together to form words (phonics skills); reading fluently; and understanding what is being read (text comprehension).

Reading is underpinned by an understanding of how sounds in spoken language, phonemes, map onto written letters, graphemes (Byrne, 1998). This ability to form and recall associations between graphemes and phonemes rests on long-term memory mechanisms (Hulme, Goetz, Gooch, Adams, & Snowling, 2007). In a recent literature review, Hulme and Snowling (2013) concluded that reading is based on the three cognitive foundations of letter-sound knowledge, phonemic awareness or the ability to manipulate the individual sounds in words, and Rapid Automatized Naming (RAN) skills. RAN skills are measured by asking children to name as quickly as they can previously learned stimuli such as colours, letters, or numbers. RAN skills are uniquely predictive of learning to read (Lervåg & Hulme, 2009); Hulme and Snowling (2013) suggested that they tap into the cognitive mechanisms that allow information to be retrieved quickly from long-term memory, and are therefore pivotal skills in learning to read.

2.1.2 Teaching Reading to Typically Developing Children

Beginning readers decode individual words, recalling phonemes from graphemes, and blending the phonemes together into words. Pedagogy in the UK regarding reading instruction has adapted to reflect this, with school curriculum emphasising teaching early reading skills through a phonics-based approach (Rose, 2006). Synthetic phonics explicitly teaches phonemic awareness, how to hear and manipulate the individual phonemes in language; grapheme-

phoneme correspondences; and the skills of decoding written words by blending sounds together to read whole words (Finnegan, 2012).

However, researchers and teachers should be aware that there are a range of strategies used to decode unfamiliar words. In addition to phonics, individuals can read unknown words through analogising, using knowledge about similar known words, and prediction, using understanding of context (Ehri, 2005). The teaching of reading should help students to use their full range of word reading skills, even while being underpinned by phonics. Furthermore, children in the beginning stages of learning to read utilise different processes to skilled readers. Developing readers individually decode words, but as reading becomes increasingly skilled, words can be decoded automatically meaning that reading is fluent and a phonics-based approach is relied on less (Macaruso et al., 2006).

It is common that some children will find learning to read difficult (Chapman & Tunmer, 2003). The National Literacy Trust (2015) estimated that 16% of adults are functionally illiterate, and difficulty with reading can mean that individuals struggle to function in daily life (Sitlington, 2008). In the UK, Rose (2009) wrote that when children experience difficulties learning to read, schools should implement high quality, personalised interventions to support their learning. Many reading interventions can result in high ratio gains, the gain in reading age over a given time period, meaning that pupils can make accelerated progress (Brooks, 2016). An alternative position to focusing on individualised interventions to ameliorate difficulties is to instead focus on the learning environment and provide high quality teaching for all to prevent difficulties occurring (Higgins, Fitzgerald, & Howard, 2015). However, given the complexity of learning to read, and that some children do find this difficult, providing tailored interventions is an effective way to support learning.

2.1.3 Teaching Reading to Children who Experience Learning Difficulties

The Diagnostic and Statistical Manual of Mental Disorders – 5th edition uses the term intellectual disability to refer to individuals who experience significant difficulties in understanding complex information, applying new skills, and in practical self-management (American Psychiatric Association [APA], 2013). In the UK, the terms mild, moderate, and severe learning difficulties have often been used to refer to individuals who experience significant cognitive impairments and difficulties in learning (Lawson, Layton, Goldbart, Lacey, & Miller, 2012). An analysis of Special Educational Needs (SEN) in England reported that although the majority of students who experience learning difficulties are enrolled in special schools which

focus on providing individualised education (Coyne et al., 2004), many of these students are educated in mainstream schools (Department for Education, 2016).

Despite this aim of special schools, reading has been de-emphasised for students who experience learning difficulties (Browder, Gibbs, et al., 2009). Historically, it has been assumed that reading is linked to Intelligence Quotient (IQ), and that expressive language and communication skills are necessary before the teaching of reading can begin (Browder, Gibbs, et al., 2009). The teaching of reading with this population in special schools has also often emphasised pre-requisite literacy skills, such as picture matching, and focused on teaching these skills before reading (Lawson et al., 2012). When literacy teaching has occurred it has often focused on recognition of key words using a sight word approach in which individuals are taught to recognise each word as a single unit as opposed to decoding words phonetically (Porter, 2005).

Traditionally, typically and atypically developing children have been considered using a comparison approach within developmental psychology; where individuals are viewed as two categorically separate groups (Graham & Madigan, 2016). An alternative view emphasises a dimensional approach which aims to study the full spectrum of variation ranging from typical to atypical (Graham & Madigan, 2016). The dimensional approach would suggest that as phonics has been found to be an effective method of teaching early reading for typically developing children (e.g., Rose, 2006), this could also be used with those pupils who experience learning difficulties and are educated in special school settings. Phonics is not the method through which all children learn to read (Gough, 1996), but because research has demonstrated its effectiveness this is generally the first method used to teach reading in schools (Rose, 2006). Interventions are then individualised for children who struggle to make progress in reading despite access to high-quality teaching. For example this may include some teaching of sight words for children who struggle to learn through phonics. All children and young people, regardless of where they are educated, should have access to the same opportunities, and so students in special school settings should have access to phonics-based methods of learning to read the same way that typically developing students do. However students in special schools are often taught using a sight word approach or instruction has focused on the development of so-called pre-requisite skills. There has been comparatively little research into phonics-based teaching with students educated in special schools. In a review of 128 studies, Browder et al. (2006) found only 13 which examined phonics instruction with this population. Ensuring practice is underpinned by evidence is an important principle to Educational Psychologists (EPs; Dunsmuir, Brown, Iyadurai, & Monsen, 2009), and, therefore, teaching recommendations should be evidence-based. Accordingly, research is needed to understand whether phonics is an effective method for the teaching of beginning reading skills to students who are educated in special school settings.

Not only is additional research on phonics with this population needed, but research also needs to consider novel teaching approaches which may engage learners. Macaruso et al. (2006) suggested that computer-assisted interventions are well-placed to deliver additional reading instruction as they can provide teaching material matched to students' current levels in a highly motivating manner. A further advantage of computerised interventions is that they do not require school staff to make resources or spend time delivering sessions; teachers can struggle to accurately implement educational interventions (Witt, Noell, LaFleur, & Mortenson, 1997), and treatment integrity has often been overlooked and assumed to be satisfactory in educational research (Lane, Bocian, MacMillan, & Gresham, 2004).

2.1.4 Headsprout Early Reading

Headsprout Early Reading is a computerised intervention aimed at teaching reading phonetically. The programme consists of 80 episodes, each designed to be completed in 20 minute sessions (Learning A-Z, 2016). Headsprout was designed to teach the five skills described by The National Reading Panel (2000) as precursors to becoming a proficient reader: phonemic awareness, phonics, vocabulary, fluency, and comprehension. Headsprout focuses its instruction on phonemic awareness, grapheme-phoneme correspondence, and how to blend sounds to decode words phonetically, but also incorporates elements of vocabulary, fluency and comprehension (Layng, Twyman, & Stikeleather, 2004b). The programme is based on discovery learning principles, using a mixture of direct instruction and engineered discovery, as this has been shown to lead to faster acquisition of phonics knowledge (Layng, Twyman, & Stikeleather, 2004a). The programme also automatically tracks the learner's performance and adjusts instruction to the appropriate level (Twyman, Layng, & Layng, 2012). See Appendix F for details of each Headsprout episode.

Headsprout requires children to practice reading skills until they have reached mastery criteria, demonstrating they can apply skills quickly and accurately (Layng et al., 2004b). The learning hierarchy proposed by Haring and Eaton (1978) stated that learned skills move through four stages: acquisition, fluency, generalisation, and adaptation. By emphasising mastery learning, Headsprout helps ensure learners are able to apply phonic skills fluently before introducing new skills. The working memory model proposed by Baddeley (1992) described the finite mental resources individuals have to hold in mind and manipulate information. Being able to recall and blend sounds with reduced mental effort, when the skills have been learned to mastery level, results in greater cognitive resources available for comprehension of the text and fluent reading.

Headsprout was designed as an individualised reading intervention to provide additional support for typically developing pupils. Studies investigating Headsprout in mainstream schools have found significant gains in oral language and early reading skills with pre-school children (Huffstetter, King, Onwuegbuzie, Schneider, & Powell-Smith, 2010); increases in reading accuracy and word recognition skills in Year 2 pupils (Tyler, Hughes, Beverley, & Hastings, 2015); and improvements in reading skills for students in kindergarten and the first grade (Twyman, Layng, & Layng, 2011).

2.1.4.1 Research evaluating the use of Headsprout with children who experience neurodevelopmental and/or learning difficulties.

Over the past 6 years, a small but growing body of research has been conducted to investigate the effectiveness of the intervention Headsprout to develop reading skills in children with Autism Spectrum Disorder (ASD), a neurodevelopmental condition which is often (although not always) associated with difficulties in learning. Headsprout has been shown to improve the word recognition skills of a 9 year old pupil in a private school for students with developmental disabilities (Whitcomb, Bass, & Luiselli, 2011), and four students with ASD attending an ASD unit attached to a mainstream school (Grindle et al., 2013).

A further pilot study implemented Headsprout in a Welsh special school, recruiting participants who experience learning difficulties and developmental disabilities. Tyler, Hughes, Wilson, et al. (2015) tracked six participants with mild or moderate learning difficulties as they completed all 80 Headsprout episodes over 13 to 21 months. The results demonstrated that the pupils were able to access Headsprout and made progress in reading skills.

Thus, a small number of studies suggests that though Headsprout was designed with typically developing children, it can be used to support the development of reading skills for students with ASD, and for children in special education schools.

2.1.4.2 Adaptations to Headsprout.

Given that Headsprout was developed with typically developing children (Layng et al., 2004b), adaptations to the programme may enhance its accessibility and acceptability for a wider population of learners. Researchers have described the additional support they have put in place to help students with additional needs access Headsprout. Plavnick et al. (2014) reported that students demonstrated poor engagement with Headsprout in the baseline phase of the study, but that the implementation of a behavioural intervention was used to promote the independent use of the programme. Furthermore, discrete trial teaching techniques were used to support students if they struggled with particular tasks in the study reported by Grindle et al. (2013).

While these approaches have focused on providing additional support to help students access Headsprout, no published reports to date have described any modifications to the intervention itself which may work to increase its accessibility. Two Headsprout tasks in particular, negation and speaking out loud, may be good targets for this purpose.

2.1.4.2.1 Negation.

In a review of working memory studies among individuals who experience learning difficulties, Lifshitz, Kilberg, and Vakil (2016) found that individuals exhibit difficulties in attention-demanding tasks involving manipulations. Tasks of greater complexity are harder for these individuals to access. Headsprout includes negation tasks whereby learners hear a phoneme or word, and are presented with a grapheme or word and an arrow on screen. Individuals are instructed to click on the grapheme or word if it matches the spoken phoneme or click on the arrow if it does not. This activity places a heavy cognitive demand on working memory as it requires learners to hold in mind the aural input whilst comparing it to the written information. Learners are required to make a decision about whether the two match by recalling information from long-term memory, and then take appropriate action.

Initial evidence that the negation tasks may be difficult for students who are educated in special school settings to access comes from a pilot study by Tyler, Hughes, Wilson, et al. (2015). The authors reported that negation activities were especially difficult to access for one of the six participants. Given the high cognitive load demanded by the negation task, it is possible that the intervention may be made more accessible for these students if these activities were removed, whilst not impacting on overall phonics skill acquisition.

2.1.4.2.2 Pupils who are non-verbal.

Research investigating whether Headsprout is an appropriate intervention for pupils with ASD has recruited participants from private schools or from special education classes attached to mainstream schools but has not yet sought to include non-verbal young people. A quarter of individuals with autism are non-verbal (Autism Speaks, 2012) and many can learn to read in the absence of spoken language (Fleischmann & Fleischmann, 2012; Goh et al., 2013). In the Headsprout intervention, only two activities ask the learner to speak out loud; in one they are asked to say the letter sounds as they click on a letter, and in another they are asked to gradually blend several letter sounds together to read a word (Layng et al., 2004b). A further unanswered question is whether Headsprout is a suitable and effective reading intervention for pupils who are non-verbal if they do not complete the speaking activities.

2.1.5 Aims of this Research

The primary aim of this study was to investigate the effectiveness of the reading intervention Headsprout on reading skills in children and young people who were educated in a special school. The secondary aim was to investigate whether adaptations to its implementation impact on effectiveness with this group; specifically whether removal of negation activities impact the outcomes for learners, and whether it is an appropriate intervention for learners who are non-verbal. No previous research has investigated making adaptations to Headsprout itself, as opposed to putting in place additional support to access the programme. A further unique element of this research is that it aimed to track pupils over a fixed period of time as they progressed through Headsprout. Other studies have taken outcome measures after participants have completed all 80 Headsprout episodes, even though this has taken different amounts of time for different individuals (Grindle et al., 2013; Tyler, Hughes, Wilson, et al., 2015).

The research questions are as follows:

1. Does using the phonics-based Headsprout intervention lead to gains in phonics skills for pupils who are educated in a special school?

2. Does using the phonics-based Headsprout intervention lead to generalised improvements in word recognition for pupils who are educated in a special school?

3. Does Headsprout lead to gains in phonics skills and word recognition for pupils who are educated in a special school when the intervention is adapted and negation activities are not used?

4. Does Headsprout lead to gains in word recognition for non-verbal pupils who are educated in a special school when the intervention is adapted and speaking activities are not used?

5. Are gains in phonics skills and word recognition maintained over time after participants have ceased using Headsprout?

It was hypothesised that the Headsprout intervention would lead to improvements in phonics skills which would generalise to improvements in word recognition, and this would be shown for participants accessing the complete intervention and those not completing negation activities. It was also hypothesised that non-verbal participants would show improvements in word recognition ability, and that improvements for all participants would be maintained at follow-up.

2.1.6 Underlying Ontology

As in the previous chapter, this research has been underpinned by a critical realist ontology; I have assumed that an independent reality exists but recognise that any attempts at explaining the word are fallible (Scott, 2005). In the context of this study, I have assumed that reading skills exist in reality and that they can be measured by the tools I have chosen. However, as informed by my ontological perspective, I also think that what is captured by such measures requires interpretation.

2.2 Method

2.2.1 Participants

Participants were eight students, aged between 7 and 19, who attended a special school in the South-West of England for pupils with Severe and Profound and Multiple Learning Difficulties. Table 1 reports the mean ages for pupils in the different conditions, and Table 2 displays the characteristics for each participant (pseudonyms were used to protect the confidentiality of the participants outside of their education setting). All participants had been identified as having learning difficulties, specifically Severe Learning Difficulties (SLD), and received special education services; six students also had a diagnosis of ASD.

Participants' IQs were not measured in this study because research has demonstrated that it is not predictive of the development of reading skills. In a meta-analysis, Stuebing, Barth, Molfese, Weiss, and Fletcher (2009) concluded that the evidence did not support the hypothesis that IQ is an important predictor of response of reading intervention. Instead, Hulme and Snowling (2013) proposed that the three cognitive foundations of learning to read are letter-sound knowledge, phonemic awareness, and RAN skills. These skills were therefore assessed at the onset of the intervention.

To characterise the sample, teacher assessments of literacy skills were obtained for participants, as well as measures of communication using the Child Communication Checklist – Short version 4 (CCC-S-IV) for verbal participants (Bishop & Norbury, 2009). Table 3 describes participants' communication skills at the beginning of the study for verbal participants. Higher scores on the CCC-S-IV indicate greater difficulty.

Students were selected for inclusion in the study using the following eligibility criteria. Participants were included in the study if they: (1) had been identified has having with SLD meaning they were educated in a special education setting; (2) were able to work at a computer

for up to 20 minutes without engaging in challenging behaviour; (3) were able to follow a two-step instruction such as turn around and clap your hands; (4) were able to respond to feedback such as praise or correction; and (5) were able to match non-identical pictures. Participants were excluded from the study if they (1) had visual or hearing impairments, meaning they would not be able to access the programme Headsprout; (2) were taking psychostimulant medication; (3) had previously used Headsprout; or (4) were currently participating in other reading interventions in addition to day-to-day classroom literacy activities. These criteria were chosen because they reflected the skills needed to access the computerised Headsprout reading intervention. In addition to the above criteria, for students in the non-verbal condition, teachers were asked to select students who did not use any spoken words or phrases in their communication. For verbal students, teachers were asked to select students who were capable of self-initiated speech in the minimum form of phrases of two or three words.

The two non-verbal participants were assigned to the condition that did not require them to complete the speaking activities in Headsprout. Of the six verbal participants, three were assigned to the Headsprout-as-usual condition and three were assigned to the no-negation condition on the basis of their scores in the Dynamic Indicators of Basic Early Literacy Skills – 6th edition (DIBELS-VI) sub-tests measuring initial sounds, phonemic segmentation, and non-word reading (Good & Kaminski, 2002). Scores in these sub-tests were summed and the three highest scoring participants were assigned to the Headsprout-as-usual condition, and the three lowest scoring participants were assigned to the no-negation condition. This decision was made because the negation tasks place a heavy cognitive demand on working memory. Therefore those individuals with stronger existing skills were placed in the Headsprout-as-usual condition as it was felt they would be better able to process the negation tasks. However, in the second week of the intervention, a participant in the no-negation condition was accidentally allowed to complete a negation activity and subsequently strongly indicated that he wanted to complete this part of the intervention too. His decision was respected and in order to not cause distress by insisting he stay in the assigned study condition he was moved to the Headsprout-as-usual condition so he could complete all parts of the programme. This resulted in two participants in the no-negation condition and four participants in the Headsprout-as-usual condition.

Table 1

Means and Standard Deviations of Participants' Ages by Condition

	Headsprout as usual			No Negation			Non-Verbal		
	M	*(SD)*	Range	*M*	*(SD)*	Range	*M*	*(SD)*	Range
Age (years)	12.83	4.63	8 - 17	11.92	1.65	10 - 13	13.33	8.13	7 - 19

Note. M = mean; *SD* = standard deviation.

Table 2

Participants' Characteristics

Participant	Age Years: Months	Gender	Ethnicity	Headsprout Condition	Statement of SEN from school records	Reading Level[a]
Chris	17:00	M	Caucasian	H as usual	Receptive and expressive language Attention SLD	1
Ben	16:08	M	Caucasian	H as usual	ASD SLD	P8
Chloe	9:03	F	Caucasian	H as usual	Hydrocephalus SLD	P8
Harry	8:05	M	Caucasian	H as usual	ASD SLD	P8
Liam	13:01	M	Caucasian	No Negation	ASD SLD	P8
Tyler	10:09	M	Caucasian	No Negation	ASD SLD	P8
Martin	19:01	M	Caucasian	Non-Verbal	ASD SLD	P7
Richard	7:07	M	Caucasian	Non-Verbal	ASD SLD	P7

Note. H = SEN = special education needs; Headsprout Early Reading Intervention; SLD = severe learning difficulty; ASD = Autistic Spectrum Disorder.
[a]Taken from teacher assessment of the National Curriculum as part of school records.

Table 3

Means and Standard Deviations of Participants'' Baseline Communication Skills

Communication Skills	Headsprout-As-Usual		No-Negation	
	M	*(SD)*	*M*	*(SD)*
Parent reported	31.00	10.10	29.50	6.36
Teacher reported	20.75	10.75	36.00	1.41

Note. M = mean; *SD* = standard deviation. Communication skills were measured for verbal participants using the Children's Communication Checklist – Short version 4(CCC-S-IV). Non-verbal participants were not included in this measure.

2.2.2 Design

This study used a single-subject research design which involved each participant acting as their own control and taking repeated measurements across time (Cohen, Manion, & Morrisson, 2000). Learning difficulties have been described as falling along a continuum, and it can be difficult to assign to precise categories (Swanson, Harris, & Graham, 2013). It was therefore deemed problematic in the context of this research to use an experimental group based design as this would require a matched control group which would be difficult to ensure with accuracy, and necessitate a reversion to IQ measurement to match the groups. Instead, the methodology of this study was influenced by Horner et al. (2005), who argued that single-subject research is well-suited to special education because it allows practical interventions to be applied in real-world settings and provides an appropriate method for research with heterogeneous populations.

Single-case experimental design aims to establish a functional relationship between independent and dependent variables through repeatedly measuring the dependent variable across time, including obtaining multiple baseline measurements to observe any trend in the data (Smith, 2013). A limitation of this research is that only one baseline measurement was taken, rather than the multiple measurements often used in single-subject research. This means that it was not possible to observe a stable baseline or observe any trends in baseline data before the intervention was introduced. The reason taken for only obtaining a single baseline measure is that it was felt to be ethically problematic to delay students accessing the intervention in order to take further measurements.

2.2.3 Measures

2.2.3.1 Dynamic Indicators of Basic Early Literacy Skills.

Four sub-tests of the DIBELS–VI were used to assess the phonics development of the six verbal participants, each taking between 2 and 3 minutes to administer. The DIBELS-VI has concurrent validity with other measures of phonological processing (Hintze, Ryan, & Stoner, 2003), and has been used successfully in research investigating the effectiveness of Headsprout with students with SEN (Clarfield & Stoner, 2005; Grindle et al., 2013; Tyler, Hughes, Wilson, et al., 2015). As the DIBELS-VI was not standardised for use with this population, raw scores were analysed rather than standardised scores.

The Initial Sound Fluency (ISF) sub-test was used to measure participants' ability to recognise initial sounds in orally presented words. Participants were presented with four pictures and asked either to point to the picture beginning with a given sound or to orally produce the beginning sound of a given word. The number of correct sounds per minute was calculated by multiplying the number of initial sounds they correctly identified by 60, and dividing this figure by the time taken to complete the assessment. The ISF sub-test had a test-retest reliability of .91 (University of Oregon Center on Teaching and Learning, 2017b). The calculated Cronbach's α using baseline data was .82.

The Phonemic Segmentation Fluency (PSF) sub-test was used to measure participants' ability to segment spoken words of three or four phonemes into their individual phonemes. Over 1 minute, participants were orally presented with words and asked to produce the individual phonemes. This sub-test had a test-retest reliability of .79 (Good et al., 2004).

Letter-sound knowledge and the ability to read words by blending sounds together was measured through the Non-Word Fluency (NWF) sub-test. Participants were presented with an A4 sheet of paper with vowel-consonant and consonant-vowel-consonant non-words, and asked to read the words over the duration of 1 minute. This sub-test had a test-retest reliability of .83 (Good et al., 2004). The ISF, PSF, and NWF sub-tests were used to assess how participants' phonics skills changed as they accessed the intervention.

The Word Use Fluency (WUF) sub-test was used as a measure of expressive vocabulary to monitor whether changes in reading skills would generalise to verbal communication. Over 1 minute participants were orally presented with a word and asked to use it verbally in a sentence. This sub-test had a test-retest reliability of between .71 (University of Oregon Center on Teaching and Learning, 2017a). Cronbach's α could not be calculated for the PSF, NWF, and WUF sub-tests because of the number of items in which participants scored 0 or did not complete.

2.2.3.2 Word Recognition and Phonic Skills test.

The Word Recognition and Phonic Skills (WRAPS) test is a non-verbal measure of word recognition (Carver & Moseley, 1994), and this was selected to investigate whether improvements in phonics skills could generalise to word recognition ability. Participants were shown an array of five words, and heard a word spoken aloud and used in a sentence; they were asked to match a written word to the spoken word. This measure has been used in previous research investigating Headsprout (e.g., Grindle et al., 2013), and as it is a non-verbal measure it was used with all eight participants. It has an internal consistency reliability of .98 (Moseley, 2004). The calculated Cronbach's α using baseline data was .72.

2.2.3.3 Letter knowledge.

To assess participants' pre-existing letter-knowledge, verbal pupils were presented with 26 lowercase letters and asked to identify the letter name and sound. Non-verbal pupils were shown three letter cards and asked to select the card that matched the given sound or letter name. This method was chosen because it has been used in similar research to assess pupils' letter knowledge (e.g., Lervåg & Hulme, 2009). The adaptation for non-verbal pupils is potentially confounding, in that there is the possibility of selecting the correct answer by chance. However, it was decided that it was preferable to have some indication of existing letter-knowledge despite the potential confound by test structure.

2.2.3.4 Colour Rapid Automatized Naming task.

RAN tasks involve individuals naming a list of familiar known items as quickly as they can, such as pictures or colours, and have been shown to be predictive of later reading skills (Hulme & Snowling, 2013). The six verbal participants were first asked to label five colours to assess whether they could identify them. If they could, participants then completed the colour RAN test devised by Denckla and Rudel (1976) in which they were presented with 50 coloured squares in five rows each consisting of 10 colours, and the time taken to complete the task was recorded. This method was chosen because it has been used in contemporary research into reading skills to assess recall speed (Lervåg & Hulme, 2009).

2.2.3.5 Children's Communication Checklist – Short.

The CCC-S-IV is a brief screening instrument designed to help identify children with speech, language, and communication needs (Bishop & Norbury, 2009). The CCC-S-IV contains 13 items in which respondents rate the frequency of communicative behaviours on a 4 point scale: 0 rarely or never (less than once a week), 1 occasionally (once a week), 2 regularly (once or twice a day), and

3 frequently or always (several times a day). The CCC-S-IV has been shown to have a high degree of internal consistency (Cronbach's α = .95) and is significantly correlated with the Children's Communication Checklist – 2nd edition (Bishop, 2003) whilst being easier for participants to complete (Norbury et al., 2016). Internal consistency for the current study was .93.

2.2.4 Intervention

2.2.4.1 Headsprout intervention.

Participants accessed Headsprout from a computer or laptop in a quiet room situated within their classroom. The initial episode of Headsprout is titled Mousing Around which introduces the learner to the activities within the programme and basic mouse skills. Participants were required to successfully complete this initial episode before beginning the intervention. School staff began each session by logging on to the website, loading the correct episode, and ensuring the computer/laptop speakers and mouse were working to enable the student to complete the episode. Participants were required to reach the criteria of 90% correct responses over the entire episode before moving onto the next episode.

2.2.4.2 Adaptations to Headsprout for all participants.

All participants completed episodes with one-to-one support from a member of staff to prompt responses and provide support when needed. As Headsprout provided feedback to learners, if they did not achieve the 90% criteria on the first time they completed an episode, they repeated each episode three times to see if the provided instruction was sufficient to overcome the experienced difficulties. If after repeating the episode the student continued to experience difficulties, the supporting adult provided prompts to guide the student through the difficulties they were experiencing. The participant would then complete the episode again with a reduction in prompts until the criteria that each participant should complete episodes with 90% accuracy and independently before moving on to the subsequent episode was met.

Additionally, if a student had still not reached this mastery criteria after the support described above, then additional table-top teaching was employed to teach the pupil the skills needed. In this case, the particular activity that the student was having difficulty completing was identified and broken down into smaller steps which could be taught at the table using visual stimuli, such as word cards, before the participant was re-introduced to the Headsprout episode. Table 5 in the results section provides information about the times when this was needed for some of the participants. During the study all participants took place in teaching as usual which involved listening to and exploring stories.

2.2.4.3 No-negation condition.

The negation activities within Headsprout episodes involved a phoneme or word and an arrow being visually displayed on screen, and a grapheme or word presented orally. Learners heard the instruction that if the two matched, they were to click on the grapheme word, and if the two did not match they were to click on the arrow. Participants in the no-negation condition did not complete these activities. Instead, the supporting adult would say "you don't need to do this, I will do it" and completed the activity as quickly as possible.

2.2.4.4 Non-verbal condition.

Headsprout episodes also contained speak out loud activities. During these a picture of a speaking face would appear on the screen and the learner would be asked to say a word or sound as they clicked on it. For participants who were non-vocal, the adult supporting the participant produced the required oral response as the participant used the mouse to respond as directed. Adults also provided additional opportunities to model blending of sounds throughout the episode. For example, if the participant clicked on the word see, the adult would model blending by saying '/s/ /ee/ /see/. Well done, you clicked on see.'

2.2.5 Procedure

Ethical approval was obtained from the University of Southampton Research and Ethics Committee on 22nd December 2015, number 18538 (Appendix G). Following ethical approval, agreement was sought from the head teacher and Special Educational Needs Co-ordinator to conduct the research in their school. Teachers were provided with details of the inclusion and exclusion criteria to identify pupils, and sent out information letters and opt-in consent forms to the parents of the eight identified pupils, all of whom gave consent. Once parental consent was obtained, the researcher met with each student to talk to them about the study and gave them the option of taking part or withdrawing without consequence. This study involved working with pupils educated in a special school who are a vulnerable population, and so it was important to carefully consider how to provide pupil information to ensure that pupils' gave informed consent and understood their right to withdraw. The pupil information sheet and consent form were read to participants individually in a quiet setting, giving information in small chunks and checking their understanding before moving onto the next section. Letters to participants and parents can be seen in Appendix H. Each time I worked with participants, either to observe them using Headsprout or to complete assessment measures, I reminded them of their right to withdraw and gained their consent to work with them again. When working with vulnerable populations it is important to acknowledge this fact, and that research is underpinned by the principle of respect

to ensure that investigation is done with participants in a way that feels empowering, rather than done to them (Coons & Watson, 2013).

Class teachers received training in Headsprout (described in section 2.2.5.2). The number of weeks participants accessed the intervention varied. All participants apart from Tyler and Richard, used Headsprout over 21 weeks. Due to participant illness, Tyler had his baseline measurements recorded 2 weeks after the other participants, and took part in the intervention over 19 weeks. Richard was delayed starting the intervention due to another pupil joining his class, and used Headsprout for 14 weeks.

2.2.5.1 Baseline measures.

Baseline measurements were conducted in February 2016, 1 to 2 weeks before the intervention began. Both the word recognition and letter-knowledge assessments were conducted with all eight participants. The four DIBELS-VI sub-tests and colour RAN test were conducted with the six verbal participants. The CCC-S-IV was completed by verbal pupils' class teachers and parents and returned prior to starting the intervention.

2.2.5.2 The intervention.

School staff working in the participants' classrooms were trained in how to use Headsprout, the adaptations for all participants, and the adaptations for the no-negation and non-verbal conditions. The researcher prepared folders for each pupil which contained sheets to record details of each session as well as when and how to put in place additional teaching activities as required. Scripts were provided for modified activities. Staff were instructed that the intervention should take place twice a week.

2.2.5.3 Time 1 measures.

In March 2016 after 4 weeks of using the intervention, Chris, Ben, Chloe, Harry, and Liam completed follow-up measures of the WRAPS and DIBELS-VI sub-tests. Martin also completed the WRAPS assessment. Data could not be obtained for Tyler, due to participant illness, and Martin, because he had not yet begun the intervention.

2.2.5.4 Time 2 and 3 measures.

In July 2016 (Time 2) all participants completed the WRAPS test and the six verbal participants completed the four DIBELS-VI sub-tests. These measures were taken again at Time 3, in September 2016, after the participants had not used Headsprout for 7 to 8 weeks due to a break for the school holidays. All of the assessments were conducted within the quiet rooms

within the participants' classrooms with the exception of Martin at Time 3. At this point Martin had left the school so, with parental consent, assessments were conducted in his home. After measurements were taken at Time 3 debrief letters were sent to parents, and read to and given to participants.

2.2.5.5 Inter observer agreement and treatment fidelity.

All outcome measures were completed by the researcher who was not blind to participant condition. To ensure the accuracy of the assessments, 25.74% of the measures were carried out by two individuals, the researcher and member of school staff who was familiar with the materials, so Inter Observer Agreement (IOA) could be calculated. All IOA met minimum standards of 80% (Horner et al., 2005). Over the course of the intervention, the researcher observed 8.61% of sessions to monitor treatment fidelity. See Appendix I for a copy of the treatment fidelity checklist.

2.2.6 Analysis

Given the single-subject design the Reliable Change Index (RCI) was used to compare data between time points. The RCI, created by Jacobson and Truax (1991), reports whether the difference in scores is reliable when the reliability of the measure used is taken into account. The RCI allows each individual's scores on a given measure to be tracked over time, and indicates if a change in score is due to the unreliability of the measure or large enough to indicate reliable, and therefore meaningful, change (Zahra & Hedge, 2010). Because it allows analysis at the level of the individual, it is suited to single-subject research.

The reliability of the measure itself is required to calculate RCI (Jacobson & Truax, 1991). Zahra and Hedge (2010) recommended using the test-retest reliability statistic in the RCI equation. The DIBELS-VI ISF, PSF, NWF, and WUF sub-tests have published test-retest reliability statistics of 0.91, 0.79, 0.83, and 0.71 respectively. However the test-retest reliability statistic for the WRAPS test is not available. Cronbach's α is another measure of a test's internal reliability (Field, 2013); this is known for the WRAPS test, 0.98, and therefore this measure of reliability was used for the WRAPS test RCI calculation. Raw scores were used to track participants' progress over time and calculate the RCI as these assessment measures were standardised with typically developing children.

2.3 Results

2.3.1 Baseline Reading Skills

Prior to initiating the intervention, all participants were assessed on their letter-knowledge, and verbal participants completed a colour RAN task, as shown in Table 4.

Table 4

Participants' Letter Knowledge and Colour RAN Scores

Participants	Letter Knowledge	Colour RAN time (sec)
Chris	39	55
Ben	12	41
Chloe	26	119
Harry	18	60
Liam	49	44
Tyler	0	80
Martin	17	-[a]
Richard	47	-[a]

Note. RAN = Rapid Automatized Naming.
[a] = Martin and Richard did not complete the colour RAN task because this was a measure requiring verbal responses.

2.3.2 Intensity of Intervention

All participants apart from Tyler and Richard accessed the intervention over 21 weeks. Excluding 3 weeks for holidays, there were 18 weeks when the participants should have had two sessions per week, meaning that they should have received 36 sessions in total. Due to illness Tyler completed baseline measures 2 weeks later than the other participants so he had 19 weeks using Headsprout; excluding 3 weeks for holidays there were 16 weeks when he could have received two sessions per week, comprising of 32 sessions in total. Richard received the intervention over 14 weeks, subtracting 1 week for half-term, he would have used Headsprout for 13 weeks. At two sessions per week, Richard should have completed 26 Headsprout sessions. Table 5 reports the number of sessions actually participated in by each participant. Only Harry exceeded the target number of sessions, and while Liam approached this figure, the remaining participants did not take part in intervention sessions as often as planned.

Table 5 displays information on accuracy and total time spent on Headsprout episodes, as well as the number of sessions in which participants engaged in table top-teaching alongside accessing the computerised intervention. As described in the Intervention section of the Method, if participants experienced difficulties with an online episode after first completing the episode three times independently and then completing it with adult prompts, they would receive table-top teaching to focus on the specific skills alongside time on Headsprout episodes. Throughout the intervention staff kept written records of how they supported students, but as the eight participants were in five different classes working with a range of teachers and support staff, the exact nature of this individualised support as they accessed Headsprout would have varied. This lack of control over the exact nature of adult support provided to participants is a potential confounding variable. However the single-subject research design, in which individuals are compared only to themselves and not against each other, helps to manage this potential variation in adult support.

With regard to the table-top teaching, Chris required no additional table-top teaching. Additional teaching using flashcards was used for Ben to learn the grapheme-phoneme correspondences in episodes 1 and 2, and for Chloe to learn the grapheme-phoneme correspondences in episodes 4 and 5. Harry used flashcards of words for episodes 17, 18, 19, and 22 to help him blend the sounds into words. Neither participant in the no-negation condition required additional table top teaching to progress through the episodes. Martin struggled to access the Headsprout intervention, and had table-top teaching using flashcards for the sounds introduced in episodes 1 and 2. The effect of teaching through Headsprout was diluted for some participants through receiving table-top teaching alongside time on Headsprout for some sessions.

Table 5

Details of Intervention Sessions Completed by Each Participant

Condition	Participant	Number of sessions received	Number of expected sessions	Number of sessions using table top teaching	Average number of sessions per week during school term	Average % accuracy in episodes	Total time engaged in episodes (hrs : mins)	Final episode reached
Headsprout-As-Usual	Chris	27	36	0	1.50	95.33	3:41	15
	Ben	28	36	6	1.56	86.14	3:41	3
	Chloe	22	36	4	1.22	90.43	4:22	5
	Harry	38	36	4	2.11	95.77	6:38	24
No-Negation	Liam	34	36	0	1.89	85.84	5:00	9
	Tyler	20	32	0	1.25	94.82	2:52	8
Non-Verbal	Martin	23	36	12	1.28	87.18	2:41	2
	Richard	17	26	0	1.31	77.00	1:36	5

Table 6 shows raw scores of phonics, expressive language, and word recognition skills taken at baseline, Time 1, Time 2, and Time 3 for all participants.

Table 6

Raw Scores on Phonics, Word Recognition, and Language Skills at Baseline, Time 1, 2, and 3

Condition	Participant	Measure	Baseline	Time 1	Time 2	Time 3
Headsprout-As-Usual	Chris	DIBELS-VI ISF	20.00	37.08	33.03	53.88
		DIBELS-VI PSF	22	28	37	42
		DIBELS-VI NWF	5	6	14	15
		DIBELS WUF	16	0	24	16
		WRAPS	20	18	28	24
	Ben	DIBELS-VI ISF	0.00	0.00	21.23	25.59
		DIBELS-VI PSF	0	1	0	2
		DIBELS-VI NWF	11	35	22	11
		DIBELS-VI WUF	0	0	0	0
		WRAPS	10	11	15	12
	Chloe	DIBELS-VI ISF	18.00	33.38	47.54	43.80
		DIBELS-VI PSF	11	0	6	20
		DIBELS-VI NWF	9	12	19	14
		DIBELS-VI WUF	0	0	6	0
		WRAPS	18	15	24	19
	Harry	DIBELS-VI ISF	3.48	13.50	11.22	4.00
		DIBELS-VI PSF	0	0	0	0
		DIBELS-VI NWF	1	13	16	9
		DIBELS-VI WUF	0	0	0	0
		WRAPS	18	14	19	12
No-Negation	Liam	DIBELS-VI ISF	5.70	14.08	18.08	13.77
		DIBELS-VI PSF	0	0	8	0
		DIBELS-VI NWF	0	8	25	16
		DIBELS-VI WUF	0	0	0	0
		WRAPS	12	14	18	13
	Tyler	DIBELS-VI ISF	0.00	-[a]	7.15	7.19
		DIBELS-VI PSF	0	-[a]	0	0
		DIBELS-VI NWF	6	-[a]	11	11
		DIBELS-VI WUF	0	-[a]	0	0
		WRAPS	27	-[a]	37	38
Non-Verbal	Martin	WRAPS	14	8	8	16
	Richard	WRAPS	27	-[b]	22	34

Note. DIBELS-VI = Dynamic Indicators of Basic Early Literacy Skills - 6th edition; ISF = initial sound fluency; PSF = phonemic segmentation fluency; NWF = non-word fluency; WUF = word use fluency; WRAPS = word recognition and phonics skills.

[a] = data not available due to participant illness.

[b] = participant not available due to participant having not started Headsprout intervention.

2.3.3 Phonics Skills Development

Table 7 shows the raw scores for the phonics sub-tests at baseline and Time 2, and the RCI analysis conducted to assess whether meaningful change took place.

Participants in the Headsprout-as-usual condition showed reliable improvements in phonics skills over the duration of the intervention. A change of at least 7.41 indicated reliable change on initial sound fluency, and a change of at least 4.94 indicated reliable change in the non-word reading skills. At Time 2, Chris, Ben, Chloe, and Harry all showed meaningful reliable change in recognising the initial phoneme of a spoken word, and in phonetically reading non-words. A change of 11.68 or greater indicated reliable change in phonemic segmentation skills. Only Chris showed reliable change on this sub-test.

In the no-negation condition, for initial sound fluency at Time 2 Liam showed positive reliable change, and Tyler's scores were approaching this threshold. Neither Liam nor Tyler exceeded the threshold for positive, reliable change at Time 2 for the phonemic segmentation, although both participants showed a positive reliable change in reading non-words at Time 2.

These findings indicate that the phonics skills of initial sound fluency and non-word reading increased meaningfully at Time 2, over the duration of the intervention, with all participants showing a reliable increase in reading non-words, and five of six participants showing a reliable increase in recognising initial sounds in words.

Table 7

RCI Analysis for Phonics Skills Between Baseline and Time 2

Measure	Condition	Participant	Baseline	Time 2	Change	RCI
DIBELS-VI ISF	Headsprout-As-Usual	Chris	20.00	33.03	+13.03	3.44*
		Ben	0.00	21.23	+21.23	5.61*
		Chloe	18.00	47.54	+29.54	7.81*
		Harry	3.48	11.22	+7.74	2.05*
	No-Negation	Liam	5.70	18.08	+12.38	3.27*
		Tyler	0.00	7.15	+7.15	1.89
DIBELS-VI PSF	Headsprout-As-Usual	Chris	22	37	+15	2.52*
		Ben	0	0	0	0
		Chloe	11	6	-5	-0.84
		Harry	0	0	0	0
	No-Negation	Liam	0	8	+8	1.34
		Tyler	0	0	0	0
DIBELS-VI NWF	Headsprout-As-Usual	Chris	5	14	+9	3.57*
		Ben	11	22	+11	4.37*
		Chloe	9	19	+10	3.97*
		Harry	1	16	+15	5.96*
	No-Negation	Liam	0	25	+25	9.93*
		Tyler	6	11	+5	1.99*

Note. DIBELS-VI = Dynamic Indicators of Basic Early Literacy Skills - 6th edition; ISF = initial sound fluency; PSF = phonemic segmentation fluency; NWF = non-word fluency.
* = above threshold for positive, reliable change

2.3.4 Word Recognition Skills Development

A change of 2.06 indicated reliable change on the word recognition measure, and raw scores and RCI analysis are displayed in Table 8. In the Headsprout-as-usual condition, Chris, Ben, and Chloe demonstrated positive reliable change on word reading at Time 2. For participants in the no-negation condition, both exceeded the threshold for positive reliable change at Time 2. For the two participants in the non-verbal condition, neither showed positive, reliable change at Time 2. Instead their scores decreased below the threshold for negative, reliable change indicating a regression in word reading skills from baseline.

Table 8

RCI Analysis for Word Recognition Skills Between Baseline and Time 2

Measure	Condition	Participant	Baseline	Time 2	Change	RCI
WRAPS	Headsprout-As-Usual	Chris	20	28	+8	7.61*
		Ben	10	15	+5	4.75*
		Chloe	18	24	+6	5.70*
		Harry	18	19	+1	0.95
	No-Negation	Liam	12	18	+6	5.70*
		Tyler	27	37	+10	9.51*
	Non-Verbal	Martin	14	8	-6	-5.70**
		Richard	27	22	-5	-4.75**

Note. WRAPS = word recognition and phonics skills.
* = above threshold for positive, reliable change
** = below threshold for negative, reliable change

2.3.5 Longer Term Impact of Headsprout on Phonics and Word Recognition Over Time

2.3.5.1 Maintenance of skills between Time 2 and Time 3.

Table 9 shows the raw scores for initial sound, phonemic segmentation, and non-word reading skills at Time 2 and Time 3, and the RCI analysis to assess whether skills were maintained for each participant between Time 2 and the Time 3 follow-up assessment. If the change in raw scores between Time 2 and 3 was lower than the RCI threshold, this would indicate that skills were maintained when the intervention ceased. If scores decreased with a change over the RCI threshold, this would indicate a loss of skills and suggest that continued access to Headsprout may be required to maintain effects.

On the initial sound measure, a change of 7.41 indicated that reliable change had taken place. No participants in the Headsprout-as-usual condition or the no-negation condition showed negative, reliable change beneath RCI threshold in initial sound fluency scores between Time 2 and 3, indicating that initial sound skills were maintained at follow-up. Changes in initial sound scores are shown in Figure 2.

On the phonemic segmentation measure, a change of 11.68 indicated reliable change had taken place. In the Headsprout-as-usual condition, no participants showed a negative, reliable change beneath RCI threshold. However between baseline and Time 2 only Chris showed a positive, reliable change in phonemic segmentation scores. For most participants in this condition their scores had not increased meaningfully during the intervention so were unlikely to have

decreased at follow-up. In the no-negation condition, neither participant showed a negative, reliable change beneath RCI threshold in their phonemic segmentation scores at follow-up, although Liam's score did decrease. Similarly these skills had not shown a meaningful increase between baseline and Time 2. Changes in phonemic segmentation scores over time are shown in Figure 3.

For non-word reading, a change of 4.94 indicated that reliable change had occurred. In the Headsprout-as-usual condition Ben, Chloe, and Harry showed a negative, reliable change beneath RCI threshold in scores between Time 2 and 3, indicating that these skills were not maintained. In the no-negation condition, Tyler maintained his skills with no change but Liam showed a negative, reliable change beneath RCI threshold in scores also suggesting that his skills were not maintained. Figure 4 shows changes in non-word reading over time.

Overall, initial sound skills generally showed positive, reliable change over the course of the intervention that were maintained at follow-up. Reading non-words improved over the time using Headsprout was actively in use, but the skills were not maintained after a break from accessing the intervention. The ability to segment words into phonemes as measured by the phonemic segmentation sub-test did not show meaningful change at Time 2, and, subsequently, there was little change in these scores between Time 2 and 3.

Table 9

RCI Analysis for Phonics Skills Between Time 2 and Time 3

Measure	Condition	Participant	Time 2	Time 3	Change	RCI
DIBELS-VI ISF	Headsprout-As-Usual	Chris	33.03	53.88	+20.85	5.51*
		Ben	21.23	25.59	+4.36	1.15
		Chloe	47.54	43.80	-3.74	-0.99
		Harry	11.22	4.00	-7.22	-1.91
	No-Negation	Liam	18.08	13.77	-4.31	-1.14
		Tyler	7.15	7.19	+0.04	0.01
DIBELS-VI PSF	Headsprout-As-Usual	Chris	37	42	+5	0.84
		Ben	0	2	+2	0.34
		Chloe	6	20	+14	2.35*
		Harry	0	0	0	0
	No-Negation	Liam	8	0	-8	-1.34
		Tyler	0	0	0	0
DIBELS-VI NWF	Headsprout-As-Usual	Chris	14	15	+1	0.40
		Ben	22	11	-11	-4.37**
		Chloe	19	14	-5	-1.99**
		Harry	16	9	-7	-2.78**
	No-Negation	Liam	25	16	-9	-3.57**
		Tyler	11	11	0	0

Note. Note. DIBELS-VI = Dynamic Indicators of Basic Early Literacy Skills - 6th edition; ISF = initial sound fluency; PSF = phonemic segmentation fluency; NWF = non-word fluency.
* = above threshold for positive, reliable change
** = below threshold for negative, reliable change

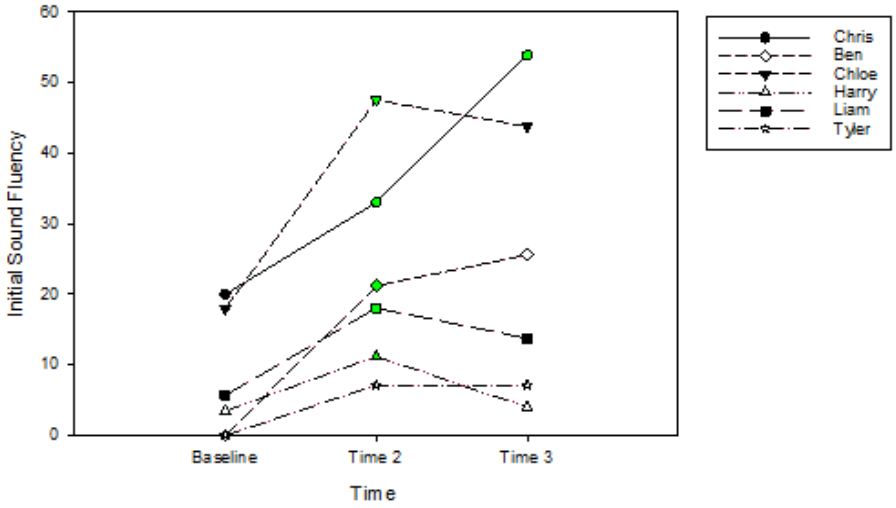

*Figure 2.*Initial sound fluency scores at baseline, Time 2, and Time 3.
Green icons indicate positive, reliable change. Coloured icons at Time 2 represent meaningful change from RCI analysis conducted between baseline to Time 2, and coloured icons at Time 3 represent meaningful change from RCI analysis conducted between Time 2 to Time 3.

Figure 2 shows the initial sound fluency raw scores for each participant at baseline, Time 2 and Time 3. The graph shows that skills in initial sound fluency increased for all participants from baseline to Time 2, that this was reliable for all except Tyler, and that these skills were maintained at follow-up.

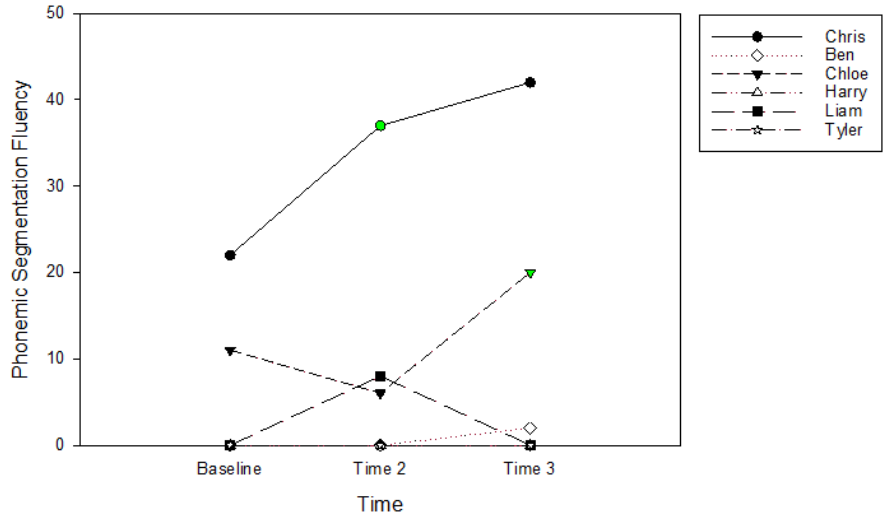

*Figure 3.*Phonemic segmentation fluency scores at baseline, Time 2, and Time 3.
Green icons indicate positive, reliable change, and red icons indicate negative, reliable change. Coloured icons at Time 2 represent meaningful change from RCI analysis conducted between baseline to Time 2, and coloured icons at Time 3 represent meaningful change from RCI analysis conducted between Time 2 to Time 3.

Figure 3 shows the phonemic segmentation fluency raw scores for the Headsprout-as-usual and no-negation conditions at baseline, Time 2, and Time 3. The graph shows that these skills only reliably changed between baseline and Time 2 for Chris.

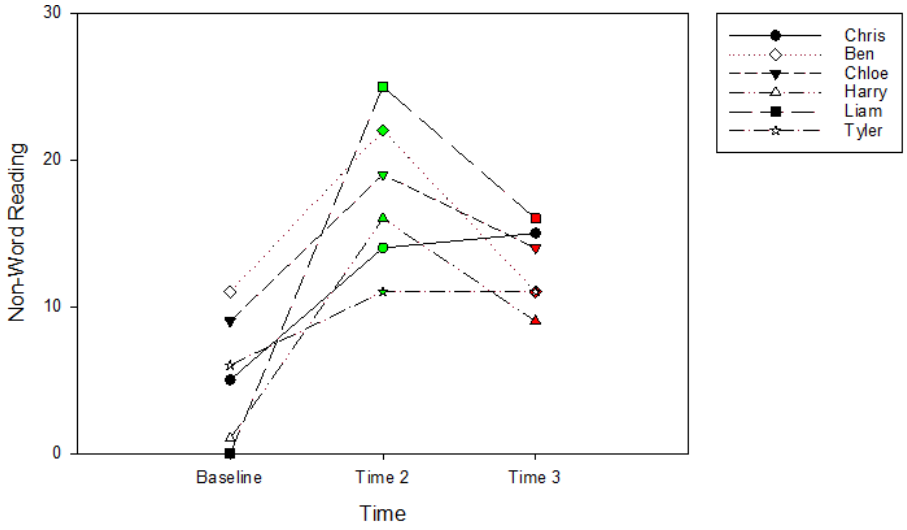

*Figure 4.*Non-word reading scores at baseline, Time 2, and Time 3.
Green icons indicate positive, reliable change, and red icons indicate negative, reliable change. Coloured icons at Time 2 represent meaningful change from RCI analysis conducted between baseline to Time 2, and coloured icons at Time 3 represent meaningful change from RCI analysis conducted between Time 2 to Time 3.

Figure 4 shows the non-word reading scores at baseline, Time 2, and Time 3 for each individual. The graph shows that all six participants showed reliable change from baseline to Time 2, but that these skills decreased at Time 3 and were not maintained.

Table 10 shows word recognition scores at Time 2 and 3; a change of 2.06 indicated reliable change on this measure. At Time 2 in the Headsprout-as-usual condition Chris, Ben, and Chloe showed positive, reliable change in their word recognition scores compared to baseline performance. However at follow-up, all four participants in this condition showed a negative, reliable change beneath RCI threshold from their Time 2 scores, indicating that these skills were not maintained when not accessing Headsprout. In the no-negation condition, both participants had shown positive, reliable change for word recognition skills at Time 2 compared to baseline. At follow-up, Tyler maintained these skills but Liam showed negative, reliable change beneath RCI threshold. The word recognition scores were variable for the two non-verbal participants. At Time 2 compared with baseline both their scores indicated negative, reliable change, but at follow-up their scores compared to Time 2 indicated positive reliable change.

Overall word recognition was variable, with five of the eight participants showing a decrease in their scores compared to baseline performance at some point over the course of the study. This assessment measure is likely to be affected by the confound of having participants select one word from a choice of five.

Table 10

RCI Analysis for Word Recognition Skills Between Time 2 and Time 3

Measure	Condition	Participant	Time 2	Time 3	Change	RCI
WRAPS	Headsprout-As-Usual	Chris	28	24	-4	-3.80**
		Ben	15	12	-3	-2.85**
		Chloe	24	19	-5	-4.75**
		Harry	19	12	-7	-6.65**
	No-Negation	Liam	18	13	-5	-4.75**
		Tyler	37	38	+1	0.95
	Non-Verbal	Martin	8	16	+9	7.61*
		Richard	22	34	+12	11.41*

Note. WRAPS = word recognition and phonics skills.
* = above threshold for positive, reliable change
** = below threshold for negative, reliable change

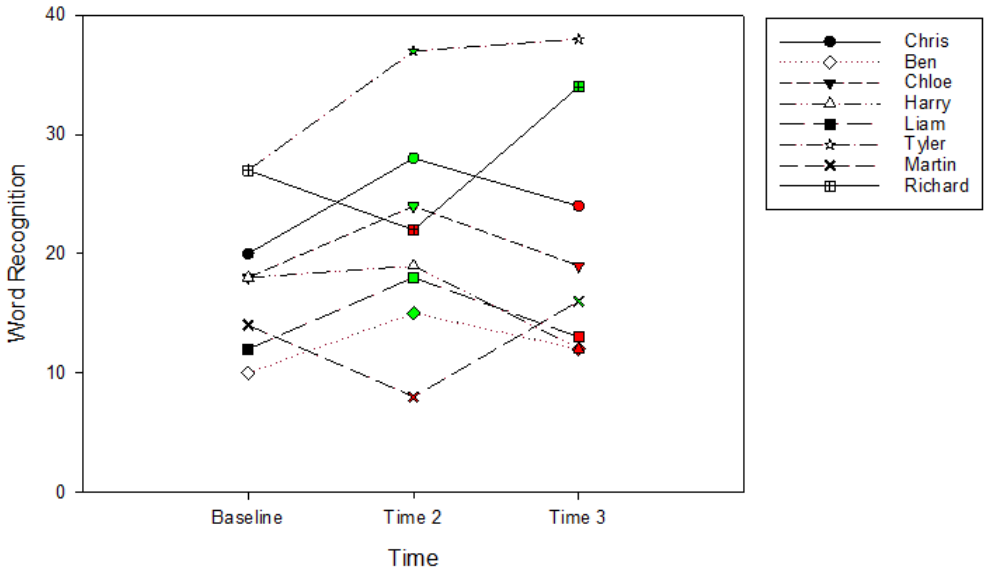

*Figure 5.*Word recognition scores at baseline, Time 2, and Time 3.
Green icons indicate positive, reliable change, and red icons indicate negative, reliable change. Coloured icons at Time 2 represent meaningful change from RCI analysis conducted between baseline to Time 2, and coloured icons at Time 3 represent meaningful change from RCI analysis conducted between Time 2 to Time 3.

Figure 5 shows that Chris, Ben, Chloe, Liam, and Tyler made reliable changes in word recognition from baseline to Time 2; at Time 3 Tyler maintained these skills whereas Chris, Ben, Chloe, and Liam did not. Harry's word recognition scores decreased between Time 2 and 3. Martin and Richard's word recognition skills were variable, only showing positive, reliable change between Time 2 and 3.

2.3.5.2 Development of skills between baseline and Time 3.

Table 11 shows the raw scores and RCI analysis conducted for phonics-skills sub-tests between baseline and Time 3. The thresholds for meaningful change are as follows: A change of at least 7.41 indicated reliable change in initial sound fluency, a change of 11.68 indicated reliable change for phonemic segmentation fluency, and a change of 4.94 indicated reliable change for non-word fluency.

In the Headsprout as usual condition Chris, Ben, and Chloe all showed positive meaningful change in initial sound fluency skills between baseline and Time 3, although Harry's skills dropped back to almost their baseline levels. At Time 3, only Chris showed positive meaningful change in his ability to segment spoken words into their phonemes, Chloe's skills increased but not above the threshold for reliable change, whereas Ben showed little change, and Harry showed no change between baseline and Time 3. Chris, Chloe, and Harry showed positive reliable change for reading non-words between baseline and Time 3, although Ben's skills decreased to their baseline levels.

In the no-negation condition Liam showed a positive reliable change in initial sound fluency skills between baseline and Time 3, and Tyler's change in scores was approaching the threshold for reliable change. Neither participant showed any change in phonemic segmentation fluency scores between baseline and Time 3, but both showed positive reliable change over the same time period in non-word reading skills.

Table 11

RCI Analysis for Phonics Skills Between Baseline and Time 3

Measure	Condition	Participant	Baseline	Time 3	Change	RCI
DIBELS-VI ISF	Headsprout-As-Usual	Chris	20.00	53.88	+33.88	8.95*
		Ben	0.00	25.59	+25.59	6.76*
		Chloe	18.00	43.80	+25.80	6.82*
		Harry	3.48	4.00	+0.52	0.14
	No-Negation	Liam	5.70	13.77	+8.07	2.13*
		Tyler	0.00	7.19	+7.19	1.90
DIBELS-VI PSF	Headsprout-As-Usual	Chris	22	42	+20	3.35*
		Ben	0	2	+2	0.34
		Chloe	11	20	+9	1.51
		Harry	0	0	0	0.00
	No-Negation	Liam	0	0	0	0.00
		Tyler	0	0	0	0.00
DIBELS-VI NWF	Headsprout-As-Usual	Chris	5	15	+10	3.97*
		Ben	11	11	0	0.00
		Chloe	9	14	+5	1.99*
		Harry	1	9	+8	3.18*
	No-Negation	Liam	0	16	+16	6.35*
		Tyler	6	11	+5	1.99*

Note. Note. DIBELS-VI = Dynamic Indicators of Basic Early Literacy Skills - 6th edition; ISF = initial sound fluency; PSF = phonemic segmentation fluency; NWF = non-word fluency.
* = above threshold for positive, reliable change

Table 12 shows the raw scores and RCI analysis for word recognition skills between baseline and Time 3. The threshold for meaningful change in word recognition was a difference in scores of at least 2.06.

In the Headsprout as usual condition, only Chris showed a positive meaningful change in word recognition skills between baseline and Time 3, although the increase in Ben's scores approached this threshold. Harry's decrease in scores was below the threshold for negative meaningful change. In the no-negation group, Tyler's change in scores between baseline and Time 3 was above the threshold for positive meaningful change. In the non-verbal group, Richard's scores were above the threshold for positive meaningful change, and the change in Martin's scores approached this.

Table 12

RCI Analysis for Word Recognition Skills Between Baseline and Time 3

Measure	Condition	Participant	Baseline	Time 3	Change	RCI
WRAPS	Headsprout-As-Usual	Chris	20	24	+4	3.80*
		Ben	10	12	+2	1.90
		Chloe	18	19	+1	0.95
		Harry	18	12	-6	-5.70**
	No-Negation	Liam	12	13	+1	0.95
		Tyler	27	38	+11	10.46*
	Non-Verbal	Martin	14	16	+2	1.90
		Richard	27	34	+7	6.65*

Note. WRAPS = word recognition and phonics skills.
* = above threshold for positive, reliable change
** = below threshold for negative, reliable change

2.4 Discussion

2.4.1 Summary of Findings

The aim of this research was to investigate whether the reading intervention Headsprout could be used to support the development of beginning reading skills in children and young people who were educated in a special school, and whether adaptations to the intervention affected development of reading skills. This was an exploratory study, the first to evaluate the Headsprout intervention in schools for students who experience SLD, and which sought to make adaptations to the programme.

The primary research question of this study was whether phonics skills and word recognition would increase as participants accessed Headsprout. At Time 2, all four participants in the Headsprout-as-usual condition showed meaningful change above the RCI threshold in their ability to identify initial sounds in words and in reading non-words, and all except Harry showed meaningful positive change above the RCI threshold in word recognition. Further research questions focused on whether reading skills would change for participants in the no-negation and non-verbal conditions. At Time 2 both Liam and Tyler showed meaningful change above the RCI threshold in reading non-words and in recognising words, and Liam showed meaningful changes above the RCI threshold in identifying initial sounds in words. Tyler's initial sound identification change score was approaching the threshold for reliable change. At Time 2, neither Martin nor Richard showed positive meaningful change above the RCI threshold in word recognition.

Participants' skills were further measured after a break of 7 to 8 weeks to investigate if they were maintained. For participants in the Headsprout-as-usual condition, initial sound skills were somewhat maintained at follow-up with no observed decreases falling below the RCI threshold. However all four showed decreases in word recognition below the RCI threshold, and Ben, Chloe, and Harry showed decreases in non-word reading below the RCI threshold. In the no-negation condition neither participant showed a decrease below the RCI threshold in initial sound skills; Liam showed a decrease below the RCI threshold in non-word reading and word recognition, but Tyler maintained both these skills at follow-up with no changes below the RCI threshold. In the non-verbal condition only Martin showed positive reliable change in word recognition at Time 3.

In addition to the results summarised above, there were some anomalies observed in the data. For example, in the phonemic segmentation sub-test Chloe showed a decrease in raw scores between baseline and Time 2, and then an increase between Time 2 and Time 3 which was above the threshold for positive reliable change. On the initial sound fluency sub-test, despite increasing at Time 1 and Time 2, Harry's score at Time 3 was close to his baseline measure.

Furthermore, on the word recognition measure, Harry's score at Time 3 was below his baseline measure. In the non-verbal group, both Martin and Richard showed a decrease in word recognition scores below the RCI threshold between baseline and Time 2, only to then show an increase in scores above their baseline measurements at Time 3. The fact that some of the observed data shows a high level of variability means caution is needed when interpreting it.

2.4.2 Interpretation of Findings

As verbal participants accessed Headsprout, improvements were shown for recognising initial sounds in words, and in non-word reading and word recognition. Participants in the Headsprout-as-usual and no-negation conditions showed a similar pattern of results, suggesting that the intervention can be used without this task. Conversely, the findings suggest that Headsprout may not be an appropriate reading intervention for individuals who are non-verbal. However, as only two participants were recruited to access Headsprout without speaking activities, this question would warrant further research. Skills in word reading and non-word recognition were not maintained at follow-up though even though initial sound skills were. This suggests that participants educated in special schools may need continued access to maintain learned skills or require the intervention delivered at the planned intensity.

Hulme and Snowling (2013) argued that learning to read is based on three cognitive foundations: letter-sound knowledge, RAN skills, and phonemic awareness. In a sample of 233 participants with an average age of 6 years and 4 months, the average time taken to complete a colour RAN task was 52.23 seconds (Lervåg & Hulme, 2009). In this study, these skills were all measured at baseline, and their influence can be seen by examining the findings for the three measures of phonics skills: initial sound fluency, phonemic segmentation fluency, and non-word reading. At baseline, Chris had strong skills in these areas: letter-sound knowledge score of 39, a RAN score of 55 seconds, and phonemic segmentation score of 22. Chris was the only participant to show positive reliable change in all three phonics sub-tests at Time 2 and 3. This improvement in phonics skills from one of the oldest students in the study could be interpreted in the light of strong skills in the foundational areas of learning to read. Ben, Chloe, Harry, and Liam demonstrated positive reliable change in initial sound and non-word fluency at Time 2. At baseline each of these pupils had a letter-knowledge score which ranged between 12 and 49, and had colour RAN scores between 41 to 119 seconds, but phonemic segmentation fluency scores of between 0 and 11. At Time 2, Tyler only showed positive reliable change in reading non-words, and had scored 0 in letter-sound knowledge task, 0 in phonemic segmentation task, and had a colour RAN score of 80 seconds at baseline. Accordingly, participants with stronger existing foundation skills made more progress in the outcome variables measured. Although it was not

possible to obtain colour RAN and phonemic segmentation scores for the non-verbal participants, Martin had a letter-knowledge score of 17 and did not show positive reliable change in word recognition over the course of the study. However, Martin struggled to access the intervention so this could be the result of lack of change, whereas Richard had a letter-knowledge score of 47, accessed the intervention more consistently, and showed positive reliable change in word recognition at Time 3.

No participants reached the threshold for positive reliable change in word use fluency. This is not surprising as expressive language skills are not targeted by the intervention, and suggests that improvements in reading skills did not generalise to oral use of language.

The assessments themselves may have affected the results. The word recognition assessment involved an element of chance, as participants were asked to match a spoken word to one of five written words. Furthermore, the participants did not show positive change on phonemic segmentation, whereas they did on other phonics measures of initial sound and non-word reading skills. However, unlike these two measures the phonemic segmentation task was entirely delivered orally with no visual materials. The lack of positive reliable change for phonemic segmentation could, therefore, either reflect that these skills did not develop, or that improvement was not reflected as participants found it more challenging to access a purely speaking and listening assessment.

Historically, the ability to learn to read has been linked to IQ, and assumptions have been made that expressive language skills should be taught first (Browder, Gibbs, et al., 2009). Teaching reading to individuals who experience learning difficulties therefore emphasised pre-requisite literacy skills (Lawson et al., 2012), while this approach was not used with typically developing children. Instead, in typically developing populations, research into the development of phonics skills suggested that learning to read was underpinned by letter-sound knowledge, phonemic awareness, and RAN skills, and accordingly reading interventions with this population targeted these skills. The findings from this small scale exploratory study indicate that similar to typically developing children, the skills of letter-sound knowledge, phonemic awareness, and RAN skills may influence the development of learning to read phonetically for students educated in a special school, and that while actively accessing a phonics-based reading intervention, some improvements were demonstrated in phonics skills and word recognition. This supports the assumption that the teaching of reading should be driven by a dimensional approach, using evidence-based teaching methods with all children, rather than separate methods taught to different groups dependant on whether they are typically developing or experience learning

difficulties. As these foundational skills are important for learning to read with all children, phonemic awareness and letter-sound knowledge could be areas of early intervention.

When interpreting the results of this study it is important to note that multiple baseline measures were not taken meaning that any existing trends in phonics-skill which may have been present before the implementation of the Headsprout intervention were not observed. It is not possible to conclude that any increases in phonics-skills and word recognition were as a result of the intervention due to the design of this research.

2.4.3 The Context of the Wider Literature

This study adds to and supports the small number of studies which have found that using Headsprout leads to improvements in reading skill for pupils with ASD (Grindle et al., 2013; Whitcomb et al., 2011), and for pupils educated in a school for students who experience mild and moderate learning difficulties (Tyler, Hughes, Wilson, et al., 2015). However, the studies by Grindle et al. (2013) and Tyler, Hughes, Wilson, et al. (2015) investigated reading skills after participants had completed all 80 Headsprout episodes, and the study by Whitcomb et al. (2011) required participants to complete the first 23 episodes. This study was the first to take place in a setting for students described as having SLD, and showed improvements in reading skills over a shorter time frame when participants accessed fewer episodes. This study has also reported that participants can show improvements in reading skills when negation tasks are not accessed.

2.4.4 Strengths of the Research

A strength of this study is that the results were analysed using the RCI, meaning it is possible to comment on whether a positive change between two scores was large enough that it demonstrated real change in the participants' scores in the context of the reliability of the measure. Previous research in this area using a single-subject design has used an analysis based on numerical comparisons only, such as percentage reading accuracy (Whitcomb et al., 2011) or raw score change (Grindle et al., 2013; Tyler, Hughes, Wilson, et al., 2015). The use of the RCI in this study means that conclusions can be drawn regarding whether change for each participant was meaningful in the context of the assessment used to measure that change.

A further strength of this research is that the intervention was implemented over half of a UK academic year in the UK, with outcome measures also taken after a 7 to 8 week break in order to assess how skills were maintained. The fact that non-word reading and word recognition skills were not maintained, but initial sound fluency skills were, suggests that participants may need

continued access to the intervention, or use the intervention with the planned intensity, to support developing reading skills.

2.4.5 Limitations of the Research

The findings of this research must be interpreted in light of the single-case design used. Although the analysis using RCI means that an individual's change in raw scores could be determined as reflecting reliable change or not, it is not possible to conclude that any reliable change occurred as a result of the Headsprout intervention. There were also a range of confounding variables not controlled for. Improvement in phonics could have occurred naturally due to teaching as usual and the time over which the study occurred. The additional time on phonics activities, rather than Headsprout itself, could also have led to observed improvements. As the current small scale exploratory study has demonstrated that Headsprout can be implemented in a special school setting, future research could employ the use of a wait-list control with the intervention implemented over a shorter time.

A further limitation is the observed intervention fidelity. As shown in Table 5, only Harry exceeded the number of planned sessions. For individuals such as Tyler who did not reach the threshold for positive reliable change in initial sound skills, lack of progress could be a function of having fewer sessions than planned. However, this explanation may not apply to all participants. For example, Chloe showed positive reliable change in initial sound fluency and non-word reading at Time 2 and 3, and word recognition at Time 2 despite only having 22 of a planned 36 sessions delivered. It may have been that foundational reading skills interacted with time spent on the intervention.

The participants' IQ or adaptive functioning levels were not formally assessed, rather their Statement of SEN was checked and reported on. However, given their attendance at a school for pupils with SLD, it was decided it was not necessary to re-diagnose them.

As progress in reading skills was inferred through improvements in the dependent variables over time, difficulties accessing interventions at this time point would also affect the conclusions drawn regarding the effectiveness of Headsprout. If participants found an intervention challenging at baseline, they would have received a low score. One consequence of taking part in the Headsprout intervention may have been an increased ability to access tasks, through developing attention and receptive language. These skills may have then generalised meaning that participants found it easier to successfully access assessment at later measurement times. An increase in scores on the dependent variables may therefore reflect an improved ability to access such tasks rather than purely an improvement in the reading skills being assessed.

2.4.6 Implications for Practice

EPs work with staff in a range of educational settings to support the learning of all students. The results of this study suggest that those students with higher foundational reading skills such as letter-knowledge and phonemic awareness may have made greater progress on the Headsprout intervention. The wider research literature also highlights the importance of letter-knowledge and phonemic awareness in learning to read. EPs can help staff to understand the importance of developing letter-knowledge and phonemic awareness to the complex task of learning to read. These areas could be targeted in early intervention work to lay the foundations for phonics-based teaching. Many studies investigating reading interventions with children and young people who experience learning difficulties often use sight word approaches (Browder et al., 2006). This study has demonstrated that a phonics-based approach may lead to improvements in early reading skills, so EPs who work with special schools can help staff to consider whether some children may benefit from phonics-based methods of teaching reading. A further finding of this research is that improvements in phonics skills did not necessarily generalise to word recognition skills. Using a continuum-based view of SEN (Long et al., 2011), this message that some children may need targeted support to apply skills to new contexts applies to all students who may be experiencing difficulties in learning to read, not just those educated in special school settings. EPs can help all schools to understand that as well as putting in place phonics-interventions, they will also need to actively support their pupils in generalising phonics skills to word reading outside of the intervention.

Future researchers working in this area should continue to investigate the effect of phonics-based reading interventions, such as Headsprout, on phonics-skills for children and young people educated in special school settings. A consideration for future research is the importance of gathering the views of the participants themselves. This study did not seek to gather information about how the participants themselves experienced the Headsprout intervention, but would have been strengthened by doing so. Informally the participants reported enjoying using the computer programme. Representing young people's views, particularly for vulnerable groups such as those educated in special school settings, can empower participants and ensure they are a partner in research rather than being acted on (Coons & Watson, 2013). Future research could also consider ways of effectively communicating information to this group of pupils, to facilitate the sharing of information and obtaining of consent. Reflecting on this research I feel that this process could have been strengthened by the use of pictorial materials to support the verbal explanation, and this is an area which future research could explore.

This exploratory study has demonstrated the reading intervention Headsprout can help children and young people who are educated in a special school to develop their phonics skills. While promising, this has only been shown in a small scale research project, and the findings require replication and extension. Now this small scale exploratory study as shown that Headsprout can be implemented in a special school setting, future research could investigate its effect on reading skills using a design which would allow these conclusions to be drawn. For example, using a single-subject design with multiple baseline measures to establish trends in the data before the intervention is introduced. A further area of study would be to explore other factors which affect why some pupils may make greater progress than others as this could help inform for whom Headsprout is most likely to be effective for when being considered as a school-based intervention. Further research should also examine the effectiveness of Headsprout without the negation activities, as only two participants took part in this condition. Use of a wait-list control would be beneficial to control for the influence of teaching as usual during the study. The findings of this study support the notion that researchers should continue to evaluate the effectiveness of phonics-based reading approaches to teaching reading with this population. This area of research has been expanding in recent years (Hill, 2016), and should continue to do so.

Appendices

Appendix A Table of Studies

Ref: 1 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Ainsworth, Evmenova, Behrmann, and Jerome (2016)	8 aged 11 to 16 years. 1 school in US. Pupils selected if they were: functionally non-verbal; had pre-kindergarten literacy skills as measured on Brigance Early Childhood Inventory and on researcher-made assessments; and accessed state alternative testing for students with severe intellectual disabilities. IQs measured from below 30 to 45.	Single subject multiple baseline. 4 conditions each of 2 participants. Conditions assigned on participant schedules, teacher recommendation, and random assignment where possible.	Letter sound correspondence portion of Accessible Literacy Learning (ALL) Curriculum. Each condition was taught 5 different letter-sound correspondences. Took place over April – June. Supposed to be 45-60 min sessions 3 times a week, many days where this did not happen. Delivered by researcher in school setting	1. All the conditions demonstrated changes in level between baseline and intervention phases. 2. Intervention was moderately to highly effective.	Letter-sound correspondence was assessed using multiple choice options and measured as number of correctly identified target letter sound associations identified during a testing period at beginning of each session.	16

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Ref: 2 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Ahlgrim-Delzell et al. (2016)	31, in kindergarten to grade 8, aged between 5 and 14 years. 22 teachers in 16 schools, US. Pupils selected if they: used any augmentative and alternative communication system to supplement verbal responding; completion or current use of foundational literacy program or able to identify at least 5 letters or sight words; able to use iPad; inability to decode text; and diagnosed with intellectual disability or developmental delay. IQs measured for all but 3 students, ranged 40-85.	Between subjects randomized control trial design. Simple random assignment blocked by teacher to treatment or control group. No statistically significant differences between the groups at pre-test.	Early Reading Skills Builder. Identify phonemes in isolation and in words, segment sounds in words, blending and decoding, and answering comprehension questions about the text. Systematic instruction using time delay and fading of model prompts. Students used iPad to select their responses. Students in the control group used iPad with sight word based business as usual intervention. 8 months of intervention delivered by class teachers. Individual lessons 15-20 minutes.	1. Significant different in favour of treatment group for phoneme identification, decoding, and total score. 2. Effect sizes of .51 blending, .88 decoding, and 1.12 phoneme identification	Curriculum-based probe measures collected each month with the final probe acting as post-test measure: 1. phoneme identification 2. blending sounds to identify words 3. decoding for picture-word matching 4. total score	15

Ref: 3 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Lemons et al. (2015)	5 children with Down Syndrome, aged 6 to 8 years, in US schools. Participants selected if they: were native English speakers; saw and heard well enough to benefit from typical classroom instruction; able to communicate primarily using speech; could attend to 20 minutes of instruction with minimal breaks; and demonstrated mastery of fewer than 10 letter sounds. Mixture of time in special education and general education settings.	Multiple baseline across participants; single subject design experiment.	Phonological awareness intervention Rode to Code. 24-45 sessions across 15 weeks (mean = 34 sessions). Delivered four times a week in 20 minute individualised sessions by three researcher-affiliated interventionists. The baseline phase was the non-adapted phonological awareness intervention, and the treatment phase was the adapted phonological awareness intervention. Primary adaptation was to support the learning of letter sounds by teaching an accompanying target word that started with the letter. Also modified activities so students spent more time actively engaged with target content.	1. Functional relation between adapted intervention and improvement in phonological awareness, identifying initial sounds in a word.	Curriculum based probes: 1. letter sounds 2. target word Woodcock Johnson III sub-tests: 1. letter-word identification 2. passage comprehension	17

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Ref: 4 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Allor, Mathes, Roberts, Cheatham, and Otaiba (2014)	141 participants began the study in grades 1-4. Aged between 6 and 10 years with a mean age of 7 years. US schools. Participants were selected if they had IQ scores between 40 and 80; were in grades 1 to 4; and were verbal. No statistically significant differences between the groups.	Between subjects longitudinal randomized -control trial. Randomly assigned within school and IQ range to treatment (n = 76) and control (n = 65) conditions.	Early Interventions in Reading intervention. Implemented over 4 academic years. 6 teachers jointly hired by school personnel and the research team to provide instruction. Daily intervention sessions for 40-50 minutes in groups of 1 to 4 students. Activities: word level, word recognition, fluency, and comprehension.	1. Students in treatment group made significantly greater progress. 2. Students with low IQs still lagged behind normative peer groups. 3. IQ had sig impact on student response to instruction. However, IQ did not have sig impact on response in terms of measures of phonological processing. 4. For children with moderate IQ, they took 3.5 years to read at 60 wpm on 1st grade text.	CTOPP subtests 1. Blending non-words 2. Blending words 3. Segmenting words TOWRE Woodcock Language Proficiency Battery – Revised subtests DIBELS subtests 1. PSF 2. NWF 3. Oral Reading Fluency	21

Ref: 5 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Hansen, Wadsworth, Roberts, and Poole (2014)	6 children in kindergarten aged 5 to 6. The participants were described as having idiopathic intellectual disabilities and/or ASD and were nominated by their teacher. Participants had to have normal hearing; be minimally verbal (able to vocally imitate a minimum of one word at a time). A self-contained special education kindergarten class in an elementary school in US.	Single subject multiple treatment design embedded in a multiple baseline across participants design.	Intervention delivered by 5 undergraduate college students. All children were concurrently taught phonics by their class teacher in small groups using Macmillan Treasures reading program for 5 hours a week. 15 min play periods, instructors individually teaching phonics skills through child-initiated play: - separating words and phrases into syllables, - initial sounds in words, - phoneme segmentation	1. Sound segmentation and initial sound fluency increased for all children, for most these changes were both visually and statistically sig. 2. Phoneme segmenting fluency increased sig for all children. 3. Children with sig learning challenges can increase critical literacy skills with a play-embedded approach.	Intervention recorded and coded as percentage of correct responses on key skills: 1. syllables 2. first sounds 3. phoneme segments	16

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Ref: 6 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Allor, Gifford, Al Otaiba, Miller, and Cheatham (2013)	3 students aged 8 to 12. Students selected who had been unable to unitise new words after participants in a research-based program for at least one academic year. 3 US schools. IQs between 45 and 59.	Single subject multiple baseline design.	Early Interventions in Reading intervention. Text based reading lessons to practice taught skills. 5 days a week, 45 minute sessions, on one-to-one basis over 14 weeks. Delivered by intervention teacher for study. Carefully designed storybooks and application lessons used. Activities in: word level; word recognition; fluency; and comprehension	1. All 3 students increased number of words they could read (5-20) to (40-75) 2. DIBELS scores from end of larger study indicated small growth, still performing inconsistently and at early 1st grade levels	DIBELS subtests: 1. PSF 2. NWF 3. oral reading fluency Cumulative word lists administered at the end of each lesson.	15

Ref: 7 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Fredrick, Davis, Alberto, & Waugh (2013)	5 students between 7 and 14 years old. IQs between 40 and 55. Students' class teachers selected individuals who: communicated verbally; performed successfully in their current Edmark sight-word reading program; and did not have any behaviour that would interfere with 15 minutes of instruction. Two self-contained special education classrooms in two different schools.	A single subject multiple baseline changing criterion design.	Phonics component of the Integrated Literacy Curriculum: 1. Initial phonics: taught 8 sounds, 14 blending words, and 14 generalisation words. 2. Functional phonics: taught 16 sounds and 4 sound combinations, 48 blending words, 15 functional generalisation words, and 20 functional phrases. Daily sessions. Instruction and data probes conducted by classroom teachers. One-to-one instruction for initial phonics and first two sound sets of functional phonics, and small group instruction for the remainder of the intervention.	1. All 5 students acquired word analysis skills that included verbal imitation of sounds, letter-sound correspondences, retrieval of letter-sound correspondences to a level of automaticity, blending, telescoping, and generalising blending to untaught words. 2. Students reached mastery criteria for each phase of initial phonics and functional phonics and a functional relation was demonstrated between instructional sequence and acquisition of word-analysis skills.	CTOPP subtest: 1. RON to measure naming speed Probes to measure: 1. initial phonics 2. functional phonics	12

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Ref: 8 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Beecher & Childre (2012)	3 students aged between 7 and 10. 1 US classroom serving students described as being diagnosed with mild to moderate intellectual disabilities and developmental delay. Students were selected who had not previously participated in the reading curriculum; had a diagnosis of moderate intellectual disabilities or developmental disabilities; and were reading at a prekindergarten or kindergarten level.	A single subject AB time series design in conjunction with pre-test post-test measures.	PCI Reading Program: Level 1, a district mandated curriculum focused on sight word reading. Teacher was lead author. The PCI program was paired with activities targeted; concepts of print, phonemic awareness, phonological awareness, listening and reading comprehension, and vocabulary. Sign language integrated as an additional component. 55 minutes of literacy instruction in a small group setting, 15 minutes of one-on-one instruction. Between August and November.	1. The use of a comprehensive reading program enhanced with sign language resulted in gains in letter identification, letter-sound knowledge, and sight word knowledge.	Woodcock Reading Mastery Test-Revised subtests: 1. supplementary letter checklist Rigby reading benchmark assessments PCI sight word list probes	17

Ref: 9 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Finnegan (2012)	52 participants, aged 5 to 12 years of age, from 5 US schools. Mean age = 8.6 years. Participants were randomly assigned to 1 of 3 treatment groups: synthetic phonics, analogy phonics, or a control group. No significant differences found between three groups. Significant cognitive disability. IQs measure for 29 students with a mean of 55.	Between subjects design. An experimental pre-post-test one-way ANOVA design with multiple performance variables.	Synthetic phonics: students learned individual letter sounds and how to blend them together. Analogy phonics: students learned the sounds of common consonants and rimes /b/ /at/. 12 individual sessions of phonics instruction, for 15-20 minutes. Delivered by researcher.	1. Significant effects on training word identification for both phonics groups compared to control group. Neither approach was superior in increasing number of words Ps could read. 2. Significant effects on transfer word identification for synthetic phonics group.	Woodcock-Johnson III Diagnostic Reading Battery subtests: 1. letter-word identification 2. word attack Probes: 1. training word identification 2. transfer word identification	17

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Ref: 10 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Coyne et al. (2012)	16 participants, 8 in LBD classes and 8 in control. 5 intervention and 4 control classrooms in 5 schools in the US. K to Grade 2. Students were selected if they had: sub-average intellectual functioning and deficits in 2 or more adaptive skills; and they received reading instruction in one of identified classrooms. LBD group pre-test scores were significantly higher than the control group on letter word identification and picture vocabulary subtests.	Between subjects design.	Literacy by Design: instructional approach and 4 multimedia e-books. Primary focus was comprehension while also focusing on phonemic awareness, phonics instruction, vocabulary and fluency. All students participated in a 90 minute block from October to May. As part of total literacy program, LBD students received 20-30 per day of individualised context-based reading instruction supported by intervention software. Delivered daily by class teachers.	1. The only subtest which showed a significant different between LBD and control groups at post-test was passage comprehension.	Woodcock-Johnson Tests of Achievement III subtests: 1. letter word identification 2. passage comprehension 3. word attack 4. sound awareness Criterion-referenced measures: 1. letter identification 2. concepts about print	18

Ref: 11 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Lemons, Mrachko, Kostewicz, and Paterra (2012)	15 children between the ages of 5 and 13 years participated. 6 received Road to Reading, 5 received Road to Reading plus Phonemic Awareness training, 4 received Rode to Code. Some IQs known, ranged between 40 and 70. Students had to have Down Syndrome; were described as having mild to moderate intellectual disabilities; be between 5 and 17 years old; no visual or hearing impairments; capable of engaging in intervention; able to name or repeat letter sounds; and be a native English speaker.	Single subject research design.	Road to Reading (RTR) and Rode to Code (RTC) interventions. Provided by 11 school staff. One-to-one sessions, four times a week over 12 weeks. RTR: increasing student knowledge of alphabetic principle to provide support for reading comprehension. RTR plus PA: combined a phonological awareness activity with RTR program. RTC: enhance phonological awareness and teach the most common sounds for 8 letters.	1. RTR and RTR plus PA interventions were moderately effective in improving reading of taught words. 2. No improvements demonstrated in oral reading fluency. 3. Limited improvements in letter sound knowledge for RTC group, can't claim due to intervention.	DIBELS subtests: 1. ISF 2. Oral reading fluency Blend sounds to produce 11 three-phoneme words Names and sounds of letters. Total number of targeted sounds and words mastered during intervention.	19

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Ref: 12 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Browder, Ahlgrim-Delzell, Flowers, and Baker (2012)	93 students described as having severe developmental disabilities including intellectual disabilities. Participants were in grades K to 5, aged between 5 and 11 years, in 3 US schools. Mixture of time in general and special education classes. Control group had a mean IQ of 43, treatment group had a mean IQ of 41. No statistically significant differences between the two groups. Randomly assigned to condition based on classroom. Students were selected if they had: an IQ of 55 or below with comparable deficits in adaptive behaviour; were enrolled in grades kindergarten to 4; read below grade 1 level; had adequate hearing and vision; and were responsive to ongoing instruction in English.	Between subjects design.	Intervention was implemented by class teachers. 3 cohorts which all used intervention over 1 year, September to April. The intervention took place during 3 academic years with 3 cohorts of students. Control group: Edmark Reading Program. Sight word approach. Treatment group: Early Literacy Skills Builder. Two parts: 1. building with symbols Targets vocabulary, comprehension, phonemic awareness, early phonic skills. 2. building with stories Teaches skills for interacting with books and listening comprehension.	1. The treatment group had a higher post-test mean score than comparison group for all DV across all cohorts. 2. Statistically significant main effect for treatment. 3. Small to moderate effect sizes. 4. Phonics skills contributed most to differences between 2 approaches.	NVLA: 1. conventions of reading 2. phonics skills	19

Ref: 13 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Allor, Mathes, Roberts, Cheatham, and Champlin (2010a)	59 participants randomly assigned to intervention or contrast group. Students began the study when they were in grades 1 to 4, aged 6 to 10. IQs ranged from 40 to 69. US schools. No statistically significant differences between the groups.	Between subjects, longitudinal randomized quasi-experimental design.	Early Interventions in Reading. Daily, small-groups of 1-4 students received reading instruction for 40-50 minutes delivered by research teacher for 2 or 3 years 60 lessons – foundation level Blending, segmenting, letter sound correspondence. 120 lessons – level 1 120 lessons – level 2 Concepts of print, phonological awareness, phonemic awareness, letter knowledge, word recognition, fluency with connected text, comprehension strategies, vocabulary and oral language development. Contrast group followed normal literacy curriculum.	1. Students made statistically significant progress across every standardised measure assessed, including measures of phonemic awareness, oral language and vocabulary, phonemic decoding, word identification, and reading comprehension. 2. Variability across students was high.	CTOPP subtests: 1. blending words 2. blending non-words 3. segmenting words TOWRE subtests: 1. phonemic decoding efficiency 2. sight word efficiency Woodcock Language Proficiency Battery – Revised subtests: 1. letter word identification 2. word attack 3. passage comprehension Dynamic Indicators of Basic Early Literacy Skills subtests: 1. phoneme segmentation fluency 2. nonsense word fluency 3. first grade oral reading fluency	17

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Ref: 14 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Allor, Mathes, Jones, Champlin, and Cheatham (2010b)	3 participants aged between 10 and 12 years. IQs ranged between 44 and 52.	Single subject design.	Early Interventions in Reading. 60 lessons – foundation level Blending, segmenting, letter sound correspondence. 120 lessons – level 1 120 lessons – level 2 Concepts of print, phonological awareness, phonemic awareness, letter knowledge, word recognition, fluency with connected text, comprehension strategies, vocabulary and oral language development. Delivered by teachers. Daily group instruction for 3 academic years.	1. All 3 students made important progress on phonemic awareness and basic phonics skills.	DIBELS Skills subtests: 1. PSF 2. NWF 3. oral reading fluency	14

Ref: 15 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Allor, Mathes, Roberts, Jones, and Champlin (2010c)	28 participants from 10 US schools in grades 1 to 4. Aged between 6 and 10. IQs ranged between 40 and 55. Randomly assigned to intervention group or contrast group receiving typical education. No statistically significant differences between the treatment and contrast groups on any pre-test measure	Between subjects longitudinal randomised trial design.	Early Interventions in Reading. 60 lessons – foundation level Blending, segmenting, letter sound correspondence. 120 lessons – level 1 120 lessons – level 2 Concepts of print, phonological awareness, phonemic awareness, letter knowledge, word recognition, fluency with connected text, comprehension strategies, vocabulary and oral language development. 40-50 minutes of daily instruction of small groups from intervention teachers. Intervention took place over 1 to 1.5 years. Total instruction time for each student varied depending on when they began the intervention and attendance. Intervention varied from 30 to 53 weeks, with a mean of 42.8 weeks.	1. Statistically significant results were found on following: CTOPP blending non-words, CTOPP segmenting words, CTOPP sound matching, TOWRE sight word efficiency, TOWRE phonemic decoding efficiency, WLPB-R letter word identification, WLPB-R passage comp, WLPB_R word attack.	Woodcock Language Proficiency Battery – Revised: 1. letter word identification 2. word attack 3. passage comprehension CTOPP subtests: 1. blending words 2. blending non-words 3. segmenting words TOWRE subtests: 1. phonemic decoding 2. sight word efficiency Dynamic Indicators of Basic Early Literacy Skills subtests: 1. ISF 2. PSF 3. NWF 3. letter naming fluency	18

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Ref: 16 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Lemons and Fuchs (2010)	24 students with Down Syndrome, aged between 7 and 16 years old (mean age = 11.97 years; mean IQ = 44). Participants were selected who were capable of participating in 2 30-minute periods of one-to-one instruction per day, 5 days a week, for 6 weeks; did not have hearing or visual impairments; could speak clearly so an unfamiliar adult could understand them; and read at least 1 word or letter-sound. Participants were excluded if they read more than 10 non-words and identified more than 30 letter sounds.	Individual growth curve analysis was used in a non-experimental design. Single subject design.	The intervention was delivered by the researcher or a tutor. 2 sessions of 30-minute one-to-one instruction per day, 5 days a week, for 6 weeks. 1st daily session: Segmenting and blending, reading decodable words. 2nd daily session: Review of sounds and sight words, practicing fluency and reading connected text to support comprehension. Analysis focused on creating growth model to explain results. 1st cohort at summer day camp. 2nd cohort at school.	1. Most children exhibited growth in taught sight words and letter-sound knowledge. 2. Children who entered the study with more advanced word identification skills made greater gains in decodable word reading. Those with more advanced phoneme segmentation skills made greater gains in nonsense word reading.	Segmenting measure. Woodcock Johnson Reading Mastery Test-Revised subtest: 1. word identification 4 probes used: 1. letter sounds 2. decodable taught words 3. nonsense words 4. taught sight words Control measure of non-taught sight words.	13

Ref: 17 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Waugh, Fredrick, and Alberto (2009)	3 students between the ages of 9 and 11 years. IQs ranged between 40 and 53. Students were described as having moderate intellectual disabilities; received special education services; verbally able to produce sounds; could attend for 20 minutes; had no visual or hearing impairments.	Single subject changing criterion design was employed to demonstrate a functional relationship.	Took place over spring and fall semesters and delivered by class teachers. First taught 5 sight words using simultaneous prompting in small group. Then taught letter-sounds and blending in one-to-one instruction. Daily probes.	1. Within a range of 55-64 sessions all the students were able to correctly identify letter-sounds and blend the sounds on taught words, and blend on at least 1 novel word.	Probes for: 1. sound sets 2. blending sets 3. generalisation words	12

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Ref: 18 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Browder, Ahlgrim-Delzell, Courtade, Gibbs, and Flowers (2008)	23 participants. Aged 5 to 10. 7 teachers in US school district volunteered. Selected students who: had IQ of 55 or below; enrolled in grades kindergarten to 4; adequate hearing and visual; responsive to ongoing instruction in English if a non-English speaker; and reading below a 1st grade level. Participants were randomly assigned to treatment or control group. No statistically significant differences between groups.	Between subjects design, randomised control group.	Early Literacy Skills Builder. Delivered by class teachers between October and May either one-to-one or in small groups of 2 to 4 students. Students did not move on to the next level until they had 75% correct responding on the lessons in the prior level. Sight words, story comprehension, phonological awareness, letter-sound correspondence, segmenting, and vocabulary.	1. There were large effect sizes for all measures of the treatment group. 2. The treatment group made significant gains on the ELSA and NVLA phonemic awareness.	NVLA Early Literacy Skills Assessment (designed as pre/post-test for ELSB curriculum). Woodcock Language Proficiency Battery (WLPB) subtest: Letter-word identification	17

Ref: 19 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Osborn et al. (2007)	43 US schools. 31 2nd grade students with cognitive disabilities in Project MORE. 22 2nd grade comparison students in matched schools. Randomly allocated by school. IQ of 70 or below. Part of much larger sample. Aged 7 to 8 years.	Between subject design.	Project MORE: implemented 2 individualised reading interventions 1. Help One Student To Succeed (HOSTS) Guided reading, word recognition, vocabulary, and spelling. 2. Reading tutors program Phonological awareness, phonics, HFW, fluency, and comprehension. Delivered by volunteer mentors. One-to-one session 3-4 days a week for 30 minutes. Over 6 months.	1. Project MORE students outperformed comparison students on DIBELS ORF. 2. Did not perform significantly better on broad or basic reading measures of Woodcock-Johnson Reading Achievement Test III.	DIBELS Skills subtests: 1. oral reading fluency Woodcock-Johnson Reading Achievement Test III subtests: 1. letter word identification 2. reading fluency 3. passage comprehension 4. word attack	15

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Ref: 20 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Bradford, Shippen, Alberto, Houchins, and Flores (2006)	3 participants aged 12 to 15 years. Self-contained setting for students described as having moderate intellectual disabilities in a public US school. Students were chosen based on teacher recommendation and performance on teacher-designed placement test. IQs ranged between 46 and 55.	A pre-test post-test single subject design with program specific criterion referenced performance measures was used.	Corrective Reading Program, Decoding A. 65 lessons, teaches basic word recognition skills such as blending, rhyming, sounding out, and word and sentence reading. 1 hour group lessons divided into 4 parts: word attack, group reading, individual reading, and workbook exercises. Lessons took place 3 days a week over 6 months. Delivered by 1st author.	1. Students demonstrated letter-sound correspondences; sounding out; blending; decoding irregular words; reading sentences; and short passages 2. Performed at 97% correct or above in oral and written letter-sound correspondence; and word recognition 3. Corrective Reading Program test re-administered 9 weeks later and able to read it.	Teacher made placement test investigated letter-sound correspondence and initial sounds. Dolch sight words or Edmark functional words after program completion. Program Mastery Tests completed before moving on to next section.	15

Ref: 21 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Conners, Rosenquist, Sligh, Atwell, and Kiser (2006)	40 participants aged between 7 and 12 years. Referred by teachers if they had an educational classification of mental retardation and substantial limitations on two or more adaptive skill areas; and could identify letters but not yet reading phonologically. Matched on age and IQ, randomly assigned to treatment or control. Mean IQ for instruction group = 53.85 Mean IQ for control group = 52.09	Between subject design.	10 weeks, for 2 lessons per week. Sound blending, letter-sound associations, sounding out words. Individual lessons delivered by researcher or research assistant.	1. Significant main effect of group. 2. Significant main effect of set, higher scores on instruction than transfer set. 3. Both improved non-word reading. 4. Beginning reading skill and general language ability related to sounding out ability.	Pre-instruction: Letter names, letter sounds, non-word reading, sight word reading, phonemic awareness. Post-instruction: Sounding out instruction and transfer sets, sounding out composite, non-word reading, sight word reading.	15

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Ref: 22 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Flores, Shippen, and Alberto (2004)	6 participants aged between 8 and 13 years. Self-contained setting for students described as having moderate intellectual disabilities in US school. The class teacher recommended students. IQs ranged between 38 and 52.	Single subject multiple probe across behaviours with embedded changing conditions design.	Corrective Reading: Word Attack Basics, Decoding A. A Direct Instruction program. Learning letter sounds and blending together into words. Taught by the class teacher 3 times a week initially in group of 6 participants then in 2 groups of 3. 3 conditions: 1. letters m and a 2. letters s and t 3. decoding CVC words	1. 5 students mastered all of instructed items and demonstrated a generalised understanding of LSC and a generalised skill in sounding out untaught words. 2. Only 2 students able to fully decode untaught words.	Probes for: 1. single letter identification 2. discrimination and blending 3. decoding – slow 4. blending – fast	17

Ref: 23 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Joseph & McCachran (2003)	16 participants aged between 7 and 10 years. 8 diagnosed with mental retardation and in special education classroom. 8 'at risk' of reading failure. IQs ranged between 55 and 76 (mean = 69.5). Students from a US school.	Single subject design.	Word sort group lesson was implemented for about 20 minutes per daily session over 2 month period. Sorting words according to spelling patterns and reading them aloud. Word study phonics technique called word sorts. Delivered by instructor.	1. On letter word identification: 3 students with MR made substantial gains, 1 student made large gain. 2. On phonological awareness score, 2 students with MR made large gains.	Woodcock-Johnson Psycho-Education Battery, Tests of Achievement III subtests; 1. letter word identification 2. word attack CTOPP	17

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Ref: 24 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Hatcher (2000)	Taught group includes 433 children from UK schools. 28 participants described as having moderate learning difficulties, aged between 6 and 14 years. IQs ranged between 55 and 75. Children matched with teacher-referred child of same children with equivalent factor score in pre-assessments.	Between subjects design.	Sound Linkage programme. Each individual session 35 minutes long, 12 week programme, and 48 teaching sessions. *4 sessions a week.* Book reading, letter names and sounds, phonological awareness training, writing sentences, and fluency. Delivered by class teachers.	1. MLD group compared against a group of children with dyslexia; the latter group performed significantly better in word reading. 2. MLD children progressed from a reading age of 6.1 to 6.5 years.	Sound linkage test of phonological awareness. Burt word reading test.	16

Ref: 25 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Hedrick, Katims, and Carr (1999)	9 participants, mean age = 9 years 8 months. 7 had diagnosis of mild mental retardation. IQs ranged between 40 and 76 (available for 7 children). The classroom was a self-contained alternative learning environment in a US school.	Single subject design.	Four Blocks Framework. A literacy curriculum. The class teacher divided school day into 45 min segments of group instruction to support new curriculum. Basal block: reading text and comprehension Literature block: reading for pleasure Word block: sight words and phonics Writing block: writing sentences 3 hours per day group input over academic year.	1. Each student made gains from pre- to post-test on TERA-2. 2. Each student made measurable progress on Brigance. 3. All students showed progress on Analytic reading inventory.	Brigance Diagnostic Comprehensive Inventory of Basic Skills Test of Early Reading Ability -2 Analytical reading inventory Story retellings	16

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Ref: 26 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
O'Connor, Notari-Syverson and Vadasy (1998)	80 participants in kindergarten, aged between 5 and 6 years. 12 classified as having mild mental retardation 5 kindergarten classes in the US: 2 general classes, 1 class of children repeating the year, and 2 special education classes.	Between subjects group design.	6 month intervention delivered by class teachers. Sessions of 5 to 15 minutes in groups of 3 to 6 children in special education classes, done in whole class groups for the general classes. 1st and 2nd: word and syllable awareness 3rd and 4th: rhyming, first sound isolation, onset-rime blending 5th and 6th: letters and sounds added to phonological activities Macmillan reading curriculum – included letter names and sounds, daily story reading, limited writing, book discussion. This study followed up participants at end of 1st grade.	Original study did not analyse outcomes for children in special education classes. 1. Not a significant difference between children with disabilities in general classes and those in special classes at the end of 1 year. 2. For children with learning disabilities and mild mental retardation, the treatment continued to show significant effects.	Woodcock Johnson Tests of Achievement subtests: 1. letter word identification 2. word attack 3. dictation Phonological segmentation test	21

Ref: 27 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Boyle and Walker-Seibert (1997)	9 participants aged between 8 and 9 years from US school. 7 had learning disabilities, and 2 were classed as having educable mental retardation. IQs ranged between 62 and 92. Students selected who knew at least 80% of phonemes already.	Single subject multiple baseline design across students was used.	Intervention took place over 12 weeks, sessions were 30 to 50 minutes long, groups of 3 students. Phonological awareness strategy incorporated segmenting and blending skills. Delivered by secondary investigator.	1. All students improved on all the measures, exception being subject 4 on auditory discrimination subtest. 2. Training in phonological awareness improves ability to blend and segment phonetically regular words and nonsense words	Letter Sound Recognition pre-test. Curriculum-based probe of monosyllabic and multisyllabic words. Blending test Segmenting test Stanford Diagnostic Reading Test Generalisation passages	12

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Ref: 28 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
O'Connor, Notari-Syverson, and Vadasy (1996)	107 participants aged 5 to 6 years. Portion classified as having mild mental retardation 5 kindergarten classes in the US: 2 general classes, 1 class of children repeating the year, and 2 special education classes. 17 children in self-contained classes for special education.	Between subject design.	At the beginning of the year, all kindergarten classes in the district used the Macmillan reading curriculum that taught: letter names and sounds, daily story reading, limited writing, book discussion. Over 6 months, sessions of 5 to 15 minutes in groups of 3 to 6 children in special education classes, done in whole class groups for the general classes. Delivered by school staff. Control classes used same reading curriculum but did not practice auditory blending, segmenting, or selecting letters to represent sounds.	Children in self-contained classes had no control group and not included in some analysis. 1. Children in self-contained classes made larger blending and segmenting gains than peers in integrated classes although difference not significant.	Curriculum measures: Sound repetition Rapid letter naming Syllable deletion Blending First sound Segmenting Rhyme production Woodcock Johnson Tests of Achievement subtests: 1. reading 2. writing	18

Ref: 29 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
O'Connor, Jenkins, Leicester, and Slocum (1993)	47 participants, aged between 4 and 6 years. Had developmental delays including mental retardation. Children who scored 30% or more in phonological category on pre-tests were eliminated from subject pool. US pre-school.	Between subjects design. Randomised block design: assigned children to 1 of 3 treatments or control group.	Taught 13 phonemes and 71 assembled real words. 7 weeks of instruction in groups of 3 to 5 children. Took place 4 times a week for 10 minutes per day. Taught by 3 graduate students.	1. Blending separated sounds, blending group performed best. On blending continuous sounds, blenders and segmenters did best. 2. Segmenting group performed best at this task. 3. Rhyming group performed best at this task. 4. Training in one area did not lead to improvement in others.	Phonological tests: 1. rhyming 2. blending 3. segmenting Mastery tests which were samples of 3 items from taught items of each of 3 tasks.	18

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Ref: 30 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
O'Connor, Jenkins, Cole, and Mills (1993)	81 participants aged 6 years old. Transitional kindergarten classrooms in US. 49% of children had delayed cognitive development. No significant differences between two treatment groups.	Between subjects design.	Reading lessons for 30 minutes each day in groups of 2 to 4 with class teacher over academic year. This study reports data from 4 years. Randomly assigned by classroom to DI Reading or Superkids. DI Reading: Letter sounds, digraphs, blending, and story reading. Superkids: Sounds introduced in initial, final, and medial positions, blending words, writing, and spelling. Also administered PIAT in spring of 1st grade, a year after began treatment.	Post-hoc analysis to compare participants on how far they progressed through programs. 1. Advanced DI treatment group outperformed limited DI treatment group. No such difference for advanced and limited superkids treatment group. But can't be sure that individual characteristics of Ps who did more of intervention aren't affecting results. 2. No significant treatment differences on reading recognition or comprehension between 2 groups.	Test of Early Reading Ability. California Achievement Test reading portion. PIAT sub-tests: 1. reading recognition 2. reading comprehension	17

Ref: 31 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Polloway et al. (1986)	41 participants classified as educable mentally retarded in grades 6 to 12. Enrolled in special education programs in US schools in self-contained classes. IQs ranged between 44 and 75. Also comparison group of 78 participants with learning disabilities, IQs ranged between 74 and 108. 1981-1982 was teaching as normal comparison 1982-1983 was Corrective Reading Program.	Within subjects design.	Corrective Reading Program: Decoding Series Daily lessons of 45 minutes. Delivered by class teachers over 1 school year. Level A – blending, rhyming, sounding out, word and sentence reading. Level B – letter and word discriminations, letter combinations, story reading, questions. Level C – students who have mastered basic decoding skills and ready to decode wide variety of words and sentence constructs All educable mentally retarded students who begin in Level A completed it, a few continued to Level B.	1. Significant difference between achievement scores in recognition and comprehension for CPR year compared to comparison year. 2. No significant main effects on comparison year suggested LD and EMR students responded similarly to teaching as normal. LD students improved at greater rate on CPR.	PIAT subtests: 1. reading recognition 2. reading comprehension	17

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Ref: 32 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Blackman, Burger, Tan, and Weiner, (1982)	34 participants classified as educable mentally retarded. Selected from a US school. Assigned to experimental and control groups.	Between subjects design.	ABDs of reading – a decoding program developed for learning disabled children. Emphasises phonemic analysis and blending prior to visual decoding skills. Taught over 25-week period – November to May. Two half-hour group sessions a week. Delivered by school staff. Treatment group also had training on a series of tasks designed to facilitate use of cognitive strategies: chunking, overt rehearsal, sorting, and blending.	1. The cognitive strategy training did not accelerate acquisition of decoding skills. 2. Both made statistically significant gains in reading measures with exception of: sequencing and syllable synthesis and analysis	Wide Ranging Achievement Test: 1. reading section ABD curriculum measures.	15

Ref: 33 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Booth, Hewitt, Jenkins, and Maggs (1979)	12 participants aged between 8 and 14 years. This group have been involved in Distar Language and Reading Programs for 4 to 5 years. School in Australia	Single subject design.	Distar language and reading programs. Daily instruction using phonics method.	1. The results of the 5 year study strongly indicate that the children who have been on all the levels of the Distar language and reading programs demonstrated mastery of most of the basic literacy skills.	Distar Mastery in Language and Reading subtests. Neale Analysis of Reading Ability Schonell Word Recognition Test	12

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Ref: 34 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Fink and Sandall (1978)	4 handicapped children and 8 non-handicapped children. 3 diagnosed with Down Syndrome, 1 with cerebral palsy. All children enrolled in an integrated pre-school classroom.	Single subject design.	Distar Reading I. 20 minute sessions each school day, delivered by teachers. Reading instruction was initially conducted in small groups for 60 sessions, and later individually for 25 sessions.	1. For the small sample under study, integrated instruction was feasible and beneficial for all children.	Wide Ranging Achievement Test: Level 1 reading subtest. Post-tests done at end of group phase, and at end of individual tutorial phase. Rate of skill acquisition.	16

Ref: 35 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Vadever, Maggart, and Nasser (1976)	107 participants from Australian schools. 15 classes were randomly assigned to 3 reading programs. 29 in Edmark group (mean IQ = 66.86), 45 in Merrill group (mean IQ = 63.80), and 33 in Sullivan group (mean IQ = 65.00). Students selected who recognised fewer than 50 words on pre-test.	Between subject design.	Emark: whole-word approach. Requires one-to-one instruction. Merrill: places emphasis on learning words in simple word families, then reading words in sets, sentences, and stories. Sullivan: emphasis sound-symbol relationships which can be generalised to phonetically regular words. Delivered by class teachers.	1. Participants in Edmark program read more words at post-test than Sullivan children. 2. Also a significant difference between Edmark and Merrill groups favouring Edmark.	50 and 150 words at pre and post-test.	12

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Ref: 36 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Bracey, Maggs, and Morath (1975)	6 participants aged between 7 and 14 years. IQs ranged from 30 to 40. Classified has having moderate mental retardation and from Hospital School in Australia.	Single subject design.	Distar Reading Level 1 Program. Teaches blending, rhyming, written symbols. Delivered by class teacher to group of 6 students. Daily lessons of 15 to 30 minutes. 5 children began reading program in July 1973. The 6th child began in February 1974. First pre-tests administered in February 1974.	1. Significant improvements in areas of blending and sounds.	Curriculum Mastery tests: 1. blending – say it fast 2. blending – spelling by sounds 3. sounds 4. reading sounds and words	12

Ref: 37 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Joseph (2002)	3 participants aged 9-10 years. Mild mental retardation. Students from a US school. Classroom for children with MR and developmental delays. Students included based on observed difficulties reading CVC words, and performance in screening test of reading proficiency.	Multiple baseline design, single subject design.	Daily sessions of 40 minutes individually delivered by instructor. Word box technique: h/a/t letters sorted into 3 boxes. Saying sounds of letters, and writing word.	1. All 3 participants' demonstrated increases in performance relative to baseline conditions for word reading and spelling. All performances 100% accurate for last 2 intervention sessions.	Number of words read correctly from probe sheet.	15

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Ref: 38 Author(s) Year	Participants	Design	Intervention (type, duration, frequency, deliverer)	Key Results	Reading Measures	Score
Tyler, Hughes, Wilson, et al. (2015)	6 participants aged 7 to 14. Participants described as having mild to moderate intellectual and developmental disabilities. Special school in Wales.	Single-case design.	Completed all 80 episodes of Headsprout Early Reading – averaged between 1 and 3 sessions per week, working individually. Phonics, fluency, vocabulary, and book reading additional activities. Took participants between 24 and 79 school weeks to complete all 80 episodes. Sessions between 15 and 20 minutes. Intervention implemented by class teachers.	Most notable gains in PSF, and NWF. 5 of 6 participants' shoed improvements in WRAPS.	DIBELS: 1. ISF 2. PSF 3. letter naming fluency 4. NWF 5. WUF WRAPS	20

Appendix B Modified Downs and Black (1998) Checklist

Author and Year:

Item	Criteria	Possible Answers	Score
Reporting			
1	*Is the hypothesis/aim/objective/research questions of the study clearly described?*	Yes	1
		No	0
		Unable to determine	0
2	*Are the main outcomes to be measured clearly described in the Introduction or Methods section?* If the main outcomes are first mentioned in the Results section, the question should be answered no.	Yes	1
		No	0
		Unable to determine	0
3	*Are the characteristics of the participants included in the study clearly described?* In cohort studies and trials, inclusion and/or exclusion criteria should be given. In case-control studies, a case-definition and the source for controls should be given. Participants should be described by level of learning difficulties or IQ level.	Yes	1
		No	0
4	*Is the participants' typical education described?* For example, in a special school or receiving some education in mainstream classes and some in special education classes?	Yes	1
		No	0
5	*Has the effect of the intervention been compared to a control?* Score Yes if the study has used a group design and has used a control group, or if the study has used a single-subject design and participants' performance at the end of the intervention is compared to their baseline levels.	Yes	1
		No	0
6	*Are the interventions of interest clearly described?* Treatments and placebo (where relevant) that are to be compared should be clearly described in terms of skills targeted in the intervention, the length of each session, the number of sessions per week, and the length of the intervention.	Yes	1
		No	0

7	*Are the distributions of principal confounders in each group of subjects to be compared clearly described?* Principal confounders are: IQ, age, other interventions, teaching as usual, and existing reading skills. Where a study clearly describes the distributions of confounders and makes an attempt to co-vary them out, score Yes. If a study only describes cofounders, score Partially.	Yes	2
		Partially	1
		No	0
8	*Is there a follow-up measure at some time after the end of the intervention to see how skills maintain over time?* For example, assessing skills 2 months after the end of intervention.	Yes	1
		No	0
9	*Are the main findings of the study clearly described?* Simple outcome data (including denominators and numerators) should be reported for all major findings so that the reader can check the major analyses and conclusions. (This question does not cover statistical tests which are considered below).	Yes	1
		No	0
10	*Does the study provide estimates of the random variability in the data for the main outcomes?* In non-normally distributed data the interquartile range of results should be reported. In normally distributed data the standard error, standard deviation or confidence intervals should be reported. If the distribution of the data is not described, it must be assumed that the estimates used were appropriate and the question should be answered yes.	Yes	1
		No	0
11	*Have all important adverse events that may be a consequence of the intervention been reported?* This should be answered yes if the study demonstrates that there was a comprehensive attempt to measure adverse events. Adverse events include participants' behaviour and engagement with the intervention.	Yes	1
		No	0
12	*Have the characteristics of participants lost to follow-up been described?* This should be answered yes where there were no losses to follow-up or where losses to follow-up were so small that findings would be unaffected by their inclusion. This should be answered no if a study does not report the number of patients lost to follow-up or does not include a follow up.	Yes	1
		No	0
13a	*If the study has a group design, does it report exact actual probability values (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?*	Yes	1
		No	0

13b	*If the study has used a single- subject design, has used either a visual analysis or Reliable Change Index to analyse the data?*	Yes	1
		No	0
External Validity			
14	*Were the subjects asked to participate in the study representative of the entire population from which they were recruited?* The study must identify the source population for patients and describe how the patients were selected. Participants would be representative if they comprised the entire source population, an unselected sample of consecutive patients, or a random sample. Random sampling is only feasible where a list of all members of the relevant population exists. Where a study does not report the proportion of the source population from which the patients are derived, the question should be answered as unable to determine.	Yes	1
		No	0
		Unable to determine	0
15	*Were those subjects who were prepared to participate representative of the entire population from which they were recruited?* The proportion of those asked who agreed should be stated. Validation that the sample was representative would include demonstrating that the distribution of the main confounding factors was the same in the study sample and the source population.	Yes	1
		No	0
		Unable to determine	0
16	*Were the staff, places, and facilities where the participants received the intervention representative of the interventions the majority of students receive?* For the question to be answered yes the study should demonstrate that the intervention took place in a school setting and was delivered by school staff. The question should be answered no if, for example, the intervention was undertaken in a specialist centre.	Yes	1
		No	0
		Unable to determine	0
Internal Validity – Bias			
17	*Was an attempt made to blind study subjects to the intervention they have received?* For studies where the participants would have no way of knowing which intervention they received, this should be answered yes.	Yes	1
		No	0
		Unable to determine	0
18	*Was an attempt made to blind those measuring the main outcomes of the intervention?*	Yes	1
		No	0
		Unable to determine	0
19	*If any of the results of the study were based on "data dredging", was this made clear?* Any analyses that had not been planned at the outset of the study should be clearly indicated. If no retrospective unplanned subgroup analyses were reported, then answer yes.	Yes	1
		No	0
		Unable to determine	0

20	*Do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?* Where follow-up or time between pre and post measures was the same for all study participants, the answer should be yes. If different lengths of follow-up were adjusted for by, for example, survival analysis the answer should be yes. Studies where differences in follow-up are ignored should be answered no.	Yes	1
		No	0
		Unable to determine	0
21	*Were the statistical tests used to assess the main outcomes appropriate?* The statistical techniques used must be appropriate to the data. For example, nonparametric methods should be used for small sample sizes. Where little statistical analysis has been undertaken but where there is no evidence of bias, the question should be answered yes. If the distribution of the data (normal or not) is not described it must be assumed that the estimates used were appropriate and the question should be answered yes.	Yes	1
		No	0
		Unable to determine	0
22	*Was compliance with the intervention/s reliable?* Where there was non-compliance with the allocated intervention or where there was contamination of one group, the question should be answered no. For studies where the effect of any misclassification was likely to bias any association to the null, the question should be answered yes.	Yes	1
		No	0
		Unable to determine	0
23	*Were the main outcome measures used accurate (valid and reliable)?* For studies where all of the outcome measures are standardised score Yes. If the study has used both standardised outcome measures and curriculum-based probes, score 1. If the study has only used curriculum-based probes, score 0.	Yes	2
		Partially	1
		No	0
Internal Validity – Confounding (Selection Bias)			
24	*Were the participants in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?* For example, participants for all comparison groups should be selected from the same school. The question should be answered unable to determine for cohort and case-control studies where there is no information concerning the source of patients included in the study.	Yes	1
		No	0
		Unable to determine	0

25	*Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?* For a study which does not specify the time period over which patients were recruited, the question should be answered as unable to determine.	Yes	1
		No	0
		Unable to determine	0
26	*Were study subjects randomized to intervention groups?* Studies which state that subjects were randomized should be answered yes except where method of randomization would not ensure random allocation. For example alternate allocation would score no because it is predictable.	Yes	1
		No	0
		Unable to determine	0
27	*Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?* This question should be answered no for trials if: The main conclusions of the study were based on analyses of treatment rather than intention to treat; the distribution of known confounders in the different treatment groups was not described; or the distribution of known confounders differed between the treatment groups but was not taken into account in the analyses. In non-randomized studies if the effect of the main confounders was not investigated or confounding was demonstrated but no adjustment was made in the final analyses the question should be answered as no	Yes	1
		No	0
		Unable to determine	0
28	*Were losses of participants to follow-up taken into account?* If the numbers of participants lost to follow-up are not reported, the question should be answered as unable to determine. If the proportion lost to follow-up was too small to affect the main findings, the question should be answered yes. If the study did not follow-up participants after the end of the intervention then score as a No.	Yes	1
		No	0
		Unable to determine	0
29	*If the study used a group design, did it have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%?*	Yes	1
		No	0
		Unable to determine	0

Appendix C Manualised Interventions

Name of Intervention	Studies Using It	Reference of Intervention	Brief Description
Accessible Literacy Learning Curriculum	1	Light and McNaughton (2009)	A comprehensive literacy program for students with significant disabilities including communication disorders. The curriculum offers brief and repetitive scripts and includes instructor responses for both correct and incorrect student responses. The letter-sound correspondence component of the ALL Curriculum was the primary focus in study 1.
Early Literacy Skills Builder (ELSB) and Early Reading Skills Builder (ERSB)	2 (ERSB) 12 18 (ELSB)	Browder, Gibbs, Ahlgrim-Delzell, L., Courtade, and Lee (2007)	The beginning levels of the ERSB were designed to overlap the phonemes and sight words taught in the Early Literacy Skills Builder: phoneme identification, blending, decoding for picture-word matching tasks. The ERSB curriculum blended iPad-based technological speech supports using GoTalk Now and systematic instruction using time delay and shaping/fading of model prompts of the ERSB program.
Road to Code	3 11	Blachman et al. (2000)	The intervention consists of three daily lesson components. First, students complete a ‘‘Say-It-and-Move-It’’ (SIMI) activity in which the instructor provides support in phoneme blending and segmenting. Next, students participate in an activity that focuses on learning the name and most common sound of letters. Finally, students play a variety of games to practice PA skills including isolating, blending, sorting, and matching sounds.
Early Interventions in Reading	4 6 13 14 15	Allor and Mathes, (2012); Mathes and Torgesen (2005a, 2005b)	Each lesson includes 8-10 activities: word level, decoding, recognising sight words, paired and individual reading, comprehension, vocabulary instruction.
Phonics Component of the Integrated Literacy Curriculum	7	Alberto and Fredrick (2007)	The Phonics Component includes Initial Phonics and Functional Phonics. Initial phonics focused on: initial emergent literacy and phonological-awareness skills, to individual letter-sound correspondences to be blended and telescoped into CVC words, and to provide many opportunities to generalize blending and telescoping skills to untaught, CVC words. The purpose of Functional Phonics was to build upon Initial Phonics by emphasizing instruction of common, functional community words and phrases.

Appendix C

Name of Intervention	Studies Using It	Reference of Intervention	Brief Description
PCI Reading Program	8	PCI Educational Publishing. (2007)	PCI Reading Program: each sight word lesson was broken into four parts: a learn-the-word activity, a trace-the-word activity, hands-on practice, and independent practice. The PCI Program was paired with activities of phonological awareness, comprehension and vocabulary instruction.
Literacy By Design	10	Coyne et al. (2012)	Creating e-books and instruction lessons on computer targeting phonemic awareness, phonics, vocabulary, fluency, and comprehension.
Road to Reading	11	Blachman and Tangel (2008)	The goals of this program are to enhance accurate and fluent word identification. The program focuses on increasing student knowledge of the alphabetic principle to provide support for reading comprehension.
Corrective Reading Program	20 22 31	Engelmann et al. (1980)	Level A teaches basic word recognition skills such as blending, rhyming, sounding out, and word and sentence reading.
Sound Linkage	24	Hatcher (1994)	The emphasis of the Sound Linkage programme is on training phonological awareness (word, syllable, rhyme and phoneme awareness and manipulation) and grapheme/phoneme linkage skills within a comprehensive and structured reading and writing programme that is tailored to the needs of the individual child.
Four Blocks Framework	25	Cunningham et al. (1999)	The Four Blocks in a multi-method, multi-level language arts program. It provides a balance between more traditional reading instruction and a contemporary, constructivist orientation toward literacy instruction. Guided reading, reading and writing own books, teaching grapheme-phoneme correspondences, and building symbols into words.
ABDs of Reading	32	No reference given	The program emphasises auditory skill components central to reading, phonemic analysis and blending, alongside introduction of a limited number of phoneme-grapheme correspondences.
Distar Language and Reading Program	33 34 36	Booth (1978)	The Distar language and reading programs cover the essential academic skills needed to approximately a third grade level in the normal school.
Sullivan reading program	35	Buchanan (1968)	The Sullivan series stresses the English sound-symbol relationships which enable the child to generalise to other phonetically regular words.

Name of Intervention	Studies Using It	Reference of Intervention	Brief Description
Headsprout Early Reading	38	Layng et al. (2003)	This is a computerised, online reading intervention. It consists of 80 episodes, each taking approximately 20 minutes to complete. The programme teaches letter sound knowledge, and reading words through blending sounds together. It has elements of fluency and comprehension through book reading activities.
Direct Instruction Reading Mastery	30	Engelmann & Bruner (1974)	Focuses on letter sounds, digraphs, blending, and story reading.
Superkids	30	Rowland (1983)	Sounds introduced in initial, final, and medial positions. Children taught to blend, write, and spell words.

Appendix D Standardised Reading Measures

Name of Standardised Measure	Studies Using It	Reference of Intervention
Woodcock Johnson III	3	Woodcock et al. (2001)
The Comprehensive Test of Phonological Processing (CTOPP)	4 7 13 15 23	Wagner et al. (1999)
Test of Word Reading Efficiency (TOWRE)	4 13 15	Torgesen et al. (1999)
Dynamic Indicators of Basic Early Literacy Skills (DIBELS)	4 6 11 13 14 15 19 38	Good and Kaminski (2002)
Woodcock Reading Mastery Test-Revised	8 16	Woodcock (1998)
Rigby reading benchmark assessments	8	Nelley and Smith (2000)
Non-Verbal Literacy Assessment (NVLA)	12 18	Ahlgrim-Delzell et al. (2008)
Woodcock Language Proficiency Battery - Revised	4 13 15 18	Woodcock (1991)
Woodcock Johnson Psych-Education Battery	23	Woodcock et al. (2000)
Brigance Diagnostic Comprehensive Inventory of Basic Skills	25	Brigance (1983)
Test of Early Reading Ability – second edition	25	Reid et al. (1989)
Analytic Reading Inventory	25	Woods and Moe (1995)

Appendix D

Name of Standardised Measure	Studies Using It	Reference of Intervention
Woodcock-Johnson III Reading Achievement Battery	19	Mather and Woodcock (2001)
Woodcock Johnson Tests of Achievement	26 28	Woodcock and Johnson (1990)
Stanford Diagnostic Reading Test	27	Karlsen and Gardner (1985)
Test of Early Reading Ability	30	Reid, Hresko, and Hammill (1981)
California Achievement Test	30	California Achievement Test (1985)
Peabody Individual Achievement Test (PIAT)	30 31	Dunn and Markwardt (1970)
Wide Ranging Achievement Test	32 34	Jastak et al. (1965)
Neale Analysis of Reading Ability	33	Neale (1966)
Word Reading and Phonic Skills Test (WRAPS)	38	Carver and Moseley (1994)
Burt Word Reading Test	24	Scottish council for research in education (1976)
Woodcock Johnson III Diagnostic Reading Battery	9	Schrank et al. (2004)
Woodcock Johnson III Tests of Achievement	10	Woodcock, McGrew, and Mather (2001)

Appendix E Studies Rejected After Full-Texts Assessed

Reference	Reason Rejected
Colozzo, McKeil, Petersen, and Szabo (2016)	Intervention took place outside of school in a specialist centre for children with Down Syndrome.
Lee and Rispoli (2016)	Paper does not make it clear that participants have learning difficulties.
Chai, Vail, and Ayres (2015)	Paper does not make it clear that participants have learning difficulties.
Keeter and Bucholz (2012)	Stories were read to improve behaviour.
Cleave, Bird, and Bourassa (2011)	Participants attended a mainstream school.
Baylis and Snowling (2011)	Participants attended a mainstream school.
Cologon, Cupples, and Wyver (2011)	Intervention took place at home.
van Bysterveldt, Gillon, and Moran (2006)	Intervention run by parents.
Cupples and Iacono (2002)	Intervention took place outside of school in a specialist centre for children with Down Syndrome.
Katims (1991)	No direct teaching, only given extra time in the library listening to stories.
Howe (1984)	Not enough information of participants and intervention included.
Gersten (1982)	Reading only measured at post-test.
Vadever et al. (1976)	Intervention taught reading using a contrived alphabet.
University of Georgia (1975)	Paper was simply a description of teaching method.
Vandever and Neville (1974)	Letter cues as aids to prompt word recognition.
Neville and Vandever (1973)	Intervention taught reading using a contrived alphabet.

Appendix F Headsprout Early Reading Scope and Sequence

Episode	Sounds and Words Taught	Skills Addressed
1	/s/, /ee/, *see*	segmenting, blending, decoding
2	/v/, /n/, /an/	segmenting
3	*Vee, San, van*	blending, decoding
4	*the*	decoding, word reading
5	review of learned elements	decoding, word reading, story reading, reading comprehension
6	/c/, /l/, /cl/	segmenting
7	*can, Lee*	segmenting, blending, capitalization, decoding, word reading
8	/sl/, /sn/, /fr/, /f/, /r/, /fl/, /cr/	segmenting
9	*Fran, feels*	segmenting, blending, decoding, capitalization, word reading
10	*fan, ran*	blending, decoding, word reading, sound-production firming
11	review of learned elements	blending, decoding, sentence reading, story reading, reading comprehension
12	*I*, *and* (as word), *out* (as word)	word reading, sentence reading, reading comprehension
13	/sp/, /pl/, /ip/, /p/, /pr/	segmenting
14	*flips, sand, sleeps, Pip*, /and/ (as sound)	blending, decoding, capitalization, word reading
15	review of learned elements	blending, word reading
16	*plan, reef, feel, Clee*	capitalization, decoding, word reading
17	review of learned elements	blending, decoding, word reading
18	review of learned elements	blending, decoding, sentence reading, story reading, reading comprehension
19	/sh/, /ish/	segmenting, sound-production firming
20	/out/ (as sound)	segmenting, blending, decoding
21	*shouts, fish*	decoding, word reading, segmenting
22	*sheep, ship*	blending, decoding, word reading
23	review of learned elements	segmenting, blending, decoding, punctuation, sentence reading, story reading, reading comprehension

24	/h/, *old* (as word), *is*, *his*	segmenting, word reading
25	/old/ (as sound), *folds, hand, cold*	blending, decoding, word reading
26	*hands, Scout*	sound production firming, blending, decoding, word reading, capitalization, sentence reading, reading comprehension
27	/sw/, /w/, /ing/	segmenting
28	*wings, swing*	blending, decoding, word reading
29	*fling, holds*	blending, decoding, word reading, sentence reading, reading comprehension
30	*peel, wing*	word reading, punctuation, story reading, reading comprehension
31	/er/, /t/, /tr/, /st/	segmenting
32	*her, plant, sweet*	blending, decoding, word reading
33	*Trish, sweep*	capitalization, blending, decoding, word reading
34	*standing*	sound-production firming, blending, decoding, word reading, nonsense-word decoding, sentence reading, reading comprehension
35	*could, would, should*	sound-production firming, word reading, blending, decoding, nonsense-word decoding
36	review of learned elements	word reading
37	*tree, sting, feet*	blending, decoding, word reading
38	*wish, sing*	sound-production firming, blending, decoding, word reading, nonsense-word decoding
39	*told*	sound-production firming, blending, decoding, word reading, sentence reading, reading comprehension
40	*hold, she, he*	word reading, story reading, reading comprehension
41	/ike/, /ake/, *like, lake*	sound production firming, discrimination practice, sounding out
42	*flake, hike*, /k/	discrimination practice and fluency, sounding out, sound-production firming, word-production firming, comprehension (sentence building)
43	*Swish, pan, cakes, pancakes, likes, take*	sound-production firming, sounding out, discrimination fluency, word-production firming, story reading, reading comprehension
44	/m/, /b/, /bl/, /d/	discrimination practice, sound-production firming, discrimination fluency
45	*bringing, seek, needs, makes, bake, dish, Mike*, /br/, /dr/	sound-production firming, discrimination practice, sounding out, discrimination fluency

46	*slips, Blake, a, some, blank, drank, flipper*	word-production firming, sounding out, capitalization, discrimination fluency
47	*brings, takes*	discrimination fluency, word-production firming, sentence building, story reading, reading comprehension
48	*wood, soon, good, tool, noon, took, food, foot*, /g/, /um/, /oo/ (both as in *soon* and as in *good*)	word-production firming, sounding out
49	*work, cooking, spoon, for, zoom, sank*, /z/, /or/	sound-production firming, discrimination fluency, sounding out
50	*come, are, in, book, looks*	discrimination fluency, word-production firming, sentence building, story reading, reading comprehension
51	*said, wants, on, sang, long*	nonsense-word decoding, discrimination fluency, word-production firming, sounding out, sentence fluency
52	*Tim, look, jumps, jump, moon, too, soon*, /j/, /im/	sound-production firming, discrimination fluency, sounding out, word-production firming, story reading, reading comprehension
53	*one, two, you, word, drink, about*, /in/ (as sound)	discrimination fluency, word-production firming, sounding out, sentence fluency, comprehension (fill-in-the-blank), sentence building, vocabulary building
54	/ill/, /ay/, /thr/, /th/	sound-production firming, discrimination fluency
55	*playing, thump, play, may, three, Jill, grand*, /gr/	capitalization, sounding out, word-production firming, story reading, reading comprehension
56	*review of learned elements*	sentence fluency, comprehension (fill-in-the-blank), sentence building
57	*sick, hides, more, plate, lid, hat, please*, /at/, /ide/, /id/, /ate/	discrimination practice, sound-production firming, sounding out, vocabulary building
58	*hide, hid*	word-production firming, story reading, reading comprehension, sentence building
59	*have, rid, we, ride, Dipper, Spike, skate, has, sat*	sounding out, vocabulary building, word production firming, capitalization, story reading, sentence fluency, reading comprehension, sentence building
60	*big, fit, got, not, little, box, sit, sink, sitting*, /ig/, /ox/, /ot/, /it/	sound-production firming, sounding out, word production firming, story reading, reading comprehension
61	*hoop, spin, think, to, Jingles, do, hot, no, fox, go, pig*	sounding out, vocabulary building, word-production firming, sentence building, capitalization, story reading, sentence fluency, reading comprehension

62	*thank, supper, did, must, but, cups, okay*, *up, us*, /ut/	sound-production firming, sounding out, word-production firming, comprehension (fill-in-the-blank), vocabulary building, story reading, reading comprehension
63	*Strummer, that, digging, there, seen, where, dust, here, butter, guitar*, /str/	sounding out, vocabulary building, word-production firming, story reading, sentence fluency, reading comprehension
64	*better, went, again, talking, help, pouted*, /en/, /ed/, /el/, /et/	comprehension (fill-in-the-blank), sound-production firming, sounding out, word-production firming, sentence building, vocabulary building
65	*shell, tied, wanted, problem, looked, felt, sad*, /ad/	word-production firming, story reading, reading comprehension, vocabulary building
66	*triangle, drums, band, played, what, horn, who, me, with*	nonsense-word decoding, vocabulary building, word-production firming, story reading, sentence fluency, reading comprehension
67	*live, first, does, far, time, Gus, give*, /ime/, /ar/, /ir/	sound-production firming, discrimination practice, sounding out, word-production firming, vocabulary building
68	*cookie, ice, bus, bird, get, card, Sprout, dime, going, star*, /spr/	sounding out, word-production firming, story reading, reading comprehension, vocabulary building
69	*cannot, fly, because, so, they, say, asked, swim, fins, my, why*, /as/	comprehension (fill-in-the-blank), vocabulary building, word-production firming, story reading, sentence fluency, reading comprehension
70	*down, cow, glow, crow, brown, how, blow, snow*, /ow/ (both as in *snow* and as in *how*)	word-production firming, sounding out, sentence building
71	*falls, tall, high, wow, low, might, when, hard, Bug*, /ug/, /igh/, /all/ (as a sound), /wh/	sound-production firming, sounding out, word-production firming, story reading, reading comprehension
72	*were, throw, balls, away, biggest, sky, four, was, than, home, small, throwing, from, them, saw, bigger*, /em/, /est/	vocabulary building, word-production firming, sentence building, story reading, sentence fluency, reading comprehension
73	*orange, read, rainbow, name, each, blue, town, yellow, color*, /ame/, /y/, /ch/, /ea/	nonsense-word decoding, sound-production firming, sounding out, comprehension (fill-in-the-blank), sentence building, vocabulary building
74	*eat, years, cheese, game*, *am*, *six, story*, /am/, /ix/	sentence building, word-production firming, capitalization, story reading, reading comprehension
75	*catch, life, planet, very, yes, Mars, be, fourth, us, sun, of, most, night*, /ife/, /es/, /un/	sounding out, vocabulary building, word-production firming, story reading, sentence fluency, reading comprehension

76	*lucky, pick, tricks, jack, tell, quack, quick, let, duck, back*, /uck/, /qu/, /ack/, /ick/	discrimination practice, sound-production firming, sounding out, word-production firming, capitalization, story reading, reading comprehension
77	*friend, who's, magnifying glass, Zog's, Diner, Dipper's, dogs, know, hello, next, today, line, beans,* /ine/, /og/, /kn/, /ex/	sound-production firming, sounding out, word-production firming, story reading, reading comprehension, vocabulary building
78	*put, water, knock, start, dirt, find, grow, mine, green, seed, other, flower, kind, watered, pot*, /ind/, /ock/	sounding out, vocabulary building, word-production firming, story reading, sentence fluency, reading comprehension
79	*leaf, leaves, wet, space, wonder, rain, worm, ground, seven, weather, la la la, tired, five, buildings, much, count, whew, lot, new, Bernadette*, /ou/, /ire/, /ace/, /ew/, /ai/	sound-production firming, sounding out, word-production firming, capitalization, story reading, reading comprehension, vocabulary building
80	*putting, that's, aren't, jungle, job, almost, hasn't, friends, possibly, use, become, she's, words, probably, people, reader, I'd, cards, tunes, their, worked, I'm, sea, isn't, write, learned, important, I'll, we're, terrific*	contractions, sounding out, sentence building, vocabulary building, word-production firming, story reading

Appendix G Ethical Approval

Find Someone Options

Your Ethics Submission (Ethics ID:18538) has been reviewed and approved

ERGO [ergo@soton.ac.uk] Actions

To: Herring E.

22 December 2015 13:28

Submission Number: 18538
Submission Name: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
This is email is to let you know your submission was approved by the Ethics Committee.

You can begin your research unless you are still awaiting specific Health and Safety approval (e.g. for a Genetic or Biological Materials Risk Assessment)

Comments
None
Click here to view your submission

ERGO : Ethics and Research Governance Online
http://www.ergo.soton.ac.uk

DO NOT REPLY TO THIS EMAIL

Appendix H Letters to Participants and Parents

H.1 Practice Pupil Parents Information Sheet

08.12.15 – V.1 ERGO Study ID number: 18538
Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.

Dear Parents/Carers,

I would like to invite your child to take part in a pilot project of a research study. I thought you might find the following information about the study helpful. Please do contact me if there is anything that is not clear or if there is anything you would like to know more about.

What is the purpose of this study?
The purpose of this study is to find out if phonics-based reading interventions can be used to support the development of reading skills in pupils with learning difficulties. In order to begin this research, I need to become fluent in using measures of phonemic awareness and word recognition. The pilot project will involve completing the following assessement measures with children in order to gain confidence: an initial sound fluency test, a phonemic segmentation fluency test, a nonword fluency test, a word use fluency test, and a word recognition test. These assessments will not be marked and no feedback on your child's performance will be offered.

Why has my child been invited?
I am inviting children of primary school age to take part in a pilot project, completing measures of phonemic awareness and word recognition in order that I can become fluent using the measures.

Does my child have to take part?
No your child does not have to take part, it is for you and your child to decide. If you would like your child to take part in this study, please sign and return the consent form attached to myself. If you agree for your child to take part they will still be free to withdraw at any time, without giving a reason, if they choose to do so.

What will happen to my child if they take part?
All children that agree to take part will work with me for between 15-30 minutes to complete five measures of phonemic awareness and word recognition. At the start of the session, all children will be provided with information about why I have asked them to participate and what my research project is trying to find out. Children will then be asked if they would like to take part in the study and to provide written consent if they are happy to take part.

What will happen if my child does not want to carry on with the study?
Children volunteer to take part. If at any point during the assessment measures they decide that they don't wish to take part any more, they are free to do so.

What are the possible disadvantages and risks of taking part?
I am aiming to make the session a pleasant opportunity for children but they may not find completing the assessment measures enjoyable. Should children become frustrated or upset, I will intervene by pausing the session and allowing them to leave if they wish to do so.

What are the possible benefits of taking part?
By helping me to become fluent using the assessment measures, I will be able to complete my research project investigating phonics-based interventions with pupils with learning difficulties. The information generated from this project may help inform decisions about who will benefit from phonics-based reading interventions and support the learning of children with learning difficulties in the future.

What will happen to the findings of the research study?
In this pilot phase of my research project there will be no findings because I will not be keeping any data from the assessment measures I use with children. After becoming fluent in these assessment measures I will then go on to complete the main part of my thesis working with children with learning difficulties. The ultimate aim is for the findings from the later study to be written up for my thesis, and communicated to staff at the school where the project will taking place. It is possible that these later findings may be presented in academic forums or submitted for publications in academic journals.

What if there is a problem?
If you have questions about your rights as a participant in this research, or if you feel that you have been placed at risk, you may contact the Chair of the Ethics Committee, Psychology, University of Southampton, Southampton, SO17 1BJ. Phone: +44 (0)23 8059 3856, email fshs-rso@soton.ac.uk

Will the results of the study be kept confidential?
All information collected during the assessments, such as answer booklets, will be securely destroyed. No information will be kept as the purpose of this is solely to help the researcher gain experience in completing the measures with children.

Who is organising and funding this research?
This study is organised by the University of Southampton alongside Emma Herring who, as a trainee educational psychogist, is funded by a doctoral studentship.

Who has reviewed this study?
This study has been reviewed and approved by the University of Southampton, Psychology Ethics Committee and University Research Governance Office. All necessary safeguarding checks and references have been successfully completed.

How can I contact the researcher if I would like further information about this study?
If you would like to find out more about my research please feel free to contact Emma Herring at the University of Southampton, Building 44a – Highfield Campus, University Road, Southampton, SO17 1BJ. (eh2g14@soton.ac.uk) or my research supervisor, Dr Hanna Kovshoff, Lecturer in Psychology, University of Southampton, h.kovshoff@soton.ac.uk

Thank you very much,
Emma Herring Trainee educational psychologist at the University of Southampton

H.2 Practice Pupil Parent Consent

CONSENT FORM (08/12/2015, V.1)

Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
Researcher name: Emma Herring
ERGO Study ID number: 18538

Please initial the box(es) if you agree with the statement(s): I have read and understood the information sheet (08.12.2015 v.1) and have had the opportunity to ask questions about the study	☐
I agree for my child to take part in this research project and agree for their data to be used for the purpose of this study	☐
I understand my child's participation is voluntary and I/they may withdraw at any time without my legal rights being affected	☐

Data Protection
I understand that information collected about my child during their participation in this study will be stored on a password protected computer and this information will only be used for the purpose of this study. All files containing any personal data will be anonymised.

Name of child (print name)…….

Signature of parent/carer/guardian……..

Date…….

H.3 Practice Pupil Parent Debrief

Debriefing Statement (08/12/2015, V.1)

Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
Researcher name: Emma Herring
ERGO Study ID number: 18538

Dear Parent/Carer,

Thank you for agreeing for your child to take part in this pilot project as part of my research. The purpose of this pilot project was for me to gain experience and become fluent at using measures of phonemic awareness and word recognition. Your child's contribution has helped me to develop my skills in using these measures so I can now apply them in my research project which will examine whether phonics-based reading interventions can increase reading skills in individuals with learning difficulties. No data will be kept from the session in which I worked with your child. If you have any further questions please contact me, Emma Herring, at eh2g14@soton.ac.uk. Thank you for helping me with my research.

Emma Herring,
Trainee Educational Psychologist, University of Southampton

If you have questions about your child's rights as a participant in this research, or if you feel that they have been placed at risk, you may contact the Chair of the Ethics Committee, Psychology, University of Southampton, Southampton, SO17 1BJ. Phone: +44 (0)23 8059 3856, email fshs-rso@soton.ac.uk

H.4 Practice Pupil Information Sheet

Participant Information Sheet (08.12.15 – V.1)
ERGO Study ID number: 18538
Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.

Please read this information carefully before deciding to take part in this research. If you are happy to participate you will be asked to sign a consent form.

What is the research about?
I am trying to find out if the computer programme Headsprout can help children learn to read. I am going to do some research to find out about this. Before I can start this project I need to learn to use some tools to measure children's reading skills.

Why have I been chosen?
I am asking children in primary school if they would like to work with me to complete the tools measuring reading skills. This will help me learn to use these tools so I can use them in my research project.

Do I have to take part?
No you do not have to take part, it is for you to decide if you would like to or not.

What will happen to me if I take part?
If you would like to take part in the project, you will be asked to provide written consent that you agree to take part. You will then work with me for between 15 to 30 minutes and complete five short tests. I will not mark the tests and I will destroy any answer booklets at the end of the session.

Are there any benefits in my taking part?
By helping me practice using the tests, I will gain experience and be able to start my research finding out about how if a computer programme can help children learn to read.

Are there any risks involved?
You may not enjoy completing the reading assessments but you can stop at any point if you would like to.

Will my participation be confidential?
After the session I will destroy the answer booklets and I will not keep any information from our work together.

What happens if I change my mind?
At any time you can change your mind and stop working with me.

Where can I get more information?
If you have any questions or aren't sure about any information on this sheet please ask me.

Thank you very much for reading this information sheet.

H.5 Practice Pupil Consent

CHILD CONSENT FORM (08/12/2015, V.1)

Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
Researcher name: Emma Herring
ERGO Study ID number: 18538

I have asked you to take part in my study about reading.

I am going to ask you to complete five short reading tests.

It is your choice if you would like to be a part of this session. If you feel uncomfortable and would like to leave, please let me know. It is ok if you feel that you would like to leave – no one will mind.

If you are happy to be a part of this, please write your name below.

Child's name ……

Date ……

H.6 Practice Pupil Debrief

Children's Debriefing Statement (08/12/2015, V.1)
Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
Researcher name: Emma Herring
ERGO Study ID number: 18538

Dear Participant,

Thank you for helping me with my project. I hope you enjoyed talking working with me.

I wanted to get better at using these tests so I would be able to start my research project looking at how children can learn to read using a computer programme.

If you have any questions about the project, or are worried about anything, please ask me or your parents.

Thank you
Emma

H.7 Parent Information Sheet

Parent Information Sheet (22.01.16 – V.2)
ERGO Study ID number: 18538
Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.

Dear Parents/Carers,
I would like to invite your child to take part in a research study. I thought you might find the following information about the study helpful. Please do contact me if there is anything that is not clear or if there is anything you would like to know more about.

What is the purpose of this study?
The purpose of this study is to find out if the phonics-based computer reading intervention called Headsprout Early Reading can be used to support the development of reading skills in pupils with learning difficulties. The study aims to investigate if not completing particular activities that children and teachers occasionally struggle to teach within Headsprout Early Reading can still lead to an improvement in children's phonic and word reading skills, and whether the intervention can be used with non-verbal children to support their reading development.

Why has my child been invited?
I am inviting children with learning difficulties, who have not used Headsprout Early Reading before, to take part in the study. Your child has been invited to take part because their school feel they may benefit from using Headsprout Early Reading programme.

Does my child have to take part?
No your child does not have to take part, it is for you and your child to decide. If you would like your child to take part in this study, please sign and return the consent form attached to school. If you agree for your child to take part they will still be free to withdraw at any time, without giving a reason, if they choose to do so.

What will happen to my child if they take part?
At school, all children who agree to take part will complete measures of phoneme awareness (the ability to identify the smallest unit of sounds in words), word use fluency, and word recognition with either myself or school staff as part of the school's normal assessment process. I would use this information to monitor their reading over the time they are completing the intervention.

The children will also work with me before the intervention begins so I can collect information about their letter knowledge, and time taken on a colour naming task. I will also give you and their teacher a copy of the Children's Communication Checklist-Short to complete to help me understand how they use language. Children will then begin to use the intervention.

All children will complete the intervention Headsprout Early Reading between 3 and 5 times a week with a member of school staff as part of their school activities until July 2016. I will work with the children again in March, halfway throught their time using Headsprout, in July, at the end of the school year, and in September, after the summer holidays. At these three times I or school staff will complete measures of phoneme awareness, word use fluency, and word recognition again in order to track their development of reading skills. On each occasion the children will work with an adult for between 15-30 minutes.

When I meet the children for the first time I will explain the study to them, and they will be asked if they would like to take part and to provide written consent if they are happy to take part. On

each occasion I meet children to collect data I will remind them that they are free to withdraw at any time if they choose to do so.

What will happen if my child does not want to carry on with the study?
Children volunteer to take part. If at any point during the study they decide that they don't wish to take part any more, they are free to do so.

What are the possible disadvantages and risks of taking part?
Headsprout Early Reading is designed to be an engaging, fun computer programme for children to use. However it is possible that children could become frustrated during the activities if they struggle to understand the activities. In order to mitigate this risk, all children will complete Headsprout Early Reading with a member of school staff who can support them through the computer tasks.

What are the possible benefits of taking part?
At the moment there is very little research which has examined the effectiveness of phonics-based reading interventions for pupils with learning difficulties. Schools are keen to ensure that all pupils make progress in their learning and want to use the most effective methods to support this. The information generated from this study may help to inform and shape the teaching methods used to teach reading skills in special schools, and may lead to schools adapting the reading interventions they use with pupils with learning difficulties.

What will happen to the findings of the research study?
The findings will be written up for my thesis, and communicated to staff at the school where the project is taking place. It is possible that the findings may be presented in academic forums or submitted for publications in academic journals.

What if there is a problem?
If you have questions about your rights as a participant in this research, or if you feel that you have been placed at risk, you may contact the Chair of the Ethics Committee, Psychology, University of Southampton, Southampton, SO17 1BJ. Phone: +44 (0)23 8059 3856, email fshs-rso@soton.ac.uk

Will the results of the study be kept confidential?
All information collected will be held in accordance with the Data Protection Act 1988. All data will be held confidentially in that each participant will be assigned a code and data stored on a password protected computer for ten years before it is destroyed. Participants' data on reading measures will be stored on a computer file in which participants will be identified through an assigned code. A separate document describing participant names, dates of birth, level of learning difficulties, and assigned code will be stored in a password protected file separate from the rest of the data on an encrypted usb stick.

Who is organising and funding this research?
This study is organised by the University of Southampton alongside Emma Herring who, as a trainee educational psychologist, is funded by a doctoral studentship.

Who has reviewed this study?
This study has been reviewed and approved by the University of Southampton, Psychology Ethics Committee and University Research Governance. All necessary safeguarding checks and references have been successfully completed.

How can I contact the researcher if I would like further information about this study?
If you would like to find out more about my research please feel free to contact Emma Herring at the University of Southampton, Building 44a – Highfield Campus, University Road, Southampton,

SO17 1BJ. (eh2g14@soton.ac.uk) or my supervisor, Dr Hanna Kovshoff, Lecturer in Psychology, University of Southampton – h.kovshoff@soton.ac.uk

Thank you very much,
Emma Herring, trainee educational psychologist at the University of Southampton

H.8 Parent Consent

CONSENT FORM (22/01/2016, V.2)

Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
Researcher name: Emma Herring
ERGO Study ID number: 18538

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet (22.01.2016 v.2) and have had the opportunity to ask questions about the study	☐
I agree for my child to take part in this research project and agree for their data to be used for the purpose of this study	☐
I understand my child's participation is voluntary and I/they may withdraw at any time without my legal rights being affected	☐

Data Protection
I understand that information collected about my child during their participation in this study will be stored on a password protected computer and this information will only be used for the purpose of this study. All files containing any personal data will be anonymised.

Name of child (print name)……

Signature of parent/carer/guardian……..

Date……..

H.9 Parent Debrief

Debriefing Statement (22/01/2016, V.2)

Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
Researcher name: Emma Herring
ERGO Study ID number: 18538

Dear Parent/Carer,

Thank you for agreeing for your child to take part in my research. The purpose of this study was for me to investigate if the phonics-based computer reading intervention Headsprout Early Reading was an effective method of improving the reading skills of children with learning difficulties. I also aimed to investigate whether not completing different parts of Headsprout Early Reading would still lead to improvements in reading skills, and if the intervention could be used with non-verbal children.

The data will be analysed to examine the changes in reading skills which occurred over the last school year and how effective Headsprout Early Reading was as an intervention. This information will be shared with the school who will use the information to inform how they support the development of reading skills.

If you have any further questions please contact me, Emma Herring, at eh2g14@soton.ac.uk.

Thank you for helping me with my research.

Emma Herring,
Trainee Educational Psychologist, University of Southampton

If you have questions about your child's rights as a participant in this research, or if you feel that they have been placed at risk, you may contact the Chair of the Ethics Committee, Psychology, University of Southampton, Southampton, SO17 1BJ. Phone: +44 (0)23 8059 3856, email fshs-rso@soton.ac.uk

H.10 Pupil Information Sheet

22.01.16 – V.2
ERGO Study ID number: 18538
Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.

Participant Information Sheet

Please listen to this information carefully.

What is the research about?
I am trying to find out if the computer programme Headsprout can help children learn to read. I am going to do some research to find out about this.

Why have I been chosen?
I am asking children in your school if they want to use Headsprout on the computer.

Do I have to take part?
No you do not have to take part, it is for you to decide if you would like to or not.

What will happen to me if I take part?
If you would like to take part in the project, you will be asked to provide written consent that you agree to take part. You will then work with me for between 15 to 30 minutes and complete five short tests. You will then use Headsprout on the computer to work on reading activities. I will meet you again to do the tasks 3 more times.

Are there any benefits in my taking part?
You will help me find out if using Headsprout on the computer can help improve the reading of children at this school.

Are there any risks involved?
You may not enjoy completing the reading assessments but you can stop at any point if you would like to. You may not enjoy using Headsprout but a teacher from school will always be with you to give you help.

Will my participation be confidential?
I will keep all the information on a password protected computer.

What happens if I change my mind?
At any time you can change your mind and stop working with me.

Where can I get more information?
If you have any questions or aren't sure about any information on this sheet please ask me.

Would you like to take part in this study? If you do you will be asked to sign a consent form.

Thank you very much for listening.

H.11 Pupil Consent

CHILD CONSENT FORM (22/01/2016, V.2)
Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
Researcher name: Emma Herring
ERGO Study ID number: 18538

I have asked you to take part in my study about reading.

I am going to ask you to complete five short reading tasks. You will then use the computer programme Headsprout in school with a teacher. I will work with you again 3 more times on the reading tasks.

It is your choice if you would like to be a part of this session. If you feel uncomfortable and would like to leave, please let me know. It is ok if you feel that you would like to leave – no one will mind.

If you are happy to be a part of this, please write your name below.

Child's name ……

Date ……..

H.12 Pupil Debrief

Children's Debriefing Statement (22/01/2016, V.2)
Study title: The effectiveness of the Headsprout Early Reading intervention at improving reading in pupils with learning difficulties.
Researcher name: Emma Herring
ERGO Study ID number:

Dear Participant,

Thank you for helping me with my project. I hope you enjoyed talking working with me.
I wanted to find out if the computer programme Headsprout could help children at your school get better at reading.

If you have any questions about the project, or are worried about anything, please ask me, your parents, or your teacher.

Thank you

Emma

Appendix I Treatment Fidelity Checklist

I.1 Headsprout-As-Usual Checklist

Procedure	Yes	No	N/A
Start of Session			
Does the tutor know which episode the pupil is currently working on? (either because they worked with them yesterday or by looking at data sheet in folder?) Are they beginning a new episode, repeating a previous episode, doing table top teaching focused on specific skills?			
If completing an episode online, the tutor is to then log on to HER website: Are they logged onto the correct student's account?			
Has the tutor navigated to the correct area on the website?			
Has the tutor checked that the volume is sufficient?			
If completing table top teaching: Does the tutor have the resources they need?			
During a Session – online episode			
Does the tutor redirect the pupil s attention back to the screen if they are inattentive?			
Does the tutor respond to requests for help by redirecting the pupil back to the activity?			
Does the tutor stop the pupil using the mouse and repeat the instruction if the pupil appears to be clicking randomly?			
During a Session – Prompting			
If it is the first/second time a pupil is completing an episode, does the tutor use no prompts? Only use prompts if pupil has attempted episode several times and struggling to learn from computer feedback.			
Does the tutor record prompts at each stage of episode in order to systematically fade their prompts? E.g. if an activity was modelled, if they directed attention to key feature, repeated instruction.			
Does the tutor systematically fade this point prompt as the episode progresses? Does the tutor use a most-to-least prompt fading strategy? Tutors to gradually fade their prompt from a point prompt to a gestural prompt and then to an independent response.			
Does the tutor to provide social reinforcement (e.g. pats on the back or saying "great reading" and "you're doing really well!") contingent on the pupil completing an activity?			
During a Session – Headsprout Stories			
If the pupil is reading a Sprout Story, are they reading the e-book version on the computer?			
If the pupil is reading a Benchmark Story, are they reading the printed version?			

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For Benchmark Stories, does the tutor have a copy of the words in the book? Do they record the words read accurately so that a percentage correct reading accuracy score can be calculated?			
If the reading accuracy score is less than 90%, this should be noted in the pupil's file so they can read the book again next sessionand repeat the previous online episode if needed.			
During a Session – Table Top Teaching			
Has the tutor identified the skill the pupil was struggling with in the online episode?			
Have they broken this skill down into several smaller steps which can be taught?			
Are the materials prepared for this session?			
During a Session - Reinforcement			
Does the tutor provide social reinforcement as the pupil completes activities? (e.g. "you're doing really well!")			
Are there any tangible reinforcers which are used as a result of being identified as motivating for the pupil (e.g. after asking parents what the pupil finds rewarding?)			
If a pupil has completed an online episode at mastery criteria, are they rewarded by placing a sticker on their poster?			
During a Session – Breaks			
If the pupil asks for a break, or it is apparent from non-verbal cues that they are finding it difficult to attend to the activity for an extended period of time, does the tutor acknowledge the request and move the pupil away from the computer?			
Is the pupil provided with preferred and calming activities?			
Does the tutor then ask the pupil if they are happy to continue? If not, the tutor can move the pupil on to other activities and resume the episode at a later time.			
After a Session – Data Recording			
Does the tutor have the pupil's personal data folder present at all times during HRC activities?			
Does the tutor look over previous data to determine which episode the pupil is working on and the prompt levels provided during previous HER activities?			
Does the tutor record data on the sheet at the end of the episode? E.g. prompts, percentage accurate, independence.			
Does the tutor record any requests for "help" or any breaks that are taken throughout the episode?			
Does the data complete the 'next steps' section of the data sheet so that the adult completing the next episode will be aware of which episode they are completing, the previous prompts used, etc.			
Is accurate data collected? (IOA with researcher)			

I.2 No-Negation Checklist

Procedure	Yes	No	N/A
Start of Session			
Does the tutor know which episode the pupil is currently working on? (either because they worked with them yesterday or by looking at data sheet in folder?) Are they beginning a new episode, repeating a previous episode, doing table top teaching focused on specific skills?			
If completing an episode online, the tutor is to then log on to HER website: Are they logged onto the correct student's account?			
Has the tutor navigated to the correct area on the website?			
Has the tutor checked that the volume is sufficient?			
If completing table top teaching: Does the tutor have the resources they need?			
During a Session – online episode			
Does the tutor redirect the pupil s attention back to the screen if they are inattentive?			
Does the tutor respond to requests for help by redirecting the pupil back to the activity?			
Does the tutor stop the pupil using the mouse and repeat the instruction if the pupil appears to be clicking randomly?			
During Negation activities, does the tutor use the words: "You don't need to do this, I will do it" and complete the task as quickly as possible?			
During a Session – Prompting			
If it is the first/second time a pupil is completing an episode, does the tutor use no prompts? Only use prompts if pupil has attempted episode several times and struggling to learn from computer feedback.			
Does the tutor record prompts at each stage of episode in order to systematically fade their prompts? E.g. if an activity was modelled, if they directed attention to key feature, repeated instruction.			
Does the tutor systematically fade this point prompt as the episode progresses? Does the tutor use a most-to-least prompt fading strategy? Tutors to gradually fade their prompt from a point prompt to a gestural prompt and then to an independent response.			
Does the tutor to provide social reinforcement (e.g. pats on the back or saying "great reading" and "you're doing really well!") contingent on the pupil completing an activity?			
During a Session – Headsprout Stories			
If the pupil is reading a Sprout Story, are they reading the e-book version on the computer?			
If the pupil is reading a Benchmark Story, are they reading the printed version?			
For Benchmark Stories, does the tutor have a copy of the words in the book? Do they record the words read accurately so that a percentage correct reading accuracy score can be calculated?			

Appendix I

If the reading accuracy score is less than 90%, this should be noted in the pupil's file so y can read the book again next sessionand repeat the previous online episode if needed.			
During a Session – Table Top Teaching			
Has the tutor identified the skill the pupil was struggling with in the online episode?			
Have they broken this skill down into several smaller steps which can be taught?			
Are the materials prepared for this session?			
During a Session - Reinforcement			
Does the tutor provide social reinforcement as the pupil completes activities? (e.g. "you're doing really well!")			
Are there any tangible reinforcers which are used as a result of being identified as motivating for the pupil (e.g. after asking parents what the pupil finds rewarding?)			
If a pupil has completed an online episode at mastery criteria, are they rewarded by placing a sticker on their poster?			
During a Session – Breaks			
If the pupil asks for a break, or it is apparent from non-verbal cues that they are finding it difficult to attend to the activity for an extended period of time, does the tutor acknowledge the request and move the pupil away from the computer?			
Is the pupil provided with preferred and calming activities?			
Does the tutor then ask the pupil if they are happy to continue? If not, the tutor can move the pupil on to other activities and resume the episode at a later time.			
After a Session – Data Recording			
Does the tutor have the pupil's personal data folder present at all times during HRC activities?			
Does the tutor look over previous data to determine which episode the pupil is working on and the prompt levels provided during previous HER activities?			
Does the tutor record data on the sheet at the end of the episode? E.g. prompts, percentage accurate, independence.			
Does the tutor record any requests for "help" or any breaks that are taken throughout the episode?			
Does the data complete the 'next steps' section of the data sheet so that the adult completing the next episode will be aware of which episode they are completing, the previous prompts used, etc.			
Is accurate data collected? (IOA with researcher)			
Does the tutor record what the pupil was doing as they completed the negation activities?			

I.3 Non-Verbal Checklist

Procedure	Yes	No	N/A
Start of Session			
Does the tutor know which episode the pupil is currently working on? (either because they worked with them yesterday or by looking at data sheet in folder?) Are they beginning a new episode, repeating a previous episode, doing table top teaching focused on specific skills?			
If completing an episode online, the tutor is to then log on to HER website: Are they logged onto the correct student's account?			
Has the tutor navigated to the correct area on the website?			
Has the tutor checked that the volume is sufficient?			
If completing table top teaching: Does the tutor have the resources they need?			
During a Session – online episode			
Does the tutor redirect the pupil s attention back to the screen if they are inattentive?			
Does the tutor respond to requests for help by redirecting the pupil back to the activity?			
Does the tutor stop the pupil using the mouse and repeat the instruction if the pupil appears to be clicking randomly?			
During the Speak Out Loud activities, does the tutor speak the word before the pupil clicks on the response on-screen? *Does the tutor ensure the pupil's focused attention before speaking?*			
Does the tutor provide additional opportunities for the pupil to hear blending by saying "/s/ /ee/ /see/. Well done, you clicked on see."?			
During a Session – Prompting			
If it is the first/second time a pupil is completing an episode, does the tutor use no prompts? Only use prompts if pupil has attempted episode several times and struggling to learn from computer feedback.			
Does the tutor record prompts at each stage of episode in order to systematically fade their prompts? E.g. if an activity was modelled, if they directed attention to key feature, repeated instruction.			
Does the tutor systematically fade this point prompt as the episode progresses? Does the tutor use a most-to-least prompt fading strategy? Tutors to gradually fade their prompt from a point prompt to a gestural prompt and then to an independent response.			
Does the tutor to provide social reinforcement (e.g. pats on the back or saying "great reading" and "you're doing really well!") contingent on the pupil completing an activity?			
During a Session – Headsprout Stories			
If the pupil being read a Sprout Story, are they reading the e-book version on the computer?			
If the pupil is being read a Benchmark Story, are they reading the printed version?			

Does the tutor redirect the pupil's attention to the book?			
During a Session – Table Top Teaching			
Has the tutor identified the skill the pupil was struggling with in the online episode?			
Have they broken this skill down into several smaller steps which can be taught?			
Are the materials prepared for this session?			
During a Session - Reinforcement			
Does the tutor provide social reinforcement as the pupil completes activities? (e.g. "you're doing really well!")			
Are there any tangible reinforcers which are used as a result of being identified as motivating for the pupil (e.g. after asking parents what the pupil finds rewarding?)			
If a pupil has completed an online episode at mastery criteria, are they rewarded by placing a sticker on their poster?			
During a Session – Breaks			
If the pupil asks for a break, or it is apparent from non-verbal cues that they are finding it difficult to attend to the activity for an extended period of time, does the tutor acknowledge the request and move the pupil away from the computer?			
Is the pupil provided with preferred and calming activities?			
Does the tutor then ask the pupil if they are happy to continue? If not, the tutor can move the pupil on to other activities and resume the episode at a later time.			
After a Session – Data Recording			
Does the tutor have the pupil's personal data folder present at all times during HRC activities?			
Does the tutor look over previous data to determine which episode the pupil is working on and the prompt levels provided during previous HER activities?			
Does the tutor record data on the sheet at the end of the episode? E.g. prompts, percentage accurate, independence.			
Does the tutor record any requests for "help" or any breaks that are taken throughout the episode?			
Does the data complete the 'next steps' section of the data sheet so that the adult completing the next episode will be aware of which episode they are completing, the previous prompts used, etc.			
Is accurate data collected? (IOA with researcher)			
Does the tutor record the pupil's attention and behaviour during the Speak Out Loud activities?			
Does the tutor record any additional blending opportunities they modelled for the pupil?			

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