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Teaching Children with Autism Reading Comprehension Skills using Online Reading Instruction: Preliminary Evaluation of Headsprout Reading Comprehension®

Corinna Grindle
Olivia Kurzeja
Emily Tyler
Maria Saville
J. Carl Hughes
Bangor University, UK

Richard P. Hastings
Freddy Jackson Brown
University of Warwick, UK

Abstract

Children with autism often exhibit difficulties with reading comprehension. Recent studies have demonstrated positive outcomes for typical learners from the internet-based reading comprehension program, Headsprout Reading Comprehension®. In the present study, a preliminary evaluation of HRC was conducted with six children with autism. The primary aim was to investigate whether it would be feasible to use HRC with children with autism and whether any adaptations to the standard teaching procedure and extra support would be needed. A secondary aim was to investigate the potential of HRC to improve reading comprehension skills. The study used a multiple case series design with six children. Results are discussed with reference to increased reading comprehension ability in the six children and the practical strategies required to support children with autism so that they may benefit from the program.

Key Words: Reading Comprehension, Headsprout Reading Comprehension®, Autism

Reading is an essential skill, affecting both basic academic progress and the ability to live independently and participate in modern society (Marchand-Martella, Slocum & Martella, 2004). However, reading is a complex skill that many children struggle to acquire (Lyon, 1998), particularly some children with a diagnosis of autism (Brown, Oram-Cardy & Johnson, 2013; Nation, Clarke, Wright, & Williams, 2006). Reading can be conceptualised in terms of two core component skill areas, decoding skills (broadly, identifying words) and language comprehension skills; Hoover & Gough, 1990; Perfetti, Landi, & Oakhill, 2005). This conceptualisation suggests that both decoding and comprehension skills are required to comprehend text, with difficulties in either of these broad skill areas likely to be accompanied by problems in reading comprehension (Nation, 2005; Perfetti et al., 2005).

Reading Comprehension and Autism

As with many skill areas, reading skills across individuals with autism are heterogeneous, with no

condition-specific profile of strengths and difficulties (Griswold, Barnhill, Mykes, Hagiwara, & Simpson, 2002; Nation & Norbury, 2005; Nation et al., 2006). However, research indicates a disparity between decoding skills and reading comprehension skills in children with autism (Frith & Snowling, 1983; Nation et al., 2006; Nation & Norbury, 2005). Nation et al. (2006) analysed the reading profiles of 41 children with autism, and found that scores on word and nonword decoding and text reading accuracy were largely within the typical range. However, for most children, reading comprehension performance was poorer in comparison with typically developing peers. Similar profiles of reading comprehension difficulties in autism have also been demonstrated in comparison to peers with a diagnosis of dyslexia (Huemer & Mann, 2010). Further, in an investigation of IQ-achievement discrepancies in autism, Jones et al. (2009) found poor reading comprehension relative to IQ to be the most prevalent profile. While individuals with autism are more likely than typical readers to exhibit difficulties in reading comprehension, other factors related to autism have been said to be better predictors of reading comprehension skills, such as decoding skills and semantic knowledge (Brown, et al. 2013).

When considering the role of semantic knowledge in reading comprehension it is clear that effective reading comprehension requires the ability to make inferences (i.e., deducing information that is not explicitly stated in the text; Cain, Oakhill, Barnes, & Bryant, 2001; Garnham & Oakhill, 1996). Cain et al. (2001) found a positive correlation between comprehension skills and inference making abilities. Inferences can be categorised into two broad types: *text-connecting inferences* (making inferences about information explicitly in the text), or *gap-filling inferences* (making inferences about information from prior general knowledge; Baker & Stein, 1981; Cain & Oakhill, 1999). Cain and Oakhill (1999) suggest that less skilled comprehenders are poor at both types of inferences, meaning they are likely to make fewer connections within the text, and less likely to incorporate general knowledge to fill the gaps or elaborate. Vocabulary knowledge also has a specific role in comprehending text; it has been suggested that to comprehend a text proficiently, we must be familiar with at least 90% of the words we read (Nagy & Scott, 2000). Subsequently, inferences must be made regarding the missing information from unknown vocabulary (Hirsch, 2003). However, poor comprehenders also typically have smaller vocabularies than their peers (Nation, 2005), suggesting that for many poor comprehenders, a prohibitive number of inferences would be necessary to obtain meaning without acquiring increased vocabulary knowledge.

Prior semantic knowledge about a text also typically predicts its comprehension (Spilich, Vesonder, Chiesi, & Voss, 1979) and because children with autism often have difficulties with semantic knowledge, this can have specific implications for their comprehension skills. For example, White, Hill, Happé, and Frith (2009) found that reading comprehension problems for individuals with autism were more pronounced when a text required more social knowledge. Wahlberg and Magliano (2004) investigated the comprehension skills of adults with high functioning autism, and found that individuals with autism were less likely than typically developing peers to use relevant background knowledge when attempting to comprehend text. Whereas typically developing peers demonstrated improved reading comprehension in the presence of cues designed to activate relevant background knowledge (such as titles and primer passages), these cues did not have an effect on the reading comprehension of individuals with autism, suggesting that inclusion of such cues may not be sufficient to elicit integration of prior knowledge with text. These findings also indicate potential difficulties identifying when inferences and integration of prior knowledge are required when reading.

To understand that an inference is required, we must be able to monitor our understanding of what we are reading. Cain, Oakhill, Barnes, and Bryant (2001) suggest that poor inference making may also be attributed to the fact that the individual is not aware an inference needs to be made, and/or the relevant information is not selected to make the inference. Cain and Oakhill (1996) found that instruction on where to find information in the text improved text-connecting inferences, but gap-filling inferences remained weak. This suggests that some poor readers may have a lower standard for coherence, which mediates effective comprehension monitoring (Perfetti, et al. 2005). Happé and Frith (2006) suggested that individuals with autism often have a processing bias towards details or individual components that can preclude extracting global meaning. This processing bias could also contribute to a lower standard for coherence when reading text, affecting reading comprehension skills including comprehension monitoring and making necessary inferences, as well as understanding the main idea of a text (Randi, Newman, & Grigorenko, 2010).

Reading Comprehension Strategies For Individuals With Autism

Although the research is limited, there is some evidence that children with autism can benefit from explicit instruction focused on reading comprehension strategies (Randi, et al. 2010; Whalon, Al Otaiba & Delano, 2009). Flores and Ganz (2007) investigated the effects of implementing a Direct Instruction (DI) program to address three known reading comprehension difficulties (statement inference, using facts, and analogies), in children with reading delays and autism or other developmental disabilities. DI programs are designed with specific instructional formats to introduce concepts and teach

academic skills. Skills are first modelled, then performed with guidance, then performed by the learner independently (Englemann & Carnine, 1991). The two participants with autism reached criterion across all three reading comprehension areas, which maintained following one month of no instruction. Notably, only minor adaptation to the program was required – visual cues were added in the 'using facts' condition for all participants. Further, it was noted that the participants engaged with the instruction at the required pace, with few off-task behaviours.

Computer-Assisted Instruction

There are a number of reasons why computer-assisted instruction (CAI) might be beneficial for children with autism: the complex social context that might accompany teacher-delivered instruction can be reduced, potentially increasing engagement with instruction (Higgins & Boone, 1996; Lahm, 1996); CAI typically incorporates an engaging visual interface, to which children with autism may respond well (Whalen et al., 2010) and there is potentially a greater capacity for individualized instruction (Ramdoss et al., 2011). Moore and Calvert (2000) compared teacher-delivered and computer-delivered vocabulary instruction with children with autism. It was found that more on-task behaviour was observed during CAI compared to a human instructor, and that substantially more vocabulary was mastered (72% and 42% respectively). Although there is limited research into the use of CAI for reading instruction with children with autism, these findings indicate encouraging potential for this mode of delivery to teach skills critical to reading comprehension.

Headsprout Reading Comprehension

Headsprout Reading Comprehension (HRC, 2010) is a computer-based program designed to teach reading comprehension strategies across 50 online episodes (Leon et al., 2011). These strategies are taught using a Direct Instruction (DI) format and include: literal comprehension (*'find the fact'*), inferential comprehension (*'find the clue words'*), main idea (*'what the passage is mostly about'*), and vocabulary (both explicit teaching of words and strategies to derive the meaning of other words from the context in which they appear). HRC uses an adaptive learning technology, whereby individual error patterns lead to additional instruction and practice opportunities (Layng, Twyman, & Stikeleather, 2003; 2004).

To date, there has been limited research conducted to evaluate HRC beyond formative evaluation. However, Layng and Layng (2012) report some encouraging results following use of HRC in a school setting. They also investigated the effectiveness of HRC with typically developing children ages 8-9 years. Four 45-minute sessions were scheduled each week, over a 6-week intervention period. Pre- and post-test data for 22 children demonstrated statistically significant improvements in reading comprehension skills beyond the expected change.

Although HRC has not previously been evaluated with children with autism, there are encouraging findings indicating HRC could be effective for children with additional learning needs. First, there is some evidence that Headsprout's Early Reading (HER) online program can be accessed and potentially improve the reading skills of children with additional needs, including children with autism (Grindle, Hughes, Saville, Huxley, & Hastings. 2013), children with ADHD (Clarfield & Stoner, 2005) and children with intellectual disabilities (Tyler et al., 2015). Given the similar instructional design and interface of these two programs, these findings suggest it would be worthwhile to investigate the effects of HRC with children with autism. Furthermore, a study conducted by Cullen, Alber-Morgan, Schnell, and Wheaton (2014) investigated the use of HRC with 6 children ages 8-10 years, all with some form of additional learning needs (including general learning difficulties and ADHD). Using a multiple-baseline across participants design, all children demonstrated improvements in reading comprehension during the intervention phase.

The current evidence-base indicates that children with autism might benefit from explicit instruction in reading comprehension strategies, and that computer-assisted instruction may be beneficial (Moore & Calvert, 2000, Ramdoss et al., 2011). Our aims are to investigate the following questions: (1) Is it feasible to use HRC with children with autism, and are any adaptations to the standard teaching procedure or (extra support) required? (2) Do reading comprehension skills improve following intervention using HRC?

METHOD

Participants

Participants, hereafter referred to as children, were three girls and three boys; all had a clinical diagnosis of autism. Mary (pseudonyms used) was 7 years 8 months and Miles was 6 years 11 months. Mary and Miles attended an autism unit attached to a mainstream local government-funded school (see Grindle et al., 2009, 2012, for a description of the educational model). Steven was 9 years 10 months. He attended a mainstream school but received full time 1:1 support from a teaching assistant. Laura was 12 years 5 months, Sarah was 13 years 4 months, and Mark was aged 10 years 11 months. These children attended a special school for children with autism.

Inclusion criteria to participate in the study were related readiness skills considered necessary for the children to benefit from HRC: (a) listening and responding to two or three step verbal instructions (e.g. 'go to the classroom and get a pencil and a pencil sharpener'), b)

pointing to some familiar objects when they were named (receptive labelling), (c) answering simple questions about a picture (e.g., responding to "what colour is it?" when an adult points to a picture of a ball), and (d) accepting verbal feedback (praise or correction). In addition, all children were capable of self-initiated speech (typically, communicating using at least five-word sentences).

All children had also completed the Headsprout Early Reading program (Grindle et al, 2013) prior to the start of this study. Although they had made significant gains in their reading fluency and accuracy, they continued to have problems with comprehending text they read. For example, after reading a short passage the children still found it difficult to answer a simple text related question or recall information from the passage. All children had additional readiness skills recommended by Headsprout: (a) reading fluently and accurately (specifically, a minimum of 140 words in two minutes), (b) basic knowledge of 'wh' questions (e.g. 'who', 'what'), (c) recognition and understanding of print conventions (e.g. questions, sentences and paragraphs), (d) ability to sit at the computer for up to 20 minutes and, (e) the ability to request for *help* using words.

The recommended entry point on the HRC episodes was assessed for all children pre-intervention using the Headsprout Placement Test. The entry point depends upon how many sections the child can read and how many mistakes they make within a set amount of time. All children were placed at episode 1 of HRC.

Setting

Teaching sessions were conducted mostly in one of the children's regular classrooms. While completing episodes, the children and their teacher sat with their backs to other children in the class who were completing other learning activities at the same time. Sometimes children were taken to a quieter room if noise and activity levels in the classroom environment proved to be distracting.

Measures

Children's reading and reading comprehension skills were assessed using the Dynamic Indicators of Basic Early Literacy Skills (DIBELS; Good, Kaminski, & Dill, 2002) and the Diagnostic Reading Analysis (DRA; Crumpler & McCarty, 2008). These assessments were chosen for their use in published outcome studies on reading and for their focus on assessing reading comprehension skills as well as reading accuracy.

All children were tested using The DIBELS Oral Reading Fluency (DORF) and Retell Fluency subtests of the DIBELS. These subtests can identify if children's aptitude at reading comprehension is consistent with their reading fluency. The DORF provides a measure of the extent to which children can read not only consistently and accurately but also quickly (i.e., fluently; see Binder, 1996). The child's score for this subtest is the number of words in a passage (a short story) that they can read accurately within 1 minute. The retell fluency subtest is a test of reading comprehension. It provides a measure of the extent to which children can retell the story that they have just read in their own words and not repeat it verbatim. The assessor scored any errors made within the passage (to obtain their DORF score) and noted the number of words they used to retell the story within 1 minute. Based on these combined results the percentage of retell fluency was calculated (a typical score for retell fluency is 25% of a child's oral reading fluency score; Good, Kaminski & Dill, 2002).

All children were tested using the DRA. To begin the assessment, each child was instructed to listen to a passage that the assessor read out to them. This is a test for auditory (listening) comprehension where the child was required to answer five comprehension questions about what they had just heard. The number of correct responses to these questions determined at which passage the child started their reading comprehension assessment.

For the reading comprehension assessment, for each passage that the child read, the assessor scored the number of reading errors they made (to obtain the reading accuracy score) and the length of time it took (in seconds) for the child to read the passage (to obtain the fluency rate score).The assessor also scored the number of comprehension questions they answered correctly/ incorrectly (to obtain the reading comprehension score) and the time it took the children to answer the comprehension questions (to obtain the processing score). Thus, the DRA assesses a child's reading accuracy, their reading fluency, their reading comprehension and their time to process and answer reading comprehension questions. The number of reading errors for each passage determined which story the child read next, or if the assessment was complete. This criterion was stated after each reading passage on the assessment form. For example, if the student made errors on less than 10% of the words in a passage they could move onto the next passage.

Design

The study used a multiple case series design (i.e., series of A-B designs) with six children. Assessments were conducted on at least two data collection points for all children: Pre-intervention (baseline), and post-tests at the end of the school (academic) year in which they had started HRC. For Laura, Sarah, and Mark, follow up scores were also obtained after the summer vacation (approximately five weeks in length) to see if reading comprehension scores changed during a period with no intervention support from staff.

Headsprout Reading Comprehension (HRC)

Materials. The HRC programme requires a computer with two speakers and a mouse. Pre- and post-test materials included testing resources, scoring sheets, two pencils, a digital timer, paper and a video recorder. At the time of the study, HRC consisted of: (1) 50 online lessons (episodes), each approximately 20 min in length; (2) five comprehension companion books (each covering familiar texts from the online episodes, vocabulary, reminders of key strategies and comprehension questions); (3) comprehension strategy posters (posters outlining the four key strategies: *find the fact* for literal comprehension questions, *looking for clue words* for inferential comprehension questions, looking for what a passage is *mostly about* for main idea comprehension questions), and *deriving meaning from context* for vocabulary questions; (4) practice worksheets; (5) five sets of practice episodes; (6) progress maps (for the participants to record each episode that they completed); and (7) completion certificates, which were provided to the children if they completed all 50 episodes. All resources were obtained from the 'My Headsprout' home page.

Teacher training. Prior to the start of the intervention, the first or second author conducted a 2- hr training session with the three tutors who would be overseeing the intervention. The training described the teaching procedures and data collection techniques to be used in the study. During the study, either the first or second authors observed HRC teaching sessions (at least once weekly for each tutor). During these sessions tutors were provided with direct feedback regarding their supervision skills and further advice provided where necessary. In particular, tutors were given feedback about appropriate prompts to give the children and prompt fading. All tutors received similar training and were assessed periodically throughout the study to ensure that procedures were implemented in a consistent fashion and that they had similar expectations about how each child should respond.

Overview of the basic teaching procedure. The HRC teaching procedure recommended for typically developing children was followed as closely as possible (see the HRC Teacher's Guide book, 2010). For example, HRC specified criteria for when children had mastered (learned) the necessary skills in each episode to be able to move onto the next episode. Data for each child's performance throughout each episode were collected by Headsprout to aid teacher decision making.

A green 'E' (Excellent) indicated the child had answered 75% or more of the story questions correctly on their first attempt. This was the recommended mastery criterion for moving onto the next episode. A purple 'S' was considered satisfactory. This indicated that the child had answered 50-74% of the questions correctly on their first attempt. Here the child was permitted to move onto the next episode but the program user guidelines recommend close monitoring of the child's ongoing data to check if performance improved in successive episodes to 75% or more. A red 'N' (Needs practice) meant that the child had answered 50% or less of the story questions correctly on their first attempt. If the child received two consecutive 'N's or three consecutive 'S's, then Headsprout guidelines recommend that the episode performance be carefully analysed (to find out what specific learning issues there were) and additional practice was suggested (HRC Teacher's Guide, 2010). In addition, HRC guidelines recommended probe tests after specific episodes to determine children's placement on the program. For example, after the child finished episode 7, if they had scored N ($< 50\%$) the guidelines recommended that the child restarted HRC from episode 1.

Our initial intent was for every child to have a minimum of three intervention sessions per week (as per HER recommendations and reported in Grindle et al, 2013). However, this was not always possible due to factors such as staffing shortages and computers not always being available for instruction. The type of instruction in intervention sessions also sometimes differed depending on the individual needs of the learner. For example, children could complete three different episodes in a week if they reached mastery criterion (75% or more) each time. Alternatively, if they did not reach criterion, they could practice the same episode three times in a week until they did reach criterion. Sometimes during the HRC sessions, the children did not use the internet program at all and their teaching instead focused on breaking down skills and teaching necessary prerequisite skills at the table (see additional teaching, below). All children celebrated their progress by recording it on the maps and wall charts provided by Headsprout and by receiving stickers and certificates.

It was important that the data collected by the computer were based on the child's unprompted performance of reading comprehension ability, so any prompts delivered by the tutor predominantly consisted of reminders to attend to the computer screen and instructions. In fact, the user guidelines recommend that tutors wait to see if the program's embedded feedback and instruction resolve any problems before they provide additional teaching support. If this does not resolve the problem, user guidelines recommend that tutors imitate the program's instruction and prompts, or translate the instruction to support the child.

Adaptations and additional instruction. For all children, adaptations to the standard teaching procedure and some additional instruction were required at some point to support their progression through the online episodes. The decision to implement additional teaching strategies was made when on-going data collection revealed

that children had not achieved mastery criterion on particular tasks within a given time frame (e.g., if they had not mastered an online episode within one week). Four main adaptations were implemented and are described below.

(1) Increasing on-task behaviour- HRC has built in features that are aimed at motivating learners to work through the episodes (e.g., computer delivered praise for correct responses, animation clips at the end of each task, and the opportunity to earn *coins* to buy additional animations). However, these features were not always sufficient to motivate the children. For example, Sarah sometimes engaged in shouting and off-task behaviour, whilst Mark engaged in off-task behaviour such as clicking on any answer, to move on. For these children, additional back-up reinforcers, including edible items and toys, was identified based on the teacher's knowledge of their preferences, and these were used in addition to the HRC animations. This adaptation helped to reduce off-task behaviour, increase motivation to complete Headsprout activities, and reduce anxiety surrounding the level of difficulty.

(2) Experiential teaching- Some of the passages within HRC assume that the children have experienced certain events. However, children with autism do not always have access to the same environments and circumstances that typical learners may have. For this reason children with autism may not necessarily be able to comprehend text by using their prior knowledge of a situation. Teachers identified such passages that discussed events that they believed to be unknown to the children and provided them with the experience of that situation to aid their understanding. For example, in episode 3, there was a passage describing a traffic intersection and cars stopping at red lights and moving forward for green lights. When this scenario was discussed with some children, they did not have prior knowledge of how the traffic lights worked and what the different colours meant. Part of their experiential teaching involved a community outing with their teachers to stand by a busy crossroads and watch the lights change and comment on how drivers responded.

(3) Additional Table Top Teaching- Sometimes children did not achieve the mastery criterion on online episodes despite repeating the episode a few times to see if the program's embedded feedback and instruction remediated the issue. Across children, they averaged six repeated episodes while they took part in the study. If the child continued to need assistance in addition to that provided by the program itself, additional table top teaching was provided. These additional teaching tasks were not always intended to teach reading comprehension skills per se. Rather, they were often designed to re-engage the child with the program by teaching key prerequisite skills. For example, if the children did not understand key words and synonyms in some of the HRC passages (which were not target words defined within the episode), the meaning of these words were taught away from the computer using such teaching tasks as picture to word matching, word to picture matching or activities that taught the child to construct sentences with the new word. As all participants lived in England, it was also necessary to teach the child the British meaning of some American words (e.g. store = shop; faucet = tap). Once the child had learned the vocabulary at the table with their teacher, they were tested again on the online episode.

(4) Teaching "Think Aloud" strategies- The HRC developers recommend that a teacher encourage children to actively engage in the program and, if the child is struggling to master episodes despite the program's embedded feedback, that they translate the instruction to support the child. Towards this aim, children were also taught how to use *think aloud strategies* as they worked through the steps needed to answer the reading comprehension questions correctly (Wilhem, 2001). The purpose of teaching *think aloud* strategies was first to model to the children exactly how skilled readers construct meaning from a text. In addition, when the children were able to independently *think aloud,* it enabled the teachers to monitor whether or not the children were using correct strategies to answer questions.

Think aloud strategies were taught in the following way. First, using passages from HRC, teachers composed questions relating to the passage (e.g. find the fact questions, find clue words questions, what is the passage mostly about or what does a specific word mean). Then, to teach *think aloud* responses that demonstrated working through the relevant strategies needed to answer the question, the teacher worked through the following phases:

Phase 1: Teacher does/ child watches (modelling of strategy). Focusing on one passage, the teacher spoke out loud and demonstrated working through five sequential steps required to find the correct answer to a comprehension question: (1) reading the passage, (2) reading the question followed by the multiple-choice answers, (3) working out which comprehension strategy the question was asking for (e.g., realizing that an inferential question requires the reader to look for *clue words* in the passage), (4) looking back at the passage to find the relevant text to answer the question, and (5) answering the question. As the teacher worked through the steps they wrote down the strategy name (e.g., Read the passage, Look back at the passage), so that the child could more easily relate each step with the correct procedure.

Phase 2: Child does/ teacher helps (providing assistance when needed). The teacher then used the same passage and asked the child to see if they could complete the five steps themselves to answer the question. Here the teacher was ready to intervene and provide help as needed. For

example, if needed, the written cue card depicting the steps (from phase 1) was placed in front of the child and the teacher prompted the child by pointing to the correct step that they needed to do.

Phase 3: Child does/ teacher watches and assesses (independent use of strategies). The teacher continued to focus on the same passage until the child independently answered the questions by working through the five steps.

The teaching then moved onto two more passages that targeted the same area of difficulty and followed the same steps as above. After this, a new passage was introduced and the child was asked to complete it independently without the teacher demonstrating first and without the cue card. If the child was successful then they returned to the online episode and if they were not successful the above steps were repeated with a different passage.

During the early episodes of HRC (episodes 1-10), all children required additional teaching away from the computer to ensure the key four comprehension strategies (literal, inferential, mostly about and vocabulary) were fluent. On average, 1 hour and 20 minutes per week, across children, was required for additional table top work. Once the children had consistently been accurate with table top activities, they would then move back onto the computer to repeat the episode.

Data Collection

Data on each child's performance were collected automatically by the HRC program (e.g., duration of each episode, number of times each episode was repeated, specific skills learned and featured vocabulary). Teachers also took descriptive data on all problems that occurred during teaching.

For the pre- and post-tests, a familiar teacher administered the test while a researcher scored the responses. The assessments were conducted as stated in the assessment manuals (see Measures, above) with the exception of the need for regular breaks, tangible reinforcement, and at times simplified instructions (e.g. using language that was more understandable to the child). The familiar teacher administered the tests in short sessions and acknowledged any requests the child may have made for a break (functional communication).

For Miles, Mary and Steven, to calculate inter-observer agreement (IOA) on assessment scores, a second observer scored at the same time as the assessor an average of 66% of assessments for each child (DIBELS – 66%, DRA – 66%). For Laura, Sarah and Mark each assessment was video recorded for IOA to be calculated, retrospectively. An average of 61% of assessments for each child were scored (DIBELS – 89%, DRA – 33%) Agreement was calculated for response reliability (agreement that a response was correct or incorrect) on standardized assessment scores. Mean IOA was calculated by tabulating agreements and dividing them by agreements plus disagreements and multiplying by 100. For Miles, Mary and Steven, IOA was 98% (range, 93–100%) across the assessments and across children. For Laura, Sarah and Mark, IOA was 95% (range, 87–100%).

RESULTS

HRC Online Data

The HRC program data on children's progress was examined first. Table 1 shows the summary data for program outcomes for each child (the number of weeks each child spent on HRC, the online episode they reached in that time, episode duration, and number of repeat episodes). With the exception of Steven, all children spent 16 weeks using HRC. Steven started HRC at the beginning of the school year and used the program for most of the academic year (32 weeks). The other children started HRC mid-way through the school year.

Reading Assessments

Table 2 shows, for each child, the standardized assessment scores for the DIBELS taken at the different time points: pre-intervention (baseline), at the end of the school year (Time 1), and for Laura, Mark and Sarah at follow-up after the 5-week summer vacation period with no intervention (Time 2). The data are presented for the total number of words read correctly in one minute (the DIBELS Oral Reading Fluency score; the DORF), the number of words used to retell the story within 1 minute (the Retell Fluency score) and the percentage of retell fluency (an average score for retell fluency is 25% of a child's oral reading fluency score). For retell fluency and retell fluency as a percentage of DORF, values enclosed in parentheses are indicative of the child being at risk of reading difficulties, including reading comprehension, in later grades (Good, Gruba, & Kaminski, 2002).

The number of correct responses recorded in 1 min improved across most measures from baseline to Time 1 for most children. For Sarah, her reading accuracy (DORF) score decreased from 62 to 48 from baseline to Time 1 and DORF remained the same at both time points for Mark (82 words). Retell fluency and retell fluency as a percentage of DORF improved from baseline to Time 1 for all children. From Time 1 to post-test (Time 2), retell fluency scores dropped off slightly for Laura and Mark (respectively, from 31 to 24 and 21 to 18), although post test scores still remained higher than baseline scores for these children.

At baseline, scores from 100% of the reading comprehension measures (retell fluency and retell fluency as a percentage of DORF), across children, indicated that

Table 1
Summary of Headsprout Program Outcomes

Child	Number of weeks on HRC	Starting episode	Episode reached	Average duration of episodes (minutes)	Number of episodes repeated
Miles	16	1	24	13.4	5
Mary	16	1	11	13	3
Steven	32	1	43	11.3	9
Laura	16	1	15	23.7	8
Sarah	16	1	9	33.5	2
Mark	16	1	15	28	6

the child would be at risk for poor reading outcomes later in life (Good et al., 2002). Not surprisingly, their reading accuracy (their DORF score) was not considered to be a problem as fluent reading was a necessary prerequisite skill for participation in HRC. At time 2, only Mary and Sarah were in the at-risk category. Sarah only completed up to episode 9, so it is possible that her retell fluency score would have increased if she had completed more episodes.

Table 3 shows, for all children, the standardized assessment scores from the DRA taken at the different time points: pre-intervention (baseline), at the end of the school year (Time 1), and for Laura, Mark and Sarah at follow-up after 5 weeks with no intervention (Time 2). The data are presented for the number of reading errors that they made (their reading accuracy score), the length of time it took (in seconds) for the child to read the passage (the fluency rate score), the number of comprehension questions that they answered correctly/ incorrectly (their reading comprehension score) and the time it took the children to answer the comprehension questions (their processing score).

In summary, comprehension scores increased for all children. At baseline, all participants achieved a compre-

Table 2
Standardised Test Results from the DIBELS

Child	Subtest	Baseline	Time 1	Time 2
Miles	Oral Reading Fluency (DORF)	65	122	-
	Retell Fluency	(10)	38	-
	Retell fluency as a percentage of DORF	(15)	31	-
Mary	Oral Reading Fluency (DORF)	93	130	-
	Retell Fluency	(11)	(27)	-
	Retell fluency as a percentage of DORF	(12)	(21)	-
Steven	Oral Reading Fluency (DORF)	100	102	-
	Retell Fluency	(9)	50	-
	Retell fluency as a percentage of DORF	(9)	49	-
Laura	Oral Reading Fluency (DORF)	54	61	50
	Retell Fluency	(5)	31	24
	Retell fluency as a percentage of DORF	(9)	51	48
Sarah	Oral Reading Fluency (DORF)	62	48	46
	Retell Fluency	(2)	(5)	(7)
	Retell fluency as a percentage of DORF	(3)	(10)	(15)
Mark	Oral Reading Fluency (DORF)	82	82	71
	Retell Fluency	(5)	21	18
	Retell fluency as a percentage of DORF	(6)	26	25

Note. Values enclosed in parentheses indicate those children who are considered "at risk" of poor reading proficiency, including comprehension (Good, Kaminski & Dill, 2002). A typical score for retell fluency is 25% of a child's oral reading fluency score. Dashes indicate where follow up data are not available.

Table 3
Standardised Test Results from the Diagnostic Reading Analysis (DRA)

Child	Reading analysis	Baseline	Time 1	Time 2
Miles	Accuracy score	74	105	-
	Comprehension score	(4)	9	-
	Processing speed (secs)	6.6	9.9	-
Mary	Accuracy score	92	88	-
	Comprehension score	(7)	11	-
	Processing speed (secs)	6.8	4.9	-
Steven	Accuracy score	106	105	-
	Comprehension score	(7)	13	-
	Processing speed (secs)	5.1	5.6	-
Laura	Accuracy score	240	182	187
	Comprehension score	(3)	(6)	(8)
	Processing speed (secs)	5	14.4	(20.9)
Sarah	Accuracy score	125	132	131
	Comprehension score	(0)	(4)	(9)
	Processing speed (secs)	4.6	(22.6)	(20.1)
Mark	Accuracy score	140	154	152
	Comprehension score	(2)	10	10
	Processing speed (secs)	3.7	(19.7)	(15.5)

Note. Values enclosed in parentheses indicate those children who are below average for their age. Dashes indicate where follow up data are not available.

hension score that was considered below average for their age group. The Time 1 comprehension data show that all scores increased and for Laura, Sarah, and Mark were maintained over a non-intervention period. The scores for Miles, Mary, Steven, and Mark increased significantly and they achieved a score that was considered adequate for their grade level. The pre- & post-tests scores for processing speed (time taken to answer comprehension questions), for all children except Mary increased.

DISCUSSION

The primary aim of this study was to evaluate the feasibility of using HRC with children with autism in a special school setting. In this regard, the present study showed that each child was able to progress through the HRC episodes with the use of additional strategies that were developed to help maintain their progression through the lessons. A secondary aim of this study was to investigate if the reading comprehension abilities of the six children with autism would be improved by undertaking the HRC program. Prior to starting HRC, all children had reading accuracy and fluency levels considered typical for their age and had basic phonological awareness due to earlier completion of Headsprout Early Reading (HER). However, all had reading comprehension scores below what is considered average for their reading age and would be considered to indicate risk of possible future academic failure. After using the HRC program for four months, these children all made gains in their reading comprehension skills. This suggests that using HRC with some additional teaching strategies may offer an effective teaching tool for children with autism. The positive findings are consistent with other studies that have evaluated the use of HER with children with autism (e.g., Grindle et al, 2013).

Data on the reading comprehension outcomes for the six children in the present study, however, do need to be treated with caution. First, the children did not complete the recommended 3 episodes/week even taking into account repeated episodes and did not reach the end of the program. Second, there were a number of difficulties or limitations with the reading tests. For example, all of the assessments used in the present study incorporated open-ended questions to assess comprehension skills. It could be argued that the additional requirement for the participants to formulate a verbal response caused a greater processing demand (Cain & Oakhill, 2006). For those with expressive language deficits (Sarah, with an average utterance length of 5 and Mark, with an average utterance length of 7), this additional demand to formulate a verbal answer may have caused their comprehension skills to be underestimated. In

addition, retell fluency required a wider range of skills (e.g., grammar, syntax and sentence production) than feature in HRC.

In terms of the focus of additional evaluation of HRC with children with autism, a number of points were highlighted by the present study. First, it will be important to establish whether the additional strategies we identified and the direct experience of situations that feature in HRC are necessary to support access to HRC by children with autism. Second, children's comprehension processing speeds were sometimes low even when comprehension scores increased (suggesting a lack of fluency). Further fluency-building strategies may need to be considered. Third, on DORF scores at post-test some children were making more errors with their reading as evidenced by word substitutions (e.g., reading "was" as "has") and word omissions (e.g., leaving out small words such as conjunctions) suggesting that they may have paid less attention to smaller words with an increase in their use of reading comprehension skills. This may be an issue that is rectified by completing all HRC episodes, but this should be monitored in future research.

Another limitation of the present study is that the effectiveness of the HRC intervention has only been demonstrated with a weak pre-post design and small number of participants who advanced at very different rates through the episodes. This limits the conclusions that can be made. Further research is needed to extend the current findings by examining the effectiveness of HRC with larger samples of children and including a control group in the study design. In addition, we also did not assess implementation fidelity across the different teachers who delivered the intervention in this study. Implementation fidelity monitors the extent to which an intervention has been implemented as planned and is critical for evaluating the reliability, validity, efficacy and effectiveness of studies (Smith, Daunic, & Taylor, 2007). Finally it would be interesting if future researchers could find ways to assess other collateral benefits of learning reading comprehension through HRC that were outside the scope of this study. This could include objective ways of measuring anecdotal reports from teachers that improvements in reading comprehension lead to better understanding and engagement in other school lessons like science.

Although this study has several limitations, the results would appear to be sufficiently encouraging to justify further larger scale research evaluation in this area, especially testing the effects of HRC for a longer period and/or for the full 50 episodes. Future studies would also benefit from the inclusion of follow-up assessment data to assess whether treatment gains are maintained following the end of the online teaching episodes. In advance of any additional evaluation of HRC, the present study offers information for practitioners working with children with autism who have difficulties with reading comprehension about how to adapt the delivery of HRC. The HRC program may represent appropriate, as well as resource and cost effective, reading comprehension instruction for children with autism.

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CORRESPONDENCE

Submitting author: Dr Corinna Grindle
Department of Psychology
Bangor University
Penrallt Road
Bangor, Gwynedd, UK
LL57 2AS
E-mail: c.grindle@bangor.ac.uk