Teaching Early Reading Skills to Children with Severe Intellectual Disabilities Using Headsprout Early Reading

Emma Herring [1] , Corinna Grindle [2, 3, 4,] & Hanna Kovshoff* [1, 5]

[1]Doctorate in Educational Psychology

School of Psychology, University of Southampton, UK

[2] School of Psychology, Bangor University, UK

[3]Centre for Educational Development, Appraisal and Research,

University of Warwick, UK

[4]The Centre of Behaviour Solutions. Ltd, UK

[5] Centre for Innovation in Mental Health – Developmental Lab

School of Psychology, University of Southampton, UK

University of Southampton, University Road, Southampton,

SO17 1BJ;

*Corresponding author

The authors declare that they have no conflict of interest.

Acknowledgements

This article was prepared from a dissertation submitted in partial fulfilment of a Doctorate in Educational Psychology degree programme. We wish to acknowledge and thank all participating pupils and staff who contributed to information utilised in this study.

Correspondence concerning this article should be addressed to Dr Hanna Kovshoff, Centre for Innovation in Mental Health, Developmental Lab, School of Psychology, University of Southampton, S017 1BJ, UK, H.Kovshoff@soton.ac.uk

Keywords: Headsprout, Phonics, Reading, Computer-based learning.

Abstract

Background: Beginning reading skills are often taught using phonics. Research has demonstrated the effectiveness of phonics with typically developing students, but less research has evaluated this method with students with intellectual disabilities (ID). **Method:** This paper evaluated the computerised phonics-based intervention Headsprout Early Reading® with eight students aged 7 to 19 years with severe ID. Six children were verbal, two were non-verbal. Four students completed Headsprout as it was designed for typically developing children, and four students accessed two adapted version of the intervention. Additional table-top teaching was used to support the intervention for some participants. **Results:** Verbal students improved in initial sound fluency, nonsense word reading, and word recognition, but did not show improvements in phonemic segmentation, regardless of whether or not they accessed the original or adapted intervention. **Conclusions:** The findings suggest that Headsprout Early Reading can be used to support development of reading skills for students with ID.

Introduction

Reading is underpinned by an understanding of how sounds in spoken language, or phonemes, map onto written letters, or graphemes (Byrne, 1998). Research has demonstrated the importance of phonics for early reading (National Reading Panel, 2000), and accordingly emphasis has been placed on adopting a phonics-based approach to early instruction (Rose, 2006). Phonics explicitly teaches how to hear and manipulate the phonemes in spoken language, phonemic awareness, and how to read phonetically by blending phonemes together into words (Finnegan, 2012).

The National Reading Panel (2000) summarised the five component skills of reading: an understanding that written words represent spoken words and have meaning; recognising and manipulating the separate sounds in words (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). Hulme and Snowling (2013) described the three cognitive foundations of learning to read, which have been shown to account for individual differences in, and be predictive of, reading skills: Rapid Automatized Naming (RAN) skills - a visual-verbal learning mechanism, letter knowledge, and phonemic awareness.

Reading has historically been de-emphasised for students with Intellectual Disabilities (ID; Browder et al., 2009). It has been assumed that reading is linked to cognitive ability or IQ, and that expressive language and communication skills are necessary before teaching reading can begin (Browder et al., 2009). Pre-requisite literacy skills, such as picture matching, have been targeted (Lawson, Layton, Goldbart, Lacey, & Miller, 2012), and when literacy teaching has occurred it has often focused on recognition of key words using a sight word approach (Porter, 2005).

Acquisition of sight words alone does not teach students the skills to read unfamiliar words, or support reading comprehension. Phonics-based teaching helps individuals develop the skills to read unfamiliar words throughout their lives, and could be used with all students, both typically developing and those with ID (Hulme & Snowling, 2013).

Not only is additional research on phonics with students with ID needed, but researchers and educators should consider novel teaching approaches aimed at engaging learners. Macaruso, Hook, and McCabe (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 second-order meta-analysis, synthesizing the findings of 25 previous meta-analyses and 1055 studies reported that the average effect size associated with direct instruction using technology was 0.31; an effect size of 0.2 is considered small, and 0.50 is considered moderate (Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011). A synthesis of 800 meta-analysis conducted by Hattie (2009) also reported an effect size of 0.37 for computer-aided instruction.

Headsprout Early Reading®

One such computer-assisted intervention is Headsprout Early Reading which teaches reading through phonics. The programme consists of eighty 20-minute episodes (Learning A-Z, 2016), and focuses its instruction on phonemic awareness, grapheme-phoneme correspondence, and blending sounds to decode words phonetically, but also incorporates elements of vocabulary, fluency and comprehension (Layng, Twyman, & Stikeleather, 2004b), the skills highlighted by the National Reading Panel (2000). The programme is based on discovery learning principles, using a mixture of direct instruction and engineered discovery (Layng, Twyman, & Stikeleather, 2004a). Headsprout automatically tracks learners' performances and adjusts instruction to the appropriate level, requiring children to practice skills until they can perform them at mastery level (Twyman, Layng, & Layng, 2012). Headsprout was designed as an individualised reading intervention to provide additional support for typically developing pupils, and much research has demonstrated its effectiveness with this population (e.g., Huffstetter, King, Onwuegbuzie, Schneider, & Powell-Smith, 2010; Tyler, Hughes, Beverley, & Hastings, 2015; Twyman, Layng, & Layng, 2011).

Over the past 6 years, a small but growing body of research has investigated the effectiveness of Headsprout on teaching reading to students with autism. For example, Whitcomb, Bass, and Luiselli (2011) were the first to report outcomes from a child with autism who had learned to read using Headsprout. Provided that the online reading instruction was paired with one-to-one educational support to provide prompts and error correction, a 9-year-old boy with autism demonstrated greater accuracy in word identification and accurate reading of Headsprout Early Reading stories following the completion of 23 episodes. Moreover, Grindle, Hughes, Saville, Huxley, & Hastings (2013) showed that pre-standardised and post-standardised reading test scores (Word Recognition Age) for four students with autism increased from 14 months to 3 years after just 14 weeks of teaching, and that these gains were maintained at follow-up after 8 weeks of no instruction. Nevertheless, despite the positive reading outcomes for the children with autism in these studies, it is important to note that extensive additional teacher support was required to ensure their progression through the online episodes.

There has also been some research using Headsprout with students with mild or moderate learning difficulties and developmental disabilities (Tyler, Hughes, Wilson, et al., 2015). Six students aged between 7 and 14 years completed all 80 Headsprout episodes over 13 to 21 months. One-to-one adult support to provide encouragement was used during episodes, and frequency-building exercises were also used to accompany the computerised sessions. All students showed improvements in phonemic awareness, nonsense word decoding, and word recognition skills.

Adaptations to Headsprout. Given that Headsprout was developed for typically developing children (Layng et al., 2004b), and that previous research has demonstrated that students with autism required additional teaching support external to the online program itself to progress, it is reasonable to suppose that adaptations to the programme may enhance its accessibility and acceptability for a wider population of learners. No published reports to date have described any modifications to the intervention itself which may work to increase its accessibility. Two particular activities within Headsprout, negation and speak-out-loud, were considered suitable targets for this purpose.

Negation activities. In a review of working memory studies among individuals with ID, Lifshitz, Kilberg, and Vakil (2016) found that individuals exhibited difficulties in attentiondemanding tasks involving manipulations. Tasks of greater complexity were harder for these individuals to access. Headsprout includes negation tasks whereby learners hear a phoneme/word, and are presented with grapheme(s)/word, and an arrow on screen. Individuals are instructed to click on the grapheme(s)/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.

There is initial evidence that the negation tasks may be difficult for children with ID to access. A pilot study by Tyler, Hughes, Wilson, et al. (2015) reported that negation activities were especially difficult to access for one of the six students in their study, and Grindle et al. (2013) described how table-top discrete trial teaching was used to help students overcome difficulties within Headsprout, including the negation activities. Given the high cognitive load demanded by the negation task, it is possible that the intervention may be made more accessible for students with ID if these activities were removed, whilst not impacting on overall phonics skills acquisition.

Speak-out-loud activities. Research investigating whether Headsprout is an appropriate intervention for students with autism, and students with ID more generally, has so far only assessed its utility with verbal children (Grindle et al., 2013; Whitcomb et al., 2011). Indeed, verbal imitation has been noted as an essential prerequisite skill for students to be able to benefit from the programme (Grindle et al., 2013). No studies to date have evaluated whether Headsprout can teach non-verbal students with ID to read. It has been suggested that the majority of individuals with ID will experience communication difficulties of some sort, with some communicating non-verbally (Boardman, Bernal, & Hollins, 2014). However, this should not prohibit children from being provided with the opportunity to learn to read in the absence of spoken language, as non-verbal individuals have been demonstrated to learn to read even in the absence of spoken language (Fleischmann & Fleischmann, 2012; Goh et al., 2013). In the Headsprout intervention, there are two main activities that 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). Given that non-verbal children would not be able to complete these tasks, and this would usually be taken as an indication that they should be precluded from accessing any Headsprout teaching, it would be useful to evaluate whether Headsprout could still be a suitable and effective reading intervention for students who are non-verbal if they do not complete the speak-out-loud activities but instead observed an adult completing them.

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 with ID; specifically, phonemic awareness, and phonics skills. The secondary aim was to investigate whether adaptations to its implementation impacted its effectiveness; specifically, whether removal of negation activities impacted the outcomes for learners, and whether it was an appropriate intervention for learners who are non-verbal.

The research questions are as follows:

1. Does using Headsprout lead to gains in phonemic awareness, phonics skills and word recognition for students with ID?

2. Does Headsprout lead to gains in phonemic awareness, phonics skills and word recognition for students with ID when the intervention is adapted and negation activities are not used?

3. Does Headsprout lead to gains in word recognition for non-verbal students with ID when the intervention is adapted and speak-out-loud activities are not used?

4. Are gains in phonemic awareness, phonics skills and word recognition maintained over time?

Method

Participants

Participants were eight students, aged between 7 and 19, who attended a special school in the UK for pupils with severe ID. In the Diagnostic and Statistical Manual of Mental Disorders 5th edition, the term intellectual disability is defined as involving impairments of general mental abilities that impact adaptive functioning in three domains: conceptual, social, and practical self-management. Both clinical assessment and standardised testing of intelligence are used when diagnosing intellectual disability, with the severity of impairment – mild, moderate, severe, or profound – determined through consideration of adaptive functioning alongside IQ scores (American Psychiatric Association, 2013). Table 1 displays the characteristics for each student (pseudonyms were used to protect the confidentiality of the students). All students had been identified as having ID; Severe Learning Difficulties (SLD) was identified in their Statement of Special Educational Needs; six students (Ben, Harry, Liam, Tyler, Martin, and Richard) also had a diagnosis of autism.

Table 1 about here

Students were included in the study if they were: (1) able and willing to work at a computer for up to 20 minutes; (2) able to follow a two-step instruction such as “Turn around and clap your hands"; (3) able to respond to feedback such as praise or correction; (4) able to match non-identical pictures; and (5) identified by their teacher as performing below expected levels of progress in literacy. Students were excluded from the study if they: (1) had visual or hearing impairments, meaning they would not be able to access 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 were the same criteria as used by Grindle et al. (2013).

For students in the non-verbal condition, teachers were asked to identify students who did not use any spoken words or phrases in their communication. For verbal students, teachers were asked to identify students who were capable of self-initiated speech in the minimum form of phrases of at least two words. Assessments of communication skills were obtained from teachers and parents of the verbal students using the Child Communication Checklist – Short version 4 (CCC-S-IV; Bishop & Norbury, 2009). The CCC-S-IV is a brief version of the Child Communication Checklist – second edition (CCC-2), a 70-item standardised assessment designed to identify children with clinically significant language impairments (Norbury et al., 2016). The CCC-S-IV consists of the 13 items that have been shown to best discriminate typically developing children from those with language impairments (Norbury, Nash, Baird, & Bishop, 2004). It was felt that the CCC-S-IV would be an accessible measure for teachers and parents to complete given its brevity. Standardised scores were not available for the CCC-S-IV but raw scores would have had to be used regardless as any standardisation would have been conducted with typically developing populations. The CCC-S-IV contains 13 items scored on a four point scale, scores range between zero and 39 and higher scores indicate greater difficulty (Bishop & Norbury, 2009). Table 2 describes verbal students' communication skills at the beginning of the study.

Table 2 about here

Measures

Dynamic Indicators of Basic Early Literacy Skills.

Due to the students having reading skills well below average for their age, with most not having any reading skills at all, all were assessed using subtests from the Kindergarten benchmark assessment materials from DIBELS-VI (Good et al., 2004). These materials evaluate prerequisite skills for early reading that can be measured before a child learns to read, including phonemic awareness. Four DIBELS–VI subtests were used to assess the phonics development of the six verbal students, each taking between 2 and 3 minutes to administer. As the DIBELS-VI was not standardised for use with this population, raw scores were analysed rather than standardised scores; raw scores show the number of correct responses in one minute.

The Initial Sound Fluency (ISF) subtest measured students' ability to recognise initial sounds in orally presented words. The *Phonemic Segmentation Fluency* (PSF) subtest measured students' ability to segment spoken words into individual phonemes. Both subtests measure phonemic awareness, one of the components of reading identified by the National Reading Panel as being absolutely essential if a child is ever to be able to read independently.

Phonics skills were assessed through the *Nonsense Word Fluency* (NWF) subtest, exploring students' ability to recall phonemes from graphemes and blend sounds.

The *Word Use Fluency* (WUF) subtest measured students' expressive vocabulary to monitor whether changes in reading skills would generalise to verbal communication.

Word Recognition and Phonics Skills test. The Word Recognition and Phonic Skills (WRAPS) test is a non-verbal measure of word recognition (Carver & Moseley, 1994), and was selected to investigate whether improvements in phonics skills could generalise to word recognition. Students' total raw score is how many words, out of 50, they can correctly identify. The WRAPS is standardised and provides a word recognition age for each student. The test is administered by the examiner speaking each word aloud and repeating it in a sentence, for example ‘orange. The orange that we eat.’ Students are asked to select, by pointing, the correct word in a row from an array of five words.

Procedure

The University of Southampton Research and Ethics Committee reviewed and approved the study, and ethical approval was obtained on 22nd December 2015, number 18538. Following this, agreement was sought from the headteacher and Special Educational Needs Coordinator to conduct the research in their school. Teachers were provided with details of the inclusion and exclusion criteria to identify students, and information letters and opt-in consent forms were sent out to the parents of the eight identified students, all of whom gave consent. Once parental consent was obtained, informed consent was sought from each student by reading them the participant information sheet explaining the study.

Staff received a training session in Headsprout designed by the first author and delivered by an experienced Headsprout practitioner. Staff were advised to deliver a minimum of two Headsprout sessions per week with one-to-one support, and guidance was given on how to support students as they were completing each episode.

Over the course of the intervention, the first author observed 9% of sessions to monitor treatment fidelity. A checklist was designed for this purpose to monitor desirable features of the intervention (e.g. appropriateness of prompting provided by staff). Treatment fidelity was assessed when the first author visited the participating school. It was not practically possible to schedule more frequent visits, hence the low percentage of observed sessions.

Headsprout as usual. In the Headsprout as usual condition, the procedure described in Grindle et al. (2013) was followed. A mastery criteria of 90% correct was required on each online episode before moving on to the next episode. If the student did not achieve mastery, they were allowed to repeat the episode up to four times to see if the programme's embedded feedback and instruction remediated the problem.

If they continued to experience difficulties, the supporting adult was instructed to prompt the child through the area of difficulty. Over successive practice episodes, the supporting adult gradually faded prompts using the most-to-least prompt fading procedure (i.e., gradually reducing prompts until the child was able to answer independently with 90% accuracy). If this strategy was not successful in enabling children to achieve mastery then table-top teaching was employed (see Grindle et al., 2013). The 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. When the student could complete the activity at the mastery criteria of 90% correct over 10 teaching trials with the table-top teaching materials, they were then re-introduced to the Headsprout episode. Table 3 in the results section provides information about the times when this was needed for some students. During the study, all students took place in teaching-as-usual activities in their literacy lessons which involved listening to and exploring stories.

No-negation condition adaptations. Students used the same procedure descripted in the Headsprout as usual condition, above, with the following modifications.

The negation activities in the Headsprout episodes involved a phoneme or word and an arrow being visually displayed on screen, and a grapheme or word presented orally. For example, students heard “if it says ‘the’ click on the word, if it does not, click on the arrow”. Students 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 for you”. They completed the activity as quickly as possible with the child observing.

Non-verbal condition adaptations. Headsprout episodes also contained speak out loud activities. During these activities, a picture of a speaking face would appear on the screen, along with different graphemes/word. Verbal students are required to say out loud the word or sound as they clicked on it. For students who were non-verbal, the adult supporting them produced the required oral response at the same time that the student clicked on the graphemes/word (i.e., there was one-to-one correspondence with the adult saying out loud the sound/word as they read it and the child clicking on it). Adults also provided additional opportunities to model blending of sounds throughout the episode. For example, if the student clicked on the word see, the adult would model blending by saying '/s/ /ee/ /see/. Well done, you clicked on see.' This again provided one-to-one correspondence between the supporting adult sounding out the written word, and the child clicking on the word which had just been spoken.

Design

The study used a single case study pretest/posttest design replicated across eight children across three conditions: (1) Headsprout as usual (Chris, Ben, Chloe and Harry); (2) No negation (Liam and Tyler) and (3) Non-verbal (Martin and Richard). Pretest measures were taken before the intervention began, posttest measures taken at the end of the academic year, and follow-up measures taken after a break of seven to eight weeks due to the school holidays.

For 25.74% of testing sessions, a second assessor scored the child's performance so Inter Observer Agreement (IOA) could be calculated. IOA was calculated by taking the total number of agreements, dividing by the total number of judgements, and multiplying by 100. All IOA met minimum standards of 80% (Horner et al., 2005), and ranged between 82.35% and 100%.

Analysis

The Reliable Change Index (RCI) was used to compare data between time points; this statistic requires the reliability of the measure itself (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 subtests 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.

Results

Intensity of Intervention

Table 3 reports the details of Headsprout sessions completed by students, the total number of teaching sessions for each student, and the number of these that used table-top teaching. Additional teaching using flashcards were used for Ben to teach grapheme-phoneme correspondences in episodes 1 and 2, and for Chloe to learn the grapheme-phoneme correspondences in episodes 4 and 5. For words taught in episodes 17, 18, 19, and 22, Harry had additional teaching using flashcards to supporting him in blending phonemes together into words. Neither student 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.

If students had completed two Headsprout episodes per week from the time that they had started the intervention and taking into account missed sessions due to school holidays, the total number of sessions completed ranged from 26 to 36.

Table 3 about here

Phonics and Word Recognition Skills Development

Table 4 shows the raw scores for the phonics subtests from the DIBELS-VI and from the WRAPS at pretest, posttest, and follow-up. RCI analyses are shown for a comparison of raw scores between pretest and posttest.

Phonics Skills. All students in the Headsprout-as-usual condition showed some reliable change improvements in phonics skills from the DIBELS subtests over the duration of the intervention. For the ISF test, a difference in pre-post test scores of at least 7.41 indicated reliable change. All students in the Headsprout-as-usual condition achieved this. For the PSF test, a change of 11.68 or greater indicated reliable change. Only Chris showed reliable change on the PSF. For the NWF test, a difference of at least 4.94 indicated reliable change. All children in the Headsprout-as-usual condition were able to achieve this.

For the no-negation condition, both Liam and Tyler met reliable change for the NWF at posttest. Liam also achieved reliable change for the ISF with Tyler being very close to meeting this threshold. Neither student met reliable change for PSF, although Liam’s scores did increase 8 points from pre-posttest.

Word Recognition. A score difference of at least 2.06 indicated reliable change on the word recognition measure. In the Headsprout-as-usual condition, Chris, Ben, and Chloe demonstrated positive reliable change between pretest and posttest, as did Liam and Tyler in the no-negation condition. Students in the non-verbal condition showed a decrease in scores below the threshold for negative, reliable change over this time.

Maintenance of Reading Skills

Table 4 also shows the raw scores for the phonics subtests and word recognition at follow-up, and RCI analyses comparing raw scores at posttest and follow-up to explore whether skills were maintained after a break of seven to eight weeks without using Headsprout (i.e., after the school summer holidays.

Maintenance of Phonics Skills. No students in the Headsprout-as-usual or no-negation condition showed negative reliable change beneath the RCI threshold in initial sound fluency between posttest and follow-up, indicating these skills were maintained.

In the Headsprout-as-usual condition, Ben, Chloe, and Harry showed a negative, reliable change beneath the RCI threshold in scores between posttest and follow-up on nonsense word reading, indicating that these skills were not maintained. In the no-negation condition, on the nonsense reading measure Tyler maintained his skills whereas Liam showed a negative, reliable change beneath RCI threshold suggesting that his skills were not maintained.

Maintenance of Word Recognition. At posttest, in the Headsprout-as-usual condition, Chris, Ben, and Chloe showed positive reliable change in their word recognition scores compared with pretest. However, at follow-up, all four students showed a negative reliable change from their posttest scores, indicating that skills were not maintained.

In the no-negation condition, both students had shown positive reliable change in word reading between pretest and posttest. Between posttest and follow-up, Tyler maintained these skills but Liam showed negative reliable change.

The word recognition scores were variable for the two non-verbal students. Between pretest and posttest, both their scores indicated negative reliable change, but at follow-up their scores compared to posttest indicated positive reliable change. Overall, word recognition was variable, with five of the eight students showing a decrease in their scores at some point over the course of the study.

Table 4 about here

Analysis of Change for Each Child

Figure 1 shows the RCI analysis for students between pretest and posttest on phonics and word recognition measures. The RCI considers the change that has taken place in the context of the reliability of the measure, to assess whether enough change has taken place that it indicates reliable change in skills being measured (Zahra & Hedge, 2010). Five of the six verbal students improved their skills in recognising the initial sounds in words, with Tyler's change approaching the reliable threshold. Only Chris showed a positive reliable change in phonemic segmentation skills. All six verbal students showed positive reliable change in their nonsense word reading fluency skills. Five of the eight students made positive reliable change in word recognition, with Harry showing only a slight increase in scores. Martin and Richard, the two non-verbal students, showed a negative reliable change on this measure.

***Figure 1.* about here**

Discussion

The aim of this research was to investigate whether the reading intervention Headsprout Early Reading could support the development of beginning reading skills in students with ID, and whether adaptations to the intervention affected development of reading skills. Specifically, we explored whether the removal of the negation activities impacted on outcomes for students, and whether or not non-verbal students could still benefit from the programme if supporting adults completed the "speak-out-loud" components. This is the first study to explore these adaptations with children with ID.

At posttest, all four students 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 nonsense words, and all except Harry showed meaningful positive change above the RCI threshold in word recognition.

In the no-negation condition. both Liam and Tyler showed meaningful change above the RCI threshold in reading nonsense words and in recognising words; Liam showed meaningful changes in identifying initial sounds in words, and Tyler's initial sound identification change score was approaching the threshold for reliable change. At posttest, in the non-verbal condition, neither Martin nor Richard showed positive meaningful change above the RCI threshold in word recognition.

At follow-up, Headsprout-as-usual condition students' 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 nonsense word reading below the RCI threshold. In the no-negation condition neither student showed a decrease below the RCI threshold in initial sound skills; Liam showed a decrease below the RCI threshold in nonsense 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 follow-up.

In addition to the findings summarised above, some anomalies were observed in the data. For example, in the Phonemic Segmentation Fluency (PSF) subtest Chloe showed a decrease in raw scores between pretest and posttest, and an increase between posttest and follow-up above the threshold for positive reliable change. It is possible that Chloe's PSF score posttest was not an accurate assessment of her skills, and that these were more accurately reflected by her follow-up score. Participant's ability to engage with assessment tasks, can impact their results, and the PSF subtest was the only measure which did not use visual stimuli, potentially making it more challenging to access. The visual stimuli in the other assessments helped to engage Chloe in the activities. On the ISF subtest, despite increasing at posttest, Harry's score at follow-up was close to his pretest measure. Furthermore, on the word recognition measure, Harry's score at follow-up was below his pretest score. On the day that the follow-up measures were taken, Harry found it difficult to engage with the assessment measures, potentially affecting his performance. The variability in Harry's scores suggests that either his skills were not maintained without regular practice, or that his difficulty engaging with adult-directed tasks impacted on his results in the follow-up assessments. In the non-verbal condition, both Martin and Richard showed a decrease in word recognition scores below the RCI threshold between pretest and posttest, only to then show an increase in scores above their pretest measurements at follow-up. One possible explanation is that as non-verbal students, they were more used to being taught to read using a whole-word approach to word recognition rather than a phonetic approach, and this was reflected in their confidence in responding with the test at baseline. The subsequent period of being taught using a different (phonetic) approach for a relatively short amount of time may have affected their confidence so that they were uncertain about how best to respond or what strategies to use at post-test, and this was reflected in their lower scores. The follow-up measures after a period of time without Headsprout may reflect a return to their existing skills. However, the fact that some of the observed data shows a high level of variability means caution is needed when interpreting it.

As verbal students accessed Headsprout, improvements were shown for recognising initial sounds in words, and in nonsense word reading and word recognition. Students 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 as appropriate a reading intervention for individuals who are non-verbal. It is possible that non-verbal students may have previously been recognising some words through a sight recognition approach supported by seeing words in familiar context. Introducing a new phonics-based method may have affected previous methods they were using and account for a decrease in word recognition.

However, as only two students were recruited to access Headsprout without speaking activities, this question would warrant further research.

Skills in word recognition and nonsense word reading were not maintained at follow-up even though initial sound skills were. This suggests that students with ID may need continued access to intervention activities to maintain learned skills or require the intervention delivered at the planned intensity, as this was something which teaching staff found challenging to implement.

The findings of this research must be interpreted in light of the design used. It is not possible to conclude that any reliable change occurred as a result of the Headsprout intervention. Change could have occurred due to teaching as usual over the duration of the study. A further limitation is the treatment fidelity. As shown in Table 3, 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 due to having fewer sessions than planned. Furthermore, only 9% of sessions were observed, meaning that it is not possible to accurately assess whether staff were delivering the sessions as intended.

This study adds to and supports the small number of studies that have found that using Headsprout leads to improvements in reading skill for students with autism (Grindle et al., 2013; Whitcomb et al., 2011), and for pupils educated in a school for students with ID (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 students had completed all 80 Headsprout episodes, and the study by Whitcomb et al. (2011) required students to complete the first 23 episodes. This study was the first to take place in a school for students with ID when two notable adaptations to the original Headsprout intervention were implemented: (1) omission of the speak out loud component for non-verbal students, and (2) omission of all negation activities in the online episodes. Although non-verbal students did not show improvements in reading skills, the children in the no-negation condition did improve. This suggests that the negation activities, which can be very difficult for children with ID to access due to their complexity, may not be an essential feature of the Headsprout intervention. Perhaps, teachers and parents should not be discouraged from using Headsprout with children with ID because of their belief that children would not make progress in their reading skills because of their inability to access the negation tasks. Further, this study was able to demonstrate improvements in reading skills for verbal students with ID where students accessed fewer episodes and received less hours of teaching time than previous studies.

In sum, this exploratory study has demonstrated that the reading intervention Headsprout can help children and young people with ID to develop their phonics skills. While promising, the findings require replication and extension. 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 could be to explore other factors which affect why some students may make greater progress than others. This could help inform better decision making in schools regarding which students would be most likely to benefit from the Headsprout intervention. Further research should also explore with more participants the potential benefits of using Headsprout without the negation activities. As only two students took part in this condition the conclusions that can be drawn from the results are limited. Use of a wait-list control would also 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 given the advantages of learning to read for all children, should continue to do so.

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Table 1

Participants' Characteristics

Participant	Age Years: Months	Gender	Ethnicity	Statement of SEN from school records
Chris	17:00	M	Caucasian	Receptive and expressive language Attention SLD
Ben	16:08	M	Caucasian	ASD SLD
Chloe	9:03	F	Caucasian	Hydrocephalus SLD
Harry	8:05	M	Caucasian	ASD SLD
Liam	13:01	M	Caucasian	ASD SLD
Tyler	10:09	M	Caucasian	ASD SLD
Martin	19:01	M	Caucasian	ASD SLD
Richard	7:07	M	Caucasian	ASD SLD

Note. SEN = Special Educational Needs; SLD = Severe Learning Difficulty; ASD = Autistic Spectrum Disorder.

Table 2

Participants' Baseline Communication Skills

Condition	Participant	Parent reported	Teacher reported
Headsprout-As-Usual	Chris	28	16
	Ben	39	34
	Chloe	18	9
	Harry	39	24
No-Negation	Liam	25	37
	Tyler	34	35

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.

Table 3

Details of Interventions Sessions Completed by Each Participant

Condition	Participant	Number of weeks completed Headsprout	Number of sessions received	Number of table top teaching sessions	Average number of sessions per week during school term	Average % accuracy in episodes	Total time engaged in episodes (hrs : mins)	Final episode
Headsprout-As-Usual	Chris	18	27	0	1.50	95.33	3:41	15
	Ben	18	28	6	1.56	86.14	3:41	3
	Chloe	18	22	4	1.22	90.43	4:22	5
	Harry	18	38	4	2.11	95.77	6:38	24
No-Negation	Liam	18	34	0	1.89	85.84	5:00	9
	Tyler	16	20	0	1.25	94.82	2:52	8
Non-Verbal	Martin	18	23	12	1.28	87.18	2:41	2
	Richard	13	17	0	1.31	77.00	1:36	5

Table 4

Pre-, Post- Intervention and Follow-up Scores and RCI Analysis for Phonics and Word Recognition Skills

		Participant							
		Headsprout As Usual				No Negation		Non-Verbal	
Variable	Time and RCI Analysis	Chris	Ben	Chloe	Harry	Liam	Tyler	Martin	Richard
ISF	Pretest	20.00	0.00	18.00	3.48	5.70	0.00	-	-
	Posttest	33.03	21.23	47.54	11.22	18.08	7.15	-	-
	Follow-up	53.88	25.59	43.80	4.00	13.77	7.19	-	-
	RCI Pretest to Posttest	**3.44***	**5.61***	**7.81***	**2.05***	**3.27***	1.89	-	-
	RCI Posttest to Follow-up	**5.51***	1.15	-0.99	-1.91	-1.14	0.01	-	-
PSF	Pretest	22	0	11	0	0	0	-	-
	Posttest	37	0	6	0	8	0	-	-
	Follow-up	42	2	20	0	0	0	-	-
	RCI Pretest to Posttest	**2.52***	0	-0.84	0.00	1.34	0.00	-	-
	RCI Posttest to Follow-up	0.84	0.34	**2.35***	0.00	-1.34	0.00	-	-
NWF	Pretest	5	11	9	1	0	6	-	-
	Posttest	14	22	19	16	25	11	-	-
	Follow-up	15	11	14	9	16	11	-	-
	RCI Pretest to Posttest	**3.57***	**4.37***	**3.97***	**5.96***	**9.93***	**1.99***	-	-
	RCI Posttest to Follow-up	0.40	-4.37**	-1.99**	-2.78**	-3.57**	0.00	-	-
WRAPS	Pretest	20	10	18	18	12	27	14	27
	Posttest	28	15	24	19	18	37	8	22
	Follow-up	24	12	19	12	13	38	16	34
	RCI Pretest to Posttest	**7.61***	**4.75***	**5.70***	0.95	**5.70***	**9.51***	-5.70**	-4.75**
	RCI Posttest to Follow-up	-3.80**	-2.85**	-4.75**	-6.65**	-4.75**	0.95	**7.61***	**11.41***

ISF = Initial Sound Fluency; PSF = Phonemic Segmentation Fluency; NWF = Non-Word Fluency; WRAPS = Word Recognition And Phonics Skills.
* = above threshold for positive reliable change
**= below threshold for negative reliable change

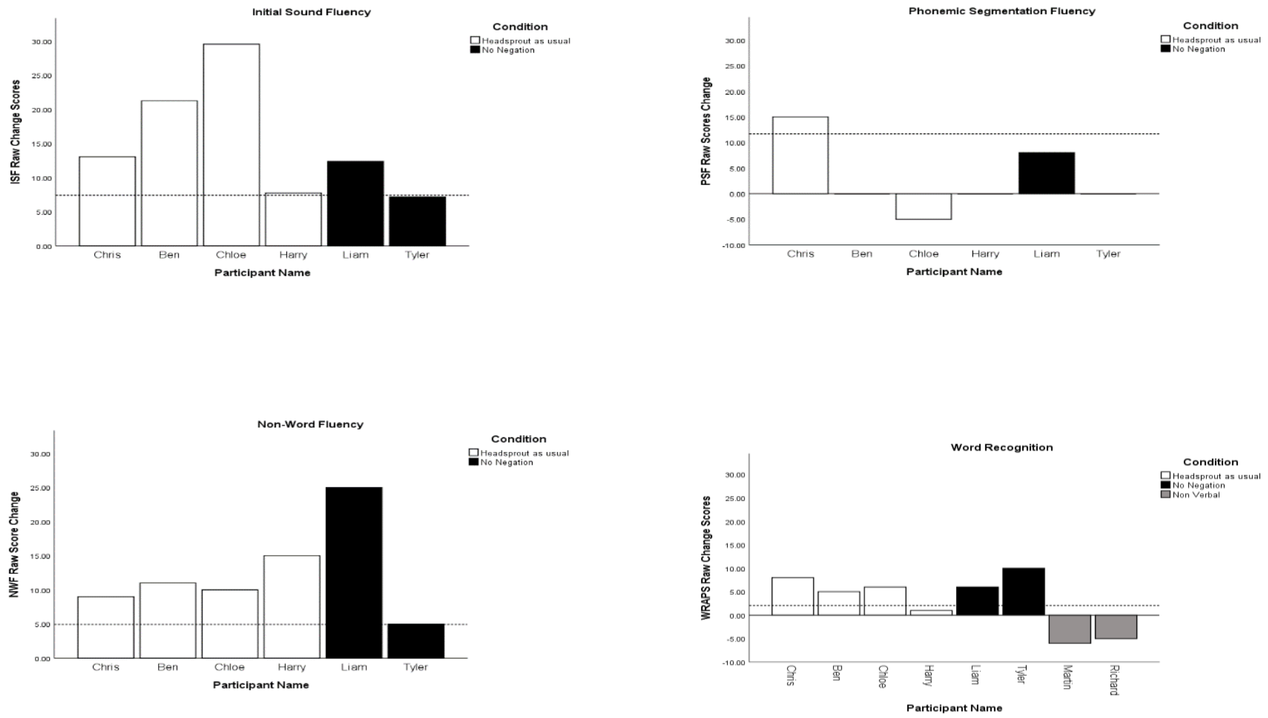

Figure 1. RCI results between pretest and posttest.
Bars represent the change of individual participants' scores between pretest and posttest intervention testing. The dotted horizontal line on each graph shows the reliable change threshold. The horizontal dotted lines indicate the change required to exceed the threshold for positive reliable change. Initial sound fluency and phonemic segmentation fluency are shown on the top row graphs. The bottom row graphs show non-word reading and word recognition.