Word Recognition Skills Moderate the Effectiveness of Reading Strategy Training in Grade 2

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Bettina Müller[a] and Tobias Richter[a]

[a]University of Kassel
Department of Psychology
Holländische Str. 36-38
34127 Kassel, Germany
E-mails:
bettina.mueller@uni-kassel.de
tobias.richter@uni-kassel.de

Ana Križan[b], Teresa Hecht[b], and Marco Ennemoser[b]

[b]Justus Liebig University of Giessen
Department of Psychology
Otto-Behagel-Str. 10F
35394 Giessen, Germany
E-mails:
ana.krizan@psychol.uni-giessen.de
teresa.hecht@psychol.uni-giessen.de
marco.ennemoser@psychol.uni-giessen.de

Corresponding author: Bettina Müller
University of Kassel, Department of Psychology
Holländische Str. 36-38
34127 Kassel, Germany
E-mail: bettina.mueller@uni-kassel.de
Phone: +49-561 804 3804

Highlights

- aptitude-treatment interaction approach with poor and good readers
- efficiency of word recognition as moderator for treatment effects
- poor readers with well-routinized word recognition benefitted
- strategy training was harmful for poor readers with inefficient word recognition
- good readers benefitted independently of their word recognition skills

Abstract

From a cognitive perspective, efficient word recognition processes are essential for the development of reading comprehension skills in primary school. In contrast, reading interventions are commonly evaluated for struggling readers as a group without assessing the influence of the students' word recognition efficiency. In this study, we followed an aptitude-treatment interaction approach to investigate the extent that the effectiveness of a reading strategy training for second graders with poor ($n$ = 119) and good reading comprehension ($n$ = 116) depends on the students' word reading skills. Compared with children randomly assigned to a control group, only poor readers with routinized word recognition benefited from the intervention, whereas the training was even harmful for poor readers with inefficient word recognition processes. Good comprehenders benefited from the training independently of their word reading efficiency. Hence, reading strategy interventions for poor readers should be implemented in consideration of the students' word recognition skills.

*Keywords:* word recognition, reading strategy intervention, aptitude-treatment interaction, reading comprehension, primary school

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## 1. Introduction

Teaching children to read is considered as one of the most important objectives of primary education. However, not all children reach a satisfactory level of reading comprehension that is sufficient to meet the demands of school and society. In each individual case, the causes of poor reading comprehension may vary, because reading comprehension is based on the interplay of cognitive processes at the (sub-)lexical, the sentence, and the text level. These processes include the abilities of decoding words accurately and fluently (Perfetti, 1985), linking single word meanings to form propositional units by semantic and syntactic integration processes (Kintsch & Rawson, 2010), and connecting and enriching the text's ideas with knowledge-based inferences (Graesser, Singer, & Trabasso, 1994) to produce a coherent mental model of the text content (Van Dijk & Kintsch, 1983). Poor reading comprehension is usually associated with deficits in one or several of these processes. The cognitive processes involved in recognizing written words and assigning meaning to these words seem to play a crucial role (Perfetti & Hart, 2002), particularly in primary school children. When readers' lexical representations are less in quality or when their word recognition processes are poorly routinized, the cognitive processes on the sentence and the text level can suffer as well because of bounded working memory resources.

One major type of intervention to foster poor readers' comprehension skills in primary school is the use of reading strategy trainings (cf. meta-analysis of the National Reading Panel, NICHD, 2000). Reading strategy trainings convey knowledge about different cognitive and metacognitive strategies to foster text comprehension processes and enhance students' self-regulated handling of texts. Research indicates that strategy trainings are most effective in the upper primary grades, whereas the results for students in the lower grades are mixed. Several studies have demonstrated that reading strategy can improve the reading comprehension of poor and good readers as early as Grade 2 (e.g., Fuchs & Fuchs, 2007; Slavin, Lake, Chambers, Cheung, & Davis, 2009), especially in peer-learning settings. Other studies have found no learning gains in Grade 2, either for all students (e.g., Van Keer & Verhaeghe, 2005) or for subgroups of students (e.g., Mathes, Howard, Allen, & Fuchs, 1998).

One plausible untested explanation for the inconsistent results is that reading strategy trainings are usually evaluated with regard to their overall effectiveness instead of examining interactions with reader characteristics that might moderate their effects. Efficient word recognition skills are often discussed as prerequisites for effective reading strategy trainings (Rosenshine & Meister, 1994). Against this background, the present research followed an aptitude-treatment interaction approach to investigate the extent that the effectiveness of a reading strategy training in Grade 2 depends on the accuracy and efficiency of students' word recognition processes. In what follows, we will back on the assumption that word reading skills moderate the effects of a reading strategy training on reading comprehension. We begin with a discussion of word recognition processes as potential sources of individual differences in reading comprehension followed by an explanation of reading strategy trainings as a means to remediate deficits in reading skills.

## 1.1 Individual Differences in Word Recognition Skills

Students learning to read in an alphabetic reading system move from a phase of acquiring phonological recoding skills, which enable them to translate written words into their phonological representation, to a phase when direct access to orthographical representations is routinized (Frith, 1986). As a result, frequent words can be recognized directly and efficiently by accessing their orthographic representations without the need to recode them into a phonological representation first (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Ehri, 2005). In the transparent German orthography, both phonological recoding and orthographic decoding skills develop continuously from Grade 1 through 4 with the steepest increase in Grades 1 and 2 (Richter, Isberner, Naumann, & Kutzner, 2012). High-quality and well-accessible orthographic representations allow rapid and reliable access to word meanings, which is a necessary prerequisite of reading comprehension at the sentence and text level (Perfetti, 2011; Richter, Isberner, Naumann, & Neeb, 2013).

Broad evidence exists indicating that deficits in each of the component processes of visual word recognition are linked to reading difficulties at other levels (Vellutino, Fletcher, Snowling, & Scanlon, 2004). In a cross-sectional study by Barker, Torgesen, and Wagner (1992) the increment of orthographic decoding on reading accuracy (i.e., the ability to read aloud an unknown text quickly and correctly) was found in about 20% of average skilled readers in Grade 3 after controlling for age, intelligence, and phonological recoding. In a sample of German-speaking primary students (Grade1 through 4), Richter et al. (2013) found that the estimate of the direct effect of orthographic decoding skills on text comprehension doubled the effect of phonological recoding skills, indicating that the lexical route quickly becomes the most relevant route for visual word recognition during reading development, at least in a transparent orthography such as German. Furthermore, the effects of phonological recoding and orthographical decoding skills on comprehension were partially mediated by the quality of meaning representations and the speed of access to these representations. Similar results occurred in Grade 3 and 4 with children learning to read in Greek (Protopapas, Sideridis, Simos, & Mouzaki, 2007), which also has a transparent orthography (see Seymour, Aro, & Erskine, 2003).

A general theoretical perspective emphasizing the crucial role of word-level skills for good reading comprehension is the *lexical quality hypothesis* (Perfetti & Hart, 2001, 2002), which claims that high-quality and well-accessible lexical representations of words are the core of successful reading comprehension. The quality of a lexical representation depends on the reliability and relatedness of its constituents that specify phonology, orthography, and meaning of a word. Given that words with different meanings can have similar phonological representations (homophones, e.g., *seed* vs. *cede*) or multiple meanings can be associated with one word, representations high in quality need to be flexible to activate the meaning fitting the context. High-quality representations enable readers to recognize words and access word meanings accurately and efficiently without much cognitive effort. As a result, more cognitive resources are available for higher-order integration and inference processes at the sentence and text level (LaBerge & Samuels, 1974; Perfetti, 1985). Thus, the accuracy and fluency of word recognition are necessary prerequisites of reading with comprehension. In Richter et al. (2013), 57% of the variance in a text-based reading comprehension test was explained by efficient phonological recoding, orthographical decoding, and access to word meanings. Furthermore, many studies have demonstrated the crucial role of word recognition in reading development. For example, a current review of 28 studies on reading development from Grade 1-9 (Pfost, Hattie, Dörfler, & Artelt, 2013) showed that primary school students with poor word recognition skills in the lower grades exhibited only marginal gains in reading skills until the end of primary school compared to students with efficient word recognition whose reading development followed a steeper gradient.

### 1.2 Reading Strategy Trainings to Foster Reading Comprehension in Primary School

A multitude of interventions have been suggested for fostering general reading skills in primary school. One well-established family of interventions are reading strategy trainings (NICHD, 2000). The basic idea of strategy trainings is to improve reading comprehension directly by fostering the self-regulated meaning making from texts. Ample evidence has well established that reading comprehension performance is associated with the ability to perform strategic activities such as summarizing (e.g., Dole, Duffy, Roehler, & Pearson, 1991), generating questions (e.g., McMaster et al., 2012; Yuill & Oakhill, 1998), activating prior knowledge (Cain & Oakhill, 1999), and detecting inconsistencies (comprehension monitoring, e.g., Cain, Oakhill, & Bryant, 2004). Thus, a systematic training of such cognitive and metacognitive strategies seems to be a promising method of helping children with poor reading comprehension.

According to a recent review of practical, nonremedial reading programs that are available to schools (Slavin et al., 2009), the reading comprehension of children in Grade 2-5 increased the most from structured programs teaching the strategies of summarizing, graphic organization, and predicting. In many of the successful reading interventions reviewed by Slavin et al. (2009), strategy instruction was combined with peer-learning techniques. These findings parallel the research by Doug and Lynn Fuchs and colleagues on peer-assisted learning strategy training (PALS, see Fuchs & Fuchs, 2007 for an overview). They showed repeatedly that reading comprehension of low and high performing students increased after a class-wide, peer-tutored instruction of the strategies of repeated reading, summarizing while reading, and prediction making compared to children in the regular reading instruction condition. The strategies of predicting and summarizing were also a part of the transactional strategy instruction examined in a study by Brown, Pressley, Van Meter, and Schuder (1996). These authors replaced the traditional reading curriculum of poor readers in Grade 2 with daily transactional strategy instruction, a complex strategy training that involves the strategies of visualizing, interpretation, and thinking aloud during reading. According to their results, the children in the treatment condition showed increased strategy use and higher comprehension scores compared to the children in the control group that received daily conventional reading instruction.

In sum, the results of extant studies support the assumption that reading strategy interventions can already have positive effects on the reading comprehension skills in Grade 2. Nevertheless, it must be noted that several studies suggest differential effects of strategies. For example, the NRP meta-analysis of 203 studies investigating reading comprehension interventions (NICHD, 2000; Chapter 4) concluded that above-average readers benefited more than below-average readers from strategy trainings. However, this finding is difficult to interpret, because it is based on studies with samples from a wide range of grade levels (Grades 3-8). Rosenshine and Meister (1994) reviewed studies on reciprocal teaching (Palincsar & Brown, 1984), a well-known dialogical instructional method that teaches the cognitive strategies of generating questions, summarizing, clarifying unknown words, and predicting. The authors concluded that the findings for Grade 3 are mixed and discuss word-level difficulties as obstacles of implementing reading strategies successfully. In fact, reciprocal teaching was originally developed as a remedial method tailored to children who exhibited poor reading comprehension despite good decoding skills (Palincsar & Brown, 1984). In studies on PALS, 10 to 20 percent of children failed to show a positive and significant increase in reading comprehension after receiving the treatment (Fuchs & Fuchs, 2005), with the highest proportion of nonresponders in the group of low-achieving children (Mathes, Howard, Allen, & Fuchs, 1998). Low-achieving children were operationally defined as students with a minimal oral reading fluency rate and low phonological recoding abilities. In sum, both theoretical and empirical arguments suggest that the individual effectiveness of reading strategy training depends on the efficiency of students' word recognition processes. The moderating role of word recognition skills should become apparent particularly in Grade 2 when individual differences still exhibit a large variance. The evidence notwithstanding, to the best of our knowledge aptitude-treatment interactions of strategy trainings with word-recognition skills have not yet been examined systematically.

**1.3 The Current Study**

The aim of the present study was to investigate the extent that the effects of a reading strategy training on the reading comprehension of children in Grade 2 depend on the accuracy and efficiency of word recognition skills children bring into the treatment. Because of the transparent German orthography, the phonological recoding skills of children learning to read in German develop quickly. As a result, most children in Grade 2 have already started to read fluently by accessing orthographic representations of an ever increasing number of words (Richter et al., 2012). However, poor readers in Grade 2 often exhibit large deficits in the quality of the underlying lexical representations and the cognitive effort needed to access these representations, which may lead to reading comprehension problems even at the text level (Perfetti & Hart, 2001, 2002). In view of the cited work, the present study was guided by two research questions:

(1) Does the treatment effect of a reading strategy training on reading comprehension interact with the efficiency of the reader's word reading processes in Grade 2?

(2) Does the pattern of the interaction effect vary between second graders with good and poor reading comprehension skills?

The outcomes of the reading strategy training were compared with those of a control group that received a training of visuospatial (non-verbal) working memory (Baddeley, 1986). Considering the relevance of word recognition skills for higher-order comprehension processes, we expected the effects of the strategy treatment to be moderated by the efficiency of word recognition processes in the group of poor readers. The reading strategy training focused specifically on higher-order comprehension processes. Thus, this type of training might overtax poor comprehenders with less high-quality word representations. Stated differently, we expected the strategy training to be ineffective for poor readers with inefficient word recognition processes, because learning strategies poses additional demands on the working memory capacity that is needed to carry out processes at the word level. In contrast, the strategy training should be beneficial for poor readers who bring well-routinized word recognition skills into the treatment.

Children with good reading comprehension skills should possess high-quality word representations leading to routinized word reading processes and available cognitive capacities to implement new reading strategies. Thus, we expected no interactions between the treatment and the good readers' word recognition skills. Instead, we expected a positive overall effect of the reading strategy training for the good readers, because this intervention should catch them at their current level of reading development by offering knowledge about strategic reading to foster comprehension.

# 2. Method

## 2.1 Design and Procedure

The study was based on an experimental pre-/post-test design with randomization at the class level. The data were collected as part of a longitudinal study investigating the effects of several kinds of reading interventions in primary school. Both, the reading strategy training and the control training were implemented in a peer-tutored learning setting, which was based on dyads consisting of one poor reader acting as tutee and one good reader acting as tutor.

Students were first screened with a standardized reading comprehension test (ELFE 1-6, Lenhard & Schneider, 2006). Five children from each participating class with the worst reading comprehension scores (below the class average) were chosen as tutees and the five children with the best reading comprehension scores (above the class average) were chosen as tutors. The best reader from the above-average readers was paired with the best student from the below-average readers, followed by the pairing of the second best readers from each group, and so forth, to achieve equal differences between tutees and tutors within the dyads. When the number of participating children from one class was not sufficient, we ranked the children of two classes together to make the assignments to the group of tutors or tutees. Children were tested afterwards with the German-speaking instrument ProDi-L (Richter, Isberner, Naumann, & Kutzner, 2012) to assess word recognition skills. The intellectual skills were assessed with the subtests of CFT 1 (Cattell, Weiß, & Osterland, 1997).

The groups of ten children (five poor and five good readers paired within five dyads) were randomly allocated to the treatment condition or the control group. Both treatments consisted of 25 sessions, each lasting 45 minutes. The training sessions occurred in addition to regular school curriculum twice a week. Afterwards, reading comprehension was assessed again with ELFE 1-6.

**2.2 Participants**

In total, 265 children from 29 primary school classes in Giessen and Kassel (Germany) originally took part in the study. The data from 30 children were excluded from the analysis because of missing ($n$ = 27) or extreme values ($n$ = 3) defined as values three standard deviations below or above the scale’s mean. The final sample consisted of 235 children (125 strategy training and 110 controls) with 119 poor readers (66 female) and 116 good readers (56 female). The treatment groups were composed of children from different classes. Hence, the number of cases per class varied between 1 and 5. Demographic characteristics (see Table 1) and average test scores were nearly identical in the original and final samples. Furthermore, no significant differences between treatment groups were found in mean intelligence scores (Table 1) within the subsamples of poor readers ($F$ (1, 114) = 1.61, *ns*) and good readers ($F$ (1, 109) = 0.08, *ns*).

**- TABLE 1 ABOUT HERE -**

**2.3 Measured Variables**

**2.3.1 Reading Comprehension**.

Reading comprehension skills were assessed with the subtest text comprehension of ELFE 1-6 (Lenhard & Schneider, 2006). The test, which is widely used in German-speaking countries, consists of 20 short, mostly narrative texts with four multiple-choice items each. The items assess the ability to identify information in the text, generate anaphoric references across sentences, and form local and global inferences. The test score is based on the sum of correct responses. The texts were presented in randomized order. The test-retest reliability over a 6-month period was 0.59 (computed as the correlation of the pre- and post-measures in the control group).

**2.3.2 Word Recognition.**

Word recognition skills were assessed with a lexical decision task, a subtest of the German-speaking computer-based instrument ProDi-L (Richter et al., 2012). The children's task was to decide whether a string of letters was a real word or a pseudoword. The real-word task can be accomplished best by comparing the sequence of graphemes and the orthographic representation in the mental lexicon. The task can also be accomplished via the indirect phonological route of word recognition, but using that method is likely to increase response times. The 18 items, half of which were real words and the other half (orthographically and phonologically legal) pseudowords, varied systematically in frequency and number of orthographical neighbors. The pseudowords varied in their similarity to actual German words. The test scores the reliability as accuracy and the efficiency of word recognition in response times. The accuracy score was computed as the mean number of correct responses (Cronbach's $\alpha = .44$). The response time score was computed as the mean response time of the logarithmically transformed response times of all items (Cronbach's $\alpha = .92$).

**2.4 Treatment Conditions**

The 25 sessions of the reading strategy training and the control treatment were conducted by university students who provided standardized spoken instructions. The trainings' materials and manuals were designed by the authors and pilot-tested in a preliminary study.

**2.4.1 Reading Strategy Training.**

The reading strategy training conveyed knowledge about three strategies to foster reading comprehension at the text level. The first strategy, *thinking about the headline*, was used to activate prior knowledge about vocabulary and the previous events taking place in the book. Children are asked to predict events later in the chapter as a means to enhance comprehension by connecting the activated prior knowledge and the incoming information of the text in the situation model (Cain & Oakhill, 1999). Afterwards, children *read phrase-by-phrase and rehearse the content of each sentence* to keep the decoded information of each sentence available for further processing. A phrase structure was inserted using spaces between subsequent phrases. After each paragraph, the tutees were required to *summarize whom and what the paragraph was about* to encourage the construction of a globally coherent representation of the text (cf. the constructionist model, Graesser et al., 1994). This representation could then be used for making predictions about the contents of the subsequent chapter and facilitating the application of the first strategy.

The strategies were introduced one-by-one in the first three sessions and were then used and practiced in the teams while reading two books. The task of the good readers was to act as tutors for their less well-performing team partners. Thus, the tutors supported their tutees in using the three strategies by asking questions. For the final paragraph of each chapter, students switched roles so that the poor readers were required to support their good reading team partners in using the strategies. Difficult words were explained at the beginning of each session to eliminate vocabulary problems. Similar to previous implementations of strategy trainings (e.g., Gold, Mokhlesgerami, Rühl, Schreblowski, & Souvignier 2004; Paris, Cross, & Lipson, 1984), the training was embedded in a detective story.

### 2.4.2 Control Training.

Children in the control condition received a training of visuospatial working memory. Labyrinths and abstract forms were used to teach four strategies to memorize and recall spatial arrangements. All instructions were given orally by the student assistants. We expected no beneficial effect of this training on participants' reading skills, because the visuospatial working memory is not essential for reading comprehension (with the exception of comprehending spatial descriptions, Baddeley, 1986).

## 3. Results

Descriptive statistics and intercorrelations for all measured variables are provided in Table 2.

**- TABLE 2 ABOUT HERE –**

Considering the way the teams of tutors and tutees were composed, we first estimated the correlation between the pre-test reading comprehension scores of the poor and the good readers to account for potential nonindependence within the dyads (cf. Cook & Kenny, 2005). It seems plausible to assume that peer-tutored learning produces nonindependent data in the way that the learning outcome of tutees might be affected by the respective abilities of their tutors. However, the product-moment correlation was not significant in our sample ($r$ = .12, *ns*), indicating independence of observations and no need to treat the poor and good readers as nested within the dyads.

Given that the good and the poor readers were identified based on a rank-ordering of the pretest scores per class (or from two classes if the number of participating children from one class was not sufficient), it seems possible that clustering effects are present in the data. We examined this possibility by determining the intra-class correlation coefficient (ICC) based on an unconditional multi-level model (students nested within classes) and the ELFE post-test scores as dependent variable (Raudenbush & Bryk, 2002; Richter, 2006). The ICC was low ($\rho \leq .05$), indicating that clustering effects did not play a major role in our data. Hence, we preceded with regular moderated regression analyses (Aiken & West, 1991, Chapter 7) to test the hypothesized aptitude-treatment interactions.

Two separate moderated regression models were estimated: one for the poor and one for the good readers with post-test reading comprehension as dependent variable and the dummy-coded treatment condition (with the control condition as reference category) as predictor. The moderating variables (mean accuracy and mean response time of word recognition) were *z*-standardized within the subsamples of poor and good readers and included as predictors in the models. In addition, the interaction terms of treatment condition and the moderating variables were included as predictors. Finally, the ELFE pre-test scores of the poor and the good readers (*z*-standardized within the two subsamples) were used as predictors to control for pre-training differences in reading comprehension and potential influences of the team partners' reading skills. All predictors were entered simultaneously into the models.

Significance tests were conducted based on a Type I error probability of .05. Regression diagnostics by graphical displays of residuals revealed no evidence that the assumptions concerning normality, linearity, and homoscedasticity of the residuals were violated in any of the models. Furthermore, neither multicollinearity of the predictors nor extreme cases with high global influence (poor readers: $0.00 \leq \textit{Cook's D} \geq 0.08$, good readers: $0.00 \leq \textit{Cook's D} \geq 0.06$) occurred in the data (Cohen, Cohen, West, & Aiken, 2003, Chapter 10).

Post-hoc probing of the interaction was computed by estimating simple slopes and conditional treatment effects for high and low values of the moderating variables (Aiken &

West, 1991, Chapter 7). Differences between the training groups were tested at conditional values one standard deviation above and below the mean of the moderator variable (cf. Cohen et al., 2003, Chapter 9).

To analyze whether the 30 excluded data files (11.23% of all data points) lead to a systematic bias in the results we performed a multiple imputation and compared the results with those of the regression analysis with listwise deletion. The missing values were assumed to be missing at random (Rubin, 1976). Twenty-two children had missing values because of technical problems, illness, or because they were initially not selected to participate in the study but then attended one of the treatments instead of another child (those replacements occurred within the first five sessions). Three values were classified as outliers, three poor readers had no team partner, and two children changed the school before the post-test. The variables included in the imputation models were the accuracy and the response time of word recognition and the ELFE pre-test and post-test scores. Five datasets were estimated with the automatic imputation method. All parameter estimates differed only at the decimal places from the results of the data set with listwise deletion, without any changes in significance. This comparison indicated that a systematic bias was not introduced into the results from the missing values. For this reason, we report the results of the regression analysis with listwise deletion.

### 3.1 Effects for the Poor Readers

The small correlation estimate of the poor readers' pre and post-test comprehension scores ($r$ = -.12, *ns*) indicates that the poor readers responded very differently to the reading strategy training: Some readers in the training group improved more strongly than others, which altered the rank order within the group of poor readers from the pre- to the post-test. The parameter estimates for the poor readers suggest the same conclusion: There was no average treatment effect for the reading strategy training compared to the control group (see

Table 3 for the estimates). However, there were significant aptitude-treatment interaction effects for the strategy training with the efficiency and accuracy of word recognition as moderating variable. As expected, the strategy training led to an increase in reading comprehension only in poor readers with (relatively) fast and accurate word recognition processes. Post-hoc simple slope analysis (Figure 1a) revealed that the negative slope of the efficiency of word recognition was steeper in the reading strategy group ($B$ = -1.3 $SE$ = 0.34, $p$ < .001, $\Delta R^2$ = .07, one-tailed) than the nonsignificant slope in the control group ($B$ = -0.16, $SE$ = 0.24, *ns*). The analysis of conditional effects showed that children with inefficient word recognition processes in the strategy training achieved worse post-test reading comprehension scores than the children with inefficient word recognition processes in the control group (estimated group difference at 1 *SD* above the mean: $B$ = -0.94, $SE$ = 0.56, $p$ < .05, $\Delta R^2$ = .02, one-tailed). In contrast, children with relatively efficient word recognition processes benefited from the strategy training ($B$ = 1.01, $SE$ = 0.56, $p$ < .05, $\Delta R^2$ = .03, one-tailed).

In addition, we found a significant interaction effect for the strategy training with the accuracy of word recognition (Figure 1b). The simple slope of accuracy was positive in the strategy training ($B$ = 0.54, $SE$ = 0.26, $p$ < .05, $\Delta R^2$ = .04, one-tailed). The differences compared to the control group, however, were not significant at the point of one standard deviation below ($B$ = -0.71, $SE$ = 0.54, *ns*) or above the mean ($B$ = 0.79, $SE$ = 0.55, *ns*). Hence, we conducted additional post-hoc probing of the interaction and estimated group differences at two standard deviations below and above the average accuracy of word recognition. At these points significant differences are indicated (2 *SD* below the mean: $B$ = -1.47, $SE$ = 0.86, $p$ < .05, $\Delta R^2$ = .02, one-tailed; 2 *SD* above the mean: $B$ = 1.54, $SE$ = 0.88, $p$ < .05, $\Delta R^2$ = .02, one-tailed).

In sum, no average treatment effect for the poor readers occurred, but the interaction with the efficiency of children’s word recognition processes suggests that routinized word recognition processes are a necessary prerequisite to benefit from the strategy training. For children with inefficient word recognition processes, by contrast, the training was even harmful relative to the control training.

**- FIGURE 1 ABOUT HERE -**

### 3.2 Results for the Good Readers

In the group of good readers, a positive and significant average treatment effect emerged for the strategy training compared to the control group (Table 3). Thus, skilled comprehenders in Grade 2 benefited from a training of reading strategies to further improve their reading comprehension. The average effects of efficiency and accuracy of word recognition measured before the training on the post-training reading comprehension were also positive and significant, even though pre-training reading comprehension was controlled. This incremental effect underscores the important role of word recognition processes for the development of reading comprehension at the text level. Consistent with our expectations, no aptitude-treatment-interaction occurred (see Figures 2a and 2b for the simple slopes). Thus, the effect of the reading strategy training did not depend on the efficiency of the good readers’ word recognition processes.

**- TABLE 3 AND FIGURE 2 ABOUT HERE -**

## 4. Discussion

The purpose of the present study was to investigate the assumption that individual differences in the efficiency of word recognition processes moderates the effects of a reading strategy intervention for poor readers in Grade 2. In line with our expectations, the results show that children responded to the intervention in different ways depending on their word recognition skills. Poor comprehenders with inefficient word recognition processes performed worse after receiving a reading strategy training compared to their same-skilled counterparts in the control condition. In contrast, poor comprehenders with efficient word recognition processes tended to benefit from this type of training. In the group of children with good comprehension skills, we observed no interactions of word recognition processes with the reading interventions. Instead, the strategy training exerted an overall positive effect on the good readers' reading comprehension. The accuracy and the efficiency of the good readers' word recognition skills were considerably higher than the poor readers' values (Table 2), suggesting that the good readers already possessed skilled word recognition processes that allowed them to spend cognitive resources on implementing the strategies rather than recognizing words. Consistent with previous research, the good comprehenders were able to improve their reading comprehension after attending a treatment of predicting, repeated reading, and summarizing compared to same-skilled students in the control condition.

These results underscore the relevance of word recognition processes for reading comprehension at the text level and for interventions that aim at fostering reading comprehension. In particular, the aptitude-treatment interaction effects between the strategy training and the efficiency of the poor readers' word recognition can be interpreted in light of Perfetti's bottleneck hypothesis (1985). Efficient processes at the word level are required to make cognitive resources available for implementing the cognitive reading strategies taught in the training. Readers whose word recognition processes are slow and effortful must dedicate a large proportion of working memory capacity to these processes. As a consequence, the reading strategies taught in the training are likely to cause interference with other reading processes, rendering the training ineffective or even harmful (see Naumann, Richter, Christmann, & Groeben, 2008 for similar ATI-effects with adult readers and a short strategy intervention). Thus, a possible explanation for the negative treatment effect for students with below-average word recognition skills is that the training failed to offer the kind of knowledge and practice that fit with these children's demands. Word recognition skills in the upper quartile seems to be a prerequisite for poor readers in Grade 2 to allocate cognitive resources to appropriately practice and implement the strategies taught in typical reading strategy trainings. Students lacking efficient word recognition processes should be given a training explicitly targeted at these processes (e.g., a reading fluency training, Kuhn & Stahl, 2003) rather than a reading strategy training.

In the subgroup of poor readers, the efficiency and the accuracy of word recognition each interacted with the reading strategy training. However, the effect was more pronounced for word recognition efficiency (measured with reaction times in a lexical decision task). The relatively low internal consistency of our word recognition accuracy scale could point to a cause of this differential result. However, this pattern of effects is also consistent with the so-called reading fluency impairment of poor readers that has been reported in studies with German-speaking children (e.g., Frith, Wimmer, & Landerl, 1998; Wimmer, Mayring, & Landerl, 1998). These studies showed that most poor readers in primary school read unfamiliar words and even pseudowords as accurately as their same-age peers with normal reading comprehension. However, they read more slowly with laborious decoding indicating that their reading fluency is impaired. Thus, in transparent orthographies the efficiency of word recognition skills seems to be a better indicator for difficulties in reading than the accuracy of these processes.

Note that our data do not rule out the possibility that the reported patterns of effects are specific to strategy trainings implemented with peer tutoring. As Connor, Morrison, and Petrella (2004) showed, third graders with below-average reading skills achieved less comprehension gains from peer-assisted reading instructions than from teacher-led instruction. Good readers, in contrast, benefited most from child-managed activities. In the same vein, a study by Van Keer and Verhaeghe (2005) revealed that second graders made significantly more progress in reading comprehension after attending a teacher-led strategy training than second graders receiving the same treatment embedded in peer tutoring. Thus, peer tutoring could have overtaxed poor readers in general, because of the lack of fit with their need for explicit instruction and modeling by a teacher.

Another crucial question we cannot answer from our data is the influence of the students' standard of coherence while reading (Van den Broek, Risden, Husebye-Hartmann, 1995). Measuring or even manipulating tutees' standards of coherence in future studies would advance this line of research, given that deep comprehension can only be achieved if readers also endorse this goal (Oakhill & Cain, 2007). In addition to this question, investigating students' strategic reading while reading outside the intervention setting would be a useful method for analyzing whether and which strategy is implemented in the daily reading routine.

## 5. Conclusion

The current results underscore that an intervention that has yielded promising effects is not likely to work for all children in the same way (e.g., Connor et al., 2004; McKeown, Beck, & Blake, 2009; McMaster et al., 2012). As suggested by cognitive theories of reading comprehension skills, struggling readers are a heterogeneous group. Deficits in all cognitive processes involved in reading comprehension – at the word, sentence, and text level – can cause reading comprehension difficulties. Thus, it is important to investigate whether different types of poor readers respond differently to reading interventions.

Our findings highlight once more the relevance of efficient word recognition skills for reading comprehension. The practical implications of the results indicate the importance of assessing students' word reading skills, in particular the efficiency of word recognition, before applying a reading strategy training in Grade 2.

References

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.

Baddeley, A. D. (1986). *Working memory*. Oxford: Oxford University Press.

Barker, T. A., Torgesen, J. K., & Wagner, R. K. (1992). The role of orthographic processing skills on five different reading tasks. *Reading Research Quarterly*, *27,* 334-345.

Brown, R., Pressley, M., Van Meter, P., & Schuder, T. (1996). A quasi-experimental validation of transactional strategies instruction with low-achieving second-grade readers. *Journal of Educational Psychology, 88,* 18-37.

Cain, K., Oakhill, J., & Bryant, P. (2004). Children’s reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology, 96*, 31-42.

Cain, K., & Oakhill, J. (1999). Inference ability and its relation to comprehension failure in young children. *Reading and Writing, 11*, 489-503.

Cattell, R. B., Weiß, R. H., & Osterland, J. (1997). *Grundintelligenztestskala 1 (CFT 1)* [German version of the culture fair intelligence scale]. Göttingen, Germany: Hogrefe.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/ correlation analysis for the behavioral sciences.* Mahwah, NJ: Erlbaum.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascade model of visual word recognition and reading aloud. *Psychological Review, 108*, 204-256.

Connor, C. McDonald, Morrison, F. J., & Petrella, J. N. (2004). Effective reading comprehension instruction: Examining child x instruction interaction. *Journal of Educational Psychology, 96*, 682-698.

Cook, W. L., & Kenny, D. A. (2005). The actor–partner interdependence model: A model of bidirectional effects in developmental studies. *International Journal of Behavioral Development, 29*, 101-109.

Dole, J. A., Duffy, G. D., Roehler, L. R., & Pearson, P. D. (1991). Moving from the old to the new: Research on reading comprehension instruction. *Review of Educational Research, 61*, 239-264.

Ehri, L. C. (2005). Learning to read words: Theory, findings, and issues. *Scientific Studies of Reading, 9,* 167-188.

Frith, U. (1986). A developmental framework for developmental dyslexia. *Annals of Dyslexia, 36*, 69-81.

Frith, U., Wimmer, H., & Landerl, K. (1998). Differences in phonological recoding in German- and English-speaking children. *Scientific Studies of Reading, 2,* 31-54.

Fuchs, D., & Fuchs, L. S. (2005). Peer-assisted learning strategies: Promoting word recognition, fluency, and reading comprehension in young children. *The Journal of Special Education, 39,* 34-44.

Fuchs, D., & Fuchs, L. S. (2007). Increasing strategic reading comprehension with peer assisted learning activities. In D. S. McNamara (Ed.), *Reading comprehension strategies. Theories, interventions, and technologies* (pp. 175-198). Mahwah, NJ: Erlbaum.

Gold, A., Mokhlesgerami, J., Rühl, K., Schreblowski, S., & Souvignier, E. (2004). *Wir werden Textdetektive (Lehrmaterial und Arbeitsheft)* [We will become text detectives, teaching material and workbook]. Göttingen, Germany: Vandenhoeck & Ruprecht.

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review, 101*, 371-395.

Kintsch, W., & Rawson, K. A. (2010). Comprehension. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 209-226). Oxford: Blackwell.

Kuhn, M. R., & Stahl, S. A. (2003). Fluency: A review of developmental and remedial practices. *Journal of Educational Psychology, 95*, 3-21.

LaBerge, D., & Samuels, S. J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology, 6*, 293–323.

Lenhard, W., & Schneider, W. (2006). *ELFE 1-6: Ein Leseverständnistest für Erst- bis Sechstklässler* [ELFE 1-6: A reading comprehension test for children in grades one to six]. Göttingen, Germany: Hogrefe.

Mathes, P. G., Howard, J. K., Allen, S. H., & Fuchs, D. (1998). Peer-assisted learning strategies for first-grade readers: Responding to the needs of diverse learners. *Reading Research Quarterly, 33*, 62-94.

McKeown, M. G., Beck, I. L., & Blake, R. G. K. (2009). Rethinking reading comprehension instruction: A comparison of instruction for strategies and content approaches. *Reading Research Quarterly, 44*, 218-253.

McMaster, K. L., Van den Broek, P., Espin, C. A., White, M. J., Kendeou, P., Rapp, D. N., Bohn-Gettler, K., & Carlson, S. (2012). Making the right connections: Differential effects of reading intervention for subgroups of comprehenders. *Learning and Individual Differences, 22*, 100-111.

National Institute of Child Health and Human Development. (2000). *Report of the National Reading Panel: Teaching children to read, an evidence-based assessment of the scientific research literature on reading and its implications for reading instruction, reports of the subgroups* (NIH Publication No. 00-4754). Washington, DC: U.S. Government Printing Office.

Naumann, J., Richter, T., Christmann, U., & Groeben, N. (2008). Working memory capacity and reading skill moderate the effectiveness of strategy training in learning from hypertext. *Learning and Individual Differences, 18,* 197-213.

Oakhill, J., & Cain, K. (2007). Issues of causality in children's reading comprehension. In D. S. McNamara (Eds.), *Reading comprehension strategies. Theories, interventions, and technologies* (pp. 47-72). New Jersey: Lawrence Erlbaum Associates.

Palinscar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction, 1*, 117-175.

Paris, S. G., Cross, D. R., & Lipson, M. Y. (1984). Informed strategies for learning: A program to improve children's reading awareness and comprehension. *Journal of Educational Psychology, 76,* 1239-1252.

Perfetti, C. A., & Hart, L. (2001). The lexical basis of comprehension skills. In D. S. Gorfien (Ed.), *On the consequence of meaning selection: Perspectives on resolving lexical ambiguity* (pp. 67-86). Washington, DC: American Psychological Association.

Perfetti, C. A., & Hart, L. (2002). The lexical quality hypothesis. In L. Verhoeven, C. Elbro, & P. Reitsma (Eds.), *Precursors of functional literacy* (pp. 189-213). Amsterdam: John Benjamins.

Perfetti, C.A. (1985). *Reading ability*. New York: Oxford University Press.

Perfetti, C. (2011). Phonology is critical in reading: But a phonological deficit is not the only source of low reading skills. In S. A. Brady, D. Braze, & C. A. Fowler (Eds.), *Explaining individual differences in reading: Theory and evidence* (pp. 153-171). New York: Psychology Press.

Pfost, M., Hattie, J., Dörfler, T., & Artelt, C. (2013). Individual differences in reading development: A review of 25 years of empirical research on Matthew effects in reading. *Review of Educational Research.* Advance Online Publication doi: 10.3102/0034654313509492

Protopapas, G. D., Sideridis, P. G., Simos, G., & Mouzaki, A. (2007). The development of lexical mediation in the relationship between text comprehension and word reading skills in Greek. *Scientific Studies of Reading, 11,* 165-197.

Raudenbush, S.W., & Bryk, A.S. (2002). *Hierarchical Linear Models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage.

Richter, T. (2006). What is wrong with ANOVA and Multiple Regression? Analyzing sentence reading times with Hierarchical Linear Models. *Discourse Processes, 41*, 221-250.

Richter, T., Isberner, M.-B., Naumann, J., & Kutzner, Y. (2012). Prozessbezogene Diagnostik von Lesefähigkeit bei Grundschulkindern [Process-oriented assessment of reading skills in primary school children]. *Zeitschrift für Pädagogische Psychologie, 26,* 313-331.

Richter, T., Isberner, M.-B., Naumann, J., & Neeb, Y (2013). Lexical quality and reading comprehension in primary school children. *Scientific Studies of Reading, 17,* 415-434.

Rosenshine, B., & Meister, C. (1994). Reciprocal teaching: A review of the research. *Review of Educational Research, 64,* 479-530.

Rubin, D. B. (1976). Inference and missing data. *Biometrika, 63,* 581-592.

Seymour, P. H. K., Aro, M., & Erskine, J. M . (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94,* 143-174.

Slavin, R. E., Lake, C., Chambers, B., Cheung, A., & Davis, S. (2009). Effective reading programs for the elementary grades: A best-evidence synthesis. *Review of Educational Research, 79,* 1391-1466.

Van den Broek, P., Risden, K., & Husebye-Hartmann, E. (1995). The role of readers' standards of coherence in the generation of inferences during reading. In R. F. Lorch, Jr., & E. J. O'Brien (Eds.), *Sources of coherence in reading* (pp. 353-373). Hillsdale, NJ: Erlbaum.

Van Dijk, T. A., & Kintsch, W. (1983): *Strategies of discourse comprehension.* New York: Academic Press.

Van Keer, H., & Verhaeghe, J. P. (2005). Effects of explicit reading strategies instruction and peer tutoring on second and fifth graders' reading comprehension and self-efficacy perceptions. *The Journal of Experimental Education, 73*, 291-329.

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades?. *Journal of Child Psychology and Psychiatry, 45*, 2-40.

Wagner, R. K, & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101,* 192-212.

Wimmer, H., Mayring, H., & Landerl, K. (1998). Poor reading: A deficit in skill automatization or a phonological deficit?. *Scientific Studies of Reading, 2,* 321-340.

Yuill, N. M., & Oakhill, J. V. (1988). Effects of inference awareness training on poor reading comprehension. *Applied Cognitive Psychology, 2*, 33-45.

# Tables

Table 1

*Demographic Characteristics of Final Sample*

| | Poor Readers (*n* = 119) | | Good Readers (*n* = 116) | |
|---|---|---|---|---|
| | Strategy | Control | Strategy | Control |
| Participants | 63 | 56 | 62 | 54 |
| Proportion of Females (Absolute Numbers) | 36 | 30 | 23 | 33 |
| Proportion German Native Speakers | 32 | 38 | 28 | 45 |
| (Absolute Numbers) | | | | |
| children with missing first language information | 18 | 9 | 18 | 4 |
| Intelligence *M* (*SD*) | 49.87 | 51.85 | 54.49 | 53.90 |
| (standardized *T*-values) | (8.44) | (8.32) | (8.75) | (12.59) |

*Note.* Intelligence = subtests Classification, Similarities, and Matrices of CFT 1 (age norms). For 13 children age information was missing and replaced by the average test age to identify their *T*-value in CFT 1.

Table 2

*Means, Standard Deviations, and Intercorrelations for All Variables by Subsample (Poor vs. Good Readers) and Treatment Condition*

| | Poor Readers | | Good Readers | | Correlations (Poor Readers Below Main Diagonal, Good Readers Above Main Diagonal) | | | |
|---|---|---|---|---|---|---|---|---|
| | Strategy | Control | Strategy | Control | | | | |
| | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) | *M* (*SD*) | 1 | 2 | 3 | 4 |
| Reading Comprehension | | | | | | | | |
| 1 ELFE $t_1$ | 3.24 (1.85) | 3.36 (1.93) | 7.60 (2.84) | 7.13 (2.74) | | .67** | .37** | -.28** |
| 2 ELFE $t_2$ | 5.59 (2.05) | 5.57 (2.18) | 11.58 (4.54) | 9.74 (4.26) | -.12 | | .54** | -.23* |
| Word Recognition | | | | | | | | |
| 3 Accuracy $t_1$ | 0.74 (0.10) | 0.72 (0.10) | 0.81 (0.11) | 0.80 (0.10) | -.17 | .08 | | .06 |
| 4 Response Time $t_1$ | 8.29 (0.31) | 8.26 (0.50) | 7.60 (0.32) | 7.75 (0.34) | -.21* | -.17 | .25** | |

*Note.* ELFE = subtest text comprehension (sum of correct answers, min = 0, max = 20; Lenhard & Schneider, 2006). $t_1$ = pre-test, $t_2$ = post-test. Word recognition = 18 items lexical decision task (subtest of ProDi-L, Richter et al., 2012). Accuracy = mean of correct responses. Response Time = mean of logarithmically transformed response times across all items.

**p* < .05, ***p* < .01 (two-tailed).

Table 3

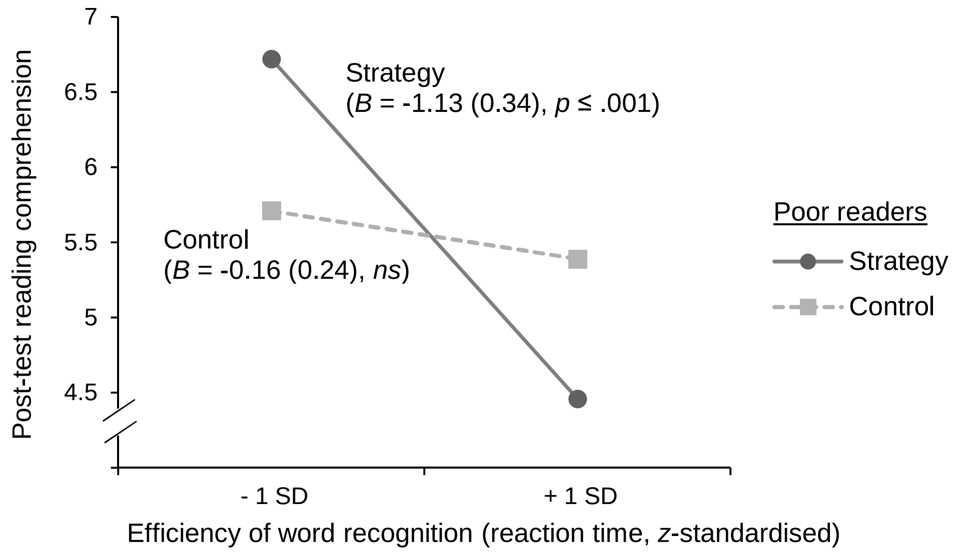
*Parameter Estimates for Moderated Regression Analyses with Post-Test Reading Comprehension as Outcome, Treatment Condition as Predictor, Word Recognition Accuracy and Response Time as Moderators, and Pre-Test Reading Comprehension of Poor and Good Readers as Covariates*

| | Poor Readers | | | Good Readers | | |
|---|---|---|---|---|---|---|
| Variable | Estimate | SE | $\Delta R^2$ | Estimate | SE | $\Delta R^2$ |
| Intercept | 5.55*** | 0.27 | | 10.15*** | 0.42 | |
| Strategy vs. Control (dummy coded: 1 vs. 0) | 0.04 | 0.38 | .000 | 1.19* | 0.58 | .022 |
| Reading Comprehension Poor Reader $t_1$ | -0.35* | 0.19 | .014 | -0.19 | 0.29 | .002 |
| Reading Comprehension Good Reader $t_1$ | -0.14 | 0.19 | .004 | 2.26*** | 0.33 | .448 |
| Word Recognition ACC | -0.21 | 0.29 | .003 | 1.20** | 0.46 | .095 |
| ACC x Strategy | 0.75* | 0.39 | .015 | 0.46 | 0.60 | .002 |
| Word Recognition RT | -0.16 | 0.24 | .048 | -0.77* | 0.45 | .005 |
| RT x Strategy | -0.97** | 0.41 | .044 | 0.62 | 0.61 | .003 |
| Goodness of fit | $R^2$ = .13, $F$ (7,111) = 2.35, $p$ < .05 | | | $R^2$ = .58, $F$ (7,108) = 21.15, $p$ < .000 | | |

*Note.* $t_1$ = pre-test. ACC = accuracy of word recognition. RT = response time of word recognition.

*$p$ < .05, **$p \leq$ .01, ***$p$ < .001 (one-tailed).

a)




b)

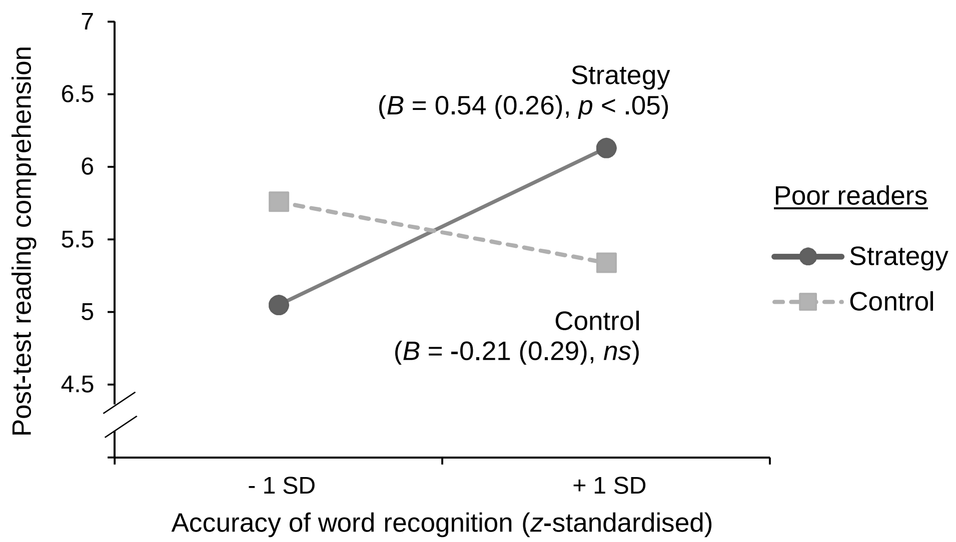
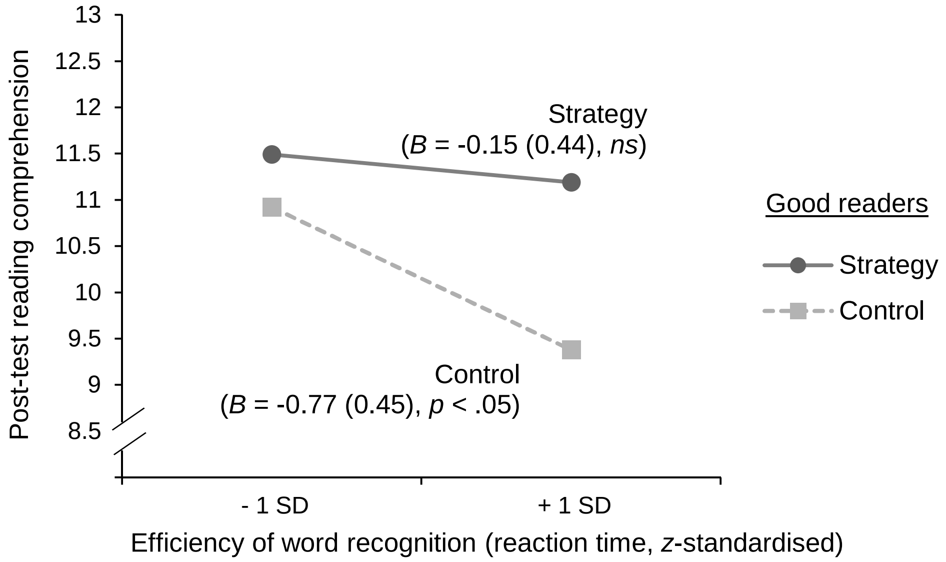



*Figure 1.* Estimates of the simple slopes per treatment condition for the poor readers.

a) The effect of efficiency of word recognition on post-test reading comprehension. Note that smaller efficiency values (i.e., faster reaction times) represent more efficient word recognition.

b) The effect of accuracy of word recognition on post-test reading comprehension. Note that greater accuracy values represent more accurate responses.

a)




b)

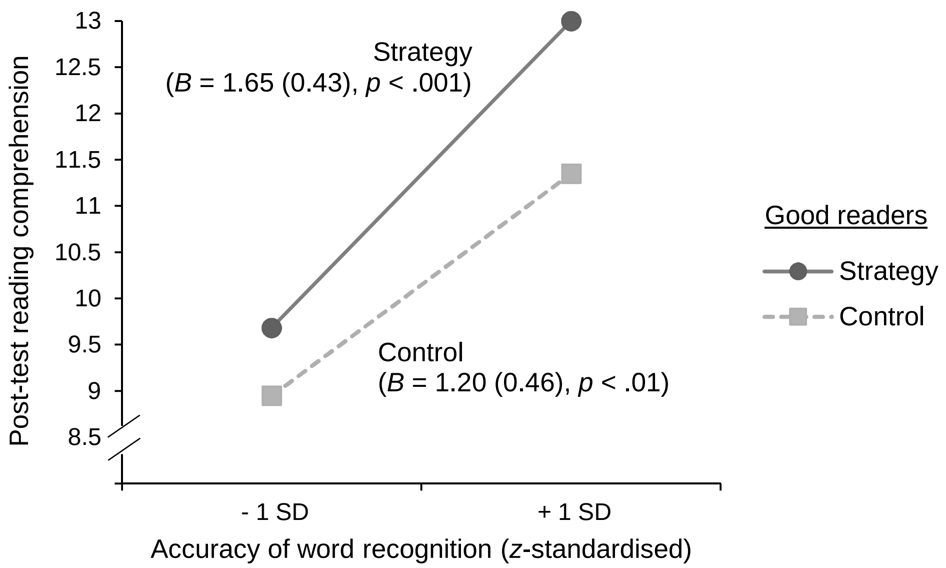



*Figure 2.* Estimates of the simple slopes per treatment condition for the good readers.

a) The effect of efficiency of word recognition on post-test reading comprehension. Note that smaller efficiency values (i.e., faster reaction times) represent more efficient word recognition.

b) The effect of accuracy of word recognition on post-test reading comprehension. Note that greater accuracy values represent more accurate responses.