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Skill Moderators of the Effects of a Reading Comprehension Intervention

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Abstract

This study utilized secondary analyses of a randomized controlled trial and investigated the extent to which prestest word identification efficiency, reading fluency, and vocabulary knowledge moderated the effects of an intervention on reading comprehension outcomes for struggling readers in sixth through eighth grades. Given that the experimental intervention included components that targeted word reading, reading fluency, and vocabulary, we hypothesized that students with lower pretest performance in those skill domains would benefit more from the intervention compared to students with relatively stronger pretest performance or students who received school-implemented (business-as-usual) intervention. Results indicated that pretest word identification efficiency and vocabulary did not moderate the effects of the intervention; however, moderation effects were observed for pretest oral reading fluency such that reading comprehension gains of students with lower pretest fluency were greater in the experimental intervention compared to students with higher pretest fluency or in the comparison condition. Reasons for the moderation effect are discussed. Findings underscore the use of moderation analyses when evaluating multicomponent interventions.

In contrast to reading interventions with students in early elementary grades, meta-analyses indicate weaker overall effects with older students (Flynn, Zheng, & Swanson, 2012; Scammacca, Roberts, Vaughn, & Stuebing, 2015). Primary barriers to remediating skill deficits of adolescent readers include instructional foci that target content and knowledge acquisition as opposed to improving reading skills, increasingly more difficult and complex text that has outpaced students' reading skills, and limited opportunities for reading text in middle and secondary grades (Swanson et al., 2016). Increasing text complexity presents a distinct challenge to adolescent readers. Several studies have demonstrated that among adolescents with below-average reading comprehension, the majority also demonstrate below-average skills in decoding, text-reading fluency, or vocabulary knowledge, with difficulties in multiple areas being the most common (e.g., Brasseur-Hock, Hock, Kieffer, Biancarosa, & Deshler, 2011; Cirino et al., 2013; Clemens, Simmons, Simmons, Wang, & Kwok, 2017).

Difficulties in foundational skills related to decoding, reading fluency, and vocabulary pose considerable barriers to higher-order text-processing abilities. The importance of word reading is obvious, as reading comprehension is impossible if the reader cannot decode the

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words in the text. Word identification skills are central components of theoretical models of reading comprehension (Ahmed et al., 2016; Cromley & Azevedo, 2007; Gough & Tunmer, 1986; Perfetti & Stafura, 2014), and studies indicate the independent contribution of word identification skills on reading comprehension on a longitudinal basis (Kendeou, Van den Broek, White, & Lynch, 2009; Verhoeven & Van Leeuwe, 2008).

Beyond accurate word identification, reading connected text with ease and efficiency plays an important role in facilitating reading comprehension. The well-established relation between decoding isolated words and reading comprehension weakens across elementary grades (i.e., beginning around age 10; García & Cain, 2014). Reading fluency is predictive of reading comprehension skills two or more years later (Reschley, Busch, Betts, Deno, & Long, 2009) and has been shown to mediate the relationship between decoding and reading comprehension (Silverman, Speece, Harring, & Ritchey, 2013). Although fluently reading words in list form or in context (i.e., connected text) is predictive of reading comprehension, fluency in context is more strongly associated with reading comprehension than fluency of reading words in lists (Eason, Sabatini, Goldberg, Bruce, & Cutting, 2013; Jenkins, Fuchs, Van den Broek, Espin, & Deno, 2003). In contrast to reading isolated words, linguistic processes central to reading comprehension, such as verbal reasoning and knowledge activation, may contribute to fluency in context by aiding syntactic processing, prediction, and self-correction of errors (Jenkins et al., 2003).

Perfetti (2010) noted that accurate or efficient decoding does not directly *cause* comprehension, because comprehension depends on the meaning of the words being known. Vocabulary knowledge is a central aspect of models of reading proficiency (Kintsch, 1988; Perfetti & Stafura, 2014) and is crucial to reading comprehension (Joshi, 2005). Even if decoding skills are adequate, reading comprehension is negatively affected when as few as 2% of word meanings in a passage are unknown (Schmitt, Jiang, & Grabe, 2011). Although the development of vocabulary knowledge and reading skills share a bidirectional relation (Joshi, 2005; Nation, 2009), longitudinal analyses support a unique and substantial contribution of vocabulary knowledge to reading comprehension as students get older (Quinn, Wagner, Petscher, & Lopez, 2015; Verhoeven & Van Leeuwe, 2008), and some have observed vocabulary to be a more important predictor of comprehension than reading fluency in later grades (Yovanoff, Duesbery, Alonzo, & Tindal, 2005).

Multicomponent interventions may be more or less beneficial depending on individual students' specific skill difficulties at intervention entry.

Interventions targeting multiple skills, such as word reading, fluency, world and vocabulary knowledge, and comprehension, are common in studies with middle and secondary school students and have demonstrated success with struggling readers (Edmonds, Vaughn, Wexler, Reutebuch, Cable, Tackett, & Schnakenberg, 2009). Although multicomponent interventions may offer the best opportunity for improving reading skills for students with deficits in multiple domains, their complexity can obscure components that are most important. It is also possible that multicomponent interventions may be more or less beneficial depending on individual students' specific skill difficulties at intervention entry. For example, a reading comprehension intervention that also includes instruction in basic reading skills, such as word study or reading fluency, and is implemented the same way for a heterogeneous group of struggling readers might have greater benefits for students with deficits in word reading or fluency skills. On the other hand, the time dedicated to basic skill instruction may be of little use to students with adequate basic skills but difficulties specific to comprehension. As a result, lower response by students with adequate basic skills may attenuate overall intervention effects.

Moderation analyses permit investigations of differential intervention effects. Although prior reading intervention work across grade levels has investigated moderating effects of variables such as intervention fidelity and quality (Boardman et al., 2016), implementation by teachers versus paraeducators (Vadasy & Sanders, 2009), English-learner status (Vaughn, Martinez, & Wanzek, 2017), and ethnicity (Denton et al., 2017), investigations of the moderating effects of pretest reading skills on intervention effects in middle and secondary school have been infrequent. Lang et al. (2009) contrasted four intensive interventions for struggling readers in high school and found that interventions were differentially effective for students based on their level of reading risk. Schünemann, Spörer, and Brunstein (2013) found that with fifth graders, students in the lowest third in terms of their reading fluency skills at pretest benefited most from an intervention that combined reciprocal teaching and self-regulated learning strategies. Although fluency skills were not explicitly targeted in the intervention, results suggested that the self-regulation components (goal setting, monitoring, self-evaluation) were most beneficial for students with poor text-reading skills. Overall, extant studies suggest that some interventions may be more or less effective based on students' level of reading skills; however, studies to date have limited analyses to broader achievement domains and have not investigated moderating effects of performance in specific skill areas.

Study Purpose

In this study, secondary data analyses from a randomized controlled trial (Fogarty et al., 2017) were used to investigate whether pretest skills, including word-reading fluency, text-reading fluency, and vocabulary knowledge, moderated the effects of a multicomponent intervention on the reading comprehension skills of students in Grades 6 through 8. Given that the intervention included components that specifically targeted word reading, reading fluency, and vocabulary, and that these activities were implemented for all students regardless of pretest skill performance, we hypothesized that the effects of the experimental intervention on reading comprehension would be greater for students with lower pretest performance in these skill areas compared to students with relatively stronger skills at pretest or who received the school-implemented (business-as-usual [BAU]) intervention.

Method

Analyses were conducted using an extant data set from a randomized controlled trial. Additional detail on participants and general methodology can be found in Fogarty et al. (2017).

Participants and Settings

The study took place in three middle schools from two districts in Texas. From an original sample of 237 students, the present analyses included 226 students with data on the pre- and posttest assessments who had been previously assigned by their schools to reading intervention classes based on low achievement on the previous year's reading accountability assessment. Students were in sixth (n = 108), seventh (n = 62) and eighth (n = 56) grades. Demographic representation was 50.4% female, 29.6% Black, 26.5% White, 26.1% Hispanic, 14.2% multiple ethnicities, 2.7% Asian/Pacific Islander, and 0.9% Native American. Students from economically disadvantaged households represented 62.4% of the sample, 9.7% received English-learner support, and 8.4% were identified as eligible for special education services. The treatment groups did not differ on a statistically significant basis on any demographic characteristics (see Fogarty et al., 2017, for representation within each condition).

Three teachers participated in the study. All teachers had been assigned to school-designed reading intervention classes that served students with low achievement in reading. Teachers were selected based on the fact that they were the only staff filling the role of intervention teacher at each of the three schools. Each teacher taught five or six classes of students daily. Teaching experience was 4, 7, and 14 years, respectively. Two teachers held a

bachelor's degree, and one held a master's degree. One teacher was certified in English language arts and history, one held generalist fourth- to eighth-grade and special education certifications, and one was certified to teach English as a second language and general education.

Design

The intervention study (Fogarty et al., 2017) used a within-teacher, randomized block, pretest-posttest design to investigate the effects of an experimental intervention on students' reading comprehension. Blocking on schools, students from participating classes were randomly assigned by class (consisting of same-grade students) within teachers to the experimental intervention (n = 112; nine classes) or typical-practice BAU intervention (n = 116; seven classes). All teachers taught a minimum of three experimental and two BAU intervention classes. All data were collected in accordance with institutional board approval.

Measures

Reading comprehension. Analyses included three measures of reading comprehension. The Gates-MacGinitie Reading Tests–Fourth Edition (GRMT) Comprehension subtest (MacGinitie, MacGinitie, Maria, & Dreyer, 2002) is a group-administered assessment that contains narrative and expository passages followed by three to six multiple-choice questions. Students are allotted 35 min to read and answer the questions. Grade-level versions of Form S were administered. Coefficient alphas of .85 and .89 were observed with our sample at pre- and posttest, respectively. The Group Reading Assessment and Diagnostic Evaluation (GRADE) Comprehension Scale (Williams, 2001) is derived from students' performance on two group-administered subtests. On the Sentence Comprehension subtest, students read 19 sentences, each with a missing word, and select the word that best completes the sentence from five answer choices. On the Passage Comprehension subtest, students have an unlimited amount of time to read six passages of narrative or expository text, followed by five multiple-choice questions. We observed coefficient alphas of .81 and .85 at pre- and posttest, respectively. Grade-level versions of Form A were administered. The Gray Oral Reading Test–Fifth Edition (GORT; Wiederholt & Bryant, 2012) was administered to students on an individual basis. Students read a series of passages orally while the examiner recorded reading errors and elapsed reading time. After reading, students were asked a series of open-ended questions that required literal or inferential comprehension. Passages were administered until a ceiling rule was reached (based on reading accuracy and rate). The Comprehension score (total number of correct responses to comprehension questions) was used in the present analyses. We observed internal consistency at pre- and posttest of .78 and .77, respectively.

Basic skill moderators. The following measures were investigated as potential moderators of intervention effects. Sight Word Efficiency (SWE) from the Test of Word Reading Efficiency–Second Edition (TOWRE-2; Torgesen, Wagner, & Rashotte, 2012) was used to assess word identification fluency. Students were provided 45 s to read a list of words of increasing difficulty, and the subtest was scored in terms of the number of words read correctly. Test-retest reliability for students ages 8 to 18 years ranges from .84 to .93. Oral reading fluency (ORF) was measured with a passage from the easyCBM system (Alonzo, Tindal, Ulmer, & Glasgow, 2006). One Grade 7 passage was administered that had a Lexile score (an index of text difficulty and complexity) of 960 (Lexiles for easyCBM passages across Grades 6 to 8 range from 600 to 1180). Students were asked to read orally from the passage while the examiner recorded the number of words read correctly in 1 min. The selected passage demonstrates alternate-form reliability with other passages from the easyCBM set ranging from .75 to .96, with an average of .91. The GRADE Vocabulary subtest (Williams, 2001) is a group-administered, untimed test. Students read a series of two- to four-word phrases that contain a target

word and select the closest synonym from five choices. Students were administered grade-level versions of Form A. Test authors reported coefficient alpha ranging from .86 to .88 for students in sixth through eighth grades (Williams, 2001).

Organization and Description of Intervention

A more comprehensive description of the experimental intervention is provided in Fogarty et al. (2017), but the primary aspects are summarized here. The Comprehension Circuit Training (CCT) intervention included 10 levels designed to scaffold text genre, instructional explicitness, text difficulty, and reader support. The intervention was modeled after a physical exercise routine and emphasized effort and practice as essential aspects of reading improvement. Each level consisted of four 50-min lessons, which were designed to be delivered three times per week. The entire CCT intervention was intended to span approximately 50 to 70 school days (i.e., 17–25 weeks). All students began with Level 1. Initial levels used narrative texts that were shorter (i.e., 400 or fewer words) and less complex (i.e., Lexiles of approximately 500) and explicit instruction of the skills and strategies. Subsequent lessons introduced expository texts, texts increased in length and complexity, and explicit instruction gradually transitioned to scaffolded instruction (i.e., prompts and supports to use comprehension skills and strategies that had been previously taught directly) and individual practice in later lessons. CCT lessons were delivered through tablet computers using instructional videos, which students watched with a partner. During all video instruction, students followed along in a workbook, which featured all text and content in the video instruction. The video instruction frequently prompted students to respond or generate content in their student workbooks. At each prompt, students paused the instruction, worked with their partner to generate responses in their workbooks, then restarted the video, which provided the correct response. Following video instruction, students also used their workbooks for practice activities, such as reading fluency or inference-making practice with their partner or teacher (see below).

CCT components. The Opening Comprehension Circuit (≈10 min) targeted words and vocabulary from upcoming text. Videos included explicit instruction in decoding and vocabulary, with activities such as multisyllabic word–reading strategies, vocabulary instruction and strategies for inferring word meaning from text, and strategies for making inferences, monitoring comprehension, and repairing comprehension (e.g., reread text, adjust for speed, and use context clues). The Warm-Up Station (≈5 min) included prereading activities in which students skimmed the text to determine type (narrative or expository); previewed the author, title, and text features to activate background knowledge; and made predictions about the text. Students marked the text with logical checkpoints that would be later used for monitoring comprehension while reading. The Reading Core Station (≈20 min) was designed to be the most important section of the intervention and included exercises to promote active construction and integration of meaning from text. Students learned that comprehension requires effort and attention, and prompts helped students actively construct meaning and update their comprehension. As the students read, they learned to focus on important information and highlighted evidence explicitly stated in the text, such as details about characters, settings, conflicts, and major events. Students stopped at the checkpoints they identified during the Warm-Up Station and were prompted to check their understanding, identify new information since the previous checkpoint, and integrate meaning from checkpoint to checkpoint. Instructional videos summarized important content after each checkpoint to ensure students received correct information. The Knowledge Flex Station (≈10 min) included postreading activities, such as text organizers to summarize information from the text, oral or written retells, and quizzes. Reading fluency was targeted in

this component, in which students practiced fluency by taking turns reading the passage aloud with their partner. During the Closing Circuit (≈5 min), students completed ORF assessments with their teacher and "inference dashes," in which they had 1 min to read a short passage aloud and answer an inference question. Students charted progress toward individualized goals (e.g., read more, read fluently, learn words, understand more while reading) using quiz or fluency scores.

Intervention Fidelity and Engagement

Implementation data were collected using student workbooks that documented the total number of CCT lessons implemented by student dyads. The mean number of lessons with at least partial completion of lesson components was 18.69 (*SD* = 5.77; range = 1–22). Partial completion of the planned lesson sequence was due to two factors. First, students progressed through the lessons more slowly than we anticipated, in some cases requiring two class periods to complete a lesson originally planned for one 50-min class period. Second, teachers were not always able to begin the CCT lessons at the start of the class period, which further limited students' ability to complete a lesson within the period. Although the average number of lessons in which students completed (approximately 18) was well below the 40 lessons originally planned, most students had worked through enough lessons such that the Lexile scores of the passages had increased to up to 1000 (from as low as 500 at start), text in the lesson passages transitioned from narrative to expository text, and direct instruction in comprehension skills and strategies was replaced by supported, scaffolded prompts to use the skills they had been taught while reading. Thus, most students completed a substantive portion of the intervention and had progressed to reading more complex texts with less explicit instruction.

Additional intervention fidelity and student engagement data were collected using direct observations. Observers included senior project staff, including the third and fourth authors, who developed a fidelity-and-engagement observation across a series of meetings. All classes were observed on at least three occasions across the study. As described earlier, each section of the intervention (Opening Circuit, Warm-Up, Reading Core, Knowledge Flex, and Closing Circuit) included activities in which students worked with a partner on video-based instruction and reading practice activities in student workbooks. Observations were conducted so that all sections of the intervention were observed at least once. Observers recorded whether each of the CCT stations was implemented by student dyads during a classroom observation. Across observations in CCT classrooms, all CCT stations were implemented with the exception of the last station (Closing Circuit), which was observed in 89% of observations where this component was planned to be implemented.

Observers also rated the overall quality of students' implementation of CCT activities and procedures on a 4-point scale, where 1 = *inconsistent with CCT procedures*, 2 = *marginally consistent*, 3 = *mostly consistent*, and 4 = *highly consistent*. The mean quality rating across all CCT components was 3.05 (*SD* = 0.31, range = 2.42–3.68). Interobserver agreement (percentage of occasions in which observers' ratings agreed) for quality ratings was 86.66%.

Teachers were asked to maintain their typical instructional practices in their BAU classes and not to use any of the CCT practices or materials. Across a minimum of five observations per teacher, no evidence of CCT procedures in the comparison classrooms was observed. Observed activities in the comparison classes included vocabulary instruction, graphic organizers, and activating background knowledge. Students were observed reading individually (silently), reading in pairs, round-robin reading, and following along with audio recordings of text.

Observers also rated student engagement and reading instruction characteristics in CCT and BAU classes. Following a classroom observation, observers rated the overall engagement of students in the class using a 1-to-3 scale (1 = *most students were not*

focused on task or instructor, frequently distracted by or peers or items not involved in the assigned task; 3 = *most students remained focused on task or instructor, maintained eye contact on instructor or peer while discussing*). The mean engagement rating was greater in CCT classes ($M = 2.11$, $SD = 0.34$, range = 1–3) compared to BAU ($M = 1.96$, $SD = 0.67$, range = 1–3); this difference was statistically significant; $t = 2.21(235)$, $p = .03$. Interobserver agreement (percentage of occasions in which observers' ratings agreed) for engagement ratings was 91.6%.

Data Analyses and Study Main Effects

Our modeling approach was similar to our investigation of intervention main effects (Fogarty et al., 2017), which we briefly summarize here. Latent variables were used to model reading comprehension at pre- and posttest using respective administrations of the GMRT, GRADE, and GORT comprehension tests. We investigated the effects of the intervention condition on the posttest comprehension factor while controlling for pretest comprehension performance and demographic covariates. The model was specified by correlating the residual terms between the pretest and posttest scores of the same measures. As reported in Fogarty et al. (2017), the standardized effect of intervention condition on the posttest reading comprehension latent variable was positive and statistically significant ($\beta = 0.08$; $p = .031$; effect size [ES] = 0.14), indicating statistically significant effects favoring the CCT group compared to the typical-practice condition in reading comprehension (Fogarty et al., 2017). Statistically significant effects favoring the CCT group were also observed on the Test of Silent Reading Efficiency and Comprehension (TOSREC; Wagner, Torgesen, Rashotte, & Pearson, 2010; $\beta = 0.13$; $p = .032$; ES = 0.28) and on an assessment of vocabulary taught in the CCT intervention ($\beta = 0.23$; $p < .001$; ES = 0.43). Statistically significant main effects were not observed for SWE or ORF.

As another index of main effects and intervention response, we also examined the percentage of students in each condition with standard scores above 90 (i.e., 25th percentile) at pre- and posttest on the GMRT and TOSREC. On the GMRT, the percentage of students in the CCT group with scores above 90 was 31.7% and 48% at pre- and post-test, respectively, compared to 30.3% and 42.9%, respectively, for the BAU group. On the TOSREC, the percentage of students in the CCT group with standard scores above 90 was 43.2% and 50% at pre- and posttest, respectively, compared to 40.4% and 37.1%, respectively, for the BAU group.

The main-effects model was used as a base model for testing the moderating effects of pretest SWE, ORF, and vocabulary in the present analyses. To make results more interpretable, scores on the moderator variables were standardized, which centered the scores at 0 with a standard deviation of 1. We included ethnicity, economic disadvantage, grade level, English-learner status, and special education status as covariates in all models. Using the base model (which included the pre- and posttest comprehension factors, dummy-coded condition variable, and the demographic covariates), separate models were run for each pretest moderator by including the moderator as an observed variable and a Condition × Moderator interaction term. To reduce the number of figures, we present one figure (Figure 1) depicting the model template used for each moderation analysis. As shown in Figure 1, pretest reading comprehension (summarized by a latent variable using the pretest administrations of the three comprehension tests), intervention condition, a moderating variable (i.e., SWE, ORF, vocabulary), and the Condition × Moderating variable interaction term were used as predictors of the posttest reading comprehension latent variable. We also controlled for demographic covariates as shown in the model. This model was repeated for each moderation analysis and differed only in terms of the moderator (SWE, ORF, or vocabulary).

TYPE = COMPLEX was used in Mplus, which controls for nonindependence in nested

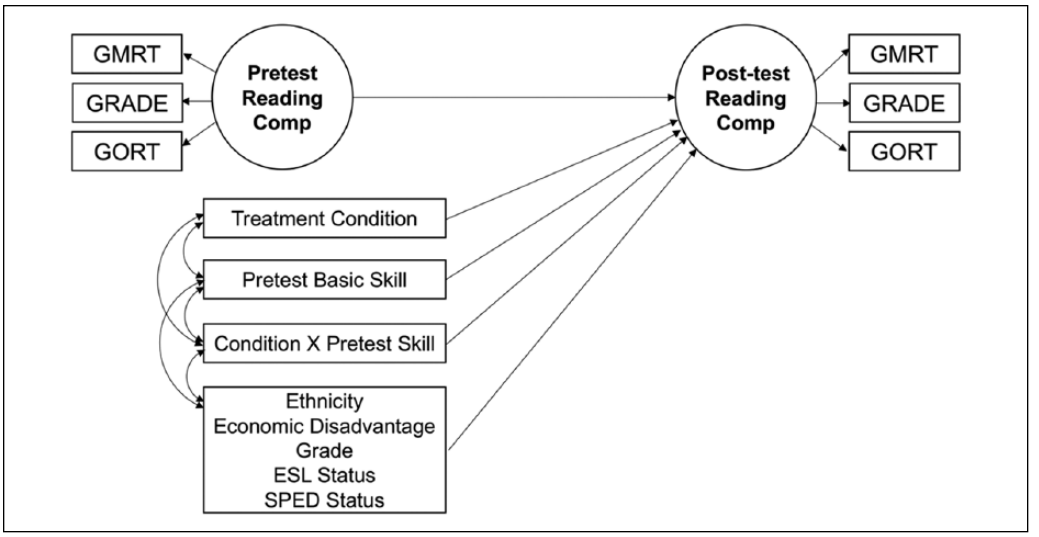

Figure 1. Model template for investigating moderation effects of pretest basic skill on posttest reading comprehension (with control for pretest reading comprehension and demographic variables). Correlations between residual terms of pretest reading comprehension measures with their posttest counterparts were included in the model but omitted from the figure to improve clarity.
GMRT = Gates-MacGinitie Reading Test Comprehension subtest; GRADE = Group Reading and Diagnostic Evaluation Comprehension Scale; GORT = Gray Oral Reading Test Comprehension score. Pretest Basic Skill refers to the pretest skill investigated as a moderator in each model (i.e., sight word efficiency, oral reading fluency, or vocabulary).

data (i.e., students were nested within teachers). MLR estimation controlled for biased standard errors due to nesting. In the case of a statistically significant moderator effect, we determined regions of statistical significance for the treatment variable conditioned on the moderator in Mplus using procedures described by Muthén, Muthén, and Asparouhov (2016).

Results

Descriptive statistics are reported in Table 1, and intercorrelations are reported in Fogarty et al. (2017) with the exception of GRADE Vocabulary (pretest scores on the Vocabulary subtest correlated with the other pretest measures used in these analyses as follows: GMRT = .33, GRADE = .46, GORT = .37, SWE = .23, ORF = .20). Skewness ranged from –.37 to .11 and kurtosis ranged from –.38 to .77 for each variable, which met assumptions of normality. Independent-sample *t* tests between the CCT and comparison groups found no statistically significant differences on pretest variables. Fit statistics indicated overall adequate fit across models and are reported in Table 2.

In separate models, the respective moderator and interaction terms were added to the base model, as illustrated in Figure 1. Results are reported in Table 2. Pretest SWE and vocabulary were not statistically significant predictors of posttest comprehension and did not demonstrate statistically significant interaction effects with intervention condition. However, pretest ORF demonstrated a statistically significant interaction with condition ($\beta = -0.116$, $p = .03$), indicating pretest reading fluency moderated the effects of intervention condition. The negative effect indicates that as students' pretest ORF scores decreased, a greater effect of the CCT intervention was observed (and vice versa).

Analyses of regions of significance produces 95% confidence intervals around the conditional effect of the treatment based on the moderator, which indicates the point(s) on a continuous moderator at which the treatment

Table 1. Descriptive Statistics for Measures Included in Present Analyses.

	CCT experimental intervention				BAU intervention comparison			
	Pretest		Posttest		Pretest		Posttest	
Measure	*M* (*SD*)	Min–max	*M* (*SD*)	Min–max	*M* (*SD*)	Min–max	*M* (*SD*)	Min–max
GMRT Reading Comprehension	85.03 (9.64)	65–109	90.07 (10.88)	65–117	84.67 (10.56)	65–107	88.45 (9.90)	65–112
GRADE Comprehension	90.15 (9.72)	58–115	93.66 (9.33)	69–115	89.79 (8.98)	68–111	92.06 (9.70)	70–115
GORT Comprehension	27.07 (5.02)	17–41	28.42 (4.50)	18–46	27.00 (4.72)	13–35	27.50 (5.05)	17–39
Sight Word Efficiency	89.99 (9.41)	66–119	94.89 (9.13)	72–116	89.45 (9.74)	55–119	94.87 (10.85)	66–128
Oral reading fluency	130.05 (28.76)	68–212	139.38 (25.72)	75–208	125.49 (30.59)	67–191	137.08 (30.81)	71–228
GRADE Vocabulary	92.23 (10.58)	59–113	—	—	90.82 (10.76)	55–115	—	—

Note. CCT = Comprehension Circuit Training; BAU = business as usual; GMRT = Gates-MacGinitie Reading Test—Fourth Edition; GRADE = Group Reading Assessment and Diagnostic Evaluation; GORT = Gray Oral Reading Test–Fifth Edition. Standard scores reported with the exception of GORT subtests and oral reading fluency. GRADE Vocabulary was not administered at posttest.

Table 2. Moderation Model Results; Condition, Pretest Moderator, and Interaction Term Predicting Posttest Reading Comprehension.

Variable	*b*	β	*p*	R^2	RMSEA or CI	SRMR
Intercept	**91.07**		**.00**			
Condition	**1.319**	**.182**	**.01**	.92	.028	.05
Pretest ORF	−0.083	−.012	.88		[.00, .05]	
Condition × Pretest ORF	**−1.223**	**−.116**	**.02**			
Intercept	**92.17**		**.00**			
Condition	0.836	.121	.09	.91	.053	.08
Pretest SWE	0.785	.113	.08		[.03, .07]	
Condition × Pretest SWE	−0.377	−.055	.45			
Intercept	**90.59**		**.00**			
Condition	0.790	.127	.07	.91	.063	.11
Pretest vocabulary	1.016	.163	.14		[.05, .08]	
Condition × Pretest Vocabulary	0.379	.061	.65			

Note. Bold type indicates statistically significant effect of the variable on posttest reading comprehension latent variable with *p* value based on unstandardized estimates. *b* = unstandardized coefficients with GMRT as the marker variable; β = standardized coefficients generated using the STDY option in Mplus, which uses the original metric of the predictor with the outcome in standard deviation units; ORF = oral reading fluency; SWE = Sight Word Efficiency; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual (<.08 indicates good fit for RMSEA and SRMR; Hu & Bentler, 1999).

effect is different on a statistically significant basis. Results indicated that for students with pretest ORF scores from the bottom of the distribution through 0.20 standard deviations above the mean of the sample (64.0% of the sample), students in the CCT intervention outperformed students in the comparison condition on posttest comprehension on a statistically significant basis. For students with prestest ORF scores ranging from 0.20 standard deviations through 2.68 standard deviations above the mean of the sample (36.0% of the sample), there was no statistically significant effect of the CCT treatment.

We also examined the effect of treatment on posttest reading comprehension for students who were one standard deviation below average, at average, and one standard deviation above average on pretest ORF. This is a more traditional use of moderation that examines the conditional effects at three different values of the moderator (Aiken & West, 1991). For students one standard deviation below the sample mean on standardized

pretest ORF, the main effect of treatment was 0.298 standard deviation units above that of the BAU comparison. The average main effect was 0.182, and the effect for students one standard deviation above the mean on standardized pretest ORF was 0.066. Thus, the results confirm the findings that students with lower ORF at pretest benefited more from CCT. It should be noted that these results used the original scale for the predictors (i.e., standardized ORF and condition with 0 = control and 1 = treatment) and the standardized outcome (i.e., posttest reading comprehension latent variable).

Our previous analyses (see Fogarty et al., 2017) did not indicate statistically significant main effects of the intervention on posttest ORF. We repeated this analysis with the subset of students that scored within the region of significance on pretest ORF. Condition did not demonstrate a statistically significant effect on posttest ORF, indicating no statistically significant effect of the CCT intervention specific to students' posttest reading fluency.

Discussion

Using an extant data set from a randomized controlled trial of an experimental multicomponent intervention that targeted adolescents' reading comprehension, we hypothesized that students with lower word identification fluency, fluency reading connected text, and vocabulary knowledge at pretest would benefit more from the experimental intervention given the inclusion of components that specifically targeted those skills. Our hypothesis was partially supported. Pretest word identification efficiency and vocabulary did not moderate the effects of the intervention. However, moderation effects were observed for pretest ORF, such that intervention effects on students' reading comprehension skills were greater for students with lower pretest fluency who received the experimental CCT treatment relative to students with higher pretest fluency or students in the BAU comparison group.

Why did students with lower reading fluency at pretest benefit more from the intervention in their reading comprehension? It is tempting to suggest that the fluency-building activities in CCT were particularly beneficial to students with low fluency at pretest, and consistent with automaticity theories (e.g., LaBerge & Samuels, 1974; Perfetti, 1985), fluency gains may have improved students' ability to process text more efficiently, thereby enhancing their comprehension. However, we did not observe statistically significant main effects of CCT on posttest reading fluency (see Fogarty et al., 2017), and in the present analyses, no statistically significant effects of condition were observed when we limited the sample to students with low fluency at pretest. Because the intervention had no apparent effect on reading fluency, it cannot be argued that comprehension gains were the result of reading fluency improvement.

A second possibility for why ORF moderated the effects of the intervention (and relatedly, why word list reading did not), may be due to how reading fluency functions as an index of reading comprehension (Fuchs, Fuchs, Hosp, & Jenkins, 2001; Reschley et al., 2009; Shinn, Good, Knutson, Tilly, & Collins, 1992). Evidence indicates a reciprocal relation between reading fluency and comprehension in which both facilitate each other (Klauda & Guthrie, 2008), relations that are due at least in part to the semantic knowledge and syntactic awareness that are activated when reading connected text, which in turn ease the processing of upcoming words, phrases, and sentences (Perfetti & Stafura, 2014). Thus, it is possible that reading fluency played a role in moderating the effects of the intervention by serving as another index of reading comprehension, despite our control for pretest reading comprehension test performance.

Considering this issue more closely, evidence indicates that reading fluency can more broadly serve as an indicator of overall reading *competence* (Fuchs et al., 2001). In addition to hypotheses that fluent reading (made possible by effortless word recognition) allows attention to be allocated to comprehension (Wolf & Katzir-Cohen, 2001), poor reading fluency may be indicative of deficits in

other important skills or behaviors. Reading fluency is a task that requires attention regulation (Jacobsen, Ryan, Denkla, Mostofsky, & Mahone, 2013). Poor readers demonstrate deficits in executive functioning skills, including attention regulation, working memory, comprehension monitoring, and inhibitory control (Carretti, Borella, Cornoldi, & De Beni, 2009; Kieffer, Vuckovic, & Berry, 2013; Oakhill, Hartt, & Samols, 2005). Low fluency in our sample may have served as an index of poor reading in general and, by extension, of difficulties in executive function required for skilled reading.

We note that in our previous analyses, the reading comprehension of students with lower comprehension at pretest benefited the most from the CCT intervention (Fogarty et al., 2017). Effects were even stronger on the TOSREC, a timed sentence-verification task in which students are allotted 3 min to indicate the truthfulness of a series of statements. It is a task that requires constant attention and active monitoring of one's comprehension of every sentence. It is possible that students may have benefited the most from the CCT intervention activities that targeted more conscious and active reading, which included text previewing, identifying difficult portions of text, highlighting important details and events while reading, and stopping at checkpoints to repeatedly evaluate their comprehension. Earlier, we noted that Schünemann et al. (2013) observed a benefit for self-regulation strategies on reading comprehension outcomes, particularly for students with low reading fluency at pretest. Our findings may be similar; it is possible that pretest reading fluency moderated the effects of the CCT intervention on comprehension by serving as an index of poor reading and associated executive functioning deficits. Although the intervention did not improve students' reading fluency, intervention activities may have improved their active engagement while reading, effects that were detected most clearly on an attention-demanding task, such as the TOSREC. We did not measure attention or comprehension monitoring, and our conclusions are speculative, but they provide interesting considerations regarding areas in which reading interventions may be optimally effective.

Although the intervention did not improve students' reading fluency, intervention activities may have improved their active engagement while reading.

Unexpectedly, pretest vocabulary did not moderate the effects of the CCT intervention. Previous studies have observed the importance of vocabulary in predicting reading comprehension (Ouellette, 2006), although more recent evidence from Ahmed et al. (2016) suggests that the role of vocabulary may not be as substantial as previously thought when shared method variance is taken into account (i.e., many previous studies have measured vocabulary with tests that require reading, as in our study). It may be that our control for pretest reading comprehension (in which vocabulary knowledge likely played a role), with tests that all required reading, left no available variance to be captured by a measure of reading vocabulary. It is also possible that the GRADE Vocabulary subtest was not sufficiently sensitive to individual differences in vocabulary knowledge to account for unique variance on the comprehension assessments. Assessing vocabulary knowledge is difficult and available methods are insufficient (Pearson, Heibert, & Kamil, 2007). Vocabulary is a knowledge variable that can be defined in terms of breadth (how many word meanings are known) *and* depth (deeper knowledge of a word, its multiple meanings, and ability to use it in multiple contexts), variables that are extremely difficult to assess with a paper-based test, which will always be limited by a small corpus of words. It may be that our assessment did not reveal sufficient differences in vocabulary knowledge to moderate the effects of the intervention.

Implications

Results of this study have implications for subsequent intervention research. Despite

prior work that has indicated that word- and text-reading fluency are best modeled as a single factor when considering the variables that underlie reading fluency (Barth, Catts, & Anthony, 2009), we observed that word- and text-reading fluency functioned differently in their moderating effects on a reading comprehension intervention. These findings further underscore the importance of assessing reading fluency of adolescent students in the context of reading comprehension intervention, which may provide a more comprehensive perspective of students' text-reading skills and potential moderators of intervention effects compared to word list reading.

Our results speak to the potential for flexibility in intervention implementation. In the case of multicomponent interventions, depending on the skill profiles of subgroups of students, researchers might tailor the intervention such that certain components are emphasized over others. With the CCT intervention, greater overall treatment effects may have been observed if students with stronger initial text-reading fluency skills were advanced to lessons in which text was longer and more complex (i.e., stretch text), and the decoding or reading fluency activities were replaced by instruction and practice in higher-order comprehension processes. Connor and colleagues (e.g., Connor et al., 2011) have shown that aligning instructional content, practice activities, student groupings, and the role of the teacher based on students' entry-level skill profiles is associated with compelling effects on student achievement. We suspect that similar considerations would be pertinent to other multicomponent interventions. Rather than all students receiving the same intervention regardless of skill profile, interventions may be tailored to address needs that are more prevalent or pose greater obstacles to reading comprehension. Alternatively, a standard intervention might be implemented for the whole group on a short-term basis, and the intervention may be adapted to meet the needs of subgroups of students who demonstrate difficulties in specific skill domains after a prespecified period of time.

In the case of multicomponent interventions, depending on the skill profiles of subgroups of students, researchers might tailor the intervention such that certain components are emphasized over others.

Moderation analyses depend on the inclusion of measures that represent the hypothesized moderating constructs, which has implications for study planning. The need for multiple assessments must be considered in light of fixed budgets, finite resources, and host schools that are increasingly restrictive in terms of available time. Researchers should consider a relevant but feasible set of variables that, given the aim and intent of the intervention, may be expected to moderate its effects. Nevertheless, even with a comprehensive set of measures and moderation analyses, results may still be difficult to interpret (as in our case). Although there is value in studies of multicomponent interventions, we also encourage smaller-scale experiments of specific components that may improve our understanding of target skills and instructional practices that best promote adolescents' reading comprehension.

Limitations

Our conclusions are limited by several factors. Our sample size was small for investigating complex models and for evaluating moderation effects. Limits to resources and testing time in the schools restricted our measurement of the moderating variables to one measure each, and additional assessments of each skill would have permitted the use of latent variables to more comprehensively represent each construct and account for error. The study included only three teachers, and although each teacher taught multiple classes and we randomly assigned students to condition by class, the small number of teachers limits the generalizability of the findings. Earlier, we suggested that pretest reading fluency served as an index of reading competence and that the intervention may have improved poor readers' comprehension monitoring or

other self-regulation skills pertinent to reading, but without measurement of those constructs, our conclusion remain speculative. The CCT intervention was not implemented to the extent we had planned, due to the pace that students completed lessons and other logistical issues. Although students still received a meaningful portion of the intervention, more robust effects may have been observed with complete implementation.

Conclusion

Among a sample of students in Grades 6 through 8 who were struggling in reading comprehension, prestest ORF moderated the effects of a mulitcomponent intervention on students' comprehension outcomes, whereas word list fluency and vocabulary did not. Moderation analyses can help determine for whom interventions are most effective, offer insight into refining interventions so that they effectively meet students' unique learning needs, and are particularly important when interventions include multiple components and target a population whose skill difficulties may be broad and varied.

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