COVER SHEET

THINKING OUTSIDE THE PHONOLOGICAL BOX: COMBINING REPEATED READING AND ACTION VIDEO GAMES TO DEVELOP READING FLUENCY IN YEAR 7 CHILDREN WITH DYSLEXIA

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Abstract

Aims: Children's reading attainments in England continue to cause concern despite a national agenda focusing on the development of phonological skills. There is also a lack of guidance regarding how to support children who continue to struggle despite early support, including children with dyslexia and those in secondary education. Italian research groups found that playing action video games (AVGs) improved word and pseudo-word reading speed for children with dyslexia through increasing visual attention. The current study aims to build on this research, exploring whether AVGs boost the effects of a reading fluency intervention, Repeated Reading (RR). The effectiveness of RR alone is also analysed. Effects of the intervention on a range of measures are considered.

Method: A single case experimental design (SCED) with alternating interventions, RR-alone and RR-plus-AVGs, was employed with eight Year 7 children with dyslexia in a UK special school.

Findings: All children demonstrated reading gains from the combined intervention, RR and AVGs. RR-alone was effective for two children and AVGs boosted the effects of RR for five children. Six children increased their reading comprehension. Children enjoyed playing AVGs. RR was viewed positively by teachers and viewed by children as improving their reading.

Limitations: Confidence in results was reduced by variability and some effect sizes not reaching significance. The special school setting for children with dyslexia may affect generalisability to mainstream schools or to struggling readers without dyslexia.

Conclusions: Implications for educational psychologists' practice are discussed, particularly how to proceed with what appears to be a promising intervention.

Key Words: Dyslexia, visual attention, reading fluency, action video games, repeated reading

INTRODUCTION

The need for reading interventions

Recent standardised achievement tests (SATs) conducted at the end of primary schooling in England showed that 26 per cent of children did not reach expected levels in reading (https://www.gov.uk/government/statistics/key-stage-2-attainment-2022). This outcome follows years of synthetic phonics instruction in schools, promoted by the government since the Rose Report (2006). It suggests that reading intervention needs to extend beyond targeting phonics and developing decoding skills, particularly for older struggling readers. Once basic decoding skills are established, intervention needs to target reading fluency to ensure development of reading comprehension (Stevens et al., 2017), crucial to learning through reading and access to the curriculum. Not being a fluent reader makes reading a frustrating and aversive experience, reducing the amount of reading practice, which further compounds any reading difficulty (Stevens et al., 2017).

Interventions for children with dyslexia

Children with a diagnosis of dyslexia are one group of children who struggle with reading. Current interventions for this group tend to focus on developing reading through targeting decoding in younger children rather than increasing fluency in older children and the need for further research into fluency has been identified (Peterson & Pennington, 2015).

Traditionally, reading difficulties associated with dyslexia have been explained by a phonological deficit (Vellutino et al., 2004). However, a visual attention (VA) deficit offers an alternative, or co-existing, explanation (e.g. Bosse et al., 2007; Valdois et al., 2019). Visual attention is defined as the ability to focus attention on relevant stimuli and screen out distracting and irrelevant information, an attentional spotlight (Goswami, 2015). In reading,

VA needs to be focused on print, and visual attention span (VAS) permits salient letters to be grouped and processed, allowing readers of English to recognise orthographic units such as ‘tion’ or ‘ough’ (Grainger et al., 2016). The VAS of proficient readers is 15 characters (Frey & Bosse, 2018) allowing whole words to be read. Beginning readers focus on one letter at a time before learning to link letters together into orthographic units with VA as the ‘glue’, (Valdois et al., 2019, p. 158) resulting in sight word recognition or lexical route reading, critical to reading fluency. Having a reduced VAS makes it difficult for dyslexic children to perceive orthographic units, leading to phonological decoding and a limited sight vocabulary past the beginning reader stage.

A study by Franceschini et al. (2013) showed that Italian children with dyslexia were able to improve word and pseudoword reading, without any reading instruction, by playing action video games (AVGs) for twelve hours over nine days. A comparison group of children who played non-action video games (NAVGs) did not improve their reading. Impressively, the AVG group maintained their improved reading at follow-up after two months. Improvements were attributed to the capacity of AVGs to enhance VA (Franceschini et al., 2013) due to their fast pace, unpredictability and requirement for peripheral processing. Similar results were achieved with Australian children with dyslexia who played AVGs, compared with NAVG controls (Franceschini et al., 2017), showing that reading improvement was not restricted to a consistent orthography such as Italian. A systematic review conducted as part of a doctoral thesis by the first author identified eight papers which utilised AVGs to successfully improve reading in dyslexic children without reading instruction, seven of which were conducted in Italy and one in Australia. A further retrieved study conducted in Poland (Luniewska et al., 2018) found that while an AVG group improved more than an NAVG group, they did not improve more than inactive controls. However, inconsistencies in testing the groups rendered this study inconclusive (Peters et al., 2019). While the remaining eight

retrieved studies showed reading improvement associated with AVG play, gains were limited: improved speed of word reading but not greater accuracy (Bertoni et al., 2019) and reading comprehension was not considered. Increasing speed without a commensurate improvement in accuracy could potentially lead to rapid but error-prone reading, impairing comprehension. Bertoni et al. (2021) hypothesised that improving accuracy may require reading intervention in addition to AVG play.

The current study

The current study aimed to replicate the improvements in reading speed found in the studies conducted in Italy and Australia utilising AVGs. It also aimed to explore effects on reading accuracy and reading comprehension since these are key to accessing the curriculum. It was hypothesised that if AVG play improved VA, any such improvement would put children in a stronger position to benefit from a reading intervention, boosting its effects. AVG play was therefore combined with a reading intervention, Repeated Reading (RR; National Research Panel, 2000), which requires children to read a short passage repeatedly until they can read it fluently. Repeated Reading was selected since a meta-analysis (Lee & Yoon, 2017) found a large effect size (g = 0.8) for secondary-aged struggling readers who received RR.

The study aimed to explore the use of AVGs in combination with RR and to analyse data in such a way that the effects of RR-alone and RR-plus-AVGs could be differentiated.

The research questions (RQs) were:

RQ 1: Is RR an effective intervention to develop reading fluency in Year 7 children with dyslexia?

RQ2: Does playing AVGs boost the effects of a repeated reading intervention on reading fluency in Year 7 children with dyslexia?

RQ3 Does RR combined with AVG play aid reading comprehension?

RQ4: What views do study participants express about the intervention?

METHOD

Study design

The study utilised a single case experimental design (SCED) with alternating treatments, in which at times, the two interventions, RR and AVGs, ran concurrently (Tate et al., 2016). Children were divided into three groups, each receiving RR alone or RR-plus-AVGs at different times (see Table 2) to avoid order effects. Each group's RR-alone and RR-plus-AVGs phases were analysed separately to determine first whether RR was effective and second whether adding AVG play during part of an RR intervention boosted the effects of RR. Discussion and questionnaires were used to explore children's and teachers' views of the two interventions, and pre-post assessment explored the effect on reading comprehension.

Participants

Children with dyslexia were chosen as a specific participant group in line with previous research, although it is acknowledged that they may not differ from children without a dyslexia diagnosis (Elliott, 2020). Participants were eight Year 7 English-speaking children who attended an independent special school for children with specific learning difficulties (SpLD) where the first author worked. A multi-professional assessment was undertaken as part of the admissions process and children were identified as having dyslexia by educational or clinical psychologists using the definition provided in the Rose Review (2009, p.9). Two of the children were bilingual, although both had been educated exclusively in English and neither read in their second language. One child spoke and had received early education in another language, but read poorly in both (See Table 1).

Interventions

Action Video Games (AVGs)

Participants played an AVG, Plants vs Zombies, Garden Warfare2 (Ubisoft), at home, chosen because it was used in a study by Bertoni et al. (2019) and was age appropriate. The game was downloaded from the Ubisoft website onto laptops (Hewlett Packard ProBook 440 G5 Notebook PCs) provided by the school for each Year 7 child. Children were asked to play daily at home during their RR-plus-AVG phase and parents were asked to record dates and times of play.

Repeated Reading (RR)

The model of RR used in the intervention was based on efficacy research for RR (Lee & Yoon, 2017; Stevens et al., 2017) and on papers providing detailed information regarding implementation (Wu et al., 2020; Zimmerman et al., 2019). Consultation with teachers produced the protocol outlined in Figure 1 below.

Figure 1: *Agreed protocol for the delivery of the RR intervention within the study*

1. Teachers select a short passage from the class reading book, *Pig Heart Boy* (Blackman, 1997) displaying it on the interactive whiteboard;
2. teachers model reading with expression, discussing meaning and syllable division of long words;
3. choral reading of the passage by all children;
4. individual silent reading with children able to ask for help with difficult words;
5. partner reading, paired children take turns reading the passage;
6. performance reading of the passage by volunteer children;
7. teachers record individual children's reading of an unpractised passage while other children answer written comprehension questions or do syllable division exercises, both based on the passage.

Study Procedure

Two teachers agreed to run the reading intervention during their usual reading lessons, four times a week for 55 minutes. The school's reading coordinator identified dyslexic children who had basic reading skills but needed a reading fluency intervention. The study was approved by the research ethics committee at University College London. Children were randomised into three research groups within two school reading groups (see Table 1). Table

1 also shows children's self-chosen gamer names, characteristics, and the type of games they played before the study commenced.

Table 1. *Participants' gamer names, assigned group, characteristics and usual game type*

Gamer name	Group	Characteristics	Game type played prior to study
Betty B	1	Male	AVG
Bobster	1	Male, bi-lingual (English & Russian)	AVG &NAVG
Fortune	2	Female	NAVG
Mulan	2	Female	NAVG
Sky Clifton	2	Male, bi-lingual (English & German)	AVG
Apple Crumble	3	Male, EHCP**	NAVG
Best Queen	3	Female, EAL*** (1st language Russian)	NAVG
Hydrogen Bond	3	Female	NAVG

*Children were invited to create their own 'gamer' names which acted as research pseudonyms
**Education, Health and Care Plan
***English as an Additional Language

All participants began with a baseline week when pre-testing took place, followed by four weeks of repeated reading (RR), then a further week without RR when post testing took place. The intervention therefore lasted for a total of six weeks, although a two-week half term meant that the study duration was eight weeks. The amount of time RR was delivered (14.6 hours over four weeks) was considered comparable to Zimmerman et al. (2019; 12.6 hours over five weeks) and allowed adequate time for the staggered introduction of an AVG

phase concurrent with part of the RR intervention. The timing of the interventions for each group is shown in Table 2.

Table 2. *Study timetable*

Group	Week 1	Week 2	Week 3	Week 4 HALF	Week 5 TERM	Week 6	Week 7	Week 8
1	Pre-test	RR/AVG	RR/AVG	AVG	AVG	RR	RR	Post-test
2	Pre-test	RR	RR/AVG	AVG	AVG	RR/AVG	RR	Post-test
3	Pre-test	RR	RR	_	_	RR/AVG	RR/AVG	Post-test/AVG

RR = Repeated Reading; AVG = Action Video Games, RR/AVG = Repeated Reading in school and AVGs at home

Group 1 and 2 continued AVG play over half term due to the challenges of uninstalling and reinstalling the game, while Group 3 continued AVG play during post testing to increase their game play in accordance with Groups 1 and 2.

Measures

Repeated measures were taken, during the four weeks of the intervention and during the pre- and post-intervention phases, of the number of words each participant could read correctly in one minute (Words Correct Per Minute, WCPM: a measure of speed and accuracy), the length of the passage the child read (Passage Length, PL: a measure of speed) and the percentage of words read correctly in the passage (Percentage of Words Correct, PWC: a measure of accuracy). Recordings were made by teachers and shared with researchers for analysis.

Children's comprehension was tested by the first author pre-and post-intervention by asking them to read passages selected from the Oral Reading Fluency test of the Wechsler Individual

Achievement Test, third edition (WIAT-III UK, Wechsler, 2017) and retell the content, following Rasinski (2004) and Zimmerman et al. (2019). Children's views of the interventions were explored in discussion following post-intervention assessment and teachers completed questionnaires eliciting their views.

RESULTS

Data was analysed following guidelines for single case intervention research standards, with visual analysis conducted initially, followed by statistical analysis to obtain effect sizes (ESs; Kratochwill et al., 2013) for the different phases of the study, RR-alone vs RR-plus-AVGs. Visual analysis examined level (means), trend and variability for each study phase following Kratochwill et al. (2013).

Visual analysis

Level

Level was assessed by examining the means of the repeated measures (WCPM, PL and PWC) within and between phases, seeking replications of effects across participants (Tate et al., 2016). When considering levels for WCPM, the average for a child in Year 7 is 100 to 140 (Rasinski, 2004). All children were below this level at baseline.

Results by group are shown in tables 3, 4 and 5.

Table 3. *Mean scores for Group 1 by intervention phase*

Measure/name	Pre	RR+AVG	RR-alone	Post
WCPM				
Betty B	97	103	101.3	108.25
Bobster	66.5	70.25	69	78
PL				
Betty B	101.5	107.375	109.8	118.75
Bobster	85	88.75	77	92
PWC				
Betty B	95.50	91.64	93.68	91.15
Bobster	79.13	85.59	89.41	85.02

Table 4. *Mean scores for Group 2 by intervention phase*

Measure/name	Pre	RR+AVG	RR-alone	Post

WCPM				
Fortune	79	80.6	76.3	90.5
Mulan	89	91.83	91	100.25
Sky Clifton	59	67	58.8	52
PL				
Fortune	81.5	83	80.4	92
Mulan	95.75	98.33	98.66	103.25
Sky Clifton	68.75	73.5	66.5	55
PWC				
Fortune	96.9	97.25	93.26	98.37
Mulan	92.82	93.3	92.57	97.28
Sky Clifton	83.37	91.20	88.54	94.70

Table 5. *Mean scores for Group 3 by intervention phase*

Measure/name	**Pre**	**RR+AVGs**	**RR-alone**	**Post**
WCPM				
Apple Crumble	50.75	75.70	70.0	85.75
Best Queen	81.5	105.5	100.45	117.25
Hydrogen Bond	69.5	84.8	64.3	85
PL				
Apple Crumble	65	81.8	77.1	88.75
Best Queen	92	111.6	108.1	121.5
Hydrogen Bond	88.25	107.2	86.3	108.75
PWC				
Apple Crumble	81.27	92.0	91.0	96.4
Best Queen	88.62	94.6	90.89	96.35
Hydrogen Bond	78.37	79.11	74.37	77.92

For seven of the children, the overall intervention, RR and AVGs combined, increased their WCPM between baseline and post-testing, with gains ranging from 11.25 to 35.75 WCPM. Additional gains during post-testing showed that gains were sustained for six children. All children showed higher WCPM scores during their R- plus-AVG phase compared with their RR-alone phase, but some differences were minimal. In relation to age-expectations, two children reached average WCPM levels post-intervention.

Six of eight children increased the percentage of words they read correctly (PWC), with gains ranging from 1.4 per cent to 15.13 per cent. Gains were smaller for children who were more accurate at baseline, perhaps because they had less room for improvement. One child (Betty B) decreased his accuracy, perhaps sacrificing accuracy for speed since his passage length

(the number of words read) increased. Six children read more accurately during their RR-plus-AVG phase than their RR-alone phase, but some differences were minimal.

Passage length (PL) principally measures speed since it considers the number of words read in a minute even if some are incorrect. Seven of eight children increased their PL, with gains ranging from 7 to 29.5 additional words read in a minute. Six children increased PL during their RR-plus-AVG phase compared with their RR-alone phase. Sky Clifton did not increase his WCPM but increased his accuracy and decreased his PL, possibly indicating that he was more accurate when he read more slowly.

Trend

Trend was examined by graphing data points for the 24 reading sessions by intervention phase for each measure for all participants, then the number of data points exceeding the highest data point in each intervention phase was compared. Comparisons made related to RQ 1 and 2, comparing RR-alone with baseline and then RR-plus-AVGs with RR-alone. A higher data point in the phase of interest was deemed a demonstration of an effect, with a minimum of three demonstrations, and preferably five, required for an intervention to be considered effective (Kratochwill et al., 2013).

Table 6 shows the number of demonstrations of an effect for each measure by intervention phase. Group 3 demonstrated the greatest number of effects. Overall, there was a greater number of three or more demonstrations of effects for RR-plus-AVGs (7) than for RR-alone (4).

Table 6. *Number of data points demonstrating an effect*

Name (Group)	**RR-alone v base**			**RR+AVG v RR-alone**		
	WCPM RR-alone	**PL RR-alone**	**ACCURACY RR-alone**	**WCPM RR+AVG**	**PL RR+AVG**	**ACCURACY RR+AVG**
Betty B (1)	2	1	0	0	0	1

Bobster (1)	1	0	7*	0	0	2
Fortune (2)	2	2	0	2	1	3*
Mulan (2)	1	1	1	3*	0	0
Sky Clifton (2)	1	1	2	1	1	1
Apple Crumble (3)	9*	1	0	2	1	3*
Best Queen (3)	10*	8*	2	4*	2	5*
Hydrogen Bond (3)	1	1	2	3*	6*	0

*≥ 3 demonstrations of effect (Kratochwill et al., 2013)

Variability

Variability, or scatter in data points within a phase, undermines the strength of conclusions that can be drawn from data patterns (Kratochwill et al., 2013). Variability was determined by considering the range of scores within a phase, maximum minus minimum, following Vannest and Ninci (2015). Most participants showed considerable variability, although variability decreased from baseline to post-intervention, suggesting sustained improvement and possibly more consistent performance.

Statistical analysis

Statistical analysis was conducted utilising Tau-U (Parker et al., 2011) via an online calculator (Vannest et al., 2016). An approximate guide to Tau-U ESs is that 0.20 represents a small change, 0.20 to 0.60 medium change and 0.80 or more, a large change (Vannest & Ninci, 2015). Two phase contrasts were calculated for each participant: Baseline vs RR-alone to identify whether RR was effective and RR-alone vs RR-plus-AVGs to consider whether AVGs boosted the effects of RR. To avoid Type 1 error a Bonferroni correction was applied (e.g. Field, 2018) and a significance level of $p<0.05/2$ (0.025) was established. Tables 7-14 summarise statistical analyses for individual participants[1].

Table 7. *Statistical analysis for Betty B, Group 1*

[1] In the statistical analysis tables, RR plus AVGs is shown as 'AVG' and RR-alone as 'RR' for space reasons. Abbreviations used are standard deviation (SD), confidence interval (CI), probability (P).

Measure	Phase contrast	Tau	SD tau	P value	CI 90%
WCPM	Base vs RR	0.16	0.39	0.66	-0.476<>0.810
	AVG vs RR	0.11	0.33	0.72	-0.429<>0.667
Passage length	Base vs RR	0.28	0.37	0.28	-0.336<>0.907
	AVG vs RR	0	0.33	1	-0.548<>0.548
PWC/accuracy	Base vs RR	-0.16	0.39	0.66	-0.810<>0.476
	AVG vs RR	0.12	0.33	0.12	-0.437<>0.687

Table 8. *Statistical analysis for Bobster, Group 1*

Measure	Phase contrast	Tau	SD tau	P value	CI 90%
WCPM	Base vs RR	0	0.36	1	-0.605<>0.605
	AVG vs RR	0.01	0.29	0.95	-0.474<>0.505
Passage length	Base vs RR	-0.25	0.36	0.49	-0.855<>0.355
	AVG vs RR	0.12	0.32	0.69	-0.401<>0.655
PWC/accuracy	Base vs RR	0.68	0.34	0.05	0.109<>1
	AVG vs RR	-0.12	0.32	0.69	-0.655<>0.401

Table 9. *Statistical analysis for Fortune, Group 2*

Measure	Phase contrast	Tau	SD	P value	CI 90%
WCPM	Base vs RR	-0.15	0.35	0.67	-0.732<>0.432
	AVG vs RR	0	0.30	1	-0.506<>0.506
Passage Length	Base vs RR	0.075	0.35	0.83	-0.507<>0.657
	AVG vs RR	0.03	0.30	0.91	-0.472<>0.539
PWC/accuracy	Base vs RR	-0.77	0.35	0.02	-1<>-0.193
	AVG vs RR	0.46	0.35	0.12	-0.039<>0.972

Table 10. *Statistical analysis for Mulan, Group 2*

Measure	Phase contrast	Tau	SD	P value	CI 90%
WCPM	Base vs RR	0.22	0.36	0.53	-0.370<>0.814
	AVG vs RR	0.09	0.31	0.76	-0.424<>0.610
Passage length	Base vs RR	0.16	0.36	0.64	-0.426<>0.759
	AVG vs RR	0.01	0.31	0.95	-0.498<>0.535
PWC/accuracy	Base vs RR	0.22	0.36	0.53	-0.370<>0.814
	AVG vs RR	-0.18	0.31	0.55	-0.702<>0.332

Table 11. *Statistical analysis for Sky Clifton, Group 2*

Measure	Phase contrast	Tau	SD tau	P value	CI 90%
WCPM	Base vs RR	-0.17	0.35	0.62	0.757<>0.407
	AVG vs RR	0.45	0.30	0.14	-0.056<>0.956
Passage length	Base vs RR	0.1	0.35	0.77	-0.682<>0.482
	AVG vs RR	0.4167	0.30	0.17	-0.089<>0.922
PWC/accuracy	Base vs RR	0.15	0.35	0.67	-0.432<>0.732

	AVG vs RR	0.33	0.30	0.27	-0.172<>0.839

Table 12. *Statistical analysis for Apple Crumble, Group 3*

Measure	Phase contrast	Tau	SD tau	P value	CI 90%
WCPM	Base vs RR	1	0.34	0.004*	0.427<>1
	AVG vs RR	0.32	0.26	0.22	-0.115<>0.755
Passage length	Base vs RR	0.54	0.34	0.11	-0.027<>1
	AVG vs RR	0.38	0.26	0.22	-0.054<>0.821
PWC/accuracy	Base vs RR	0.31	0.34	0.36	-0.255<>0.891
	AVG vs RR	0.22	0.26	0.40	-0.215<>0.660

Table 13. *Statistical analysis for Best Queen, Group 3*

Measure	Phase contrast	Tau	SD tau	P value	CI 90%
WCPM	Base vs RR	1	0.34	0.004*	0.427<>1
	AVG vs RR	0.16	0.26	0.54	-0.276<>0.599
Passage length	Base vs RR	0.88	0.34	0.01*	0.314<>1
	AVG vs RR	0.10	0.26	0.70	-0.336<>0.538
PWC/accuracy	Base vs RR	0.40	0.34	0.24	-0.164<>0.982
	AVG vs RR	0.66	0.26	0.01*	0.229<>1

Table 14. *Statistical analysis for Hydrogen Bond, Group 3*

Measure	Phase Contrast	Tau	SD-tau	P-value	CI-90%
WCPM	Base vs RR	-0.35	0.35	0.32	0.932<>0.232
	AVG vs RR	0.79	0.26	0.0028*	0.355<>1
Passage length	Base vs RR	-0.15	0.35	0.67	0.732<>0.432
	AVG vs RR	0.81	0.26	0.0022*	0.375<>1
PWC/accuracy	Base vs RR	-0.2	0.35	0.57	-0.782<>0.382
	AVG vs RR	0.28	0.26	0.28	-0.155<>0.715.

Overview of results

No guidance was identified in the literature on SCEDs on how to combine visual and statistical analyses. It was decided to tabulate results for levels, trend and Tau-U for each participant for each reading measure and to consider improvement in more than half of measures (≥5/9 indicators) as evidence of effectiveness for an individual, following Kratochwill et al. (2013). Tables 15 and 16 correspond to RQ1 and 2 and give a broad overview, with a tick where children showed any improvement, regardless of magnitude, including any ES≥ 0.2. Negative indicators, where no measurable improvement was made, are marked ‘X’.

Table 15. *Positive and negative indicators for the effectiveness of RR compared with baseline (RQ1)*

Name (Group)	**Tau -U**			**Levels**			**Trend**			**Total no. positive indicators**
	WCPM	PL	PWC	WCPM	PL	PWC	WCPM	PL	PWC	
Betty B (1)	X	✓	X	✓	✓	X	X	X	X	3
Bobster (1)	X	X	✓	✓	X	✓	X	X	✓	4
Fortune (2)	X	X	X	X	X	X	X	X	X	0
Mulan (2)	✓	X	✓	✓	✓	X	X	X	X	4
Sky Clifton (2)	X	X	X	X	X	✓	X	X	X	1
Apple Crumble (3)	✓	✓	✓	✓	✓	✓	✓	X	X	*7
Best Queen (3)	✓	✓	✓	✓	✓	✓	✓	✓	X	*8
Hydrogen Bond (3)	X	X	X	X	X	X	X	X	X	0

Positive evidence of change ✓ No evidence of change X

*Criterion for overall effectiveness of RR alone = ≥5 positive indicators

Table 16. *Positive and negative indicators for AVGs boosting effects of RR (RQ2)*

Name (Group)	**Tau - U**			**Level**			**Trend**			**Total no. of positive indicators**
	WCPM	PL	PWC	WCPM	PL	PWC	WCPM	PL	PWC	
Betty B (1)	X	X	X	✓	X	X	X	X	X	1
Bobster (1)	X	X	X	✓	✓	X	X	X	X	3
Fortune (2)	X	X	✓	✓	✓	✓	X	X	✓	*5
Mulan (2)	X	X	X	✓	X	✓	✓	X	X	3
Sky Clifton (2)	✓	✓	✓	✓	✓	✓	X	X	✓	*6
Apple Crumble (3)	✓	✓	✓	✓	✓	✓	X	X	✓	*7
Best Queen (3)	X	X	✓	✓	✓	✓	✓	X	✓	*6
Hydrogen Bond (3)	✓	✓	✓	✓	✓	✓	✓	✓	X	*8

Positive evidence of change✓ No evidence of change X

*Criterion for effectiveness of AVG plus RR vs RR alone = ≥5 positive indicators

Outcomes

RQ1 Is RR an effective intervention to improve reading fluency in Year 7 children with dyslexia?

Applying the criteria outlined above, and as can be seen in Table 15, RR-alone was effective for two participating children, Apple Crumble and Best Queen. They both showed large and significant ESs for increases in WCPM for RR-alone (Tau = 1, p=0.004). Fortune and Hydrogen Bond showed no positive effects of RR-alone, Sky Clifton showed minimal effects, while the remaining three children made some improvement, although this did not reach significance in Tau-U analysis.

RQ2 Does playing AVGs boost the effects of a repeated reading intervention on reading fluency in Year 7 children with dyslexia?

Table 16 shows that RR-plus-AVGs was more effective than RR-alone for five participating children: Fortune, Sky Clifton, Apple Crumble, Best Queen and Hydrogen Bond. Hydrogen Bond showed large and significant ESs for WCPM (Tau=0.79, p=0.0028) and PL (Tau= 0.81, p=0.0022); Best Queen showed a medium and significant ES (Tau)for PWC (accuracy), while other children showed medium or small ESs (Tau) that were not significant. One child, Betty B showed no boost to his reading fluency for RR-plus-AVGs, while Bobster and Mulan showed fewer effects than for RR-alone.

There were three children who did not meet ≥5/9 indicators for either RR-alone or RR-plus-AVGs: Betty B, Bobster and Mulan. However, they showed improvement on some measures, suggesting that the overall intervention, RR combined with AVGs, improved their reading fluency.

RQ3 Does RR combined with AVG play aid reading comprehension?

The number of facts retold by each child was counted and converted to a percentage of the possible maximum. Figure 2 indicates children's performance pre (T1)- and post (T2)-intervention.

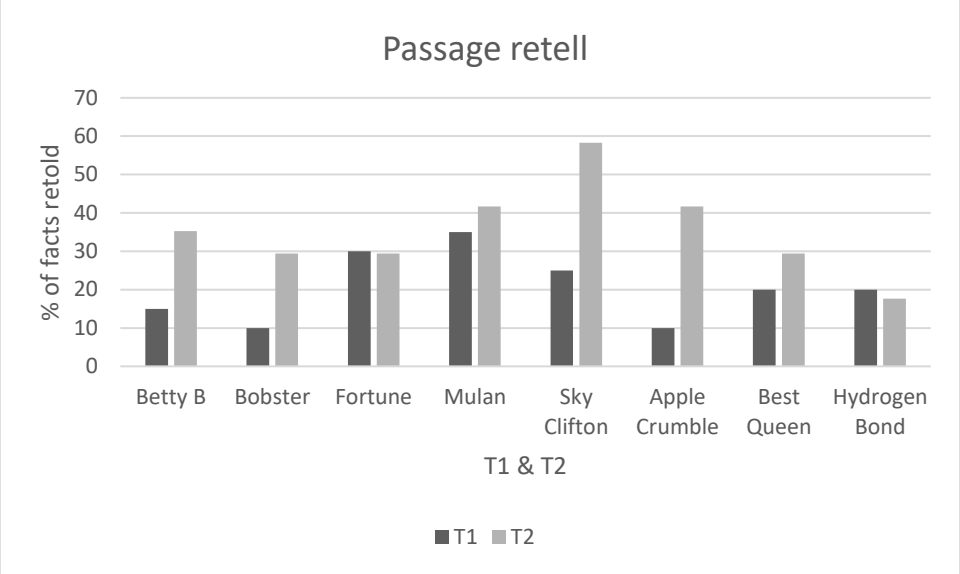

Figure 2 *Percentage of facts retold pre (T1) and post (T2) intervention*

In post-intervention testing, six children increased the percentage of facts retold. Hydrogen Bond slightly reduced the percentage of facts retold on post-testing and the percentage for Fortune remained static. Four children showed a substantial increase in the percentage of facts retold post-intervention, at least doubling the pre-intervention percentage, demonstrating gains in reading comprehension.

RQ4: What views do study participants express about the intervention?

Children thought that playing AVGs helped reading although the purpose of the study had not been shared with them. For example, one child compared playing the game to the reading process: '*The game made me think what to do next …. Like, if you're hiding and thinking about how to attack the big zombie, it's like when you read a book and you think before you read a big word.'* Children enjoyed playing AVGs, spontaneously giving marks out of ten

ranging from seven to ten, and one child commented, '*It was nice to play a game instead of reading.'* Two children expressed reservations based on the game lacking challenge or preferring to play with a friend rather than as a single player. Children thought RR improved their reading e.g. *'After three times, I could read it very well and fluently and fast.'*; *'It makes you notice punctuation more.'* There were references to RR being 'annoying' due to the repetitive element, but worthwhile because of reading improvements. Increased motivation from game play was indicated e.g. '*… maybe when you play the game, you're more interested in stuff.'; 'It started my brain… it energised my brain.'* Repeated reading increased confidence: one child, explaining how RR helped her reading aloud, said, '*It stops you being in front of the class and going, Oh no, I don't want to do this!' '*

Teachers found RR improved reading fluency. One teacher commented, '*All of the children read more accurately and with expression... They increased their awareness of punctuation, reading rate and how to alter their voice to add more inflection and emphasis. … they became better at decoding. Rather than just rushing past a word, they focused on decoding the words.''*

Acceptability of RR was explored by asking children whether they would make Year 6 children do RR and if so, whether they would make any changes. Children made constructive improvement suggestions for RR, such as changing the order of the RR protocol and using discrete passages rather than a book to avoid disrupting narrative flow. Proposed changes to the protocol were increased opportunities for partner and choral reading and individual reading occurring before choral reading so that '*everyone knows the words'*. Acceptability to teachers was explored by asking whether they would continue to use RR. Both teachers indicated that they would. However, teachers found that RR delivery four times per week for four weeks became tedious and suggested using RR over a longer period with fewer sessions each week once the protocol was established. Teacher questionnaires are included in Appendix 1.

DISCUSSION

The current study investigated the effects of RR and AVGs on the reading fluency of eight Year 7 children with dyslexia in a special school. Action video games have been shown to develop reading speed in Italian dyslexic children (Franceschini et al., 2013) and in English-speaking dyslexic children (Franceschini et al., 2017), although reading accuracy was not improved by AVG play (Bertoni et al., 2019). Previous studies were conducted in university laboratory settings using measures of word and pseudoword reading, whereas the current study was innovative, and had ecological validity, by combining AVG play with a reading intervention in a school setting, using the class reading book. The alternating treatment design, with staggered commencement of AVG play by children randomised into three groups allowed the relative contributions of RR and AVGs to be considered. The study found that the overall intervention (RR combined with AVGs) was effective for all eight participants in increasing aspects of reading fluency. RR-alone was effective for two of eight children and five of eight children showed higher scores on measures of reading during the RR-plus-AVG phase, indicating that AVGs boosted the effects of RR for them. Six children increased accuracy and seven increased speed of reading in response to the overall intervention, perhaps helping to confirm that improved accuracy requires AVGs combined with a reading intervention (Bertoni et al., 2021). The combined intervention improved reading comprehension for six children.

Group 3 made the greatest gains, both for RR-alone and for RR-plus-AVGs. The use of the alternating treatment design enables us to explore this finding further. Since Group 3 were the last group to play AVGs, perhaps the cumulative effects of RR were responsible (four weeks of RR), rather than the boost offered by AVGs. However, if this were the case, then Group 1, who had RR plus AVGs first, followed by RR alone, should have shown similar gains.

Moreover, Hydrogen Bond in Group 3 showed no effects of RR-alone and only responded to the intervention when AVGs were introduced.

It is also important to consider non-responders in a SCED (Sturgiss & Clark, 2020). Betty B was the lowest responder. One reason may be that he was the most proficient reader at the start of the intervention based on his baseline measures and so was unable to demonstrate as much improvement as lower scoring children. A second possible reason was that he played AVGs before the intervention, whereas most children played NAVGs, and he may therefore have derived any benefits prior to participating in the study.

Researchers conducting previous studies linking AVG play and reading improvement attributed gains to VA enhancement. While the current study showed that more children benefited from RR-plus-AVGs than from RR-alone, it is not possible to attribute this to improvements in VA, which currently can only be measured in a laboratory setting (see below). Discussions with children suggested that increased motivation may have been a factor. Effects of AVGs may result from increased arousal and motivation rather than from cognitive factors (Bavelier & Green, 2019). 'A videogame with no obvious link to reading remediation may be an effective way to lower pressure and anxiety and increase motivation and compliance in more frustration-prone individuals,' (Cancer et al., 2020, p.3). Children still struggling with reading in secondary school would seem likely to be frustrated and therefore to fit the observations by Cancer et al. (2020).

While laboratory studies were able to measure VA, the current school-based study conducted by an EP, lacked the necessary specialist equipment and expertise to do so. A randomised control trial (RCT) conducted by Peters et al. (2021) in Australia, published after the current study was completed, used an AVG (Fruit Ninja) for 5 hours (10 x 30 minutes) to improve text reading, accuracy, speed and comprehension, without reading instruction, in a group

study with 64 dyslexic children aged eight to thirteen. The researchers were able to measure VA before and after the period of AVG play using a laboratory procedure, a flicker fusion task, and found that children with the greatest gains in VA made the greatest gains in reading. The study provides further evidence that VA may be implicated in reading improvements made by children playing AVGs and illustrates the technical nature of VA measurement.

Can RR plus AVGs be considered an evidence-based intervention?

Fuchs et al. (1993) suggested that interventions for delayed readers need to increase WCPM scores by two to three words per week to achieve age-related expectations for reading. An ambitious target, this equates to an increase of eight to twelve WCPM for the four active weeks of the current intervention. Seven of eight children met that target, with most achieving at the top end of the target and two greatly exceeding it with +35 or more additional WCPM. This would appear to offer adequate evidence for the intervention to be recommended by EPs to schools seeking a fluency intervention for dyslexic children beginning secondary school. However, the study limitations discussed below indicate that the intervention explored in the current study might best be seen as promising, rather than evidence based.

Study limitations

Some differential gains between the two interventions: RR-alone and RR-plus-AVGs, were small, many ESs were not found statistically significant and children showed considerable variability in each phase, reducing confidence in results. The focus on children with dyslexia, employed to replicate previous research, means that it is uncertain whether the intervention would be effective for children with reading fluency difficulties who are not identified as dyslexic. Similarly, the special school setting may have influenced the intervention, affecting whether it would generalise to mainstream settings. For example, both teachers undertaking

RR had a specialist qualification in teaching children with specific learning difficulties and may have additional skills compared with mainstream teachers. A further limitation is that since RR and AVGs ran concurrently at times, the possibility cannot be entirely discounted that gains represent the cumulative effects of RR, rather than reflecting the impact of AVGs. The study had reduced experimental control compared with laboratory research because 'classrooms and schools are not labs but complex, messy and idiosyncratically local social ecologies' (Luke, 2008, p.16). For example, only four parents returned records of game play so that four children played for an unspecified amount of time and timing of AVG play was dependent on IT personnel installing and removing the game from laptops which was not their priority. This meant Groups 1 and 2 had four weeks of game play since games were not removed from their laptops at half term, while Group 3 had only three weeks.

Future research

While the results of the current study suggest the combination of RR and AVGs should be described as 'promising' rather than 'evidence-based' in light of the limitations outlined above, Horner et al. (2005) suggested that SCEDs may be useful for an initial investigation of intervention effectiveness, followed by a group study if justified by results. Large n studies would provide the evidence-base that is currently incomplete. Such studies could usefully incorporate a factor analysis to consider whether VA, motivation or both are causal factors if AVGs improve reading.

Understanding that dyslexia may be related to VA and not solely to phonological deficits may broaden EPs' views of dyslexia/reading difficulties, but this knowledge is of limited use if EPs and schools cannot assess VA as they can phonological awareness (PA). Franceschini et al. (2012) assessed VA in pre-schoolers using a cancellation task which could be explored as

an accessible form of assessment without specialist equipment. Assessing VA as well as PA would allow interventions to be tailored more closely to children's needs.

Should EPs recommend promising interventions?

Fox (2011) advocates 'practice-based evidence' rather than evidence-based practice, pointing out that an intervention derived from a scrupulously run RCT may not be effective for a particular school or child. It is suggested that EPs, with their knowledge of individual schools and children, are in a position to consider whether a promising intervention is appropriate to address a particular problem. In the case of the intervention described in this paper, salient problems might include: secondary pupils lacking reading fluency; Year 6 pupils moving on to secondary education and needing a summer school catch-up intervention; or children who have failed to respond to previous interventions, particularly those who feel that nothing works for them, who are giving up on becoming readers. EPs can use their research and evaluation skills to gather data to add to the evidence base for reading interventions, contributing to answering the questions 'what works, for whom, and in what setting?' (Petticrew & Roberts, 2003), extending the range of potential interventions on offer for struggling readers.

Conclusion

Combining RR and AVGs offers an innovative approach to developing reading fluency in Year 7 children with dyslexia, which may be more engaging than conventional approaches. Its brevity makes it feasible and economic for schools to implement as a catch-up intervention. Ideally, AVG play would occur at school to ensure compliance. Although previous research has only considered children identified as dyslexic, EPs may feel that the intervention would be helpful for struggling readers without a 'diagnosis' since these two groups of children have similar needs. In conclusion, the intervention warrants further

research. The tentative, but promising evidence from this and previous studies suggests that it could offer a new strand of intervention to explore for children and young people who have failed to make adequate progress using traditional phonic approaches.

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APPENDIX 1 Teacher questionnaires

Teachers' questionnaire responses are shown in Table A1

Table A1. *Teachers' questionnaire responses*

Name	Question: How did you feel about delivering the intervention? E.g. was it easy, difficult, enjoyable or too restrictive?
Teacher A	Once we were into a routine, I enjoyed the intervention and found it an effective and organised way to draw students' attention to specific aspects of reading that are often indirectly taught. At times it was restrictive and the students found it monotonous towards the end.
Teacher B	I felt it was very easy to deliver. I did not mind the set nature of the programme as it made it easy to plan and prepare for. It was also very easy to give on the spot feedback as the expectations were clear and easy to follow.
	Question: Would you use this intervention again? Why or why not? Would you do it in the same way or would you change it? Please explain how you would change it if that was your answer.
Teacher A	I will continue to use the approach. I will use the methods from the study as I have now become very efficient at using them and selecting passages. My preference would be to either have a week every half term focused on reading fluency or to incorporate the repeated readings into a lesson every few weeks.
Teacher B	Yes, because students were reading with more fluency and some students even reported they felt it was successful and they were more fluent. I know the children enjoyed the video game portion as they would give this feedback.
	Question: Do you think the intervention would be useful to other teachers? How or why not? Do you have any thoughts on the context in which it would work for others e.g. primary or secondary, one to one or small group etc.
Teacher A	Yes, I think it is an effective intervention that can easily be adapted into both small group and whole class activities. The intervention helps both teachers and students become aware of the skills needed to improve reading fluency by focusing in on a small piece of text. I think it would be most impactful for readers between 8-12 and for older struggling readers.
Teacher B	Any teacher could use this to work on improving a student's fluency. I could see this working for later primary age children and early secondary years.
	Question: What effects did you observe from the intervention in the children?

Teacher A	All of the children read more accurately and with expression during the presentation portion of the session. They increased their awareness of punctuation, reading rate and how to alter their voice to add more inflection and emphasis. In addition, they became better at decoding. Rather than just rushing past a word, they focused on decoding the words. The children that I worked with were very willing and cooperative with the tasks. Whilst I would not say that they found it enjoyable, they did see the benefit and improved their metacognition of what 'fluent reading' is/sounds like.
Teacher B	They did really like the 'present to class' task and seemed to take that seriously – even making sure they stood up straight and read very clearly. I was pleased to see one student improve his loudness and another worked hard on monitoring punctuation to help slow down his rate of speech and pause at appropriate times and I saw this carry over in other classes.