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Enhanced recognition of written words and enjoyment of reading in struggling beginner readers through whole-word multimedia software

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ABSTRACT

The effectiveness of a reading intervention using the whole-word multimedia software 'Oxford Reading Tree (ORT) for Clicker' was compared to a reading intervention using traditional ORT Big Books. Developing literacy skills and attitudes towards learning to read were assessed in a group of 17 struggling beginner readers aged 5–6 years. Each child was given each of the two interventions, and the order of intervention was counterbalanced across the group. Each intervention was integrated into the literacy hour over five consecutive days. Measures of written word recognition, written word naming, phonological awareness and attitudes towards computers were taken before and after each intervention. Significant gains in performance were found following both interventions for all of the literacy measures, but significantly greater gains in written word recognition and enjoyment of instruction were found following the Clicker than Big Book intervention. These results suggest that whole-word multimedia software could be a useful classroom aid for supporting early literacy skills in children who are struggling with learning to read.

1. Introduction

To become a successful reader children must learn how to recognise words in text automatically and fluently as well as comprehend their meaning. Not all children learn to read without difficulties and previous studies have demonstrated that most poor readers have problems establishing fluent and accurate word identification skills (Adams, 1990; Stanovich, 1988; Torgesen, 1998). Reading acquisition is thought to involve two key processes: (1) developing alphabetic knowledge for decoding unfamiliar word forms and (2) establishing orthographic, whole-word, recognition skills that enable familiar words to be recognised rapidly (Castles & Nation, 2006). For word recognition to become automatic and unconscious, Ehri (2005) proposes four alphabetic phases are necessary (pre-alphabetic, partial, full, and consolidated) which form connections between word spellings and their pronunciation and meaning. Whilst orthographic processing is believed to be autonomous in skilled readers (Perfetti, 1992), the acquisition of whole-word recognition skills is thought to be dependent on alphabetic processes (Ehri, 2005).

Previous studies have shown that weaknesses in phonological decoding skills are the most frequent cause of reading difficulties (Perfetti, 1985; Rack, Snowling, & Olson, 1992; Siegel, 1989). Weaknesses in decoding skills make reading independently difficult and laborious leading to misreading words and producing errors (Torgesen, 2002). If not corrected, this could lead to further inaccurate letter-to-sound pattern associations when the reader encounters similar words (Share, 1995, 2004) and affect the development of fluent word reading ability. As most poor readers have difficulties acquiring alphabetic knowledge, they require a lot of practice and exposure to text to be able to recognise written words fluently (Ehri, 2005).

Clearly, it is important to provide training that supports the development of alphabetic knowledge in children struggling with learning to read. However, the English language is permeated with phonologically irregular or inconsistent words, such as "*come*", "*were*", and "*gnome*", which cannot be decoded accurately with grapheme–phoneme correspondence rules. As irregular and inconsistent words occur frequently in early reading texts, children need to learn to recognise these words as whole-word units, so as to avoid making regularization errors when decoding skills are applied (such that "*come*" is read as "*come*" to rhyme with "*home*"). For struggling readers, with poor phonological skills, learning to recognise words explicitly as whole-word units may provide a means by which they can build up a sizable

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lexicon of familiar words (both regular and irregular), thus enabling them access to texts that they would otherwise struggle to read. This in turn may reduce the likelihood of poor readers "giving up" on the act of learning to read, especially if the learning of whole-words is taught in an interactive and engaging environment.

Seemingly, the most effective means of supporting reading acquisition in English involves attending to both phonological decoding skills and whole-word recognition skills, in particular throughout the first 3 years of early education (Torgesen, 1998). McKenna argued that "until automatic decoding and fluency is reached, word recognition will constitute a major bottleneck in the child's effort to negotiate text" (McKenna, 1998, p. 46). Only when this bottleneck has been tackled can attention and conscious mental effort be used for understanding the text rather than trying to recognise the words comprising it (Ehri, 1995, 2005; McKenna, 1998; Perfetti, 1992).

The amount of practice a child has in reading also plays an important role in developing word identification skills (Cunningham & Stanovich, 2001; Share, 2004). Cunningham and Stanovich (2001) showed that automaticity and speed in recognising written words can be affected and delayed by the lack of practice in reading and exposure to written text. These authors suggest that children should be provided with as many reading experiences as possible. However, children that struggle with learning to read may develop a negative attitude towards reading (McKenna, 1998) as they find it a difficult task. Consequently, poor readers may become less motivated than their peers of average or good reading ability. As a result, struggling beginner readers may not develop reading fluency, automaticity, or adequate comprehension skills, and can fall even further behind their achieving peers (Ehri, 2005; Stanovich, 1986).

Keeping children that are struggling with learning to read motivated seems to be critical in helping to reduce the likelihood of them giving up on the task. New advances in technology are available to teachers that may help address the difficulties poor readers experience. A range of computer-based packages can be used in the classroom, which aim to provide instruction through interactive, multimedia, learning experiences. Many of these offer unique and specific features, such as touch-screens, digitised speech, drill generation and adaptation algorithms, individualised learning sequences, and feedback that is synchronised to the child's pace of learning, all of which can lead to increased motivation and developing self-confidence in children who are at risk of reading failure (Mioduser, Tur-Kaspa, & Leitner, 2000).

A growing body of evidence has shown that well-designed educational multimedia intervention programs can be beneficial in supporting different aspects of literacy skill in struggling readers, including phonological awareness, visual word recognition, and reading comprehension (see Blok, Oostdam, Otter, & Overmaat, 2002; MacArthur, Ferretti, Okolo, & Cavalier, 2001; for reviews). However, most of these studies used programs that present words in isolation, which differs from educational practice as teachers tend to choose commercial software programs with a storybook format (Wood, 2005), or that has been derived from familiar reading materials, which complements existing reading schemes and provides extra practice (Davidson, Elcock, & Noyes, 1996). Furthermore, most previous studies have removed children from their naturalistic classroom setting when administering the intervention (DeJean, Miller, & Olson, 1999), so the effectiveness of multimedia software in supporting early literacy acquisition when delivered by the class teacher is not well known. Multimedia software may also address the motivational issues facing many poor readers, but very few studies have explored this.

In the present study we investigated if the whole-word multimedia software 'ORT for Clicker' facilitates developing literacy skills in Year 1 children that are struggling with learning to read. ORT for Clicker is a multimedia software program, designed to promote whole-word recognition skills. This series of on-screen talking storybooks is produced by Crick Software and Oxford University Press and is based on the Oxford Reading Tree (ORT) scheme that is used in a large number of primary schools across the UK. In a previous study, Karemaker, Pitchford, and O'Malley (in press), found significantly greater gains in written word recognition, written word naming, and phonological awareness following instruction with this multimedia software compared to traditional ORT printed texts in typically developing, average, readers. They attributed this difference to the multimedia features (auditory and visual cues) incorporated into the software that highlight words when spoken by a narrator. Here, we adopt a similar classroom-based intervention study to explore if ORT for Clicker is also effective in supporting the development of early literacy skills in children that are struggling with learning to read, and whether or not intervention with this software changes poor readers' attitudes towards reading.

2. Method

2.1. Design

An AB–BA counterbalanced intervention design was adopted in which children from two different primary schools were each given two interventions (ORT for Clicker and traditional ORT Big Book). The study was conducted in both schools over a five week duration in which participating children were assessed on key measures of literacy skill in the week preceding (pre-test measure) and following (post-test measure) each intervention (see Table 1).

Table 1
Summary of study design.

	School 1 ($n = 8$)	School 2 ($n = 9$)
Week 1	Pre-test assessments	Pre-test assessments
Week 2	Intervention I ORT for Clicker "Strawberry Jam"	Intervention I ORT Big Book "Kipper the Clown"
Week 3	Post-test assessments	Post-test assessments
Week 4	Intervention II ORT Big Book "Kipper the Clown"	Intervention II ORT for Clicker "Strawberry Jam"
Week 5	Post-test assessments	Post-test assessments

2.2. Participants

Three classroom teachers at the UK educational level Year 1, key-stage 1, from two primary schools that varied in socio-economic status, were asked to identify children they considered to be struggling readers compared to class peers. Twenty-two children were identified all of whom had informed parental consent to participate in the study. Each child was given the Word Reading subtest of the Wechsler Individual Achievement Test (WIAT) (Wechsler, 2005) so as to obtain a standardised measure of their reading ability. This subtest assesses early reading (phonological awareness), word recognition, and decoding skills. A standard score of 90 or below on this subtest represents low-average readers whereas a standard score of 80 or below represents borderline or extremely poor readers. Only children that achieved a standard score 90 or less (below average) were given the interventions. This resulted in five children being excluded from the study as they achieved standard scores within the normal range (above 90). The final group consisted of 17 children. Table 2 reports the characteristics of each child and the schools from which they were recruited.

2.3. Materials

The interventions used two different stories from the Oxford Reading Tree Scheme (“Strawberry Jam” and “Kipper the Clown”). One story was given in each of the intervention weeks. Stories were selected that were deemed suitable for Year 1 of the ORT scheme. “Strawberry Jam” (Hunt & Brychta, 2003a) is a story about a family where the father wants to make his own jam. The following keywords are integrated into the story: *about, an, had, help, his, home, make, over, put, ran, some, time, too, took, want(ed), were, your*. “Kipper the Clown” (Hunt & Brychta, 2003b) is a story about some children trying to put on a circus. The keywords used in this story are: *after, be, did, good, had, his, laugh, made, man, pull(ed), put, want(ed), what*.

Both Strawberry Jam and Kipper the Clown are available in ORT for Clicker and Big Book printed format, and in each format both the number of pages (16) and text are identical. The ORT for Clicker version is produced and published by CrickSoftware (2006) and highlights each word in the story (in red) whilst being read aloud by a narrator. Six activities are also provided to help reinforce the keywords used in each story: “words”, “word practice”, “sentences”, “comprehension”, “writing” and “make a book”.

The ORT Big Book version is a larger printed text of the regular sized books used for individual reading, measuring ~14 by 13 in. The larger text and images of the Big Book version are visually accessible from a distance so can be read aloud by the class teacher to the whole class or smaller groups of children. Typically, the class of children sit in a circle looking at the book, and the teacher points to the words and pictures as s/he is reading. Teaching notes support the traditional Big Book version, in which prompts, suggestions, and activities are provided. These activities are highly similar to those provided in the ORT for Clicker version.

The following materials were used to measure key aspects of literacy skill pre- and post-intervention.

2.3.1. Written word recognition

Visual word recognition skills were assessed using a lexical decision task (LDT). A total set of 90 letter strings, comprising 45 words and 45 nonwords, were presented randomly on a PC–laptop controlled by E-prime software. Task instructions were presented on the laptop screen and read aloud by the experimenter before administering the experimental trials. The experimenter told each child that they were about to see a mixture of words and nonsense words and they had to press the green key on the key-board (the ‘C’ key covered by a green sticker) when they saw a familiar word and to press the red key (the ‘M’ key covered by a red sticker) when they saw a unfamiliar nonsense word. Ten practice trials, consisting of five words and five nonwords, were given to each child so as to familiarise them with the task, after which the experimental trials were administered. Each trial started with a fixation cross which was displayed in the centre of the screen for 500 ms, followed by a centrally presented letter string, which remained on the screen until the child responded by pressing either the red

Table 2
Gender (M = male, F = female), chronological age (CA), and WIAT reading for the 17 children drawn from two schools (and three classes) varying in socio-economic status (SES) and order of interventions given (I and II).

Child	Gender	CA (months)	WIAT (standard score)	School (class) SES intervention order
AM	M	75	86	School 1 (class 1) low SES I Clicker II Big Book
AJ	M	72	90	
CA	M	71	85	
KA	M	76	83	
KI	F	72	88	
NA	M	75	86	
SH	F	80	89	
EL	M	76	85	
N 8	M:F 6:2	M (SD) 74.6 (2.9)	M (SD) 86.5 (2.3	
BE	M	72	85	School 2 (class 1) high SES I Big Book II Clicker
ED	M	70	90	
IS	F	68	89	
JA	M	72	87	
KY	F	73	87	
RA	M	77	83	
N 6	M:F 4:2	M (SD) 72.0 (3.0)	M (SD) 86.8 (2.6)	
HA	M	78	89	School 2 (class 2) high SES I Big Book II Clicker
GR	F	70	84	
PA	F	71	84	
N 3	M:F 1:2	M (SD) 73.0 (4.4)	M (SD) 85.7 (2.9)	
Group N 17	Group M:F 11:6	Group M (SD) 73.4 (3.2)	Group M (SD) 86.5 (2.4)	Kruskall Wallis[a] CA & WIAT ns

[a] Kruskall–Wallis signed rank test (corrected for ties) showed no significant difference in either CA ($H = 2.0$, $p > .05$) or WIAT scores ($H = .7$, $p > .05$) across the three groups.

or green key. Feedback was given after each response in the form of a smiley cartoon face for a correct response and a sad cartoon face for an incorrect response.

The 90 experimental trials were presented in three blocks of 30 trials, with each block consisting of 15 words and 15 nonwords. As each block took about 10 min to complete administration of the three blocks were separated with breaks of up to one day, in order to reduce boredom and ensure that each child completed all 90 experimental trials. Trial order was randomised within each block and the order of blocks was counterbalanced across children.

Letter strings were presented using black lower case letters in 28-point black Comic Sans font against a white background. The 45 words were carefully selected from word lists provided by the National Curriculum for children in Reception, Years 1 and 2. Five words were taken from the Reception word list so as to prevent floor effects. Twenty-five high frequency keywords were selected from the ORT stories used in the interventions. A further 10 words were taken from the Year 1 list and finally 5 Year-2 words were included in order to prevent ceiling effects. By changing some of the letters in the 45 real words a set of 45 pronounceable novel nonsense words (e.g., "pid") was created that were matched to the real words for length and familiar letter sequences. The word and nonword stimuli used are listed in Appendix A.

2.3.2. Written word naming

Naming of written words was assessed using a single word oral reading task (SWORT), in which each child was asked to read aloud the 45 word stimuli used in the LDT. The task began with instructions presented on the laptop screen that the experimenter read aloud followed by the experimental trials. Each trial started with a fixation cross displayed centrally for 500 ms, followed by central presentation of an individual word in black lowercase 28-point Comic Sans font against a white background. The experimenter recorded the child's response by pressing the 'Y' key for when they named a word correctly and the 'N' key when they named a word incorrectly or when no response was given. Trial order was randomised across participants.

2.3.3. Phonological awareness

Phonological awareness was assessed using three subtests (rhyming, segmentation, and graphemes) from the Phonological Awareness Test (PAT) (Robertson & Salter, 1997). The rhyming subtest consisted of 20 items, which were given over two 10-item tasks: discrimination (e.g., "do hop and mop rhyme?") and production (e.g., "what rhymes with shower?"). The segmentation subtest consisted of 30 items, which were given over three 10-item tasks of increasing difficulty (sentences, syllables, and phonemes), that required each child to clap to each word, syllable, or phoneme spoken by the experimenter in a sentence or word respectively. The graphemes subtest consisted of 58 items and required each child to produce the corresponding sound (phoneme) to different consonants, short vowels, consonants blends, consonants digraphs, R-controlled vowels, vowel digraphs and diphthongs.

2.3.4. Attitude questionnaire

A measure of attitude towards computers in the classroom was obtained for each child using three of the seven subscales (16 items in total) of the Young Children's Computer Inventory (YCCI) version 5.14 (Knezek & Miyashita, 1993). This inventory is intended for use with children in the first 3 years of schooling and uses a three-smiley-face Likert scale to record the level of agreement with each statement (happy-face = agree, neutral-face = undecided, sad-face = disagree). Items from the three subscales that focus on computer importance (i.e., knowledge of how to use computers; e.g., "I would work harder if I could use computers more often"), computer enjoyment (i.e., amount of pleasure derived from using computers, e.g., "I enjoy doing things on a computer"), and motivation (i.e., the child's perseverance, e.g., "I enjoy working on a difficult problem") were selected (see Appendix B).

2.4. Procedure

The class teacher delivered each of the two interventions for 1 h each day over five consecutive days (Monday to Friday) during the daily literacy hour. The interventions were designed specifically to reflect the structure of a typical literacy hour. Each session began with a 15-min whole-class "shared work" activity followed by a 15-min whole-class "word/sentence level work" activity. A 20-min "focus" activity was then given in which each child worked individually on specific tasks. The session ended with a 10-min "plenary" where the teacher consolidated ideas from the lesson with the whole-class.

The class teacher used ORT for Clicker (version 5.2) with a SMART interactive whiteboard during the whole-class activity. Each of the struggling readers was then given a focus activity where they worked through the accompanying Clicker activities on an individual laptop computer (Toshiba, M300) using an attached mouse and headphones. For the Big Book intervention, the class teacher read aloud the Big Book story to the whole-class, with the book facing towards the children. This was followed by a focus activity in which each of the struggling readers worked through individual activities using pen, paper and regular sized ORT books. Appendix C provides an overview of the different activities conducted in the Clicker and Big Book interventions for one day of the intervention week.

The experimenter administered the pre- and post-intervention measures of literacy skill to each child individually, in a quiet area free from distraction. Tasks were administered over several short sessions (lasting ~15 min) over five consecutive days, in the following order: lexical decision, PAT rhyming, segmentation, graphemes, single word oral reading, and attitude towards computers questionnaire.

3. Results

Two sets of analyses were conducted to investigate the effect of intervention at both the group- and participant-level.

3.1. Group-level analyses

Independent *t*-tests were conducted to examine differences in baseline performance on each measure of literacy skill between children from School 1 and 2. No significant differences were found ($p > .05$, at least) so data were collapsed across schools. Table 3 reports group mean performance ($n = 17$) for each measure of literacy skill assessed at baseline, and following the ORT for Clicker, and traditional ORT Big

Table 3
Group mean score (standard deviation) for the different measures of literacy skill (LDT, SWORT, and PAT) and attitude towards computers questionnaire (AQ, where scores range from 1 to 3 reflecting most-least agreement) attained at baseline and after the ORT for Clicker and traditional ORT Big Book interventions.

Measure		Mean (sd)		
		Baseline	Clicker	Big Book
LDT	Words/45	18.06 (8.2)	23.82 (8.7)	21.35 (8.1)
	Nonwords/45	29.88 (9.2)	27.24 (10.9)	27.35 (10.2)
SWORT/45		7.35 (7.3)	12.06 (8.1)	10.94 (8.2)
PAT	Rhyme/20	12.59 (6.3)	15.24 (5.5)	14.82 (5.9)
	Segmentation/30	15.29 (4.3)	17.53 (5.0)	17.47 (5.5)
	Graphemes/58	23.29 (6.3)	26.94 (7.3)	28.29 (9.1)
AQ	Importance	1.44 (.39)	1.37 (.39)	1.47 (.38)
	Enjoyment	1.24 (.33)	1.06 (.15)	1.20 (.21)
	Motivation	1.42 (.39)	1.45 (.39)	1.44 (.40)

Book, intervention. For each literacy measure, repeated-measures ANOVA, followed by pairwise comparisons using Newman–Keuls ($p = .05$, at least), were conducted to explore differences in mean performance across assessment time. Effect sizes, using Cohen's d (Cohen, 1988), are also reported.

3.2. Written word recognition (LDT)

For recognising real words, a significant effect of assessment time was found ($F(2, 32) = 15.86$, $p < .0001$) as each intervention led to significant gains in word recognition compared to baseline (Clicker mean performance gain = 5.76; Big Book mean performance gain = 3.29). Larger effect sizes were found for the Clicker ($d = .68$) than Big Book ($d = .4$) intervention, and pairwise comparisons showed significantly more words were recognised correctly after intervention with Clicker than Big Book ($d = .29$). In contrast, no significant difference in performance across assessment time was found for the group's ability to recognise nonwords ($F(2, 32) = 1.51$, $p = .237$).

Further analyses were conducted on the different sets of words (intervention keywords, reception, Year-1, and Year-2 words) used in this task to see which word sets, if any, the interventions targeted. Table 4 reports group mean performance (standard deviation) for each word set at baseline and following each of the two interventions. Results showed significant effects of assessment time for all word sets except Year-2 words (intervention keywords: $F(2, 32) = 21.78$, $p < .0001$; reception words: $F(2, 32) = 8.42$, $p = .001$; Year-1 words: $F(2, 32) = 4.53$, $p = .019$; and Year-2 words: $F(2, 32) = 2.08$, $p = .142$). Both interventions resulted in significant performance gains compared to baseline for the intervention keywords (Clicker $d = .71$; Big Book $d = .42$) and reception words (Clicker $d = .76$; Big Book $d = .71$), although improvement in recognising Year-1 words was significant only for the Clicker intervention ($d = .57$). Furthermore, compared to Big Book, intervention with Clicker led to significantly greater gains in recognising the intervention keywords ($d = .29$).

3.3. Written word naming (SWORT)

For reading aloud of single words a significant effect of assessment time was found ($F(2, 32) = 18.64$, $p < .0001$) and pairwise comparisons showed that each intervention led to significant gains in performance compared to baseline only (Clicker mean performance gain = 4.71; Big Book mean performance gain = 3.59).

To investigate further if the two interventions targeted specific word sets comprising this task, additional analyses were conducted on group mean performance for each word set (see Table 4). Significant effects of assessment time were found for all word sets except Year-2 words (intervention keywords $F(2, 32) = 23.59$, $p < .0001$; reception words $F(2, 32) = 5.4$, $p = .01$; Year-1 words $F(2, 32) = 5.81$, $p = .007$; and Year-2 words $F(2, 32) = .79$, $p = .462$). For each word set, significant performance gains were found of a similar magnitude for the Clicker (intervention keywords $d = .68$, reception words, $d = .43$, Year-1 words $d = .40$) and Big Book (intervention keywords $d = .49$, reception words, $d = .34$, Year-1 words $d = .46$) interventions compared to baseline only.

Table 4
Group mean score (standard deviation) for the different sets of words comprising the lexical decision task (LDT) and single word oral naming task (SWORT) produced at baseline and after the ORT for Clicker and traditional ORT Big Book interventions.

Task	Mean (sd)		
	Baseline	Clicker	Big Book
LDT			
Intervention words/25	10.12 (5.4)	14.0 (5.6)	12.41 (5.4)
Reception words/5	3.12 (1.2)	4.0 (1.1)	3.94 (1.1)
Year-1 words/10	3.53 (1.7)	4.59 (2.0)	4.12 (1.9)
Year-2 words/5	1.29 (.99)	1.24 (1.0)	.88 (.78)
SWORT			
Interventions words/25	4.12 (4.2)	7.12 (4.6)	6.35 (4.9)
Reception words/5	1.82 (1.6)	2.47 (1.4)	2.35 (1.5)
Year-1 words/10	1.18 (1.5)	1.82 (1.7)	2.0 (2.0)
Year-2 words/5	.24 (.4)	.35 (.5)	.24 (.4)

Table 5
Performance difference after interventions I and II for (i) individual children and (ii) the group of children (mean, standard deviation), from Schools 1 and 2, for each of the literacy measures. Mann–Whitney U (MWU) and *p* statistics are given for each measure of literacy skill.

Child	School order	LDT				SWORT		PAT						AQ					
		Words		Nonwords				Rhyme		Segmentation		Graphemes		Import.		Enjoy.		Motiv.	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
AM	School 1	4	2	−9	0	3	5	10	−4	5	3	−1	7	0	0	0	0	0	0
AJ		−1	3	1	2	6	−5	1	0	−1	0	8	1	0	0	0	0	0	0
CA	I Clicker	−2	−1	1	−6	5	−2	3	−3	0	0	2	5	0	0	0	0	0	.2
KA		5	7	7	−9	11	−4	0[a]	0[a]	8	−1	3	5	0	.1	0	0	0	0
KI	II Big Book	2	1	0	−1	1	4	11	−1	3	1	3	3	−.5	.7	−.6	0	0	0
NA		11	−1	−3	0	4	5	6	1	0	−1	4	5	−.3	.3	−.2	.2	.4	−.4
SH		7	−5	−1	−3	7	0	4	1	5	−3	1	8	.1	−.1	−.2	.2	0	0
EL		−1	3	5	−16	8	1	4	0	0	4	7	4	0	0	−.4	.4	0	0
N = 8	M	3.1	1.1	.1	−4.1	5.6	.50	4.9	−.75	2.5	.38	3.4	4.8	−.09	.13	−.18	.10	.05	−.02
	(SD)	(4.5)	(3.6)	(4.9)	(6.0)	(3.1)	(4.0)	(3.9)	(1.8)	(3.3)	(2.3)	(3.0)	(2.2)	(.20)	(.26)	(.23)	(.15)	(.14)	(.17)
BE	School 2	1	11	−3	−15	1	3	2	−1	3	2	4	4	0	0	0	−.2	0	0
ED		3	4	−2	−7	5	0	1	0	6	−1	4	1	−.1	.1	.2	−.4	0	0
IS	I Big Book	2	6	0	−2	1	5	0	0	2	1	4	2	0	−.3	0	−.2	0	−.2
JA		0	5	4	−5	0	3	3	0	0	1	4	4	.2	−.3	0	0	0	0
KY	II Clicker	1	2	−8	10	0	1	4	0	3	−2	0	1	.2	−.2	0	0	0	0
RA		5	6	−13	−2	0	0	−5	1	−1	1	−1	1	0	0	0	−.2	0	0
HA		4	3	1	0	2	1	0[a]	0[a]	2	0	3	2	0	0	−.2	−.4	0	0
GR		2	8	15	−16	1	2	0	0	1	0	1	0	0	0	0	−.2	0	0
PA		4	6	−5	2	2	8	0	1	−1	2	1	0	0	0	0	0	0	.2
N = 9	M	2.4	5.7	−1.2	−3.9	1.3	2.6	.56	.11	1.6	.44	2.2	1.7	.03	−.08	.0	−.18	.0	.0
	(SD)	(1.7)	(2.7)	(7.9)	(8.2)	(1.6)	(2.6)	(2.6)	(.60)	(2.4)	(1.3)	(2.0)	(1.5)	(.10)	(.15)	(.10)	(.16)	(.0)	(.10)
	MWU	34.5	10.5**	28.0	36.0	7.0**	26.0	12.0*	28.5	31.5	32.5	30.5	8.5**	27.0	20.5	19.0*	7.5**	31.5	35.5

[a] Performance was at ceiling for each assessment time.
* $p < .05$.
** $p < .01$.

3.4. Phonological awareness (PAT)

For all three subtests of the PAT, significant effects of assessment time were found (rhyme awareness: $F(2, 32) = 7.37$, $p = .002$; segmentation: $F(2, 32) = 8.93$, $p = .001$; grapheme awareness: $F(2, 32) = 19.16$, $p < .0001$), as each intervention resulted in significant improvements compared to baseline. Similar effect sizes were found for both interventions across subtests (Clicker: rhyme awareness $d = .45$; segmentation $d = .48$; grapheme awareness $d = .54$; Big Book: rhyme awareness $d = .37$; segmentation $d = .44$; grapheme awareness $d = .64$).

3.5. Attitude towards computers questionnaire (AQ)

Table 3 reports the mean score (standard deviation) generated by the group of struggling readers for each of the three measures from the attitude towards computers questionnaire. Scores range from 1 to 3, where a score of 1 indicates the most agreement and a score of 3 indicates the least agreement with each of the items used. Results revealed no significant effect of assessment time for either computer importance ($F(2, 32) = 1.15$, $p = .33$) or computer motivation ($F(2, 32) = .41$, $p = .66$). In contrast, a significant effect of assessment time was found for computer enjoyment ($F(2, 32) = 9.95$, $p < .001$), as the group of struggling readers expressed significantly greater agreement with the computer enjoyment items on the attitude questionnaire after they had received the ORT for Clicker intervention compared to both baseline and intervention with Big Book.

3.6. Participant-level analyses

To explore if the performance gains reported above found at the group level for each of the two ORT interventions were driven by individual children participant-level analyses were conducted. For each child, differences in performance following the ORT for Clicker and traditional Big Book interventions were determined for each of the measures of literacy skill and attitudes towards computer (see Table 5). Results showed that each of the 17 struggling readers showed improvement in at least one measure of literacy skill after each of the two interventions, although considerable variation was shown across children for each task, and across tasks for individual children.

Additional analyses were conducted to explore the effect of order of intervention across schools. For each measure, differences in mean performance across schools were explored using Mann–Whitney Signed Ranks Test (because of the small Ns). As reported in Table 5, significant effects of intervention order across schools were found for recognising words (LDT) after intervention II, reading words aloud (SWORT) after intervention I, rhyme awareness (PAT) after intervention I, grapheme awareness (PAT) after intervention II, and computer enjoyment (AQ) after interventions I and II. For each of these measures, significantly greater gains were found across school after intervention with Clicker compared to Big Book, except for grapheme awareness, where significantly greater gains were found after School 1 received Big Book whilst School 2 received Clicker.

4. Discussion

We evaluated whether ORT for Clicker supports emergent literacy skills of struggling beginner readers. This multimedia intervention has been shown to be effective for typically developing readers of the same age (Karemaker, Pitchford, & O'Malley, in press; see Parette, Hourcade, Dinelli, & Boeckmann, 2009 for a review) and is also likely to benefit children who are struggling with learning to read, as ORT for Clicker is based on processing whole-words, rather than phonics which usually an area of weakness for poor readers.

Results showed that, compared to baseline, both the ORT for Clicker and traditional Big Book intervention lead to significant gains in performance for the group of struggling readers for all measures of literacy skill administered, namely written word recognition, written word naming, and phonological awareness. In addition, all of the 17 children showed improvement in at least one measure of literacy skill after receiving each intervention. This suggests that both methods of implementing the ORT scheme (i.e., multimedia software and traditional printed texts) are effective in supporting development of early literacy skills in children that are struggling with learning to read. However, comparing performance gains to a matched group of children who did not receive either of the ORT interventions is necessary to provide confirmatory evidence for this claim. Our results with struggling readers corroborate those found previously with typically developing readers (Karemaker, Pitchford, & O'Malley, in press) and illustrate that the ORT scheme can support literacy acquisition across a wide range of ability and SES.

Comparing across interventions, greater gains were found at the group-level after intervention with Clicker compared to Big Book for recognising written words. Clicker intervention significantly facilitated struggling readers' ability to recognise words rather than non-words, particularly the set of high frequency keywords used in the ORT stories and the set of words being taught over Year 1. In addition, greater gains in performance were found in recognising and naming written words, and awareness of rhyme, across schools after intervention with Clicker compared to Big Book. Only awareness of graphemes was shown to be significantly better across schools when intervention with Big Book was administered after intervention with Clicker. Together, these results suggest that ORT for Clicker is more effective than traditional printed ORT texts in supporting early literacy skills in children that are struggling with learning to read. However, larger scale studies are needed to support the findings from this relatively small-scale study. In addition, long-term studies are needed to establish if the specific effects of Clicker intervention found here persist with extended use of the multimedia software.

Specific features incorporated into the multimedia software that are not present in the traditional printed books may account for the differences found. ORT for Clicker has an in-built visual and auditory feature that highlights individual words or sentences whilst being read out by a narrator, and children can access this feature upon request whilst working through the story or accompanying activities. This feature afforded by the multimedia software enables children to focus on individual words in written text that is being read out to them thereby reinforcing the mapping between orthography and phonology (De Jong & Bus, 2002; Korat & Shamir, 2007) and serves to focus attention at the whole-word level.

A more general feature of the ORT scheme that may also have supported whole-word recognition skills in the group of poor Year 1 readers is the repeated exposure of high frequency keywords. Children's word recognition, fluency, and comprehension skills have been shown

to improve more when a small set of words are repeated within sentences and passages of text than when sentences and passages contain mainly different words (Adams, 1990). Through repeated exposure lexical representation are formed enabling familiar written words to access phonology directly (Share, 2004). Accordingly, Stuart, Masterson, Dixon, and Quinlan (1999) recommended graded reading materials, such as ORT, that "systematically reinforce vocabulary already encountered through multiple repetitions, and which introduce new vocabulary little by little within a context of known words" (page 119).

Repeating keywords could play a central role in supporting struggling readers developing literacy skills as this enables mappings to be formed at the whole-word level between orthography and phonology and thus reduces the need to rely on decoding skills that poor readers find difficult. It is possible that Clicker may reinforce orthography to phonology mappings to a greater extent than traditional books with repeated keywords, because Clicker is able to provide pronunciations of unfamiliar words without the need of a teacher. By clicking on unfamiliar words, children are able to receive accurate pronunciation of novel words used in the text and they can access this feature upon demand when working individually with the software. Video-observations made during intervention with Clicker showed that the struggling readers regularly accessed this feature, above and beyond the minimum required to successfully complete the activities.

It is also possible that the computerised implementation of the ORT stories in Clicker could have engaged children more than the traditional printed books. This may be particularly important for children that are struggling with learning to read as it may keep them on task for longer if they find working with the software enjoyable. Results from the attitude towards computers questionnaire administered to the poor readers in the study support this hypothesis. Children's ratings of computer enjoyment were found to increase significantly throughout the study, especially after using Clicker. This finding is consistent with McKenna (1998), who suggested that e-books promote a positive attitude towards reading. McKenna argued that early positive reading experiences are associated with high levels of support and success rates. It might be possible that multimedia software, such as ORT for Clicker, can bridge the gap between good and poor readers before the gap becomes wider or attitudes towards reading in struggling readers become adversely negative (McKenna, 1998).

The potential of multimedia software, such as Clicker, in supporting struggling readers must be evaluated within the context of the classroom environment. Many struggling readers need support beyond the level that can reasonably be expected from the teacher. Multimedia software can be used to extend the role of the teacher in providing instructions, feedback, and presenting children with multiple opportunities to practice, which they can work through at their own pace (Reitsma, 1988). As we have shown that poor readers find multimedia software more enjoyable than traditional reading books, prolonged use of e-books may be an effective aid in the classroom for supporting developing literacy skills in children that are struggling with learning to read.

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Appendix A

See Table A1.

Table A1
Stimuli used in the lexical decision and oral reading tasks.

ORT intervention words		Reception words		Year-1 words		Year-2 words	
Words	Matched nonwords	Words	Matched nonwords	Words	Matched nonwords	Words	Matched nonwords
about	abond	and	ind	bed	det	yellow	yelter
an	en	they	thim	his	hin	eight	teigh
had	dal	big	cag	more	moso	where	whust
help	welk	see	teeg	then	wesb	wednesday	wednesdau
home	wame	said	faip	were	lere	these	thamp
make	mage			once	kon		
over	ovel			night	yatoe		
put	pid			some	shom		
ran	rop			came	hame		
time	bime			down	drot		
too	noo						
took	hoos						
want	nand						
wanted	wented						
your	yurt						
after	dawoe						
be	ob						
did	tul						
good	harc						
laugh	healt						
made	yade						
man	mun						
pull	grel						
pulled	heapel						
what	whut						

Appendix B

See Table A2.

Table A2
Attitudes towards computers questionnaire (AQ), comprising of 16 items drawn from three subscales of the Young Children's Computer Inventory (Knezek & Miyashita, 1993).

1	I enjoy doing things on a computer	1	2	3
2	I am tired of using a computer	1	2	3
3	I will be able to get a good job if I learn how to use a computer	1	2	3
4	I concentrate on a computer when I use on	1	2	3
5	I enjoy computer games very much	1	2	3
6	I would work harder if I could use computers more often	1	2	3
7	I know that computers give me opportunities to learn many new things	1	2	3
8	I can learn many things when I use a computer	1	2	3
9	I enjoy lessons on the computer.	1	2	3
10	I believe that the more often teachers use computers, the more I will enjoy school	1	2	3
11	I believe that it is very important for me to learn how to use a computer	1	2	3
12	If I do not understand something, I will not stop thinking about it	1	2	3
13	When I do not understand a problem, I keep working until I find the answer	1	2	3
14	I enjoy working on a difficult problem	1	2	3
15	I think about many ways to solve a difficult problem	1	2	3
16	I never forget to do my homework	1	2	3

Subscale	Items
Computer importance	3, 6, 7, 8, 10, and 11
Computer enjoyment	1, 2[a], 4, 5, and 9
Motivation/persistence	12, 13, 14, 15, and 16

[a] Reversal of item negatively worded.

Appendix C

See Table A3.

Table A3
Example of a literacy hour intervention plan.

Shared work	Word/sentence work	Focus group		Plenary
Clicker & Big Book	Clicker & Big Book	Clicker	Big Book	Clicker & Big Book
Before reading: • look at the cover. Ask the children to predict what they think the book is about	• Write the word "had" on the board. Ask the children to think of other words ending with the sounds "-ad", e.g. Dad, bad, sad	• Identify rhyming words and relate them to spelling patterns, match rhyming words to pictures, and write sentences about the word "Dad" whilst using rhyming words to describe him (e.g., "Dad is glad")	• Find and list words (using the regular sized story books) that rhyme with the word "Dad" and write sentences about "Dad" using rhyming words to describe him	• Look at the word "Dad" again (page 1) and ask the children to remember the words that rhyme with it (like in the word/sentence work). They can make up a word if they want to but it has to rhyme
• Read the title	• Which of these three options rhyme with "Dad"? – sad sat sack – bat bad bag – glad glum grab – mat map mad			
• Talk about whether the book is going to give facts about strawberry jam or tell a story				
During Reading: • Begin to read "Strawberry Jam". Ask the children to read the story with you. Praise and encourage them while they read, and prompt as necessary	• Show and explain the children the activity			
• Point out capital letters, full stops, and speech marks. Stop reading at page nine when the car is locked. What happens next?				

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