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Teaching Early Reading Skills to Children with Intellectual and Developmental Disabilities Using Computer-Delivered Instruction: A Pilot Study

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Abstract

Many children with Intellectual and Developmental Disabilities (IDD) have considerable difficulty learning basic reading skills. Increasing evidence suggests individuals with IDD may benefit from instruction incorporating components of reading found to be effective for typically developing children. However, little research into reading instruction for children with IDD has incorporated these components. There is evidence for the efficacy of Headsprout® *Early Reading* program for typically developing children, and emerging evidence suggesting that children with autism can benefit from the program. The current study investigated the accessibility of Headsprout® *Early Reading* for children with IDD, and whether there were any measurable effects of the program on important early reading and language skills. Six children aged between 7 and 14 years with mild to moderate IDD completed the program, and all made measurable improvements across reading measures, demonstrating children with mild to moderate IDD can access (i.e., progress through and benefit from) the program.

Reading is an essential skill, and being unable to read affects many aspects of life, from basic academic progress to 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 children with Intellectual and Developmental Disabilities (IDD). The National Assessment of Educational Progress (National Assessment of Educational Progress; Institute of Education Sciences, 2007) found that around two thirds of children with IDD have considerable difficulty learning basic reading skills.

The increased focus on curriculum inclusion and academic content within education, in addition to greater accountability for individual progress in recent years (e.g., *'Every Child Matters',* 2004, UK; *'No Child Left Behind',* 2001, US), presents a compelling argument to establish and develop accessible methods for teaching reading in this population. It has been suggested that an 'accessible' curriculum should not only enable participation, but also enable academic progress, and that this should be done through making the necessary curriculum adaptations and providing additional support (Wehmeyer, 2006; Weh-

meyer, Lattin, Lapp-Rincker, & Agran, 2003). However, there is a dearth of information and guidelines regarding effective approaches for teaching reading or other academic skills for children with Intellectual and Developmental Disabilities (IDD) (Marks, 2000; Wehmeyer, 2006).

Reading research and instruction for individuals with IDD has typically focused on sight-word reading approaches (Katims, 2000). In a meta-analysis of 32 single-subject studies into sight word reading approaches with individuals with moderate and severe disabilities, Browder and Xin (1998) found such approaches were highly effective in teaching sight word vocabulary in this population. However, there was a lack of evidence for acquired sight words being used in functional academic or daily living contexts. Furthermore, acquiring reading skills through sight word reading instruction alone does not necessarily enable the learning of more generative decoding skills, thus limiting the potential for fluent reading skills (National Reading Panel, 2000).

Increasing evidence suggests individuals with IDD may similarly benefit from instruction incorporating components of reading found to be effective for typically developing (TD) children (Allor, Mathes, Roberts, Jones, & Champlin, 2010; Browder, Ahlgrim-Delzell, Flowers, & Baker, 2012; Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Aldozzine, 2006). Specifically, phonics-based instruction directly focused on the teaching of decoding skills may lead to positive outcomes (Joseph & Seery, 2004; Whalon, Otaiba, & Delano, 2009). There is an evidence base indicating effective approaches for teaching reading to TD children that was systematically reviewed by the National Reading Panel (NRP, 2000). In this review, the NRP proposed five component skills as necessary to become a functional reader: phonemic awareness (recognizing words are formed with separate sounds); reading phonics fluently (linking these sounds to specific letter combinations); extending spoken vocabulary to become reading vocabulary (understanding written words mean something); fluency (reading orally with speed, accuracy and appropriate prosody); and comprehension (understanding what is read). These core components are widely used by educators in the US to guide reading instruction and evaluate reading programs (Armbruster, Lehr, & Osborn, 2001, Simmons & Kame'enui, 2003, Begeny, Schulte, & Johnson, 2012).

Despite these recommendations, research into reading instruction for children with IDD has not typically incorporated these evidence-based components, and has rarely included phonics instruction (Browder et al., 2006; Joseph & Seery, 2004). In a review of over 100 studies investigating literacy in IDD between 1975 and 2003, Browder et al. (2006) found only 36 had any measure of reading fluency, only five focused on phonemic awareness, and only 13 focused on phonics. Further research is required to establish what approaches and programs incorporating evidence-based components are accessible, or may be made accessible, for children with IDD (Browder, Gibbs, Ahlgrim-Delzell, Courtade, Mraz, & Flowers, 2009; Whalon et al., 2009). With the dearth of information available on the development of reading skills with children with IDD who are second language learners, the effects of such programs with these children is also important to investigate. Additionally, for a curriculum to promote inclusion, there is a need to investigate programs that may be used with both TD children and children with IDD (Wehmeyer, 2006).

Headsprout® *Early Reading* (HER) is an internet-based program, available worldwide, and designed to teach the skills and strategies necessary for efficient, fluent reading. HER is designed for TD beginning readers, aged 4–7 years (kindergarten through to second grade). Comprising 80, 20-minute lessons (episodes), HER includes instruction in phonemic awareness, print awareness, phonics, sounding out, segmenting and blending, and explicitly incorporates the five components of reading proposed by the NRP (Layng, Twyman, & Stikeleather, 2003). HER is an adaptive learning technology—every mouse-click forms data on individual learners' progress that is used to provide additional instruction or to ensure repeated practice of components not yet fluent. In this way the instruction is individually adapted to each child's responses. Further to this, there are additional frequency-building materials to provide extra support for children who require it. In addition to an empirically informed development process (Layng et al., 2003), there is increasing evidence suggesting that HER can help improve reading skills for many children, including TD children (Huffstetter, King, Onwuegbuzie, Schneider, & Powell-Smith, 2010; Twyman, Layng, & Layng, 2011) and children with ADHD (Clarfield & Stoner, 2005).

Although HER is not designed for children with IDD, this program was selected for investigation with this population because there are a number of aspects of the program that suggest it might be beneficial for children with IDD – it is adaptive, highly visual, and the additional frequency-building materials provide resources to support diverse learners. Furthermore, preliminary findings suggest the program can be implemented with children with autism to improve reading and language skills (Grindle, Hughes, Saville, Huxley, & Hastings, 2013; Whitcomb, Bass, & Luiselli, 2011). Grindle et al. (2013) enrolled 4 children with a diagnosis of autism (aged between 5 and 7) in HER. With some additional procedures to enable access (e.g., additional Discrete Trial Teaching for areas of difficulty, dividing episodes over 2–3 sittings, and delivery of additional reinforcers to increase motivation), all four children completed the program. Notable improvements in early literacy skills and word recognition were seen across participants after the intervention.

Table 1
Age and Diagnoses of Participants at Baseline and Completion of HER, and Estimate of Verbal Ability as Measured by BPVS-II Score at Baseline

Participant	Gender	Chronological age (yrs,mnths)		BPVS-II age equivalent at baseline	Diagnoses/statements of special educational needs[1]
		Baseline	Post-test		
Rose	Female	7,9	9,1	3,9	General developmental delay. Difficulty with development of motor skills, speech and language skills and social skills
Catrin	Female	14,4	15,8	8,10	Global developmental delay. Significant delays in language and social development
Medwyn	Male	11,1	12,10	7,10	William's syndrome. Strong verbal skills but language delay. Delayed in development of basic educational skills.
Ben	Male	12,11	14,6	5,1	Severe communication disorder
James	Male	13,8	14,9	7,7	Global Developmental Delay
Dewi	Male	11,11	13,0	7,5	Global Developmental Delay

[1] *Statements of SEN describe difficulties and stipulate the educational support to which a child is entitled based on statutory assessment*

The current pilot study investigated two questions: 1. Can children with IDD access (i.e., progress through) HER and what adaptations may be necessary to achieve this access? 2. Are there measurable effects of the program on key early reading and language skills of children with IDD?

METHOD

Participants

We chose six children (2 female, 4 male) aged between 7 and 14 to participate based on their documented difficulties with literacy. All children had previously been exposed to attempts to teach reading skills; however, limited progress had been made (see DIBELS scores in Table 1). No data was available regarding the exact amount of exposure to reading instruction prior to this study; however, all had reportedly received typical provision in their early schooling. All had learned some basics of the alphabetic principle (i.e., sounds of the alphabet) and some sight words; however, instruction had not focused on other important components such as phonemic awareness, phonics (beyond identifying individual sounds) and fluency. All children were considered to potentially benefit from instruction at the level of HER (i.e., instruction focused on decoding skills). As can be seen in Table 1, participants had a range of developmental delay, and attended special needs schools in the same county in North Wales. Three children (Ben, James and Dewi) were predominantly Welsh speaking, and therefore learning to read in a second language. All three had previously been exposed to both English and Welsh reading instruction; however, limited progress had been made in reading in either language. Demographic and other information about each of the children is summarised in Table 1.

Materials and setting

HER comprises 80 online episodes, averaging around 20 minutes, during which the program directly delivers instruction to each learner. The episodes include explicit instruction in synthetic phonics, incorporating fluency-based activities to ensure concepts are mastered in each lesson (see Procedure or Layng et al., 2003, for more detail). Episodes were delivered on computers that were available within the schools, either on standard computer monitors or interactive whiteboards. When the latter were used, we placed a table and chair in front of the whiteboard, and provided a mouse for participants to interact with the program.

In addition to the online episodes, frequency-building exercises accompany the HER program. There are two tiers of this additional support—*Targeted Practice* and *Intensive Practice*. Because the participants in this study had significant learning difficulties, we used the *Intensive Practice* program to provide increased practice of material covered in the online episodes. We made some adaptations to materials for this additional support. Previous use of the program indicated some children had difficulty with the layout and print size of the *Intensive Practice* material. Therefore, we used a flashcards protocol (Graf & Lindsley, 2002), in which cards with the *Intensive Practice* stimuli were presented, thus altering the medium of delivery but not the content or fluency aims of this tier of support. We also designed alternative data recording sheets to allow for multiple attempts to be recorded.

HER also includes 80 stories comprising material covered in the program. These were printed out for participants to read after specified episodes. Licenses for all participants allowed access to progress reports and further information on implementation protocol (*Headsprout Teacher's Guide,* 2010). Teachers also downloaded and printed a progress map from the Headsprout website for each child to display in the classroom as a visual representation of their progress.

Measures

Episode data. Because we were interested in how children with IDD access HER, we collated performance data from the episodes for each participant. HER records individual data on each learner enrolled in the program, including: *number of episodes per week, number of episode repetitions* (required when accuracy falls below 90%), *episode accuracy* (providing a percentage score indicating how well episode content was mastered), *interactions per episode* (indicating how many responses a learner has given in an episode) and *episode duration* (time taken to complete each episode). Formative evaluation data collected by Headsprout indicates that, for typically developing children, average accuracy is 94%, average number of interactions per episode is 190, and average episode duration is 17 minutes.

Reading and early literacy skills. Due to the participants in this study having minimal reading skills, reading assessments were selected on the basis of their measurement of early reading and decoding skills. As such, they are not specifically designed for children with IDD or children of the age range represented in this study.

We conducted the following reading tests:

The *Dynamic Indicators of Basic Early Literacy Skills 6th edition, First Grade Scoring Booklet Benchmark Assessment* (DIBELS; Good & Kaminski, 2007), including measures of: *initial sound identification*, *phoneme segmentation fluency*, *letter naming fluency, nonsense words fluency*, and *word use fluency*. The DIBELS assesses fluency in core component skills predictive of reading success, providing correct responses per minute across these skills. This assessment was chosen because it assesses some of the component skills required when reading, therefore providing insight into some of the decoding deficits of children in this study. DIBELS scores are typically interpreted in terms of indicators of risk, with different benchmarks for children depending on their grade indicating whether they are at risk of later reading difficulties (Good, Gruba, & Kaminski, 2002). Due to the participants in this study having minimal reading skills, the subtests used were devised for children in kindergarten and first grade, despite children being aged between 7 and 14 years. Therefore, these risk categories do not provide the same information as they would for children in those grades. However, they do give some indication of the educational meaning of the improvements in fluency scores.

The *Word Recognition and Phonic Skills assessment* (WRaPS; Carver & Mosely, 1994) assess progress in word recognition skills. In this assessment, the child is read a word and asked to choose the correct word from a choice of four or five. The assessment places children within a word recognition stage, from one (almost no word recognition knowledge) to 10 (moving towards mastery of clusters and digraphs necessary for word recognition). This assessment was chosen due to the interesting insight it provides into phonic skills when identifying written words.

The Welsh language version of the *All Wales Reading Test* is an additional measure used with the three participants who were predominantly Welsh speaking. These participants did also engage in reading through the medium of Welsh during enrollment in HER; however, this was exposure to whole word reading rather than through phonics instruction. Not all the letters in the English alphabet make the same sounds as in the Welsh alphabet, and the Welsh alphabet also has additional sounds made up of two consonants (e.g., 'dd', pronounced as the 'th' in 'them'). Therefore, HER would not teach them alphabetic knowledge relevant to Welsh. However, Welsh is a highly regular phonetic language; therefore, it was of interest to investigate whether the phonemic awareness, segmenting and blending skills taught in HER generalized across languages, through measuring improvements in Welsh reading scores. The specific test used (*Ein Stori Ni)* required children to match a picture to the correct word from a list of three or four words, therefore measuring word identification receptively. Because the specific test used was designed for typically developing children of a younger age, standardized scores were not available. Therefore, we used raw scores and age equivalent scores to illustrate performance. The San Diego Quick Assessment (La Pray & Ross, 1969) was also included for James and Dewi as an additional measure of word reading to investigate potential effects on word reading fluency. Children are asked to read blocks of words that increase in difficulty. The assessment provides an indication of instructional level and allows for the calculation of word reading fluency.

Secondary measures: Language skills. We conducted the *British Picture Vocabulary Scale* 2nd edition (BPVS-II; Dunn, Dunn, Whetton, & Burley, 1997) at baseline to provide an estimate of verbal ability. We also conducted the *Test for the Reception of Grammar 2nd edition* (TROG-2; Bishop, 2003) to measure potential collateral effects on linguistic comprehension. These are widely used standardized tests by Speech and Language Therapists in the UK. The TROG-2 involves presenting the child with four pictures and reading a sentence that relates to one of the pictures. The child is asked to choose the correct picture, with items increasing in difficulty. A direct measure of

reading comprehension was not conducted due to some participants beginning with very limited decoding skills. Therefore, we included this assessment to measure linguistic comprehension before and after the program.

Interobserver agreement

All assessments (other than the WRaPS and Ein Stori Ni in which responses were marked on the page by the child) were double-scored, either while the assessment was conducted or from an audio recording of the assessment. We calculated Interobserver agreement (IOA) by dividing the number of agreements by the number of judgements and multiplying by 100. The IOA for each measure was as follows: DIBELS (pre-test, 93.72%; post-test, 94.25%); BPVS (pre-test, 99.42%; post-test, 100%); TROG-2 (pre-test, 99.75%; post-test, 100%).

PROCEDURE

Pre program. We assessed all participants on all measures before beginning the program. Additionally, prior to episode one, *mousing around* was completed: this is a short introductory online episode that familiarizes the child with the instructional language of the program and provides practice of appropriate responding prior to introducing the reading episodes.

The first 10 weeks of the intervention was a training phase in which the researchers were involved and staff were trained to implement the program. This was in part due to researcher availability to provide this support, rather than to any predetermined idea of what might constitute adequate training for the education staff. Participants were enrolled during this training phase. An initial training session was held, in which an overview of the program was provided, including examples of episodes, key aspects of implementation, and modeling of the additional activities. During the training phase, both the researchers and staff conducted sessions with participants, providing further opportunity for modeling and feedback on implementation.

For the remainder of the program, staff at each school took the lead in conducting the intervention with monthly support from researchers. In each school, we trained the child's class teacher and a teaching assistant to implement the program, and monitored online episode data and frequency-building data to ensure fidelity of implementation. For two participants (James and Dewi) school staff conducted the entire program, after initial training, with minimal researcher support. This was due to them being enrolled after the 10-week training phase, but in a setting that had other children enrolled and had therefore received staff training and support during this training phase.

HER online episodes. Episodes were conducted according to implementation guidelines provided by Headsprout. Participants engaged in episodes at a computer set up ready to access their individual profile. A researcher or staff member remained with the child while they were interacting with the program. However, they did not interact with the child other than to offer encouragement to stay on task. This was to ensure there was no interference with the sophisticated correction procedure built into the program, and that the responses made provided accurate feedback of the child's current ability and progress. When each child finished an episode, online data were checked to ensure they had attained the required level of accuracy, set at 80% in each episode. They were accompanied back to the classroom and chose a sticker to place on their progress map that indicated which lesson they had completed. Implementation guidelines stipulate that children should complete at least three episodes per week (*Headsprout Teacher's Guide,* 2010).

HER Sprout Stories™. In accordance with implementation guidelines, children were also required to read stories provided by the program after specified episodes. If the child struggled, we reminded them to sound out the word, and implemented the Model-Lead-Test error correction procedure as described below in the *Intensive Practice* exercises.

HER Intensive Practice flashcards. The *Intensive Practice* tier of the HER program was conducted after the episodes specified in the HER protocol. This comprises 100 frequency-building exercises consisting of individual sounds and words and 17 oral reading fluency exercises designed to ensure children were fluent on the materials taught in specific episodes before they progress to the next episode. As previously outlined, in this study we used a modified flashcards procedure rather than the sheets provided with the *Intensive Practice* materials. A researcher or classroom assistant worked with the child at the table and conducted practice sessions using a Model-Lead-Test format (Engelmann & Carnine, 1982). This involved demonstrating the procedure by responding to four cards (model), then repeating this along with the child (lead), and then the child responding alone (test). This ensured participants understood the procedure, and also served as a warm-up activity prior to timing. We then told the child they would be timed for one-minute, and to answer as quickly and accurately as possible. Because HER was not designed specifically for children with IDD, we reduced the number of correct responses required for reaching criterion to that recommended for children aged between five and six years, which varied between 25 and 50 correct responses per minute. Correct and incorrect responses were recorded on each child's data sheet. To demonstrate mastery, participants had to obtain the target for the specific activity over three timings before the child could move onto the next episode of the program. We employed a correction procedure after each timing, again using the Model-Lead-Test format outlined previously. This was repeated until the participant responded correctly to all errors made during the timing.

Table 2
Individual Progress and Episode Data Showing Average Episode Accuracy, Number of Interactions, and Time to Completion for Each Participant

Participant	Average % accuracy in episodes	Total time engaged in episodes (hrs:mins)	No. of interactions across episodes	No. of school weeks to complete	Average no. of episodes per week of school term
Rose	95	28:17	21,750	59	1.36
Catrin	99	18:00	20,324	24	3.33
Medwyn	93	23:53	22,603	74	1.08
Ben	95	22:23	25,934	79	1.01
James	99	18:10	19,536	50	1.6
Dewi	98	17:59	19,853	50	1.6

Group	Average % accuracy in episodes	Average time per episode (hrs:mins)	Average no. of interactions per episode
1000 typical learners	94	00:17	190
Current participants	92	00:16	270

HER Intensive Practice Oral Reading Fluency. We also conducted oral reading fluency measures as part of the *Intensive Practice* program. Participants were required to read a short passage, and the number of words read correctly per minute was recorded. As with the flashcards, oral reading fluency targets had to be met in three timings before progressing, and we used the same error correction procedure.

We repeated assessments once each child had completed the program (i.e., after they had completed all 80 episodes/lessons). The time taken to complete 80 lessons varied for each child.

Additional procedures

An amendment to the procedures outlined above was only required for one participant. As was found for a number of the children in the Grindle et al. (2013) study, Ben experienced difficulty responding appropriately to a task involving negation (*'If it does not say (chosen word), click on the arrow')* introduced in Episode four of HER. As a result, his percentage accuracy scores for this episode remained below 60% despite numerous repetitions. Using a similar procedure to that outlined in Grindle et al., (2013), this component was broken down and taught away from the program to enable progression through the episodes. These teaching trials were conducted over seven sessions until Ben had mastered the instruction and generalized this to the episode. Having identified a reinforcer (logos from cartoon channels), a token economy system was used whereby tokens were earned for correct responses that could be exchanged for a logo. Logos were initially earned for five correct responses (FR5), and then for every 10 responses (FR10). Ben subsequently completed episode 4 with 96% accuracy.

RESULTS

HER Online Data

Table 2 summarizes overall progress of all participants through the 80 HER episodes.

Episode Data. Time to completion varied considerably between participants, with those children with stronger reading skills prior to beginning the program (Catrin, James, and Dewi) taking the least time (see Table 2). All participants enrolled in the training phase completed more episodes on average per week during the initial 10 weeks during which the researcher was supporting and training the teachers, than the subsequent teacher-led intervention. Over all episodes, Rose and Medwyn required four episode repetitions, Ben required three episode repetitions (all for episode 4, in which negation was introduced), and Catrin, James, and Dewi required no episode repetitions.

Data collected by HER from 1000 typically developing children indicates that average accuracy is 94%, average number of interactions per episode is 190, and average episode duration is 17 minutes. Percentage accuracy scores indicate how much instruction was required to meet the criteria for completing an episode, with a lower percentage indicating more instruction was required to master the learning objectives. The data in Table 2 show that all participants demonstrated similar average duration and correct responding in completed episodes as the data from TD learners. Participants with IDD also demonstrated

Table 3.
Individual Scores on DIBELS Subtests at Baseline and Post-test, and Individual Improvement Scores for All Participants

Participant	DIBELS fluency subtest	Baseline	Post-test	Change
Rose	Initial sounds	8	13	+5
	Phoneme segmentation	(0)	18	+18
	Letter naming	(16)	34	+18
	Nonsense words	(2)	(11)	+9
	Nonsense word sounds	7	41	+34
	Word use	8	30	+22
Catrin	Initial sounds (/16)	15	15	0
	Phoneme segmentation	18	24	+6
	Letter naming	93	102	+9
	Nonsense words	(8)	41	+34
	Nonsense word sounds	33	119	+86
	Word use	52	62	+10
Medwyn	Initial sounds (/16)	15	16	+1
	Phoneme segmentation	13	27	+14
	Letter naming	(21)	50	+29
	Nonsense words	(2)	(10)	+8
	Nonsense word sounds	23	48	+25
	Word use	26	26	0
Ben	Initial sounds	5	9	+4
	Phoneme segmentation	(0)	17	+17
	Letter naming	78	73	−5
	Nonsense words	(4)	(20)	+16
	Nonsense word sounds	25	79	+54
	Word use	0	24	+24
James	Initial sounds	16	16	0
	Phoneme segmentation	(4)	25	+21
	Letter naming	(7)	72	+65
	Nonsense words	(17)	(23)	+6
	Nonsense word sounds	58	63	+5
	Word use	25	31	+6
Dewi	Initial sounds	14	16	+2
	Phoneme segmentation	33	40	+7
	Letter naming	68	81	+13
	Nonsense words	(17)	32	+15
	Nonsense word sounds	67	100	+33
	Word use	32	64	+32

Parentheses indicate scores that suggest children are 'at-risk' of later reading difficulties

above average interactions within episodes, which could indicate increased errors leading to additional instruction and practice. However, the average episode duration and accuracy suggest these increased interactions were more likely due to quicker than average responding within fluency activities in episodes where participants were familiar with presented stimuli (as was the case in early episodes for all participants). This indicates that the participants in this study did not require more instruction within the episodes than typically developing children.

Reading and language assessments

DIBELS. Scores between baseline and post-test increased for all participants, most notably in phoneme segmentation fluency (gains ranging from 6 to 21 per minute), nonsense words (gains ranging from 6 to 34 per minute), and nonsense word sounds (gains ranging from 5 to 86 per minute). Table 3 indicates that on some subtests, children who were scoring in the 'at-risk' category at pre-test demonstrated reduced risk at post-test. Of particular interest is Nonsense word fluency scores for Rose, Catrin and Dewi, indicating meaningful improvement in an important decoding skill.

WRaPS. With the exception of Catrin, who scored almost at ceiling at all times of testing, all participants demonstrated improvements in word recognition at post-test, most notably Rose and Medwyn who gained 12 and 16 months word recognition age respectively (see Table 4).

San Diego Quick Assessment. Both James and Dewi demonstrated increased word reading accuracy and fluency (see Table 5). James read 13 additional words accurately, increasing his reading rate from 16 to 24 words per minute and moving up one instructional level, and Dewi reading eight additional words accurately and doubling his reading rate to 40 words per minute.

All Wales Reading Test. James and Dewi made considerable gains in Welsh reading ability of 1 year 9 months and 2 years 6 months word reading age respectively over a 16-month period (see Table 6). Ben increased his raw score from 0 to 13, however made no measurable improvement on age equivalent score.Standardized scores were not available for this assessment due to James, Dewi and Ben being beyond the age at which such scores could be extrapolated.

TROG-2. With the exception of Rose, all participants made gains in age equivalent scores. Catrin gained 1 year, Dewi gained 6 months, and Ben increased from <4 years to 4 years. The most notable gains were seen for Medwyn, who gained 2 years 6 months, and James who gained 3 years 10 months.

DISCUSSION

The first question addressed in the present pilot study was whether children with IDD can access (i.e., progress through) a mainstream online reading program, HER, and what adaptations may be necessary to achieve this. All six participants completed the program, (with five out the six requiring no additional input), indicating children with

Table 4.
Individual Scores on the WRaPS assessment at Baseline and Post-test, and Individual Improvement Scores for All Participants

Participant	WRAPS scores	Baseline	Post-test	Change
Rose	Stage (/10)	6	9	+3
	Age equivalent (yrs,mnths)	6,7	7,7	+1yr
Catrin	Stage (/10)	10	10	0
	Age equivalent	8+[1]	8+[1]	0
Medwyn	Stage (/10)	2	7	+5
	Age equivalent	5,5	6,9	+1yr, 4m
Ben	Stage (/10)	6	8	+2
	Age equivalent	6,8	7,3	+7m
James	Stage (/10)	9	10	+1
	Age equivalent	7,6	8	+6m
Dewi	Stage (/10)	9	10	+1
	Age equivalent	7,9	8+[1]	+3

[1] *This assessment only provides age equivalents up to 8years of age.*

IDD can access the program, and that not all children require adaptations to enable this progress.

All participants enrolled in the training phase completed a greater number of episodes per week during the training phase than the subsequent teacher-led intervention period, suggesting the intensity of the intervention decreased over time. Crucially, only one participant completed the episodes at a rate that is recommended by the program developers (i.e., at least three per week). The formative data on outcomes of the program for typically developing children were based on the progress of children who completed at least three lessons each week, therefore this is the minimum suggested to achieve the reported outcomes of the program for typically developing children (M. Leon, personal communication, 28th June, 2012). It is possible that the significantly reduced rate of episode completion demonstrated by the participants in this study reduced the impact of the program on their reading skills. Future implementation and evaluations should therefore more closely monitor the fidelity of this aspect of implementation.

Children with IDD might not be expected to complete episodes with the same frequency as TD children (accounting for potentially slower responding due to episode repetition or splitting episodes over sessions). However, participants in this study demonstrated similar progress in terms of accuracy and duration of episodes, suggesting they were able to access the program in a similar way and at a similar pace to TD children. Furthermore, unlike previous research with children with autism and other disabilities, only one participant required additional input beyond the episodes and *Intensive Practice* exercises, requiring a small adaptation to enable progression through the program. This suggests time to completion could also be similar to that found with TD children for some children with IDD, highlighting the suggestion that others' low expectations for these children may be a variable preventing them becoming successful readers (Kliewer & Biklen, 2001; Kliewer, Biklen, & Kasa-Hendrickson, 2006).

The second question we wanted to address in this study was whether there are measurable effects of the program on key early reading and language skills of children with IDD. All participants had typically made no measurable gains in reading skills from year to year during their schooling. Although no historical data on the reading scores of these children were available, the fact that all children were well beyond beginning reading age and had very minimal reading skills at pre-test indicates that they had made little recent progress in reading. This suggests that any improvements seen were likely to be related to the use of HER, even for those children who took considerable time to complete the program.

With this context in mind, after completing HER, all six participants demonstrated improvements in reading skills, most notably in phonemic awareness, nonsense word decoding, and word recognition skills. The extent to which these reading skills generalized to improved oral reading fluency and overall reading age was not captured in any of

Table 5.
Individual Scores on the San Diego at Baseline and Post-test

Participant	San Diego scores	Baseline	Post-test	Change
James	Corrects	32	45	+13
	Corrects per min	16	24	+8
	Instructional level equivalent	1st Grade	2nd Grade	+1yr
Dewi	Corrects	37	45	+8
	Corrects per min	20	40	+20
	Instructional level equivalent	2nd Grade	2nd Grade	0

Table 6.
Individual Scores on the All Wales Reading Test at Baseline and Post-test

Participant	Scores	Baseline	Post-test	Change
Ben	Raw score	0	17	+17
	Age Equivalent	–	–	–
James	Raw score	27	40	13
	Age Equivalent	6,5	8,2	+1yr 9m
Dewi	Raw score	28	42	+14
	Age Equivalent	6,5	8,11	+2yr 6m

the measures used with Rose, Catrin, Medwyn, or Ben. However, James and Dewi demonstrated increased fluency in word reading. With the exception of the DIBELS, the reading assessments used did not have specified test re-test reliability or alternative versions for repeat assessment. Although these measures still give an indication of improved reading skills, assessments known to have high test re-test reliability would be beneficial for future research. Assessments of oral reading fluency and broader phonological abilities are also needed to further elucidate the potential effects of HER for children with IDD. Furthermore, although it might be that smaller gains made by some children were due to the intensity of the intervention being much lower than recommended, this needs to be investigated further. In addition, it is important to be cautious about the findings since no control comparisons were available in this pilot study. Further research with additional assessment and implementation resources would enable the inclusion of a control group, thus further elucidating the effects of HER for children with IDD as compared with typical provision. Such controls and increased intensity of the programme would also reduce the threat of history on the validity of the study—with participants taking between 50 and 79 weeks to complete the programme, it is a possibility that other variables impacted reading skills during this time.

Improvements in language assessments were variable across participants and time of testing. However, some notable improvements were made on the *TROG-2* and the *word use fluency* subtest that indicate there may be collateral effects on other language skills that merit further investigation. Additionally, improvements in Welsh reading ability indicate the collateral effects on an additional language is also worthy of further investigation, particularly measuring of component skills (such as phonemic awareness, segmenting and blending) in Welsh. Standardized scores were not available for this assessment due to James, Dewi and Ben being beyond the age at which such scores could be extrapolated.

There are a number of limitations of using raw scores and age equivalent scores (as opposed to standardized scores) when measuring skill development. Raw Scores simply indicate the number of correct responses made during the assessment, rather than providing any information on performance relative to others of the same age (Maloney & Larrivee, 2007). Age equivalent scores essentially indicate the age at which a particular Raw Score is the average score (Salvia et al., 2006). One significant issue with using age equivalent scores in isolation is that they can be misinterpreted to imply that improvement typically occurs at a constant rate across time, when in fact smaller changes in raw scores can lead to greater changes in age equivalent score as chronological age increases (McCauley & Swisher, 1984). A further issue is that it is not possible to calculate a specific age equivalent score for individuals who score very low or very high, causing measures of change in these scores to be insensitive for many individuals. Additionally, the validity of age equivalent scores for children with IDD is questionable on the basis that little is know regarding the different processes used by individuals to attain raw scores (Couzens et al., 2004). In the context of the data presented in this study, the Raw Scores and Age Equivalent scores together give an indication of whether Welsh reading performance improved during the period of intervention. However, future research investigating measures that might allow for calculation of standardized scores would be beneficial to elucidate the effects of HER on Welsh reading skills.

The data from this pilot study demonstrate that children with IDD can access and may benefit from HER, suggesting children with IDD can benefit from phonics-based reading instruction incorporating the five essential components of reading instruction (NRP, 2000). The increasing evidence that many children with additional needs can access HER (e.g., Clarfield & Stoner, 2006; Grindle et al., 2013), and the indication from the current study that some children with IDD can progress through the program at a similar pace to TD children, also has significant implications for the potential use of the program as part of an inclusive curriculum. Furthermore, with expert instruction provided directly through the online program, high quality access to this core curriculum area can be provided with minimal training. However, as the current study indicated it was more difficult to maintain the intensity of the intervention when it was teacher-led, an appropriate training and support model for high fidelity use of the program requires further investigation.

There are a number of considerations for future research. In addition to the general issues of training, time and staff resources in SEN settings, an important consideration in the timescale of program completion is the input required through implementing the *Intensive Practice* additional support, which includes over 100 frequency-building exercises. In the present study, we decided that all participants would complete these additional exercises because of their language and learning difficulties. Howev-

er, because all participants started at Episode one of the program (which begins with reading basics suitable for TD children from the age of four) and their episode data were comparable to that of TD children, it may be that this additional tier of support is not necessary for all children with IDD to complete the program and obtain significant outcomes. Further research using either the *Targeted Practice* tier (including only 25 additional exercises) or the standard intervention (episodes and stories alone), may increase the feasibility of conducting the program with the recommended intensity, also reducing time to completion and thus enabling the evaluation of the effects of the program as a whole for children with IDD.

Although all participants were receiving educational services for children with IDD and BPVS scores indicate each had an IDD, no specific measure of adaptive skills or IQ was conducted. To investigate the parameters for beneficial use of HER with children with IDD, clearer information is required to define the population in future research. Such information could also enable investigation of predicting factors in the level of support children may require in order to benefit from the program.

In terms of theoretical contribution, this study provides some interesting insight into appropriate and effective practices for teaching reading to children with IDD. Research previously outlined indicates that children with IDD might benefit from instruction incorporating components of reading instruction found to be essential for TD children, suggesting there is not necessarily a special pedagogy specific to children with IDD. The results of this pilot study are consistent with this idea, demonstrating that an evidence-based approach not specifically designed for children with special needs, but built on general principles of learning, can potentially be effective for children with IDD.

This is the first study that we are aware of investigating the use of an online reading program designed for TD children with children with IDD. Given that children with IDD have historically underachieved in this crucial academic area, and the challenge of teaching complex functional reading skills to many children with IDD, this study represents the beginning of an exciting area for future research that could have significant impact on children with IDD and their academic achievement.

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