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ABSTRACT

Repeated reading is a popular intervention used to help struggling readers by exposing them to the same text multiple times. While the approach has been effective in L1 and some EFL settings, little research has explored its effectiveness compared against a control group or among ESL learners. Our study examined reading rate gains using words per minute and four eye-tracking measures with 46 mid-intermediate ESL learners grouped into three 14-week treatment groups: a control group that read 26 text passages (about two per week) just once through, another that read the same passages twice in each sitting, and a third that read the passages three times per sitting. Data collection on unfamiliar reading passages took place at 7-week intervals. While results indicated no significant difference among the groups, reading rate did improve significantly in all measures within the first seven weeks but tapered off in the final seven weeks. Eye-tracking measures revealed that readers made fewer regressions and skipped fewer words but gazed at words for less time by week 7, a finding that suggests reading fluency interventions helped students become more fluent readers. While these findings corroborate previous L1 and EFL research and provide support for the efficacy of reading fluency intervention, more research is needed to understand specific contexts in which repeated reading is most efficacious.

INTRODUCTION

The speed at which readers extract meaning from text, or reading rate, is a primary area of interest among second language (L2) reading theorists and practitioners due to its important role in fluent L2 reading. Fluent readers quickly extract phonological and morphosyntactic information from words and phrases which, it is theorized, allows them to direct cognitive resources to comprehending text (Chang, 2010; Grabe, 2004, 2009). Successful comprehension encourages readers to read more and become even more fluent in what Nuttall (1996) described as a virtuous circle. When this process is slow or inefficient, the result is disfluent reading that results in a vicious cycle where poor comprehension leads to less enthusiasm for reading that further limits fluency development (Coady, 1979; Nuttall, 1996).

Several methods are available to teachers when helping students improve their reading rate, including extensive reading, speed reading drills, and repeated reading (RR) practices (Chang, 2010). Repeated reading, which has its theoretical roots in automaticity theory (Logan, 1997) involves reading a particular text repeatedly to develop fluency in that text (Samuels, 1979). It is widely utilized in first language (L1) contexts in which numerous studies have shown its effectiveness in raising students' reading rates in instructional contexts (National Reading Panel, 2000). L2 research has likewise shown the benefit of RR interventions (Chang & Millett, 2013), but for various reasons, practitioners have been more reluctant to utilize the approach, possibly because it cuts into limited classroom time (Gorsuch & Taguchi, 2010), is perceived as boring to students (Chang & Millett, 2013), or is thought to have little long-term or transfer effects to new readings. To investigate these critiques, we developed a study to explore whether a small number of repetitions in a RR program can affect long-term reading rate gains on unpracticed texts and whether local reading processes are affected by a semester-long RR program after accounting for lexical frequency.

LITERATURE REVIEW

RR as a Reading Rate Increaser

Repeated reading has been studied extensively in L1 English settings as a means for improving reading fluency among beginning readers and learning-disabled children (Lee & Yoon, 2017; Kuhn & Stahl, 2003; Meyer & Felton, 1999; National Reading Panel, 2000; Therrien, 2004). Rate gains have been observed both when students read the same text repeatedly and when reading unfamiliar texts after RR intervention (Dowhower, 1987; Kuhn, 2005; Lee & Yoon, 2017; Rasinski, 1990; Therrien, 2004). In Lee and Yoon's (2017) meta-analysis of 34 studies of RR among reading-disabled primary- and secondary-grade students, all studies reported WPM rate gains from pretest to posttest with posttest means about 1.41 standard deviations higher than pretest WPM rates.

Far less attention has been paid to RR research in adult language learning contexts (see Taguchi, Gorsuch, & Sasamoto, 2006). The few existing studies report mixed results and are almost exclusively limited to foreign language environments involving silent RR (see Table 1 for summaries). Taguchi and colleagues (Taguchi, 1997; Taguchi & Gorsuch, 2002; Taguchi, Takayasu-Maass, & Gorsuch, 2004), who conducted three studies of adult Japanese EFL learners, found in two of the three that learners significantly increased in reading fluency between pre- and posttests by 20 and 40 words per minute (WPM) respectively over 10 weeks of RR instruction with large Cohen's d effect sizes (Plonsky & Oswald, 2014). In the third study, which included 17 weeks of instruction, learners decreased in WPM (-3) with a small effect size. Taguchi et al (2004) attributed the negative results to unequal difficulty of pre- and posttests. However, in a follow-up study, Gorsuch and Taguchi (2008) controlled for text difficulty and still found mixed results: when reading to respond to short answers, students increased their reading rate by 20 words per minute over an 11-week RR curriculum, but when reading to respond to a free recall task, students decreased in rate by nearly as much (-18 WPM).

Chang (2012) replicated elements of the previous studies among adult Taiwanese EFL learners over 13 weeks of instruction. Chang used vocabulary-controlled, stand-alone passages from an ESL reading textbook and found an increase of 23 WPM, though this was not significant. Chang and Millett (2013) examined whether RR led to greater gains on practiced or unpracticed texts and found almost identical WPM increases (+47 and +45 respectively). While the authors did not clarify if these increases reached a threshold for statistical significance, their results reflect the largest effect size of any adult L2 RR studies to date. Overall, results of reading rate in EFL RR studies show that rate can increase over a treatment involving repeated reading of segmented novels and when reading stand-alone passages for simple comprehension purposes; further, results suggest that reading rate increases are equally robust when reading familiar and unfamiliar texts. When unfamiliar texts are more difficult than practiced texts, however, or when students are expected to offer a free recall of the story, reading rate gains are lost.

Table 1. Summary of Previous Post-Secondary EFL RR Studies

Study	**Context (Language background)**	**RR per passage**	**Length (weeks)**	**Total Sessions**	**Gain (WPM)**	**Cohen's d**
Taguchi (1997)	EFL (Japanese)	7	10	30	+20	1.19
Taguchi & Gorsuch (2002)	EFL (Japanese)	5	10	28	+40	1.33
Taguchi et al (2004)	EFL (Japanese)	5	17	42	-3	-0.14
Gorsuch & Taguchi (2008)	EFL (Vietnamese)	5	11	22	SA +20 RT -18	0.53 -0.49
Chang (2012)	EFL (Taiwanese)	5	13	26	+23	1.48
Chang & Millett (2013)	EFL (Taiwanese)	5	13	26	PT + 47 UN +45	1.58 1.55
Lynn (2021)	ESL (Chinese/Japanese)	5 3	14	18	+6.4 +1.2	.20 .05

Note: Gains and their corresponding Cohen's D values reflect within group comparisons. *SA* was a passage followed by short answer questions. *RT* was a passage followed by open-ended recall questions. *PT* means "Practiced Text" and was a condition in which readers encountered the same texts in pre and posttest conditions in contrast to *UN*, or unpracticed texts, in which posttest texts were unfamiliar to the readers.

Because of the limited number of studies, all of which examine EFL readers with Asian first languages, the results are hard to generalize beyond a rather limited context. Lynn (2021) broke new ground by examining RR of stand-alone passages in an adult ESL context. Results showed that treatments of 3 and 5 RR rounds both resulted in reading rate gains over a semester of treatment (+1.2 and +6.4 WPM respectively). Although Lynn's participants were also L1 speakers of Asian languages, the ESL setting is nevertheless important to consider since students are likely exposed to more written English in that environment than EFL students; as a result, ESL learners may have little room to increase their reading rate due to their environmental exposure to English texts. Additional research of adult ESL RR is needed to explore this possibility further.

To partially fill this gap, Rich et al. (2021) looked at the attentional resources used in early and late word-level reading of stand-alone texts in a single instance of one RR treatment among ESL readers using an eye-tracker. Their results indicated that ESL readers became faster when reading the same text repeatedly and that speed increases were seen at the earliest stages of letter and word decoding and recognition as well as later text-integration stages of reading. Ostensibly, this means that ESL readers do have room to increase reading rate, but whether increased rates are transferable to unfamiliar texts and whether RR treatments over a semester affect both early and late reading processes has not yet been explored. The purpose of the present study is to examine reading rate changes over a semester of ESL RR treatments and to examine where reading rate changes occur—whether they reflect early word decoding/recognition processes or later integration/comprehension processes or both—using eye-tracking as the methodological approach.

The questions of intensity and duration

Lynn (2021) used the term intensity to refer to the number of reading repetitions per session; most RR research methods involve students rereading the same passage three to seven times in each session. L1 studies of children have shown RR to be effective with as few as three re-readings (Young, Bowers & MacKinnon, 1996). Taguchi and Gorsuch (2002) and Taguchi (1997) found that five and seven repetitions both resulted in significant reading gains. Lynn (2021) compared a semester-long treatment of three and five repetitions and found that both groups increased in WPM with the five-repetition group increasing by 5.2 WPM more than the three-repetition group, though neither group showed significant change over the semester. Given that the groups showed similar results, Lynn argued that fewer repetitions may be sufficient for rate increases, which can reduce the class time dedicated to RR practices and prevent students from becoming bored reading the same text upwards of seven times. It should be noted that the L2 studies of adult learners have only compared RR treatment groups without contrasting results against a control group with no RR intervention, a disconcerting trend common within L1 RR research as well (Kuhn & Stahl, 2003; Therrien, 2004). Thus, while three, five, and seven reading repetitions all appear to translate to rate gains, results are inconsistent; further, there is a lack of evidence among L2 readers for the benefits of limited RR—that is, three readings or even just two—nor has there been sufficient control to establish the basic efficacy of RR among ESL readers.

Duration of treatment is another modifying factor among RR studies with L1 research showing gains in different lengths of treatment. van Bon et al. (1991) found rate improvement in 14 weeks while Rasinski (1990) reported gains after just two days. Rate increases have also been seen after three weeks (Stoddard et al., 1993) and seven weeks (Homan et al. (1993). L2 researchers tend to observe changes over longer durations ranging from 10 weeks (Taguchi, 1997) to 17 weeks (Taguchi et al., 2004). There is no clear pattern to indicate whether longer durations result in differing rate gains, though Lynn (2021) showed that adult ESL readers made the greatest rate gains (+21 WPM) after four weeks of RR treatment and then declined (but never regressed) in reading rate after eight, eleven, and thirteen weeks of treatment. Given the inconsistent and sparse data on duration, more research is needed to illuminate how duration of RR treatments affect reading rate.

Research questions

To contribute to the still emerging adult L2 RR research, we designed a study to help fill many of the gaps mentioned above. This included examining ESL readers from a variety of language backgrounds who were assigned to either a two-repetition (RR2) or three-repetition (RR3) treatment condition and compared against a control group who received no RR interventions. Reading rate measures were taken on unpracticed texts at seven and fourteen weeks of intervention. In addition to the common WPM measure of reading rate which all previous studies have used, we wanted to examine local reading processes that are thought to reflect attentional resources by collecting eye-movement data as well. Eye tracking is a common research approach in psychology and cognitive science that assumes a link between eye movement and cognition, or what is often referred to as the 'eye-mind hypothesis' (Just & Carpenter, 1980; Pollatsek, Reichle, & Rayner, 2006), which assumes that what is looked at is what a reader is processing cognitively, and duration of that gaze reflects processing effort (Rayner, 2009).

The benefit of collecting eye-tracking data in addition to WPM data is that gains or losses in reading rate can be pinpointed more directly to early word recognition or later reading behaviors. The present research was thus guided by the following research questions:

1. To what extent does the **intensity** of a RR treatment (1, 2, and 3 readings) affect reading rate and early and late reading behavior among adult ESL readers?
2. To what extent does the **duration** of a RR treatment (7 and 14 weeks) affect reading rate and early and late reading behavior among adult ESL readers?
3. To what extent does the **interaction** between intensity/duration affect reading rates?

METHODS

Participants

Forty-six ESL students participated in this research, 29 of whom were female, and 17 were male. Ages ranged from 18 to 43 years ($M = 21$). Native languages included Spanish (25), Japanese (7), Chinese (5), Korean (3), Portuguese (3), and one speaker each of French, Mongolian, and Thai.

All participants were enrolled in an intensive English program (IEP) associated with a large research institution in the western United States. The English program offers six levels of courses which include classes in reading, writing, listening/speaking, and grammar, and students are placed in a level through multiple placement tests that are calibrated to the ACTFL proficiency scale (ACTFL, n.d.) and administered by trained assessment faculty; all study participants were drawn from the mid-intermediate proficiency level. There were three sections at this level, and students were assigned to treatment groups according to section placement.

Texts

All texts used in this experiment were taken from the developmental reading series *Reading Horizons*, books 2 and 3, which provides a collection of short, expository passages. Topics were chosen as stimuli for this study to provide variety and reduce the chance any given topic would be especially familiar to some students (see Table 2). Word counts for the 8 passages ranged from

558 to 771 (M = 691). All passages were considered easily readable for students in this study based on word frequency and readability measures.

Table 2. Reading Passages and Measures of their Lexical Properties

Topic	Snakes	Sharks	Nebulas	Thunder-storms	3D Games	J.K. Rowling	Theodore Roosevelt	Elvis Presley	*M*	SD
Tokens	703	645	588	679	691	688	762	771	691	59.1
Types	282	244	232	248	222	309	333	333	275	45.2
TTR	.40	.38	.39	.37	.32	.45	.44	.43	0.40	0.0
1,000	78%	77%	89%	83%	88%	82%	81%	82%	83%	4%
2,000	15%	9%	3%	7%	3%	3%	4%	5%	6%	4%
3,000+	6%	13%	7%	7%	4%	12%	12%	12%	9%	3%
CEFR ≤ B1	91%	93%	89%	91%	96%	81%	79%	87%	88%	6%
Flesch Reading Ease	80.5	79.1	73.8	74.8	80.5	76.4	75.2	69.2	76.2	3.8

Note: TTR = Type/Token ratio; 1,000 = the one thousand most frequent words in English according to BNC-COCA; 2,000 = the second most common thousand words in English; 3,000+ = words beyond the first 2,000 most frequent words in English; CEFR ≤ B1 = Words appearing in A1, A2, and B1 of the Common European Framework of Reference for Language.

Apparatus

We used an SR Research EyeLink 1000 Plus eye-tracker with a spatial resolution of 0.01° sampling at 1000 Hz. Participants were seated 63 centimeters from the display screen with their heads stabilized. All text presented on the display screen was monospaced font at an 18-point font size with 1.5 line spacing. Text was presented in paragraph form and was divided across multiple consecutive screens.

Procedure

Throughout the semester, all students completed 26 RR sessions in which they read a total of 26 passages from the *Reading Horizons* books in class (generally two passages per week), though students did not read passages reserved for eye-tracking data collection. During each in-class reading session, the control group read the assigned passage once, group RR2 read the same passage twice, and group RR3 read the same passage 3 times. All students set goals for reading rate and comprehension score on their initial reading of each passage and individually tracked their speed and scores by hand using a projected stopwatch in class.

Eye-tracking data collection occurred at three points in a 14-week semester corresponding approximately to weeks 1, 7, and 14. Participants were asked to read each passage just once as quickly as possible while still understanding the meaning since each text was followed by a multiple-choice comprehension test. Following a 9-point calibration, participants completed a practice trial session and then two data collection trials with a recalibration procedure between each trial.

The eight reading passages were distributed in a modified Latin Square design between Group A and Group B. Both groups consisted of an equal distribution of participants assigned to the three conditions (control, RR2, and RR3) so that all participants read the same four passages but at different times while the other four passages were divided between the groups. See Table 3 for the reading schedule. In each session, the order in which the two data collection texts appeared was randomized. Students were in control of advancing through the readings but were not permitted to return to previously read material.

Table 3. Modified Latin Square Reading Schedule

Group	Group Makeup	Week 1	Week 7	Week 14
A	Equal parts control, RR 2, and RR 3	Snakes; Nebulas	Thunder; J.K. Rowling	Roosevelt; Sharks
B	Equal parts control, RR 2, and RR 3	Roosevelt; Sharks	Elvis; 3D Games	Snakes; Nebulas

Data analysis

In addition to calculating words per minute, we also analyzed two early eye-tracking variables 1) skip rate and 2) gaze duration, as well as two late variables 3) regressions-in and 4) late reading time. Skip rate indicates the proportion of words which received no fixations during first pass reading, even if they were subsequently fixated upon in later passes. Rayner (1998) indicates that approximately 25% of words are skipped because they are small, highly predictable or functional, or because the reader accidentally overlooks them (Rayner, Slattery, Drieghe, and Liversedge, 2011). Skip rate is an early measure because it may reflect words that readers deem unessential in initial processing of text. Gaze duration is a millisecond-level measure of the summed duration of all fixations in a word between the time it is first entered until it is exited and is likely related to initial letter or word decoding processes.

Regressions-in reflect a count measure similar to skip rate and indicate whether a word was viewed moving from right to left. Conklin and Pellicer-Sánchez (2016) explain that short regressions can indicate initial word processing difficulty while longer regressions may signal difficulty comprehending or integrating the text or resolving ambiguity. Late reading time is the sum of all fixation durations in milliseconds on a word, minus the gaze duration. This measure may indicate text difficulty and time needed to integrate morphosyntactic information or comprehend text.

The R programming language was used to conduct the data analysis (R Core Team, 2020). Descriptive statistics were calculated using the psych package (Revelle, 2020). The lme4 package (Bates et al., 2015) was used to create a linear mixed effects model for each of the five outcome variables. The fixed factors were treatment group and time, and the random effects were word and participant. For the outcome variable of reading rate, only the random effect of participant was included. An omnibus ANOVA was conducted to determine if there was an interaction between treatment group and time using Sattherwaite's method. Tukey adjusted post-hoc pairwise comparisons were conducted using the emmeans package (Lenth, 2020). When no statistically significant differences were found among treatment groups at each time, fixed effects were examined in separate one-way mixed effects ANOVAs. The effect size sigma was calculated for each pairwise comparison to measure the size of mean differences using the effsize package (Torchiano, 2020). Sigma values function similar to Cohen's d values in that they report mean differences as a value of population standard deviation with the difference being that sigma takes into account the random effect variance.

The final data analysis step determined the amount of variance that could be explained by the models, following Nakagawa & Schielzeth's (2013) method. A marginal R^2 and conditional R^2 value were calculated to determine explained variance by fixed factors and a combination of the fixed factors and the random effects respectively of a given model. Before data analysis was conducted, the continuous variables of gaze duration and late reading time were log transformed. In all cases, the data met the assumptions of normality, linearity, and heteroscedasticity.

RESULTS

Prior to addressing the three research questions, we display a summary of data points in Table 4 which indicate reading speed and behavior measures across variables of intensity and duration. We refer to week 1, 7, and 14 measures as pre-test, mid-test, and post-test respectively.

Table 4. Descriptive Statistics Organized by Intensity Group and Duration for the Five Outcome Variables

Measure	Group	Pre-Test (week 1)	Mid-Test (week 7)	Post-Test (week 14)	Sig.
		M (SD)	M (SD)	M (SD)	
WPM	1x	213.2 (49.5)	261.1 (80.2)	213.3 (65.5)	
	2x	216.5 (93.7)	247.0 (78.4)	238.5 (73.8)	
	3x	211.5 (69.5)	240.7 (74.3)	266.1 (113.0)	
	Avg	214.0 (72.3)	249.5 (76.2)	239.2 (85.0)	0.005
Skip	1x	.41 (.49)	.41 (.49)	.40 (.49)	
	2x	.44 (.50)	.40 (.49)	.42 (.49)	
	3x	.44 (.50)	.41 (.49)	.41 (.49)	
	Avg	.43 (.49)	.41 (.49)	.41 (.49)	0.001
Gaze Duration	1x	291.8 (187.3)	276.6 (167.8)	275.3 (175.6)	
	2x	298.7 (197.5)	280.7(190.8)	281.3 (189.2)	
	3x	276.4 (186.8)	265.1 (168.5)	258.3 (169.8)	
	Avg	290.5 (191.3)	271.5 (176.8)	273.0 (180.0)	0.001
Regression	1x	.16 (.42)	.15 (.41)	.14 (.40)	
	2x	.17 (.43)	.14 (.38)	.14 (.39)	
	3x	.22 (.50)	.20 (.47)	.17 (.43)	
	Avg	.18 (.45)	.16 (.42)	.15 (.40)	0.001
Late Reading	1x	336.0 (276.6)	326.5 (282.2)	239.2 (275.4)	

2x	351.8 (292.7)	327.7 (247.8)	306.5 (239.8)	
3x	296.9 (223.0)	335.3 (306.9)	336.5 (309.1)	
Avg	334.5 (274.2)	329.9 (280.7)	288.8 (276.4)	0.001

Note: The unit for gaze duration and late reading is milliseconds, and skip and regression figures reflect a count ratio.

RQ 1: Effects of intensity

The first research question investigated the intensity of the RR treatment. Data pertaining to WPM as well as all four reading behavior measures showed that the three groups differed, though none of the group differences proved to be significant. Thus, we found no evidence that RR2 and RR3 groups differed from a control group when comparing unpracticed reading speed and behavior outside of class.

RQ 2: Effects of duration

Our second research question investigated whether reading speed and behavior changed after 7 and 14 weeks of RR practice. Results showed a number of significant differences in almost all comparisons. The following results are divided into five sections which correspond to the five outcome variables: WPM, skip rate, gaze duration, regression count, and late reading time. Descriptive statistics organized by time and treatment group are presented in Table 4. The final row in each column, which is labeled "Avg", represents an average score for a given outcome variable at a given time regardless of treatment group.

WPM Results. Results showed a statistically significant effect of duration on reading rate: $F(2, 76) = 5.78$, $p = .005$. A post-hoc analysis showed only a statistically significant difference in reading rate across duration from pre-test to the mid-test: Participants increased their reading rate by nearly 39 words per minute with a moderate to large effect size (See Table 5 and Figure 1). Despite non-significant results, effect sizes show that there were moderate differences between the mid-test and post-test (a decrease of 16 words per minute) and between the pre-test and post-test (an increase of nearly 23 words per minute). The marginal R^2 value indicated that 4.2% of the variance in participant reading rates could be explained by the variable of duration. The random effect of participant explained 31.5% of the variance in reading rates, which indicated a high degree of variability in reading rate across participants in the study. In total, the entire model could account for 35.7% of reading rate variance (see Table 6 for a summary of R^2 values).

Table 5. Summary of the Post-hoc Pairwise Comparisons for Reading Rate

Contrast	Difference	95% CI	t-ratio	σ	p
Pre v. Mid	-38.9	[-66.4, -11.4]	3.39	-0.77	.003
Mid v. Post	16.0	[-11.9, 43.9]	1.37	0.32	.363
Pre v. Post	-22.9	[-51.2, 5.3]	-1.94	-0.45	.134

Note: The unit is words per minute.

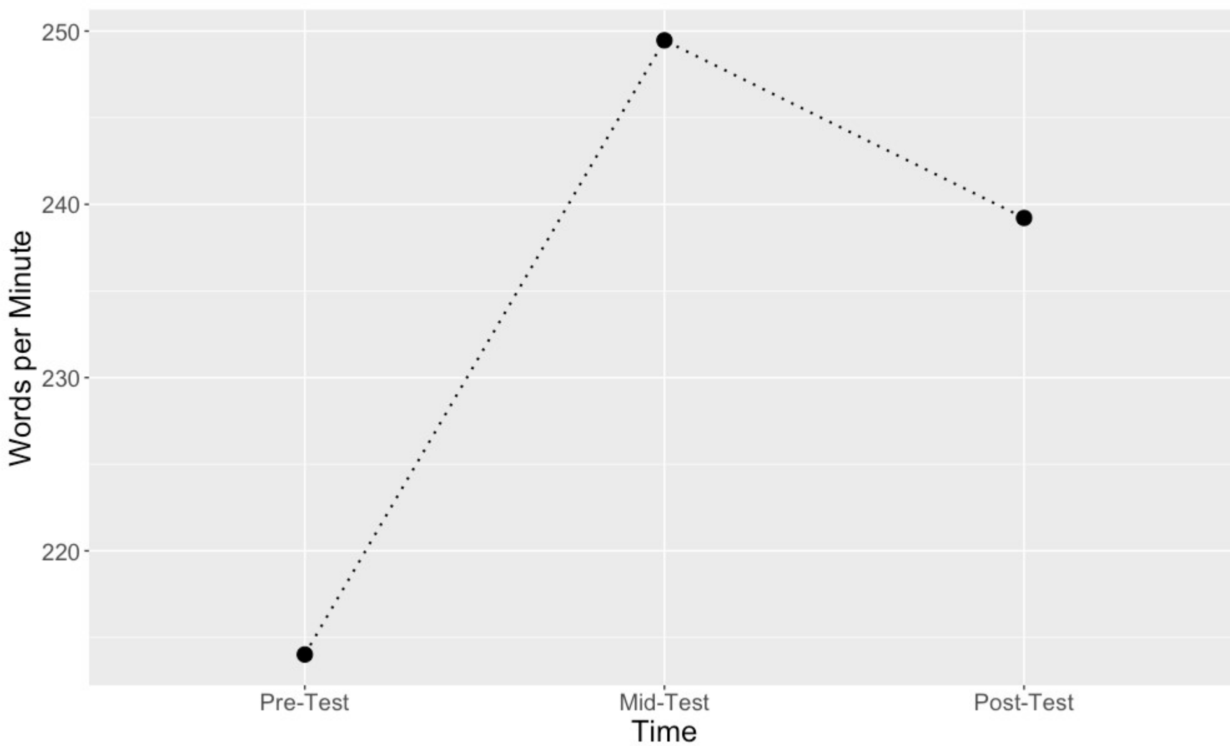

Figure 1. Change in Reading Rate over Duration

Table 6. A Summary of R2 Values for Each Model

Variable	WPM	Skip	Gaze duration	Regression	Late Reading
Time	.042	.001	.002	.001	.003
Word	n/a	.010	.031	.007	<.001
Participant	.315	.009	.013	.003	.001
Total	.357	.020	.046	.011	.004

Skip Results. Results revealed a statistically significant effect of duration on skip rate: $F(2, 114{,}576) = 39.52$, $p < .001$, and a Tukey post-hoc analysis confirmed significant differences at each time. From pre-test to mid-test, there was a decrease of three words skipped per 100 words, an increase of two words skipped per 100 words between the mid-test and post-test, and a decrease of roughly one word skipped per 100 word from pre-test to post-test (see Table 7 and Figure 2). Despite the significant differences observed, the small effect sizes indicate that the differences were negligible. The marginal R^2 value ($R^2 = .001$) showed that 0.1% of the variance in skip rate could be explained by the variable of time. The random effect of word could explain 1.0% of the variation in skip rates ($R^2 = .010$) while participant could explain 0.9% of the variance ($R^2 = .009$). In total, the fixed effects and random effects accounted for a very small proportion of variance in skip rates, approximately 1.9% (refer to Table 6).

Table 7. Summary of the Post-hoc Pairwise Comparisons for Skip rate.

Contrast	**Difference**	**95% CI**	**t-ratio**	**σ**	**p**
Pre v. Mid	.030	[.021, .038]	8.86	0.07	<.001
Mid v. Post	-.020	[-.028, -.013]	-6.03	-0.05	<.001
Pre v. Post	.009	[.002, .016]	3.13	0.02	.005

Note: The is a ratio of skips per 100 words.

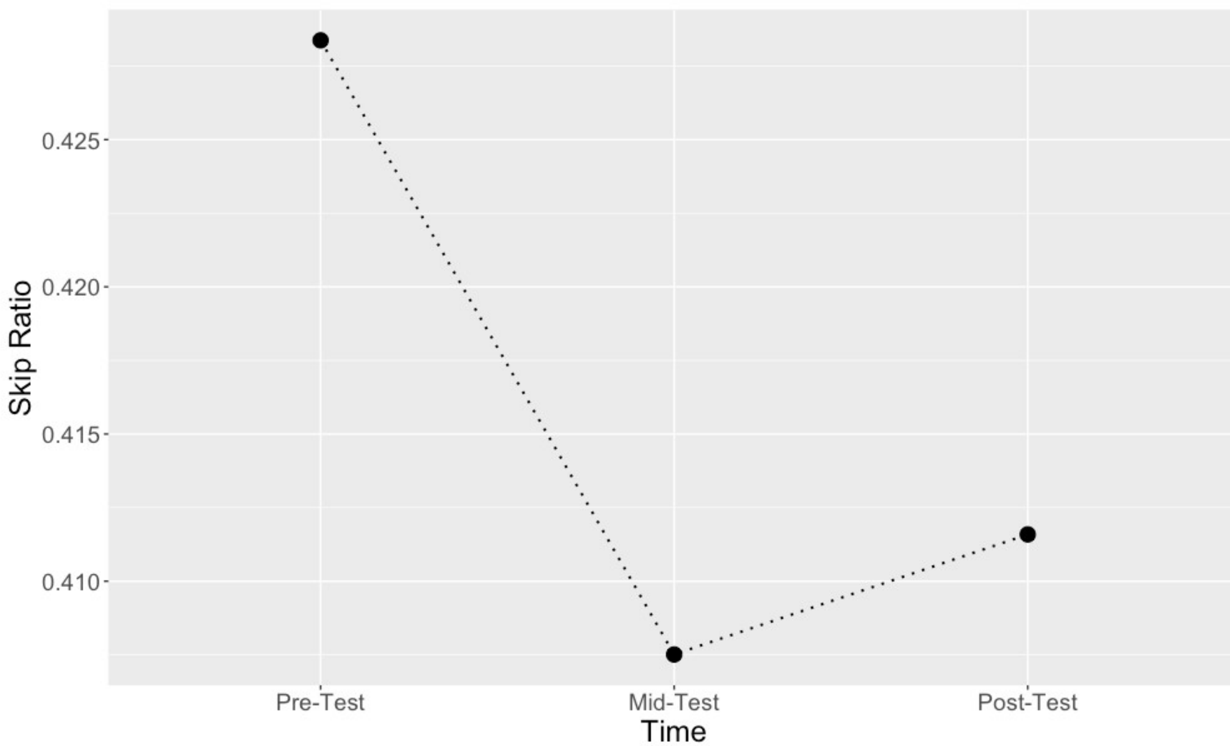

Figure 2. Change in Skip Rate over Duration

Gaze Duration Results. Gaze duration results showed a statistically significant main effect for treatment duration: $F(2, 105{,}284) = 140.65$, $p < .001$. A post-hoc analysis revealed that there were statistically significant differences between the pre-test and mid-test (17.6 ms per word decrease) and between the pre-test and the post-test (17.9 ms per word decrease) (see Table 8 and Figure 3). However, the small effect sizes indicated that although significant, those differences were negligible. The fixed effect of time accounted for 0.2% of the variation in gaze duration ($R^2 = .002$), while the random effects of word ($R^2 = .031$) and participant ($R^2 = .013$) could explain 3.1% and 1.3% of the variance in gaze duration respectively. In total, the entire model could explain 4.6% of the variation in gaze duration (refer to Table 6).

Table 8. Summary of the Post-hoc Pairwise Comparisons for Gaze duration.

Contrast	Difference	95% CI	t-ratio	σ	P
Pre v. Mid	17.6	[14.3, 21.0]	12.40	0.11	<.001
Mid v. Post	0.2	[-3.2, 3.6]	0.15	0.01	.987
Pre v. Post	17.9	[15.1, 20.7]	15.01	0.11	<.001

Note: The unit is milliseconds per word.

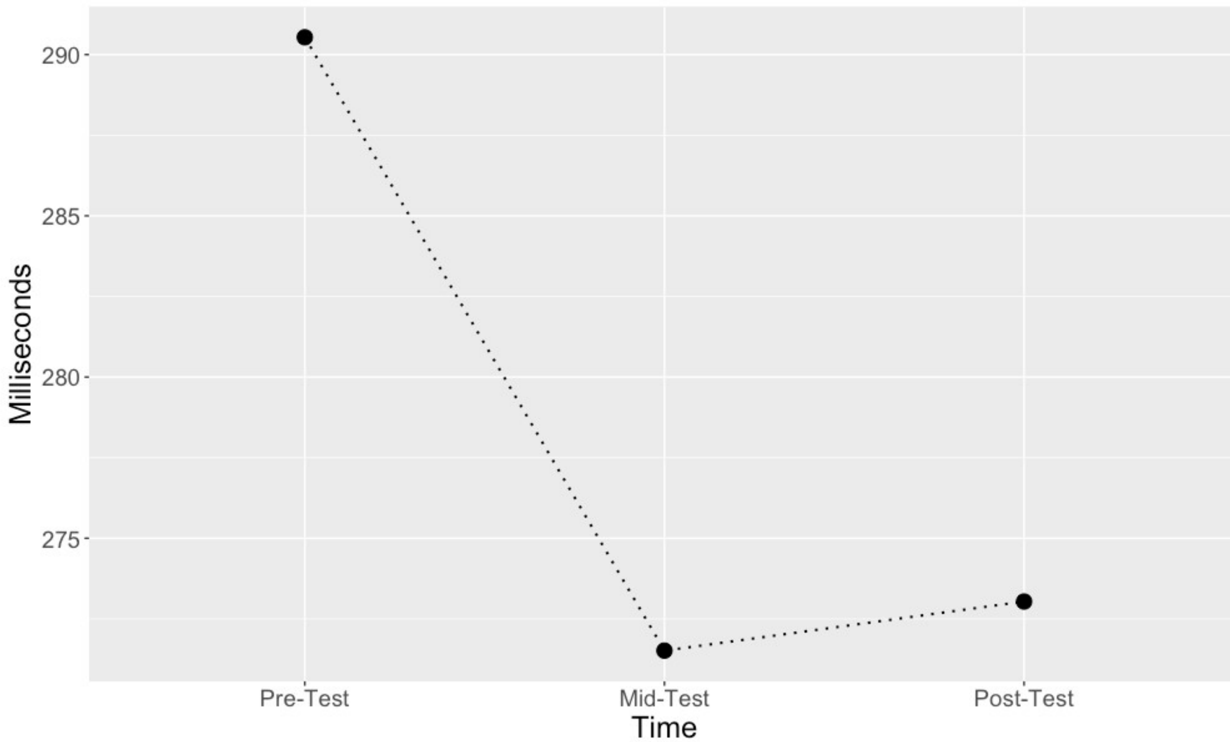

Figure 3. Change in Gaze duration over Duration

Regression Results. An analysis of main effects showed a statistically significant effect of duration on regressions: $F(2, 109{,}179) = 67.73$, $p < .001$. A post-hoc analysis revealed that there were significant differences in regressions for each pairwise comparison with the differences as follows: a decrease of two regressions per 100 words from pre-test and mid-test, a decrease of one regression per 100 words from mid-test to post, and a decrease of three regressions per 100 words between pre-test and post-test (see Table 9 and Figure 4). Again, the small effect sizes indicated that differences were negligible. The R^2 value indicated the variable of time could explain 0.1% (R^2 =.001) of the variance in regressions. The random effects of word (R^2 = .007) and participant (R^2 = .003) could explain 0.7% and 0.3% of the variance in regressions. In total, the model could explain only 1.1% of the variation in regressions (refer to Table 6).

Table 9. Summary of the Post-hoc Pairwise Comparisons for Regressions.

Contrast	Difference	95% CI	t-ratio	σ	p
Pre v. Mid	.020	[.013, .027]	6.63	0.05	<.001
Mid v. Post	.011	[.003, .018]	3.45	0.03	.002
Pre v. Post	.031	[.024, .037]	11.48	0.07	<.001

Note: The unit is a ration of regressions per 100 words

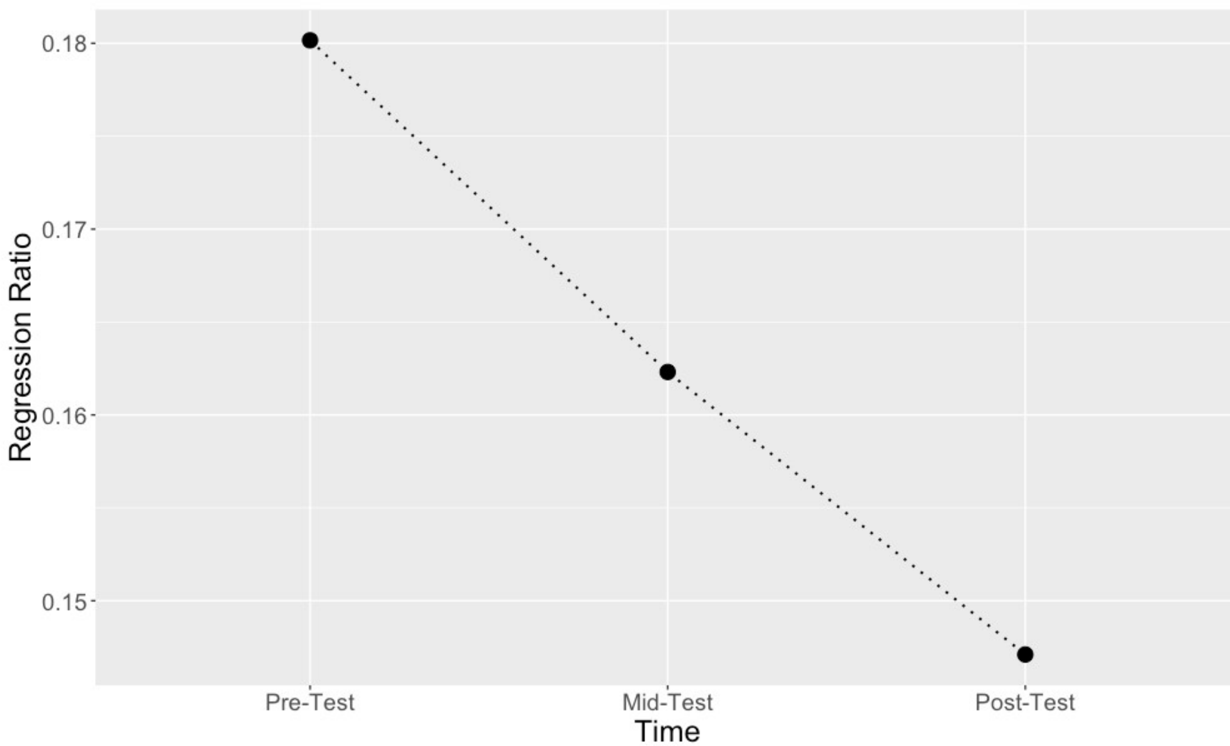

Figure 4. Change in Regressions over Duration

Late Reading Time Results. An analysis of main effects revealed a statistically significant effect of duration on late reading time: $F(2, 10{,}316) = 32.39$, $p < .001$. The post-hoc analysis revealed significant differences for each pairwise comparison: a decrease of 20 ms per word from pre-test to mid-test, a decrease of 26 ms per word from mid-test to post-test, and a decrease of 46 ms per word from pre-test to post-test (see Table 10 and Figure 5), though the small effect sizes indicated the differences were negligible. The fixed effect of duration could explain 0.3% of the variance in late reading time ($R^2 = .003$) while the random effects of word ($R^2 > .001$) 0% of the variation in late reading time and participant ($R^2 = .001$) could explain an additional 0.1%. In total, the fixed effect and random effects could explain less than 1% of the variance in late reading times, only 0.4%.

Table 10. Summary of the Post-hoc Pairwise Comparisons for Late Reading Time.

Contrast	Difference	95% CI	t-ratio	σ	p
Pre v. Mid	20	[10.1, 30.0]	4.72	0.07	<.001
Mid v. Post	26	[15.1, 36.8]	5.61	0.10	<.001
Pre v. Post	46	[35.4, 56.7]	10.12	0.17	<.001

Note: The unit is milliseconds per word.

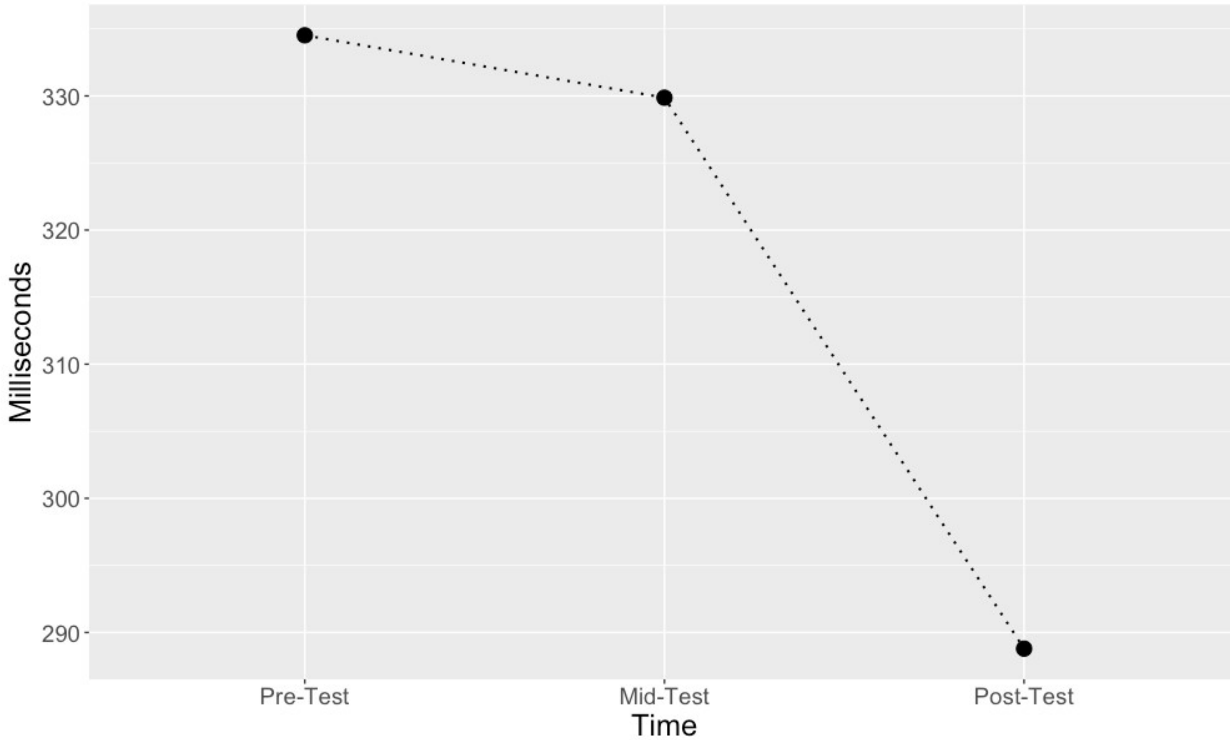

Figure 5. Change in Late Reading over Duration

RQ 3: Interaction of Intensity and Duration

Research question 3 investigated interaction effects between intensity and duration. While significant interactions were found for skip rate $F(4, 155{,}649) = 11.96$, $p < .001$, gaze duration $F(4, 123{,}456) = 17.49$, $p < .001$, regressions $F(4, 155{,}103) = 4.62$, $p = .001$, and late reading $F(4, 24{,}537) = 7.44$, $p < .001$, there was no interaction effect for WPM. Further, subsequent Tukey post-hoc comparisons showed that in no instance was there a significant difference between treatment groups (intensity) in any of the three times (duration) for any of the measures save one interaction within the regressions measure. The RR3 group had a higher regression rate (.17) than the RR2 group (.14) at the post-test ($\sigma = -0.16$, $p = .038$). While a statistically significant difference was found, the difference was not meaningful based on the effect size. It is likely that the large sample size resulted in an over-powered sample, leading to this statistically significant difference.

DISCUSSION

The purpose of this study was to examine the effects of intensity and duration of a RR treatment among adult ESL learners using words per minute to measure reading speed in addition to eye-tracking measures. While previous WPM research has shown mixed results for EFL students (Chang, 2012; Chang & Millett, 2013; Gorsuch & Taguchi, 2008; Taguchi, 1997; Taguchi & Gorsuch, 2002; Taguchi et al., 2004), Lynn's (2021) study found positive results among adult ESL learners. Our findings corroborate those studies which find evidence of increased WPM on unfamiliar texts following RR treatments after more than 10 weeks of instruction. In fact, our participants saw gains after just seven weeks of instruction. The addition of eye-tracking measures allowed us to further examine the processes underlying any WPM improvements, and results showed that both early and late reading behaviors were affected by duration of treatment.

In response to our first research question we found nominal change and no significant difference for intensity on WPM or any of the eye-tracking measures. We had anticipated at least some differences given that RR studies have enjoyed a history of meaningful results despite the paucity of prior use of control groups (Kuhn & Stahl, 2003; Therrien, 2004). Instead, our results seem to echo those from Lee and Yoon's (2017) meta-analysis of 39 RR studies of reading-disabled primary and secondary students. In their analysis, corrected WPM scores did not differ significantly between 2 and 3 RR, but 4 or more repetitions resulted in a significant difference; this may explain why EFL studies have only examined 5 or more reading repetitions. The range of evidence suggests that small intensities (<RR3) have little effect on reading rate development, but we speculate that higher intensities would show significant gains in WPM and possible eye-tracking measures.

Our second research question investigated duration which showed significant differences among nearly every measure at 7 and 14 weeks of RR intervention. Results indicated a statistically significant increase of 39 WPM after 7 weeks and a (non-significant) increase of 23 WPM after 14 weeks. This is consistent with RR studies such as Taguchi (1997) and Taguchi and Gorsuch (2002) which saw increases between 20 and 40 WPM over 10 weeks. Thus, it appears that ESL learners from a variety of language backgrounds do increase their WPM when engaging in a reading program that emphasizes reading fluency.

Measures of reading behavior helped explain the attentional processes that affected the WPM gains. Skip rate, an early measure of word recognition and predictability, decreased at all times. That is, participants skipped fewer words at each data collection point, a finding we did not expect given that readers typically skip about 25% of words normally (Rayner, 1998), and with increased speed, we expected readers to skip even more words. On the other hand, both gaze duration and late reading decreased after 7 and 14 weeks suggesting that though students were skipping fewer words, they were also spending less time on each word, which would indicate a pattern of shorter attention to more words. Meanwhile, regressions decreased from time 7 to 14, which also indicated less need to backtrack to clarify meaning. Thus after 7 and 14 weeks of reading practice, readers became more fluent in terms of less time on words and less backward-moving saccades. Both early and late reading measures contributed to the WPM gain suggesting that a fluency-based reading program helps students improve both word recognition and lexical and morpho-syntactic integration processes.

Given that intensity was not a significant discriminator of reading measures, our final research question revealed almost no significant interactions between intensity and duration. The only statistically significant result of interest was a 3% difference in regressions between the RR2 and RR3 groups during the 14-week data collection period. Given the small effect size, it seems spurious to interpret this change as anything other than chance, particularly given that all regression measures decreased across time, including RR3.Thus we found no evidence that RR treatment discriminated readers at different time points. We wonder if this might not be the case if a higher number of repetitions per passage were used since previous research has almost exclusively examined 5 or more RR per passage. It is hard to predict the results of a higher repetition rate compared to a control group since such a study has not been conducted. Based on the present results which show no advantage for RR over a single reading, we speculate that such a study among adult ESL readers might likewise show no advantage for RR. Were this to be the case, it may suggest that merely engaging in a fluency reading program is sufficient to realize gains; additional class time and practice devoted to RR may be unnecessary. Ideally future research will shed light on this question.

CONCLUSION

While the outcomes of this study corroborate previous studies which show a reading rate gain for students engaged in a RR curriculum, this study adds to the literature by comparing RR gains to a control group and further using eye-tracking measures to investigate which behaviors contributed to rate gains. We found that reading rate and behavior changed in meaningful and significant ways as a result of time, yet there was no advantage for students who had practiced rereading a passage two or three times during a semester-long treatment compared to those who were directed to only read each passage once. In other words, merely engaging with a fluency-based reading curriculum appeared to be sufficient for students to improve their reading rate. Further, any amount of reading instruction enabled readers to extract meaning from text more efficiently and fluently in terms of eye-movement behavior by gazing at more words for shorter durations and returning to fewer words in later reading. Thus, readers in this study became faster, more fluent readers over 7 and 14 weeks as a product of engaging with any amount of repeated reading. In light of these results, we encourage reading teachers to include an element of fluency instruction in their curriculum.

There are a number of limitations which should be controlled for in future studies. For instance, we only compared RR2 and RR3 groups to a control, but Lee and Yoon (2017) found that significant differences in treatment emerged only after readers were exposed to 4 reading repetitions per passage. Thus, future research could replicate the present study with greater repetitions per passage and compare these results to a control group. The present study is likewise limited by the reading passages that were intentionally selected to match students' reading proficiency. We wonder what RR gains might occur with more difficult readings as this would likely resemble the original purpose of RR which was to increase the fluency of struggling readers. It may be that our passages were too easy for readers to make any sort of obvious gains. Likewise, the sampling of readers we used reflected a narrow band of intermediate-proficiency English language users. A wide band of readers covering novice and superior readers would likely show a much wider gap in RR efficacy, and we hope that future research will demonstrate this in order to help clarify for whom and in what contexts RR is most effective. We further acknowledge that our participant pool was rather limited and spread out among three treatment groups. Further research with more readers and more balanced representation from various language backgrounds would certainly strengthen the interpretability of future findings.

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