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Effects of Supplemental Computer-Assisted Reciprocal Peer Tutoring on Kindergarteners' Phoneme Segmentation Fluency

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Abstract

Phonemic awareness is a critical early reading skill that gives students a strong foundation for beginning reading. Without effective interventions or supplements to core reading programs, many students fail to acquire these skills. The present study examined the effects of using computer-assisted peer tutoring to supplement kindergarten students' instruction in phonemic awareness. Results of the study indicate three of the four participants made substantial gains in phoneme segmentation fluency. Implications for future research and practice are discussed.

Keywords: Peer Tutoring, Computer-Assisted Instruction, Phonemic Awareness

Reading is a fundamental skill that influences almost every other area of learning. When children become efficient readers early, they are much more likely to experience better educational outcomes throughout their school years (Armbruster, Lehr, & Osborn, 2001; Bursuck & Damer, 2011). Unfortunately, millions of children in the United States are left behind due to early reading failure; and for whom, the adverse effects can last a lifetime. For these children, early identification and effective interventions in reading become critical in setting the precedent for successful outcomes.

In order to pinpoint key skills and effective methods central to reading achievement, the National Reading Panel (National Institute of Child Health and Human Development [NICHHD], 2000) examined over 100,000 studies on reading components and interventions and identified five essential areas of reading instruction for all children. The five areas were phonemic awareness, phonics, fluency, vocabulary, and text comprehension. Within these five areas, phonemic awareness is considered a foundational skill. Bursuck and Damer (2011) define phonemic awareness as "the ability to hear and manipulate the smallest units of sound in spoken language" (p. 6). Competency in phonemic awareness improves a child's ability to read

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Pages 33-48

and spell; whereas deficits in phonemic awareness can impact overall reading achievement (Armbruster et al., 2001; Ball & Blachman, 1991; NICHHD, 2000; Weiner, 1994). Effective phonemic awareness instruction that focuses on having children think about and manipulate individual sounds in spoken language is indisputably important and should be a part of the core reading program.

Unfortunately, as many as 20% to 30% of students will require additional reading instruction to supplement and enhance the core reading program (Reschly, 2005; Vaughn & Roberts, 2007). Within the response to intervention multi-tiered framework, these are the students who are identified with reading difficulties, who have not responded to the Tier 1 core reading instruction, and who are in need of "catching up" with their peers through a supplemental, secondary intervention (Fuchs & Fuchs, 2005). In phonemic awareness instruction at the Tier 2 secondary instructional level, Vaughn and Roberts (2007) offered three guidelines of instruction to support at-risk students by (a) teaching phonemic awareness early, (b) ensuring the instruction is fun and engaging for students, and (c) assessing students' phonemic awareness skills frequently.

One empirically validated method of providing the needed supplemental instruction to students who are academically at risk is peer tutoring (Heron, Villareal, Yao, Christianson, & Heron, 2006; Maheady, Mallette, & Harper, 2006). Peer tutoring does not consume a substantial amount of teacher time, and can provide students with frequent opportunities to practice targeted skills (Heron et al., 2006). Additionally, reciprocal peer tutoring allows both students with similar academic needs to receive "double doses" of practice as both tutors and tutees, and therefore can be especially beneficial for at-risk readers. However, one challenge for peer tutoring is that the tutor needs to be able to present the task accurately to the tutee and have the correct response available in order to provide accurate feedback (Wood, Mackiewicz, Van Norman, & Cooke, 2007). This can be difficult in reciprocal peer tutoring with students who exhibit limited skills being targeted for practice. A solution to the concern of having two low performers who lack accurate tutoring skills is to make correct responses available through audio feedback (Cooke, Mackiewicz, Wood, & Helf, 2009; Mackiewicz, Wood, Cooke, & Mazzotti, 2011; Van Norman & Wood, 2008). For example, Van Norman and Wood (2008) used a reversal design embedded within a multiple baseline design to determine the differential effects of a reciprocal peer tutoring program with and without a prerecorded sight word model on the accuracy of tutor feedback with six kindergarten students at risk for reading difficulties. Students were taught the components of reciprocal peer tutoring and asked to tutor each other on unknown, phonetically irregular sight words. Each of the prerecorded sight words was presented on a tutoring card accompanied with a voice output and recording device, called Mini-Me™, that allowed the tutor to activate the recording, compare it to the word produced by the tutee, and to provide praise or error correction accordingly. Results indicated that the peer tutoring with prerecorded sight words produced higher percentages of accurate feedback when compared to the peer tutoring condition without the prerecorded sight words. Additionally, three of the six participants produced substantial increases in the accuracy of word identification from pretests to posttests.

In providing support to mothers who had limited English proficiency, Cooke et al. (2009) trained three Latino mothers to tutor their preschool children in English vocabulary using Talking Photo Albums (Attainment Company Inc, 2007). Participants used the Talking Photo Albums to provide audio feedback during tutoring sessions. Results of the study indicated that all participants (i.e., mothers and children) made substantial gains in naming objects in English, and children were able to generalize from pictures of objects to the authentic objects themselves.

Most recently, Wood, Mustian, and Cooke (2012) used a simultaneous treatments design to compare two types of vocabulary instruction through the use of a computer-assisted reciprocal peer tutoring program embedded with audio prompts (i.e., recording of text read aloud in PowerPoint® slides) to promote accurate tutor feedback. The study compared morphograph (i.e., word part) instruction to a traditional whole word approach and examined vocabulary use by 8 seventh graders who were identified with mild to moderate disabilities. Results indicated that students were better able to generalize to unknown words when morphograph instruction was added, indicating a functional relation between morphograph instruction and increased generalization of vocabulary.

When considering the adoption of a cost-effective reciprocal peer tutoring for young at-risk learners as a Tier 2, supplemental phonemic awareness instructional program, a computer-assisted model with embedded audio prompting may be advantageous. Furthermore, there is currently no research addressing the use of computer-assisted peer tutoring programs to improve young children's phonemic awareness skills. To extend the research base, the purpose of this study was to evaluate the effects of a supplemental phonemic instruction program using computer-assisted reciprocal peer tutoring with embedded audio prompting. The specific research questions for this study were as follows:

1. To what extent did a computer-assisted reciprocal peer tutoring program increase kindergarten students' phoneme segmentation fluency?
2. To what extent did the computer-assisted reciprocal peer tutoring program change the participants' risk status on the phoneme segmentation fluency benchmark measure from pretest to posttest?
3. What were students' opinions regarding the computer-assisted reciprocal peer tutoring program?
4. What were the classroom teachers' opinions regarding the feasibility and outcomes of computer-assisted reciprocal peer tutoring?

Method

Participants and Setting

The participants were four kindergarten students identified as "at risk" or "some risk" for reading failure based on the Dynamic Indicators of Basic Early Literacy Skills™ (DIBELS; Good & Kaminski, 2002) Phoneme Segmentation Fluency (PSF) winter benchmark results (Good, Kaminski, & Smith, 2002). According to the DIBELS instructional recommendations (Good, Simmons, Kame'enui, Kaminski, & Wallin, 2002), "at risk" was defined as any student with a score of fewer than 7 correctly segmented phonemes and "some risk" as any student with a score equal to or greater than 7, but fewer than 18 on the DIBELS PSF winter benchmark (i.e., middle of kindergarten, pretest). Each student also had a low rate of absenteeism during the first two quarters of kindergarten and were enrolled in general education classrooms. Table 1 shows each participant's demographic information, including scores from the DIBELS PSF winter and spring benchmark assessments. Two additional kindergarten students who did not qualify for the study after initial DIBELS PSF winter benchmark assessments (i.e., scoring higher than 18 phonemes per minute) were paired with the third and fourth participants to form the second and third tier tutoring pairs. However, only the data on the four target students were collected and analyzed.

This study took place in a public elementary school in the Southeastern United States. The school served 903 students in kindergarten through grade 5 and had a student population of 23% Latino, 58% Caucasian, and 13% African American. A small office with a computer

Table 1
Students' Demographic Information

Student	Age	Gender	Ethnicity	DIBELS PSF Winter Benchmark	DIBELS PSF Spring Benchmark
Monica	5–9	Female	African American	3 (At risk)	19 (Emerging)
Nick	5–8	Male	Latino	7 (Some risk)	67 (Established)
Randall	6–10	Male	Caucasian	6 (At risk)	43 (Established)
Justin	6–10	Male	Multiracial	7 (Some risk)	61 (Established)

Note: PSF = Phoneme Segmentation Fluency. Scores shown as number of correct phonemes in 1 min. Winter benchmark represented pretest. Spring benchmark represented posttest.

desk and a round table located within the main office of the school was the setting in which all assessments, instruction, and data collection took place.

Materials

A laptop computer with an external mouse was used during all tutorial sessions and Microsoft PowerPoint® was used to create the tutorials (see Wood et al., 2007 for examples). Each tutorial slide included two major parts: (a) a picture in a 4″ by 4.5″ size, that was downloaded from a clip art program to represent the targeted word and placed at the upper portion of the slide; and (b) four "action" images with embedded audio prompts, located at the bottom portion of the slide, for tutor's instruction. The four "action" images, displayed from left to right, included (a) a picture of a smiley face holding its one hand to its ear to resemble "listen," (b) an image of a three or four red, separated boxes to represent the number of phonemes in the word, (c) an image of the three or four red boxes joined together with a black arrow striking through the boxes to prompt for saying the whole word, and (d) a "next" arrow placed at the right lower corner of the slide (see Figure 1 for a sample slide). A digital recorder was used to make an audio recording of the primary experimenter's (second author) voice saying each phoneme slowly (i.e., segmenting each word) and saying the word at a normal rate. Both the "smiley face" and the "joined boxes" images were hyperlinked with the experimenter's voice saying the targeted word at a normal rate; whereas the "separated boxes" image was linked to the audio of the experimenter's saying each phoneme. Copies of the scoring sheets, a clipboard, stopwatch, and a pencil for scoring were used for probes.

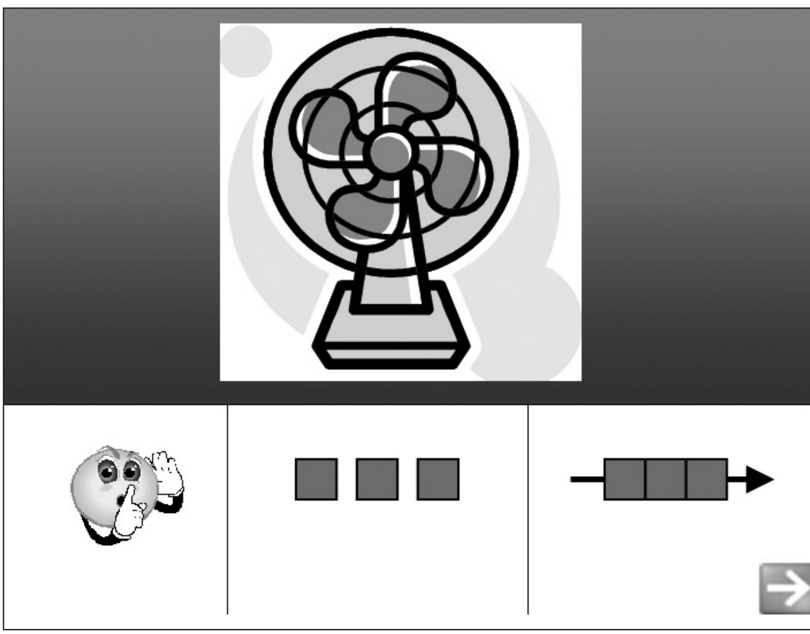

Figure 1. Sample PowerPoint® slide used during the peer tutoring condition.

Dependent Variables and Measurement

The primary dependent variable measured in this study was phoneme segmentation fluency, defined as the number of correctly segmented phonemes in 1 min. It was measured using 20 progress monitoring probes from the *DIBELS Progress Monitoring Phoneme Segmentation Fluency Kindergarten Scoring Booklet* (Good et al., 2007). After all 20 progress monitoring probes were used, the probes were repeated for administration beginning with probe one. To avoid word repetition in assessment, the experimenter started with the last word and progressing back to the first word on the probe . The DIBELS PSF measure is a standardized, individually administered test of phonemic awareness that assesses a student's ability to segment three- and four-phoneme words into their individual phonemes fluently. The PSF measure has been found to be a good predictor of later reading achievement (Good & Kaminski, 2002).

DIBELS PSF probe administration took place three times per week. Procedures for delivering the probes followed DIBELS guidelines for PSF assessment. Participants were timed for 1 min during each fluency probe. The experimenter said each word on the probe, and the student was prompted to orally state the individual phonemes for that word. A phoneme segment scored as correct was defined as any different, correct, part of the word represented by sounds that corresponded to the word part. Elongation or overlapping of segmentation was counted correct for each different, correct, and sound segment of a word. Each correct phoneme was marked with an underline. A student did not receive credit for a phoneme segment if he or she (a) did not say a sound after 3 s, (b) did no segmentation at all (e.g., repeating the entire word), (c) omitted segmentation, or (d) mispronounced segmentation. Incorrect responses were indicated with a slash mark.

In addition to the DIBELS PSF progress monitoring measure, the winter and spring PSF benchmark assessments were administered, as a pretest and posttest, respectively, and compared as a collateral measure to determine any change in each student's risk status. Procedures to administer the PSF winter and spring PSF benchmarks were the same as those described for the probes. DIBELS PSF is given in the middle of the kindergarten year (winter benchmark) and at the end of the kindergarten year (spring benchmark). Scores and status for the PSF winter benchmark (Good et al., 2007) are as follows: 0 to 6 phonemes per minute (At Risk), 7 to 17 phonemes per minute (Some Risk), and 18 and above (Low Risk). Scores and status for the PSF spring benchmark (Good et al., 2002) are as follows: 0 to 9 (Deficit), 10 to 34 (Emerging), and 35 and above (Established). Students in the current study were assessed on the PSF winter benchmark two weeks before baseline. They were assessed on the PSF spring benchmark one week after the final maintenance probe.

Interobserver Agreement

An undergraduate assistant served as the second observer to collect the interobserver agreement (IOA) data for 36% of the data collection sessions across all students and conditions. An item-by-item (i.e., phoneme-by-phoneme) analysis was conducted to compare agreements between the experimenter and the second observer. IOA was calculated by dividing the number of agreed phonemes divided by the number of agreed and disagreed phonemes, and multiplied by 100. IOA across students and conditions was 97%.

Social Validity

Social validity data were collected from the participants' and teachers' perspectives using questionnaires concerning the usefulness and feasibility of the computer-assisted reciprocal peer tutoring program. The first author conducted an interview with each participant at the conclusion of the study using an eight-item, Likert-type questionnaire (no, not sure, yes) to obtain his or her opinions about the peer tutoring program. Additionally, the school's five kindergarten teachers also completed a seven-item, Likert-type questionnaire regarding the feasibility and effects of the intervention.

Experimental Design

This study used a multiple probe across students design (Cooper, Heron, & Heward, 2007) to evaluate the effects of peer tutoring on students' phoneme segmentation fluency. The basic feature of a multiple probe design is that baseline data are not collected on a continuous basis during the baseline phase, but instead, probes are conducted intermittently. This design is particularly well suited for a study in which continuous baseline measures on behaviors such as academic skills may possibly lead to practice effects.

Procedures

Baseline. Three weeks prior to baseline, students began instruction in the school's core kindergarten reading instruction in *Reading Mastery I* (Engelmann & Bruner, 1995); however, the participants continued to struggle with basic phonemic awareness skills as evident from their DIBELS PSF winter benchmark scores. No supplemental phonemic awareness instruction was provided during baseline.

Tutor training. Tutoring pairs were formed based on similar DIBELS benchmark scores and stability of data during baseline. The experimenter trained each tutoring pair on the role of tutor and tutee and steps of peer tutoring during two 20-min training sessions immediately prior to the intervention phase. Each tutor received instruction on good tutoring behaviors (e.g., speaking clearly), and the scripted, step-by-step tutoring procedure. Training continued until each student could present the content and respond to his or her partner's correct and incorrect responses for three consecutive slides. No data were collected during tutor training. Each tutoring pair was taught to use the following script based on picture cues displayed on each PowerPoint® slide.

Tutor said, "Listen," and then clicked on the picture of the smiley face holding its hand to its ear to play the audio reading of the word (e.g., "fan").

Tutor prompted the tutee, "Say the sounds."

After the tutee responded, the tutor then clicked on the image of the separated boxes to play the audio segmentation of the word (e.g., "/f/ /a/ /n/"). If the tutee gave a correct response (i.e., matching to the audio), the tutor provided verbal praise (e.g., "good job," "that's correct") and moved on to the next task on the slide. If the tutee was incorrect, the tutor said, "Try again" and then repeated the step until the tutee provided the correct response.

After the tutee correctly segmented the word, the tutor then said, "Say it fast."

The tutee provided an oral response, and the tutor clicked on the image of the joined boxes with a black arrow. If the tutee gave a correct response, the tutor provided verbal praise and clicked on the "next" image to transition to the next slide. If the tutee was incorrect, the tutor said, "Try again" and then repeated the step until the tutee provided the correct response.

Computer-assisted peer tutoring. During the intervention, the tutor followed the procedures taught during tutor training and delivered the peer tutoring program via an explicit instruction approach to teach component phonemic awareness skills (i.e., segmenting and blending). Each session lasted approximately 7 min and addressed a total of eight words comprising three and four phonemes (e.g., mop, slip) that were taught or learned by each tutoring pair. The tutor presented four words and then the tutor and tutee switched roles so that the tutee presented the remaining four different words. During the next session the same set of eight words was used, but each student practiced the words (as a tutee) he or she had taught (as a tutor) during the previous session. In other words, one set of eight words was used for two consecutive sessions so that both participants taught and practiced all eight words. Sessions took place three times per week for each tutoring pair. The experimenter observed every tutoring session and prompted a tutor if he or she made an error in tutoring procedures. The experimenter had to prompt (e.g., "Don't forget to click the arrow.") the tutors no more than two times per session. After every session, a probe on the DIBELS PSF was administered individually to students.

Maintenance. When students' performance showed improvement and when data were stable for at least three consecutive sessions during the intervention phase, the tutoring program discontinued for that pair. Data were collected once per week during the maintenance condition.

Procedural Fidelity

A 72-item, peer tutoring checklist was used and consisted of a list of steps each tutoring pair was to follow in order to successfully complete the peer tutoring program independently. The second observer collected procedural fidelity for 37% of all tutoring sessions across all participants. Procedural fidelity was calculated as the number of steps followed correctly divided by the total number of steps and multiplied by 100. The mean percentage of procedural reliability was 99% (range = 96%–100%).

Results

Phoneme Segmentation Fluency

Monica. During baseline, Monica's probe data showed a low, stable data path with a mean of 10.6 phonemes per minute (range = 8–12). During the peer tutoring condition, Monica's data showed a steady and gradual increase with a mean of 25.6 phonemes per minute (range = 12–35). Although Monica did not meet the mastery criterion of three consecutive sessions at 35 phonemes per minute, she scored 35 phonemes in three of her last four intervention sessions. The maintenance condition was not conducted for Monica because she failed to achieve the mastery criterion during intervention.

Nick. Nick's baseline data indicate a slight increase from session 1 to session 2, but his data remained stable for the remainder of the baseline phase with a mean of 15 phonemes per minute (range = 12–16). During intervention Nick's data showed an immediate change in level and trend and had a mean of 53.2 (range = 41–63). Because Nick was able to meet and exceed mastery criterion, he entered the maintenance phase of the study. Maintenance data were collected once per week for two weeks and Nick maintained or exceeded fluency levels he had attained during intervention.

Randall. Randall's baseline data indicate a stable trend with a mean of 6.9 phonemes per minute (range = 3–10). Because of his stability at baseline, he was part of the second tutoring pair to enter intervention. Randall was paired with Hayley, whose data were not collected during this intervention. Hayley's high scores on the winter benchmark test indicated she did not need the intervention. However, her teacher recommended her to continue being a part of the study for potential social improvements. During intervention, Randall's data demonstrated a clear change in level and trend with a mean of 40.0 phonemes (range = 25–49). After meeting mastery criteria, maintenance data were also collected once per week for a period of two weeks. Randall's maintenance data had a mean of 43.0 phonemes per minute (range = 40–46).

Justin. Justin's data during baseline indicated an increasing trend during the first 6 sessions, but the data path decreased in trend and stabilized during the remainder of his baseline probes. His baseline data had a mean of 19.3 phonemes per minute (range = 6–25). Because of the variability in his baseline data, Justin was the last student to enter intervention. Once peer tutoring began, Justin's data showed an immediate change in level with a somewhat decreasing but stable trend. Justin's intervention data had a mean of 51 phonemes per minute (range = 49–55). Due to due time constraints only one maintenance probe was conducted. Justin exceeded the set mastery level during the maintenance phase with 55 phonemes segmented correctly per minute.

Winter and Spring Benchmarks

Table 1 shows students' scores from both the DIBELS winter and spring benchmarks. Results from the winter benchmark (pretest) indicated that all participants were either in the "At Risk" or "Some Risk" categories as indicated by the DIBELS scoring guide. These data are also displayed on Figure 2 as open triangles. The participants' winter benchmark scores ranged from 3 to 7 with a mean of 4. On the posttest spring benchmark assessment, all participants improved their scores with a range of 19 to 67 and a mean of 47.5, moving them all out of the "At Risk" or "Some Risk" status. Specifically, Nick, Randall, and Justin all had scores that placed them in the "Established" range. Monica's spring benchmark scores moved her into the "Emerging" range.

Social Validity

All students indicated they liked using the computer with a partner, and they all agreed that they learned new words using the computer program. One student stated, "It was fun to be the teacher." All students indicated that the steps required to complete the tutoring program were easy to follow and did not take a long time. Another student said, "I liked seeing the pictures of new words every week."

Five kindergarten teachers responded to the questionnaire, and all strongly agreed that supplemental instruction in phonemic awareness is extremely important for struggling learners. Teachers responded that students' time spent learning phonemic awareness skills was

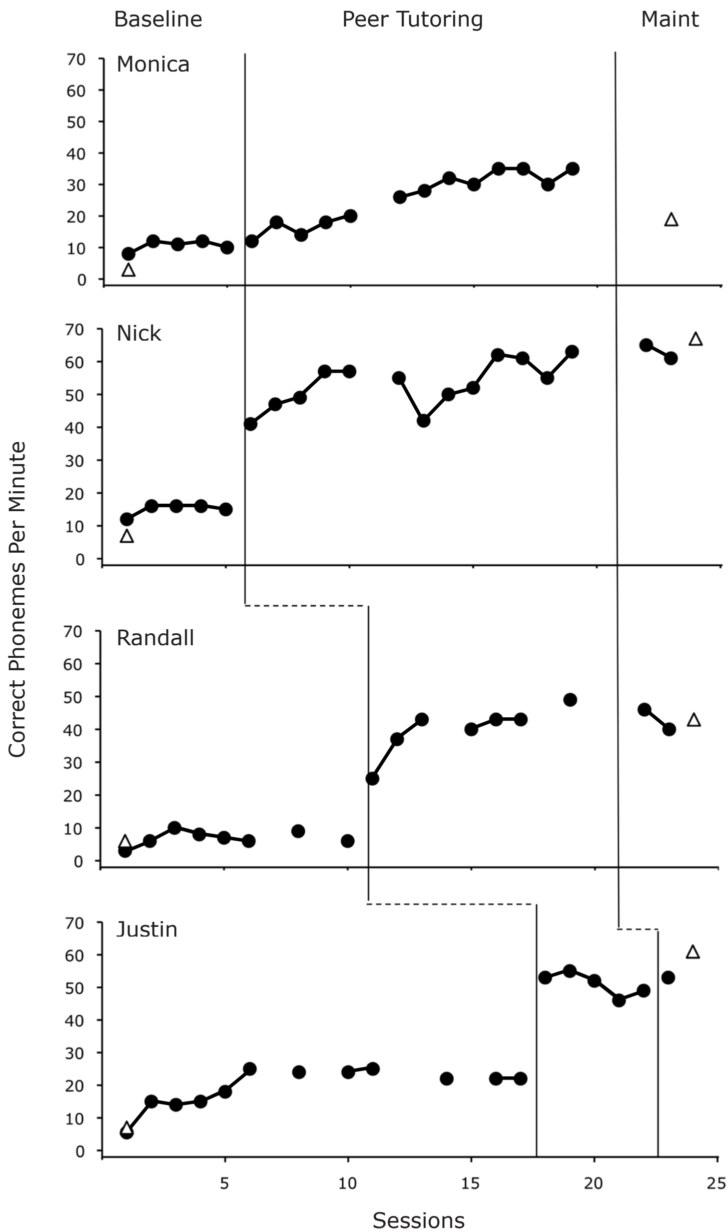

Figure 2. Number of correct phonemes per minute across experimental conditions by each student. Open triangles indicate DIBELS Winter and Spring Benchmark scores.

an important investment and noted they would want to use this as a supplementary intervention in their classrooms.

Discussion

This study examined the effects of computer-assisted reciprocal peer tutoring on the phoneme segmentation fluency of kindergarten students who were struggling with phonemic awareness. Results from this study indicated that peer tutoring improved the phoneme segmentation fluency of all students. Three of the four students showed dramatic improvement when peer tutoring began. This might be due to the explicit audio-recorded models on how to segment words and the immediate feedback they received in the tutoring sessions. Monica's improvement was gradual and did not reach the high levels of her peers' performance. It is possible that Monica may have lacked some basic phonological awareness skills (e.g., counting the number of words in a spoken sentence) that were not covered in the tutoring program.

Findings from this study are consistent with previous research on peer tutoring with audio prompting (Cooke et al., 2009; Mackiewicz et al., 2011; Van Norman & Wood, 2008; Wood et al., 2012), showing that computer-assisted peer tutoring can improve students' academic success. This study extends the research on the efficacy of computer-assisted reciprocal peer tutoring by teaching phonemic awareness skills to kindergarten students.

Limitations and Directions for Future Research

This study has several limitations that should be addressed in replications or extensions of the research. First, no criteria were set to determine when to move students into the maintenance phase. Second, maintenance data were collected only twice for Nick and Randall, once for Justin, and not collected for Monica. Future studies should include specific criteria for moving into maintenance and should collect repeated measures during maintenance to establish level, trend, and stability of students' performance. Third, the experimenter needed to prompt tutoring pairs up to two times per session (e.g., "Don't forget to click with the mouse."). As a result, students never conducted tutoring sessions completely independent of adult guidance. Future research should investigate the design of computer-assisted instructional components (e.g., built in prompts and reminders) that could reduce adult support. Fourth, tutoring sessions were conducted one tutoring pair at a time in separate, quiet room with an adult supervisor; therefore, the extent to which students could peer tutor using computers in a typical classroom is unclear.

Future research should evaluate this intervention with tutoring pairs or multiple pairs in a typical classroom. Fifth, since peer tutoring was embedded into computer-assisted instruction, the contributions of these strategies (peer tutoring vs. computer-assisted instruction) are unclear. Future research could compare the effects of each strategy on students' phoneme segmentation fluency. Finally, students had received Direct Instruction in *Reading Mastery* during the course of the study. Although the classroom teachers started the program a few weeks before baseline and had not completed the first level by the end of the study, it is likely that students had some practice with segmenting during the program's phonemic awareness exercises. This practice may have contributed to students' gains made during peer tutoring.

Implications for Practice

Results from this study also have several implications for practice. The social validity data collected from students and teachers indicate that using computer-assisted peer tutoring for supplemental instruction is not only beneficial and fun for students, but also is feasible for teachers to implement and monitor. Additionally, the procedural fidelity data indicate that students as young as 5 years can implement reciprocal peer tutoring procedures appropriately. The experimenter prompted students to use correct procedures no more than two times per session. This suggests that students might be able to peer tutor with minimal guidance and prompting from teachers. Furthermore, teachers might find computer-assisted peer tutoring to be a viable Tier 2 support for struggling readers (Vaughn & Roberts, 2007).

Previous research (Cooke et al., 2009; Mackiewicz et al., 2011; Van Norman & Wood, 2008; Wood et al., 2012) provides evidence that reciprocal peer tutoring with audio prompting can improve student performance. Once teachers learn how to create slides (Figure 1) in PowerPoint® or other slideshow software, they can set up computer-assisted peer tutoring to supplement instruction on other academic skills (Wood et al., 2007).

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