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Original Research

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Effects of Reading Racetracks and Self-Graphing on Literacy Performance of Struggling Students With Behavioral Problems

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Abstract

Literacy influences all aspects of life. Unfortunately, a rising number of students struggle with reading and spelling, which can result in enormous educational barriers. Difficulties in literacy accompanied by learning-related problem behavior can create additional risk factors. Effective interventions for these students should consider individual needs and focus on multiple components of learning simultaneously. The present single-case study focused on the effects of motivational reading racetracks, with and without self-graphing, on the word-reading and spelling performance of three third graders with severe literacy and behavior problems. Our intervention was carried out three times a week over a 5-week period. The results show strong effects of the racetracks on reading, while the self-graphing component did not seem to be an additional booster. Regarding spelling, the ability to read words was not equivalent to being able to spell all words correctly. However, effects were found when self-graphing was added. In sum, the data suggest that, while it was effective to practice reading using racetracks without motivational reinforcers, it was not sufficient to merely practice spelling. Nevertheless, self-graphing had a positive effect on spelling when attention was focused on spelling the words correctly.

Keywords: *peer-reading racetracks, self-graphing, word reading, word spelling, behavioral difficulties*
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Introduction and Literature Review

Literacy—Reading and Spelling

Literacy plays a central role in school curricula. Whether for assessments, written assignments, or mathematical problem-solving, adequate reading and spelling skills lay the groundwork for academic success (Reid & Lienemann, 2013). As a result, students with persisting difficulties in reading and/or spelling experience greater challenges in all content areas than their normally achieving peers (Verduin & McLaughlin, 2012). It is estimated that 74% of all children who are diagnosed with a reading disability by third grade will continue to manifest severe problems in decoding symbols to determine a text's meaning in later life (Shaywitz et al., 1994). Specifically, Kiuru (2011) found that students with spelling difficulties are less likely to attend and graduate from secondary education. Against this backdrop, it is significant that about 19% of fourth graders in Germany and 17% of fourth graders in the United States do not read at a proficient level (Hußmann et al., 2017).

While reading and spelling are strongly associated (Furnes & Samuelsson, 2011; Georgiou et al., 2012; Landerl & Wimmer, 2008), learning to spell is generally more difficult than learning to read (Bosman & Van Orden, 1997). This is especially true for languages with relatively inconsistent letter-sound correspondence, such as English (Gangl et al., 2018). The present study was conducted in Germany. In German, the pronunciation of words is more predictable than in English, based on their written form. This makes spelling easier. However, spelling still poses a significant challenge to students and, as mentioned earlier, is usually more difficult to acquire than reading (Wimmer & Mayringer, 2002).

According to the dual route theory (DRT), when reading aloud, skilled readers use both a system of rules that connect letter-sound relations and sight words stored in memory (Coltheart et al., 1993). Sight words are stored as a unit in memory and are recognized and read automatically. Ehri's theory of sight-word reading is based on the connection between the spelling of a word and its pronunciation as stored in one's memory. That is, the "sight" of a familiar word activates affiliated information like pronunciation, meaning, and spelling (Ehri, 2005).

Several experiments that included sight word reading have demonstrated that four or fewer exposures to targeted pseudo-words were sufficient for students to be able to read those words more fluently and to retain information about the words' spelling in memory (Share, 2004). In that connection, Share (2004) emphasized the importance of saying the word versus just seeing the word. Once children operate fully alphabetically (Ehri, 2005) and are familiar with letter-sound correspondences, they can quickly retrieve sight words from memory. Through repeated encounters with sight words, students will also be able to recognize and store multiletter units that were present in different words. Because these readers have to connect fewer units when decoding new words, their word-identification skills improve (Pikulski & Chard, 2005).

Students in the upper elementary grades are at a critical phase in their reading development, as the prominent goal in reading shifts from learning to read to reading to learn from texts with increasing complexity and information density (Toste et al., 2017). Students with reading difficulties, who have less access to sight words, have to resort to the non-lexical route more often (Ardoin et al., 2013), and the additional cognitive load that stems from slowed word processing is likely to have a negative impact on comprehension (Stevens et al., 2017).

Students With Behavioral Difficulties and How to Support Their Reading and Spelling

One group of students who consistently struggle with literacy tasks is children with emotional behavior disorders (EBD; Roberts et al., 2020). Many studies have established a relationship between EBD and

severe problems in reading and spelling (e.g., Horbach et al., 2020; Martin et al., 2006; Metsäpelto et al., 2017; Walters, 2016). Having to attend to both problems simultaneously poses great challenges for teachers, especially because students with EBD are less likely to respond to traditional literacy interventions (Jacobson et al., 2013). However, meta-analyses by Roberts et al. (2020) and Rivera et al. (2006) indicate that explicit reading instruction, as well as peer tutoring, can be very helpful for teaching literacy skills to students with reading difficulties and problem behavior.

In an ongoing debate on whether spelling should be taught intentionally or if it can be learned incidentally—that is, without instruction (Peters, 1985)—recent research suggests that explicit spelling instruction is crucial (Atkinson et al., 2014; Graham & Santangelo, 2014). For instance, Kuhl (2020) found that direct teaching and systematic spelling instruction had the highest effects on German-speaking students' spelling performance. Additionally, Squires and Wolter (2016) pointed to the importance and efficacy of interventions targeted at the orthographic rule system when teaching students how to spell in alphabetic languages, such as German.

In their meta-analysis, Graham et al. (2018) found that reading interventions have a significant effect on spelling (Cohen's $d = 0.56$); specifically, instruction that includes repeated reading of specific words can make the spelling of these words more memorable. However, while incomplete orthographic representations are sufficient for students to quickly recognize a word visually when reading, spelling requires higher-quality orthographic representations (Conrad, 2008; Galuschka et al., 2020). Thus, while an incompletely or inaccurately stored word might be read correctly, lack of orthographic completeness can lead to mistakes in spelling.

Reading Racetracks

Among available interventions, racetrack procedures offer a promising option for helping students with literary and behavior difficulties to practice spelling (Rinaldi & McLaughlin, 1996). These explicit techniques adopt simple board-game rules and are set up using a round racetrack with blank fields, each field containing a targeted task to be completed; in addition, intense iteration and immediate feedback are provided (Verduin & McLaughlin, 2012). Racetracks have been employed effectively to deepen different literacy skills in students with learning and behavior problems (Barwasser, Urton, & Grünke, 2021; Barwasser, Urton et al., 2021; Barwasser, Hertel, & Grünke, 2021; Barwasser et al., 2022; Erbey et al., 2011; Grünke & Barwasser, 2019; Sperling et al., 2019; Verduin & McLaughlin, 2012). Further, Lämsä et al. (2018) found that including games can increase the time that children are willing to spend on a task, which is especially important for skills that need repetition in order to be retained. In particular, the authors reported the potential to engage students in literacy interventions, resulting in improvement of basic reading skills.

Peer-Tutoring

Another promising way to engage students with academic and emotional problems in literary interventions involves embedding reading instruction in a peer-mediated setting, where students work together in pairs, small groups, or in multiple group formats (Lee & Yoon, 2017). By allowing students to assume a more active role in their learning (Faggella-Luby & Deshler, 2008), peer tutoring has been found effective for both academic tasks and social behavior outcomes (Moeyaert et al., 2021).

Self-Graphing

Motivation plays a central role in reading (Cooper et al., 2007; Marinak & Gambrell, 2008) and spelling (Sideridis, 2005), especially for learners with behavioral challenges. Sideridis (2005) reported that weak spellers had significantly lower goal attainment intention and low motivation levels compared to good spellers. Adding motivational boosters to an intervention seems to be beneficial in keeping students motivated.

Guzman et al. (2018) indicate in their meta-analysis that self-monitoring strategies have a significant large positive effect on the reading performance of K-12 students. Especially with regard to reading interventions, self-graphing procedures can lead to greater effects. In addition, when students understand the purpose of certain learning tasks, their motivation increases (Menzies et al., 2009). For example, during reading intervention with students with EBD, the addition to peer tutoring of self-graphing, whereby students can see their own data, creating a visual representation of their performance over time (Albers & Hoffman, 2012; Gunter et al., 2002), has been found to lead to decreased disruptive behavior, active responding, and improved word reading per minute (Joseph & Eveleigh, 2011; Sutherland & Snyder, 2007).

Purpose of the Study and Research Questions

Due to the importance of literacy and the large number of students who struggle with reading and spelling, research on interventions targeting both reading and spelling for at-risk students is critical. As illustrated above, when working with children with EBD, adding motivational components to an intervention is especially crucial. This single-case study aimed to evaluate the effects of a reading racetrack procedure in a peer-mediated setting, with and without a self-graphing procedure as a moderator, on both sight-word reading and spelling. Participants were third-grade students with poor reading and spelling skills who also displayed severe behavior problems. The research questions that guided our study were as follows:

1. Does a peer-tutorial racetrack intervention have a positive impact on the sight-word reading of struggling primary school students with behavior problems?
2. Does adding a self-graphing procedure focusing on reading and spelling outcomes have a positive effect on the sight-word reading of struggling primary school students with behavior problems?
3. Does a peer-tutorial racetrack intervention have a positive impact on the spelling of sight words by struggling primary school students with behavior problems, even though spelling is not an explicit focus?
4. Does adding self-graphing focused on reading and spelling outcomes have a positive impact on the spelling of sight words by struggling primary school students with behavior problems?

Methods

Participants and Setting

The study was conducted with students from a third-grade classroom at an elementary school in the western part of Germany. Informed consent forms from parents were acquired before the selection of final participants began. Students had to meet the following criteria to be eligible for the study: (a) a percentile rank (PR) of <15 in a standardized reading test (SLRT II, see below), (b) a PR of <15 in a standardized spelling test (HSP, see below), (c) classification as having externalizing problem behavior according to a screening tool for EBD filled out by the lead classroom teacher (ITRF-G, see below), and (d) an inability to write targeted words correctly in a researcher-created word pretest (see below).

Using the above inclusion criteria, we identified a total of nine students. The final selection of our three participants was done by the teacher based on her appraisal of students' motivation and ability to function well in small groups. Our students belonged to one of three teams, consisting of one tutor and two tutees each. The tutors were our participants' classmates who performed averagely in literacy and did not show any signs of EBD. Of the remaining two tutees in each team, all of them struggled with reading and spelling, but none of them demonstrated any serious behavior problems. Basic information about the three participants (collected using a teacher questionnaire, see below) may be found in Table 1.

Table 1. *Description of Participants*

Participant	Age	Grade	Gender	First language	Reading (PR)	Spelling (PR)	ITRF-G
Peter	10 years, 2 months	3	male	German	12	13	15
Tim	9 years, 8 months	3	male	German	13	10	14
Ben	9 years, 5 months	3	male	German	12	14	17

Six graduate students in special needs education served as test leaders and interventionists and were intensively trained by the first author before the start of the study.

Design

A multiple-baseline design across participants (in the form of an A-B-BC plan) was applied (Ledford & Gast, 2014). The three groups started the intervention on different days. Our research plan consisted of a baseline condition (Phase A), a reading racetrack procedure (Phase B), and additional self-graphing (Phase BC). The sessions took place three times a week for 20 minutes over a period of 5 weeks. They were carried out in available classrooms that were not in use at the given time. Dates and time frames for the sessions were scheduled in advance with the respective lead classroom teachers. All groups started the baseline condition at the same time. The interventionists worked together in pairs and rotated to conduct the training among the three participants in order to avoid test leader effects.

Screenings to Choose Participants and Measures for Data Collection

SLRT II

The SLRT II is a diagnostic instrument for the differentiated testing of difficulties in the lower levels of the hierarchy of reading competencies. The procedure includes a 1-minute reading fluency test with two subtests focusing on word reading and pseudoword reading. Parallel test reliability coefficients range from.90 to.98 for the number of correctly read words in the 1-minute reading fluency test for the word and pseudoword lists (grades 2–6). Norms are available for second to sixth grade (N = 1747).

HSP

The HSP is used to determine spelling competency. It comprises 15 individual words and four sentences that children must write down as they are dictated. HSP 3 (for third grade) was administered as a group test. The test scores are derived from five evaluation components: the number of correctly spelled words, grapheme hits, spelling strategies, superfluous orthographic elements, and upper-character errors. Spelling strategies are divided into alphabetic, orthographic, and morphemic strategies. In the present study, only the orthographic strategy scores were included. Nationwide comparative scores for Grades 1–10 from a norm table are used to determine student learning compared to a representative sample. Validity is given in comparison to other spelling tests (May 2012).

ITRF-G

The Integrated System Teacher Report Form (ITRF) test (Volpe et al., 2018) represents a multilevel screening procedure to identify student behavior difficulties. In the present study, the German translation of the English version (ITRF-G) was used. In the research conducted, the screening form was filled out by the lead classroom teachers, as they are in the best position to assess the students' behavior. Responses are rated on a 4-point scale ranging from 0 to 3, with 0 indicating that the behavior is not problematic and

3 indicating a severe problem. A short version consisting of 16 items was administered. The items are created based on the factors "learning-related behavior" and "oppositional/disruptive behavior." The short version shows high internal consistency and sufficient test–retest reliability in terms of reliability and high external validity for all scales (Volpe et al., 2018).

Teacher Questionnaire

The teacher questionnaire included questions about each student's age, date of birth, gender, special needs, and First Language (L1) and Second Language (L2). This questionnaire was filled out by the lead classroom teacher.

Word Pretest

Reading was tested with the help of two PowerPoint presentations listing multisyllabic technical words from the animal kingdom because the topic of animals was going to be the next topic in science education at the participating school. The words and the topic were chosen in cooperation with the teachers. The two PowerPoint presentations took place on the same day, with a break between them. Initially, the presentations contained 50 words each (100 words in total) and proceeded as follows: A word is shown on a slide, which automatically switches to the next slide at 1-second intervals. A slide with an animal word is followed by three slides, each depicting a hash symbol (#). The child must read the word aloud correctly when it appears, at the latest, at the first hashtag symbol. The test leader marks sight words that are read correctly within one second of their appearance as "1" and words that are not read correctly with "0." The same 100 words were assessed through dictation on 2 consecutive days. Subsequently, 30 words that the majority of the participants did not read or spell correctly were selected for the intervention.

Data Collection

The measurements consisted of (a) a PowerPoint presentation to assess sight-word reading and (b) dictation to measure spelling. For the reading assessment, the pool of 30 training words was assessed every time in random order. The spelling measurement contained only 20 randomly presented words out of the 30 because writing down 30 words for each measurement was found to be overwhelming for students. At each measurement point, spelling was assessed first via group dictation, and then reading was assessed in an individual setting.

Reading

A PowerPoint presentation was used to measure reading skills. As mentioned above, it contained 30 slides with one word printed on each (30 words), with each slide presented for 1 second (see Ehri, 2005), as during the word pretest condition. Between every slide containing a word, three slides containing a hashtag were shown, creating a 3-second pause between every word to be read to slow down speed. The order of the words within the PowerPoint presentation was different at each measurement point. Student performance was measured by the number of words read correctly.

Spelling

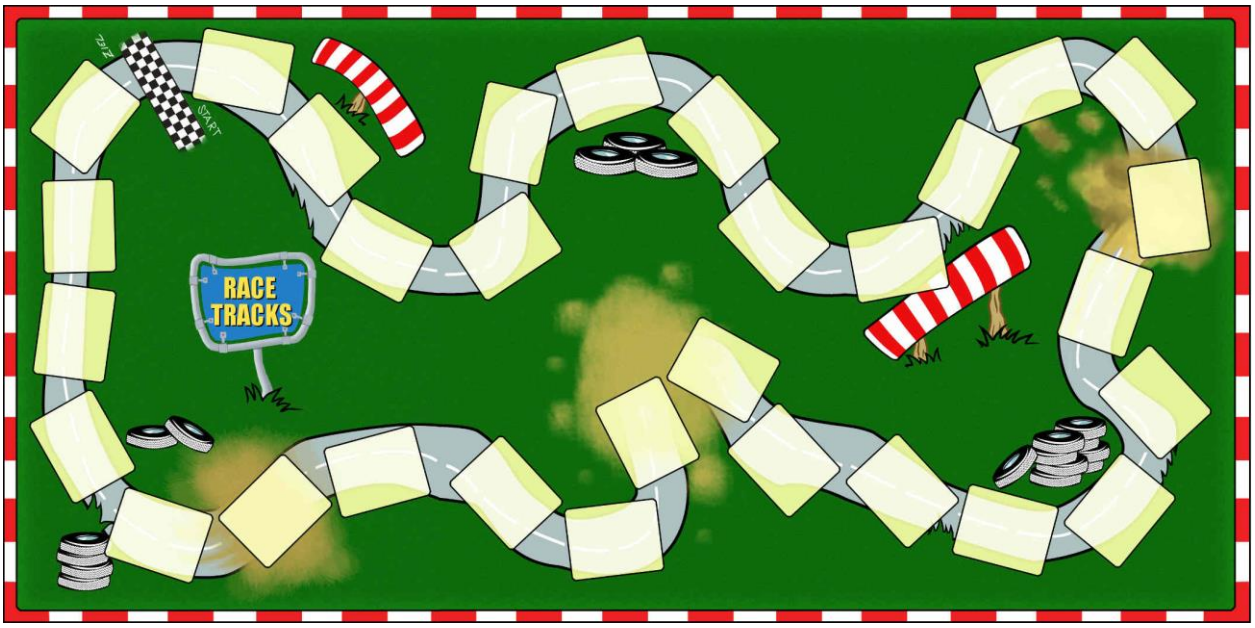
To measure spelling, 20 words were dictated to the students by an interventionist at each measurement point. The words were randomly selected from the students' individual word pools (30 words), ensuring that (a) the same words were not used in consecutive measurements and (b) words were presented equally often to the students over the course of all measurements. Interventionists took note of the words used on pre-formatted worksheets. Student performance was measured by the number of correctly written words.

Intervention Materials

The materials included colored racetrack maps that depict a car race, made up of 30 rectangular fields

(Figure 1), on which are placed individual 1.2- x 2.0-inch flashcards, each printed with a sight word on one side and a race car on the other.

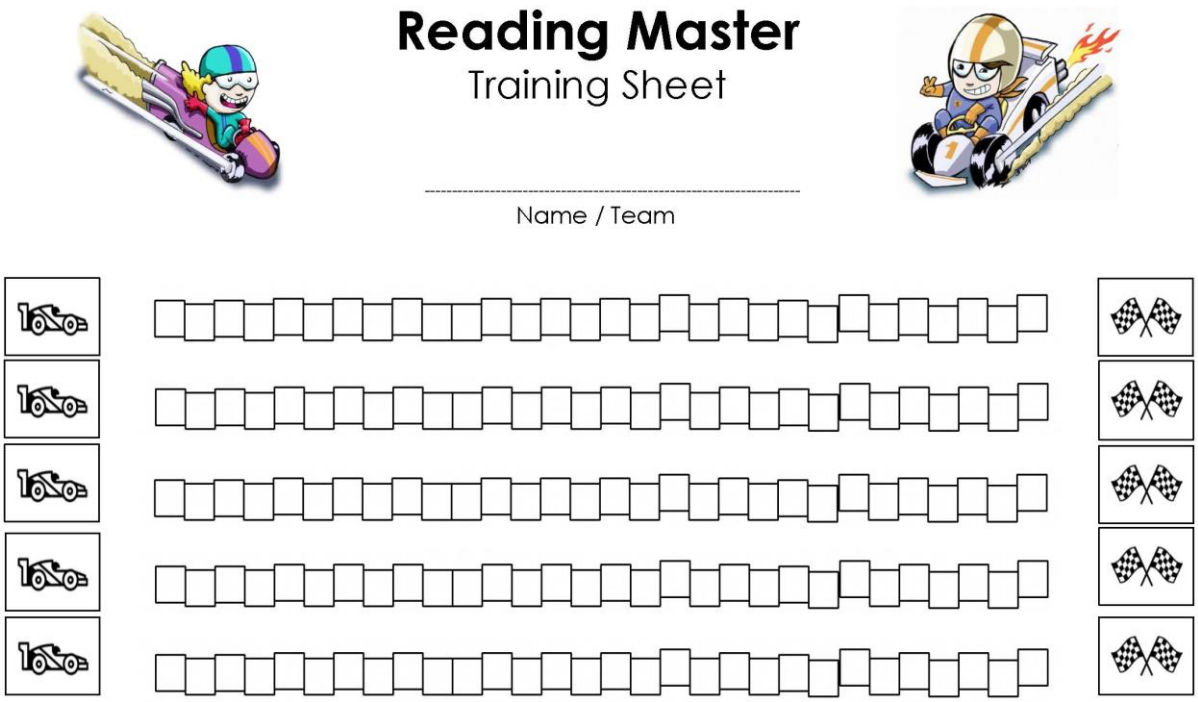
Figure 1. *Racetrack Game Board*



A game piece and die accompanied the game board. In addition to the materials for the racetracks, large 8.3- x 11.7-inch flashcards containing the words were used to implement the direct instruction at the beginning of each support unit.

In addition, students received self-graphing sheets (Figure 2) showing 30 small squares (one for each intervention session) in a row between a start and a finish symbol, as well as child-friendly drawings of race cars. To show individual progress and increase motivation (Sutherland & Snyder, 2007) during Phase C, the tracks could be colored by the tutees according to the number of correctly read words and correctly spelled words (since the tutees wrote down only 20 words, the distance on the sheets was reduced by 10 fields, to a total of 20).

Figure 2. *Self-Graphing Sheet*



Procedures

Baseline

In order to assess the change in sight-word performance and the number of correctly spelled words written without support, each student's baseline was first recorded with regard to the 30 selected words for reading and the 20 words for spelling. The students first completed worksheets with cognitive puzzle tasks and math tasks for 10 minutes. To avoid failure in this phase, it was emphasized that students did not have to complete all tasks before the worksheets were collected by the interventionists. Measurement of sight vocabulary was carried out directly after the intervention session—number of words read correctly was measured using a 30-word PowerPoint presentation. Subsequently, the number of correctly written words was measured by means of a randomized dictation of 20 words.

Treatment

Each session consisted of two phases. During the first phase (10 minutes), the group sat in a semi-circle in front of the interventionists, who used direct instruction to teach the reading of the word material with the help of flashcards. Only 10 words out of the 30-word pool were drawn randomly for each session to reduce cognitive load. All words were presented equally often to the students during Phase 1. During the second phase (10 minutes), each tutor/tutee team played the racetrack game at a table. The racetrack procedure was planned according to the research of Barwasser, Hertel, & Grünke, 2021; Barwasser, Urton, & Grünke (2021); Barwasser, Urton, Grünke, Sperling, & Coker (2021); and Barwasser et al. (2022).

First, the tutee rolled the die, advanced on the squares according to the number shown on the die, flipped the flashcard that was lying on the square, and read the word aloud. After giving the tutee at least 3

seconds to self-correct, if necessary, the tutor corrected, and the tutee tried to read the word again, until it was read correctly, followed by praise and encouragement from the tutor. The die was then rolled again. All flashcards that had been read remained on the board with the words facing up and were skipped on subsequent rounds. If the duo had worked through all the words before the 10 minutes were up, the cards were laid out again.

During Phase C, self-graphing was added to the intervention. The tutees were given two self-graphing sheets—one for the number of correctly read words and one for the number of correctly written words. After each measurement, the tutees were allowed to color in the number of boxes on the self-graphing sheet corresponding to the results of the test and were thus able to track their learning progress for reading and spelling.

After each intervention session, as in the establishment of the baseline, the number of correctly written words was assessed via dictation in a group setting, while the number of words read correctly was assessed individually with each student.

Treatment Fidelity

To monitor the accuracy and consistency of the intervention, a questionnaire was created to record treatment fidelity, consisting of data about the intervention session (date, time, session number, intervention group, and interventionists). First of all, the presence/absence of the participants was documented. This was followed by the second part of the questionnaire, which was comprised of a checklist made up of the following categories: environment/external circumstances, planning, material, course of support, diagnostics, feedback, and student behavior. Closed questions were answered for each support unit to ensure adherence to and review of the framework of the intervention. The last part of the questionnaire consisted of three open-ended questions aimed at soliciting comments on special features of the intervention, as well as notes on further implementation, ambiguities, and need for clarification. The questionnaire was filled out by the acting university graduate student after each measurement point. In addition, another interventionist was consulted for one-third of the intervention time as an external rater. Interrater reliability equaled 100%.

Data Analysis

To analyze the data, the statistics program R was used. In the following, visual inspection and descriptive data are followed by a more in-depth analysis using the following overlap measures. The Mean Baseline Difference (MBD) was used to measure the average increase of reading and spelling from baseline. Non-Overlap of All Pairs (NAP; Parker et al., 2011a), Percentage Exceeding the Median (PEM; Ma, 2006), and the Tau-U with A trend correction (A vs. B + trendB – trendA; Parker et al., 2011b;) were also used.

Results

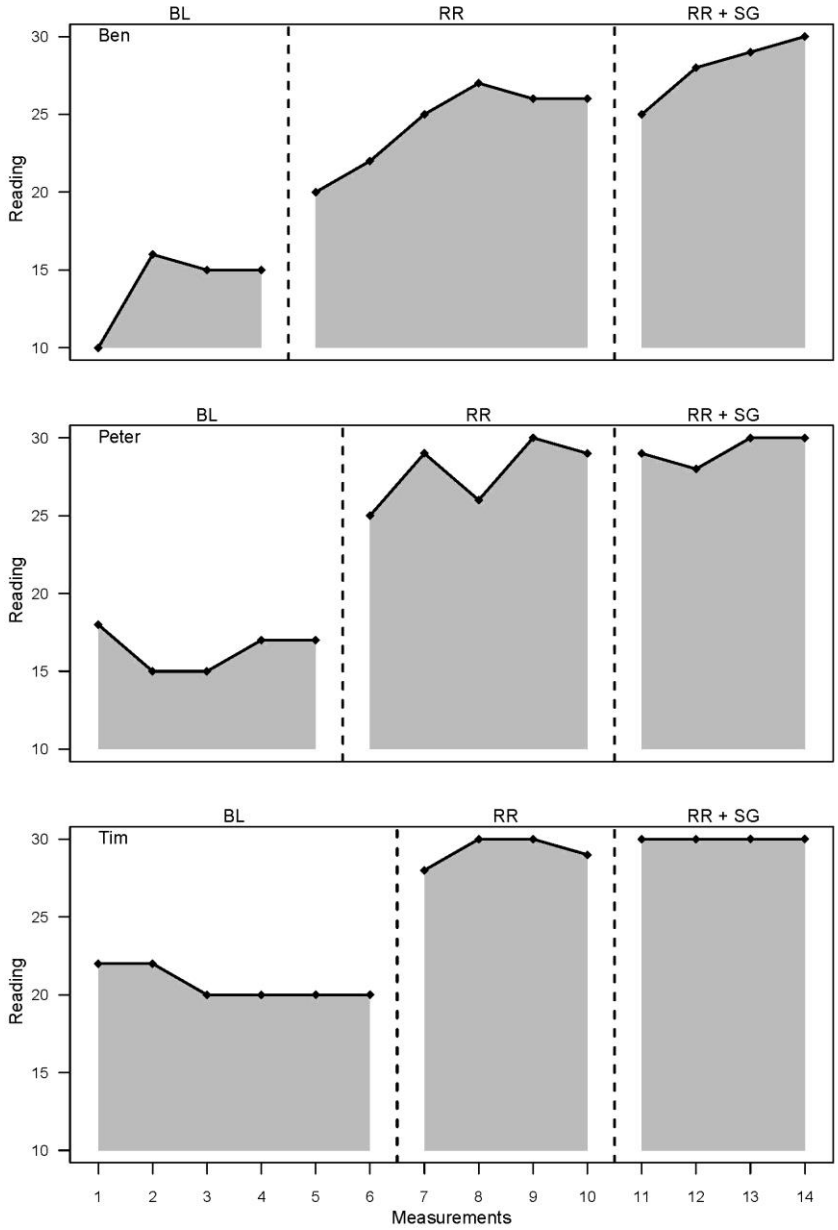
Visual Inspection

Reading

Figure 3 shows that all three students entered the baseline with comparatively high reading scores. Ben even showed a rapid increase in Phase A at the second measurement point; however, it stagnated. In Phase B, a strong level effect was observed for all participants, and all seemed to respond directly to the intervention. Due to the strong level effect, Peter and Tim quickly reached the maximum number of words to be read. Ben showed a classic increase in Phase B, but this seemed to stagnate toward the end. Due to the rapid increase in the number of correctly read words in Phase B, there was little room for improvement in Phase C. In Ben's case, after the stagnation in Phase B, there was an upward trend again

in Phase C. Tim showed a classic ceiling effect, whereas Peter's values were similar to his last values of Phase C.

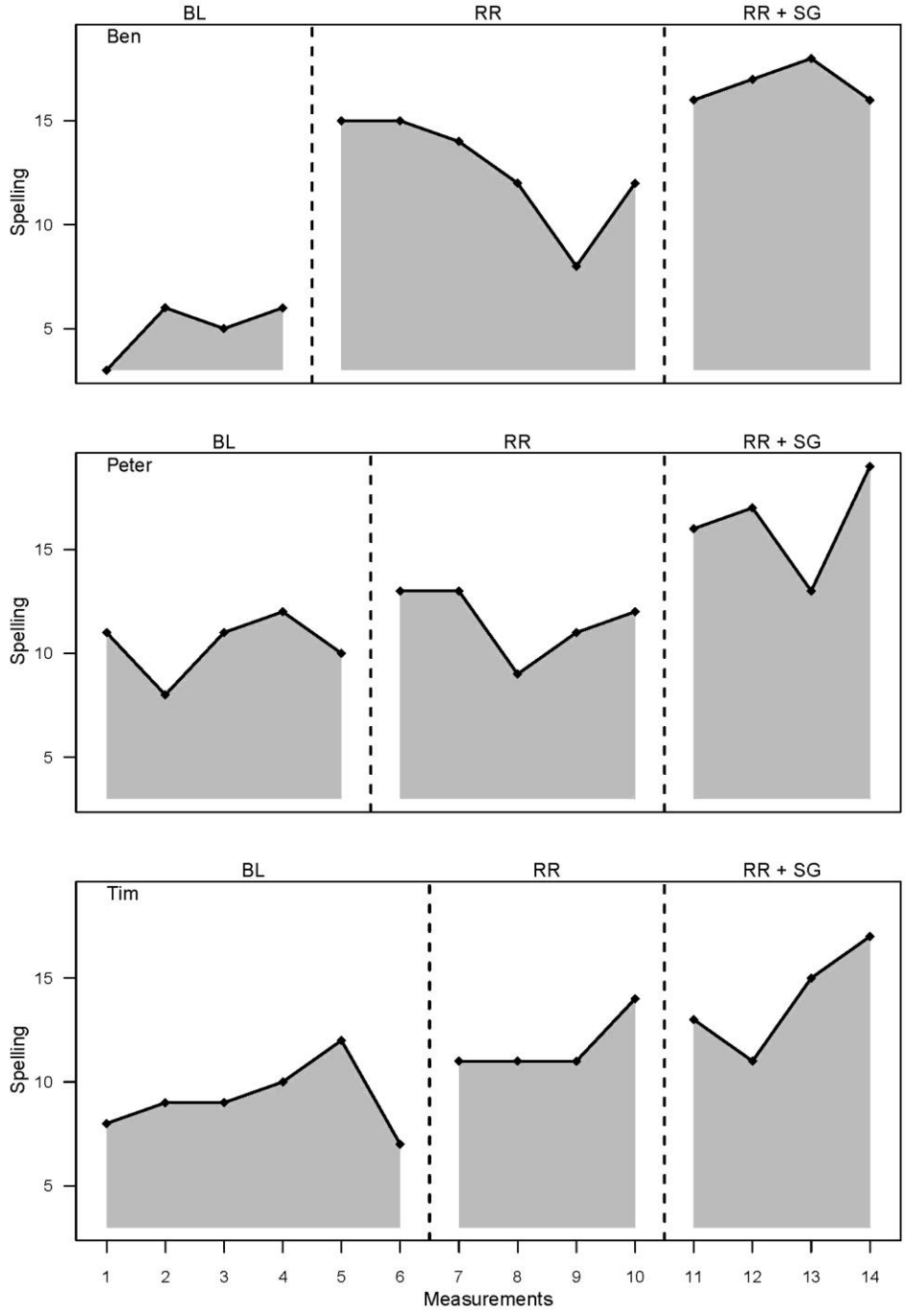
Figure 3. *Reading Performance of Participants Over the Course of the Study*



Spelling

With regard to spelling, Figure 4 shows that our three third-graders started with relatively high values in baseline, and with Ben there was again a small increase in Phase A. However, while Ben's Phase A values moved upward, the other two showed a downward trend toward the end of Phase A. In Phase B, strong level effects can again be seen. Ben showed a strong negative trend in Phase B, whereas Tim's values increased toward the end. Peter's values were again similar in the A and B phases. However, there was a clear increase in Phase C, where the students had to pay additional attention to writing the word correctly. Peter and Tim showed a strong increase, whereas Ben's values in Phase C went down again toward the end.

Figure 4. *Spelling Performance of Participants Over the Course of the Study*



Statistical Analysis

Reading

As shown in Table 2, Peter entered with a mean value of 16.40 in Phase A, reached a mean value of 27.80 in Phase B and of 29.25 in Phase BC. His increase was 69.51% from Phase A to Phase B and 5.22% from Phase B to Phase BC, with an overall maximum value at the end of the study of 30.00. Tim entered with a

higher value at the baseline *(M* = 20.67), reached a value of 29.25 in Phase B and 30.00 in Phase BC, which was also the maximum value. His increase from Phase A to Phase B was 41.51% and 2.56% from Phase B to Phase BC. Ben had the lowest mean value in Phase A (*M* = 14.00); it increased to 24.33 in Phase B and 28.00 in Phase BC, but reached the maximum value of 30.00 at the end of the treatment. The improvement from Phase A to Phase B was 73.79% and 15.08% from Phase B to Phase BC, which represents the strongest increase across the phases.

Table 2. *Descriptive Data for Words Read Correctly*

	N(A)	N(B)	N(BC)	*M*(A)*SD*	*M*(B)*SD*	*M*(BC)*SD*	Max A	Max B	Max BC	MBD A-B	MBD B-BC
Peter	5	5	4	16.40 (1.34)	27.80 (2.17)	29.25 (0.96)	18.00	30.00	30.00	69,51%	5,22%
Tim	6	4	4	20.67 (1.03)	29.25 (0.96)	30.00 (0.00)	22.00	30.00	30.00	41,51%	2,56%
Ben	4	6	4	14.00 (2.71)	24.33 (2.73)	28.00 (2.16)	16.00	27.00	30.00	73,79%	15,08%

Note. N = Measurements; A = Phase A; B = Phase B; BC = Phase BC; *M* = Mean; *SD* = Standard deviation; Max = Maximum value; MBD = Mean baseline difference.

With regard to the overlap measures, Table 3 demonstrates that from Phase A to Phase B, all participants reached a maximum value of 100.00 for the NAP (p <.01) and the PEM. Tau U values showed a large change for all subjects from Phase A to Phase B (0.67-0.73; p<.01). Comparing Phase B to Phase BC, overall effects were lower. The NAP showed medium effects, with only Ben's values being statistically significant (p <.05). The PEM showed no effects for Peter, a moderate effect for Ben, and a strong effect for Tim. Finally, the Tau U showed moderate effects for Tim and Ben and a small change for Peter. However, these results were not statistically significant.

Table 3. *Non-Overlaps for Words Read Correctly Comparing A to B and B to BC Phases*

	NAP (A-B)	*p*	NAP (B-BC)	*p*	PEM (A-B)	PEM (B-BC)	Tau-U (A-B)	*p*	Tau-U (B-BC)	*p*
Peter	100.00	<.01	70.00	.19	100.00	50.00	0.67	<.01	0.17	.73
Tim	100.00	<.01	75.00	.09	100.00	100.00	0.73	<.01	0.25	.25
Ben	100.00	<.01	85.00	<.05	100.00	75.00	0.73	<.01	.29	.24

Note. NAP = Non-overlap of all pairs; PEM = Percentage exceeding the median.

Spelling

The descriptive data in Table 4 for the number of correctly spelled words show that, overall, compared to reading, Phase A started with lower values. The increase from Phase A to Phase B was strongest for Ben (153.40%), followed by Tim (28.14%) and Peter (11.54%). A more significant increase was seen from Phase B to Phase BC, based on the mean values for Peter and Tim. At the end of the intervention, the maximum values for Peter, Ben, and Tim were 19.00, 18.00, and 17.00, respectively.

Table 4. *Descriptive Data for Words Spelled Correctly*

	N(A)	N(B)	N(BC)	*M*(A)*SD*	*M*(B)*SD*	*M*(BC)*SD*	Max A	Max B	Max BC	MBD A-B	MBD B-BC
Peter	5	5	4	10.40	11.60	16.25	12.00	13.00	19.00	11.54%	40.08%
Tim	6	4	4	9.17	11.75	12.67	12.00	14.00	17.00	28.14%	7.83%
Ben	4	6	4	5.00	12.67	16.76	6.00	15.00	18.00	153.40%	32.28%

Note. N = Measurements; A = Phase A; B = Phase B; BC = Phase BC; *M* = Mean; *SD* = Standard deviation; Max = Maximum value; MBD = Mean baseline difference.

In Table 5, the overlap measures for spelling show weaker effects overall than for reading. Regarding the comparison between Phase A and Phase B, the NAP indicated medium effects for Peter (74.00, p =.12) and Tim (88.00, p <.05) and strong effects for Ben (100.00, p <.01). The PEM showed no effects for Peter and strong effects for the other two students (100.00). The Tau U result showed a small change for Peter and a moderate effect for Tim and Ben. However, all values were not statistically significant. Comparison between Phase B and Phase BC showed moderate effects for Peter and Tim and strong effects for Ben, although the value for Tim was not significant. The PEM showed moderate effects for Tim and a highly effective treatment for the other two. Finally, the Tau U showed a moderate effect for Tim (p =.18) and a large change for Peter (p <.05) and Ben (p <. 001).

Table 5. *Non-Overlaps for Words Spelled Correctly Comparing A to B and B to BC Phases*

	NAP (A-B)	*p*	NAP (B-BC)	*p*	PEM (A-B)	PEM (B-BC)	Tau-U (A-B)	*p*	Tau-U (B-BC)	*p*
Peter	74.00	.12	95.00	.01	60.00	100.00	0.17	.46	0.64	<.05
Tim	88.00	<.05	78.00	.10	100.00	75.00	0.38	.12	0.36	.18
Ben	100.00	<.01	100.00	.01	100.00	100.00	0.22	.37	0.80	<.001

Note. NAP = Non-overlap of all pairs; PEM = Percentage exceeding the median.

Discussion

Main Findings

The ever-increasing number of children with reading and spelling difficulties poses immense challenges for schools and teachers, compounded by the heterogeneity of the student body and an increase in behavior problems. The intention of this single-case study was to evaluate the benefits of reading racetracks on the sight-word reading performance of three low-performing elementary school children with EBD and to test the effects of an additional self-graphing technique. Furthermore, we investigated whether the participants were able to remember and apply information about the spelling of the words during the reading intervention without explicit spelling instruction. Self-graphing was evaluated as a moderator for spelling.

With regard to sight-word reading, the racetracks had a clear positive influence on all three students with

remarkable effects. That is, the students improved immediately after the onset of the intervention. Some words were already stored in students' mental lexicon during the baseline condition, but the values stabilized toward the end of the baseline. Due to strong increases in Phase B, the effects in Phase BC, where self-graphing was added to the intervention, were small, as expected. With the exception of Ben, a further small increase can be seen in Phase BC. The data indicate that it is sufficient to practice the training words using the racetracks, without additional motivational reinforcements. Tim showed the smallest increase from Phase A to Phase B, as well as from Phase B to Phase BC. Ben demonstrated by far the strongest percentage increase from Phase B to Phase BC. A large change was noted for all subjects from Phase A to Phase B and moderate to slight effects from Phase B to Phase BC, but the latter were not significant.

Regarding spelling, it can be concluded that reading the printed words aloud was not sufficient for participants to learn to spell them correctly. All students started with only a few correctly spelled words during Phase A. Ben demonstrated a strong level effect from Phase A to Phase B, but it continued as a negative trend and only increased again at the end. Similarly, Tim showed a positive increase at the close of Phase B. Finally, Peter's measurements were difficult to interpret, due to the variability in the data. When using self-graphing in the BC phase, Ben and Peter showed a level effect, with a clear increase toward the end of training for Peter and an increase at the beginning and a decrease toward the end for Ben. Tim did not seem to react immediately to the self-graphing but showed a clear positive increase in the number of correctly spelled words afterwards. Overall, the effects on the spelling of words were weaker than those for reading. The increases from Phase A to Phase B were mostly small. Nevertheless, the effects from the B to the BC phase were significantly stronger, with Peter and Ben showing especially remarkable improvement. The most distinct increase was achieved by Ben, the smallest by Tim.

In short, we were able to demonstrate that students can enhance their spelling over the course of a reading intervention with an added self-graphing procedure, even without explicit spelling instruction. These results align with the findings of Reitsma (1983) and Share (1999, 2004), showing that reading printed words aloud not only improves students' reading of those words but that, additionally, information about the spelling of those words is stored in memory. During self-graphing, our participants tracked both their reading and their spelling. This procedure seemed to boost the outcome over using only the reading racetrack game. Slight increases in spelling when self-graphing are consistent with findings by Sideridis (2005), showing that when students understand the purpose of a task, they are more motivated.

With regard to the influence of reading interventions on the spelling outcome of the same words, the results of our study are partly in line with those of Frith (1980), who found that an improvement in the reading of words and consequent storing of more complex word patterns result in better spelling. Further, a meta-analysis by Swanson et al. (2003) estimated the average correlation between reading words and spelling to be.70. Similarly, Ahmed et al. (2014), as well as Georgiou et al. (2019), noted that for learners in grades one to four, the ability to read words makes it easier to spell them correctly. Nevertheless, learning to spell is more dependent on specific instruction than on incidental learning, and spelling occurs through production rather than word recognition (Perfetti, 1997). Finally, Bosse et al. (2014) showed that greater orthographic learning took place when words were written down, as opposed to when they were performed orally. These results might also be reflected in our study. That is, spelling production did not take place, but perhaps the students would have been better at spelling if they had practiced writing these words in addition to reading them.

Even though the students in our study were able to store additional information about the spelling of the words that they read during the reading intervention, the results do not suggest that inherent spelling instruction or no spelling instruction is sufficient to support students in their spelling skills, especially for struggling spellers. Thus, the outcome of our study further supports the argument that explicit spelling instruction is recommended to support struggling writers in their spelling (Graham & Santangelo, 2014;

Wanzek et al., 2006). Finally, the use of a self-monitoring strategy like self-graphing resulted in a positive effect on student outcomes for spelling, which supports previous findings that literacy interventions should include motivational components.

Limitations

Despite considerable strengths, this study was also subject to certain limitations. For example, the use of a single-case design limits the generalizability of the findings. Nevertheless, such a design holds great value when looking at individual students. That is, single-subject designs offer insight into individual learning trajectories and consequently allow for fast adjustments of support based on the findings. In addition, the results yield information about the length of time it takes for students to respond to the intervention. This, in turn, enables practitioners to determine whether the dosage, the extent to which the learners are confronted with a learning object, is sufficient, or whether support is needed for an extended period of time.

Research has shown that the dosage plays an important role in the context of interventions (Kamil et al., 2008; Vaughn et al., 2010). The two phases of each session during the intervention in the current study were very short (10 minutes per phase), resulting in a 20-minute session plus additional time for data collection. Due to school regulations during the COVID-19 pandemic, it was not possible to extend the sessions. Kratochwill et al. (2013) noted that at least three measurement time points per phase are sufficient to be able to analyze and interpret the data. With regard to the measurements, we cannot exclude the possibility that reading and writing influenced each other and that the multiple measurements might have had some training effect. To counter this argument, however, the training words were presented in random order each time. Finally, the word material contained only 30 words. To evaluate the effect that the self-graphing procedure had on students' reading and spelling without ceiling effects, more words could be included in future experiments.

Implications and Future Directions

According to the meta-analysis by Williams et al. (2017) of the influence of spelling and reading intervention on spelling outcomes in students with learning disabilities (LD), there are still gaps in the research about the effects of both interventions on spelling performance and whether there is a transfer effect on untrained material. Thus, more research is needed in this area. To improve spelling, explicit spelling instruction and practice are needed (Devonshire & Fluck, 2010; Graham & Santangelo, 2014; Wanzek et al., 2006). Specifically, Wanzek et al. (2006) found that reading interventions consisting of phonics training (see also Williams et al., 2017) and direct feedback on misspelled words resulted in improved spelling outcomes for students with LD. Thus, future studies could combine phonics training with direct feedback on spelling to improve spelling outcomes.

To support the findings of the current study, it would be interesting to replicate the intervention with a larger group of students who have more diverse characteristics (age, type of school, rural and urban settings). Additionally, reading racetracks could be compared with another reading intervention to find out which is more effective, and groups trained with the reading racetracks could be compared to groups that also practice self-graphing. With regard to spelling, it would be interesting to contrast a reading intervention with explicit spelling instruction against one with implicit or no training in spelling. All of this could be implemented using an experimental group design. Finally, it would be interesting to include second-language learners in future studies, given the growing number of such students worldwide.

Conclusion

The purpose of this study was to evaluate the effects of a reading racetrack intervention and an additional self-graphing procedure on the sight-word reading of struggling readers and how both methods affect the

ability to spell correctly without explicit spelling instruction. Results show strong effects on sight-word reading as a result of the reading racetracks intervention, whereas self-graphing had no additional effects. This indicates that the reading racetracks, due to their motivational, game-like character, might not need additional motivational support. For spelling, the reading racetracks intervention alone did not provide sufficient support to result in improved performance. However, the self-graphing component did lead to improved spelling, indicating that with regard to spelling, motivation and paying attention are beneficial. In sum, however, neither the racetracks nor the self-graphing procedure, nor both methods applied simultaneously seem to be sufficiently effective to teach spelling.

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