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Ameliorating Children's Reading-Comprehension Difficulties: A Randomized Controlled Trial

Paula J. Clarke, Margaret J. Snowling, Emma Truelove, and Charles Hulme
University of York

Abstract

Children with specific reading-comprehension difficulties can read accurately, but they have poor comprehension. In a randomized controlled trial, we examined the efficacy of three interventions designed to improve such children's reading comprehension: text-comprehension (TC) training, oral-language (OL) training, and TC and OL training combined (COM). Children were assessed preintervention, midintervention, postintervention, and at an 11-month follow-up. All intervention groups made significant improvements in reading comprehension relative to an untreated control group. Although these gains were maintained at follow-up in the TC and COM groups, the OL group made greater gains than the other groups did between the end of the intervention and follow-up. The OL and COM groups also demonstrated significant improvements in expressive vocabulary compared with the control group, and this was a mediator of the improved reading comprehension of the OL and COM groups. We conclude that specific reading-comprehension difficulties reflect (at least partly) underlying oral-language weaknesses that can be effectively ameliorated by suitable teaching.

Keywords

reading, reading-comprehension difficulties, randomized controlled trial, children's reading difficulties

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The goal of reading is to extract meaning from text. Many children cannot fully achieve this goal. The simple view of reading (Gough & Tunmer, 1986) suggests that there are two components to the reading process: decoding and language comprehension. Children with specific reading-comprehension difficulties decode texts accurately when they read aloud, but they show significant problems in comprehending these texts. Previous estimates suggest that up to 10% of primary-school children may fall into this category (Nation & Snowling, 1997), and as a result, these children have significant educational difficulties that often go unnoticed in the classroom. In this article, we present the results from a large-scale, randomized controlled trial that shows that these children's reading-comprehension skills can be improved by suitable remedial teaching. The results lend support to the view that weaknesses in oral-language (OL) skills are a causal factor in reading-comprehension failure. In addition, these results highlight the crucial role of vocabulary knowledge in reading comprehension.

Research on children with specific reading-comprehension difficulties has shown that such children commonly display a range of language impairments, including problems with listening comprehension, vocabulary, oral expression, narrative production, figurative language, and grammar (Nation, 2005; Nation & Snowling, 1997; see Hulme & Snowling, 2009, chap. 3, for a review). When these children read for meaning, their difficulties often extend beyond literal interpretation to higher levels of processing, such as making inferences (Cain & Oakhill, 1999) and monitoring comprehension (Ehrlich, Remond, & Tardieu, 1999). Given the range of problems documented in these children, a number of factors likely play a role in causing their reading-comprehension difficulties. Training studies represent a powerful technique for identifying possible causal relationships between different underlying skills and reading-comprehension difficulties.

Although there has been a good deal of research on how to teach reading comprehension, only a few small-scale studies have evaluated the effectiveness of training individual component skills. In children with specific reading-comprehension deficits, inference training (McGee & Johnson, 2003; Yuill &

Corresponding Author:
Charles Hulme, Department of Psychology, University of York, York YO10 5DD, United Kingdom
E-mail: ch1@york.ac.uk

Joscelyne, 1988; Yuill & Oakhill, 1988) and mental-imagery training (Oakhill & Patel, 1991) have both been shown to be helpful. Johnson-Glenberg (2000) adopted a multicomponent approach and contrasted a visualizing/verbalizing program (Bell, 1986) with a reciprocal-teaching program (Palincsar & Brown, 1984). Both programs improved children's reading, language, and memory skills. To date, however, no studies have used a randomized controlled design to investigate the influence of multiple factors on reading comprehension.

In the present study, we evaluated three different approaches to ameliorating reading-comprehension difficulties. The first approach centered on developing strategies to support text comprehension (TC). It brings together and extends earlier approaches involving inference training (Yuill & Oakhill, 1988), metacognition (Ehrlich et al., 1999), and reciprocal teaching (Johnson-Glenberg, 2000).

The second approach focused on training strategies for understanding and producing oral language. Listening comprehension and vocabulary are two key oral-language skills. Given the strong relationship between listening comprehension and reading comprehension ($r = .90$; Gernsbacher, 1990), improvements in one should lead directly to improvements in the other (as suggested by Perfetti, Landi, & Oakhill, 2005). There is also a close relationship between vocabulary knowledge and reading comprehension (Anderson & Freebody, 1981), and previous research has established that expressive-vocabulary skills can be successfully trained in typically developing children (see Stahl & Fairbanks, 1986, for a review). There is therefore good reason to believe that an oral-language program that includes vocabulary training should lead to improvements in reading comprehension.

Our third approach made explicit links between written and spoken language by highlighting strategies that could be used across both domains. This combined (COM) approach integrated all components from the TC and OL interventions.

We hypothesized that if specific reading-comprehension difficulties arise primarily from factors that are specific to reading (such as a failure to use "look-back" strategies), the TC program should produce the most significant improvements in reading comprehension. Conversely, if a more basic weakness in understanding and using spoken language is the primary causal factor, then the OL program should be most effective. Finally, if both reading-specific processes and oral-language skills play separate roles in causing reading-comprehension problems, then the COM program should be most effective.

Method

Design

To address these hypotheses rigorously, we conducted a randomized controlled trial with children clustered within schools. All three interventions were delivered by the same teaching assistant in each school. To show that any gains made by the intervention groups were greater than the gains made as a consequence of standard classroom instruction, we included a waiting-list control group that did not receive any additional teaching.

Twenty schools took part in the study. Each school employed one teaching assistant to implement the intervention programs. Eight participants within each school were randomly assigned to the four conditions: OL, TC, COM, and control. Children's performance was assessed at pretest (Time 1), after 10 weeks of intervention (Time 2), following 20 weeks of intervention (Time 3), and at a delayed follow-up approximately 11 months after the intervention finished (Time 4).

Participants

The flow of participants through the study is summarized in Figure S1 in the Supplemental Material available online. To identify children with specific reading-comprehension difficulties, we conducted screenings in Year 4 classrooms (8- to 9-year-old children) in 23 schools in Yorkshire, England. The socioeconomic backgrounds of the schools varied from very low to high (as assessed by parental income, parental educational level, and percentage of children eligible for free school meals). All of the children were taught in mainstream classrooms following the English national curriculum. At screening, group-administered measures of spelling (an adapted version of Wechsler Objective Reading Dimensions, WORD; Wechsler, 1993), nonverbal IQ (Raven's Standard Progressive Matrices; Raven, 1998), and listening comprehension (adapted from the Neale Analysis of Reading Ability: Second Revised British Edition, NARA II, Form A; Neale, 1997) were given to whole classes of children. In each school, children who achieved the lowest listening-comprehension scores relative to their peers were identified. Of these children, only those with age-appropriate spelling and nonverbal ability (standard scores > 80) were selected to complete individually administered tests of reading comprehension and reading accuracy (NARA II, Form B; Neale, 1997) and the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999).

Within each school, children with the greatest discrepancies between their reading comprehension (NARA II) and reading fluency (TOWRE) were selected for the study. When possible, we only selected children with age-appropriate passage-reading accuracy (NARA II reading-accuracy standard score > 85) so they would possess sufficient decoding skills to access our teaching materials. However, in the case of 18 children, our criterion for passage-reading accuracy had to be relaxed (NARA II reading-accuracy standard score > 80), which resulted in the inclusion in the study of some children with more general reading difficulties (low accuracy and comprehension) than the children we were specifically targeting. A minority of children who were screened showed good absolute levels of reading comprehension (NARA II reading-accuracy standard score > 106) coupled with large discrepancies

between their reading-comprehension and reading-accuracy scores, but these children were not included in the intervention. These selection procedures resulted in a sample of children with an average discrepancy between reading comprehension and reading fluency of 16 standard-score points.

Eighty-four children out of the 160 children in the final sample satisfied a stringent criterion for a specific reading-comprehension impairment (1 *SD* discrepancy between TOWRE and NARA II reading comprehension; see Table S1 in the Supplemental Material available online for a demographic breakdown of the sample). This was not an epidemiological sample, and children from two schools were not tested further after the screenings, but we can still conservatively estimate that 7.5% (i.e., 84) of the 1,120 children we screened had specific reading-comprehension difficulties.

Measures

Reading-comprehension measures. Two standardized measures were used to assess reading comprehension: NARA II, Form B (Neale, 1997), which was used at Times 1 through 4, and the Wechsler Individual Achievement Test 2nd Edition (WIAT II; Wechsler, 2005), which was used at Times 1, 3, and 4. When completing the NARA II, children read passages aloud and responded orally to open-ended comprehension questions. The WIAT II uses a range of reading material (e.g., sentences, passages, nonfiction, fiction, reviews), which children read either silently or aloud before responding orally to open-ended comprehension questions.

Vocabulary measures. The Vocabulary subtest from the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), which was used at Times 1, 3, and 4, required children to define a series of words. We also devised a bespoke vocabulary test to assess children's knowledge of words that were taught directly in the OL and COM interventions. This measure followed the same procedure as the WASI (responses scored 0–2 points). Vocabulary items were chosen to be at the tier-two level (Beck, McKeown, & Kucan, 2002); these items are useful, relatively high-frequency words with an age of acquisition that is greater than the child's chronological age. The bespoke test consisted of 24 words (16 taught words and 8 comparable nontaught words; assessing nontaught words allowed us to determine the extent to which children showed generalization to novel items). To assess the specificity of the interventions, we used an arithmetic test, the WIAT II Numerical Operations subtest (Wechsler, 2005), at Times 1 through 4.

Interventions

The contents of the teaching programs were guided by the meta-analysis conducted by the National Reading Panel review (National Institute of Child Health and Human Development, 2000) and incorporated a range of techniques shown to be effective for improving reading-comprehension skills, including comprehension monitoring, cooperative learning, graphic/semantic organizers for learning new vocabulary, story-structure training, question answering, question generation, summarization, and multiple-strategy teaching. At the core of each program was reciprocal teaching (Palincsar & Brown, 1984), which brings together four key techniques: clarification, summarization, prediction, and question generation. This form of multiple-strategy teaching centers around discussion between children and a tutor in which scaffolding is gradually reduced as children's skills develop.

The interventions were developed by the research team and were delivered by teaching assistants, who received 3.5 days of intensive training and fortnightly refresher training during the intervention phase. The research team observed each teaching assistant giving lessons (and provided feedback) on at least four occasions. Each intervention had the same basic structure and consisted of three 30-min sessions per week (two in pairs, one individually) for 20 weeks (30 hr of intervention per child). Each session comprised an introduction, followed by activities from each of the intervention components, and a plenary session for consolidation. Activities were built around a theme and a passage of text. The programs followed the principle of distributed practice, which has proven successful in training oral language, phonology, and reading skills to children younger than those in the current study (Bowyer-Crane et al., 2008).

TC program. An overview of the structure of the TC and OL interventions is shown in Figure 1. The TC program comprised four components: metacognitive strategies, reciprocal teaching with text, inferencing from text, and written narrative. All teaching in this program involved working with written texts.

In the first component, children learned and utilized five metacognitive strategies (reread, look-back, visualize, think aloud, and self explanation) and applied them to answering a set of comprehension questions. In the second component, children completed activities to promote reading comprehension using the four key skills of the reciprocal-teaching approach. Activities were designed to increase children's understanding of the passages by teaching them to clarify unknown words and phrases, discern the key information and global meaning of the passage, use their own knowledge to predict missing information and guess what happens next in the passage, and ask relevant questions. In the third component, children learned about different inference types, from basic cohesive inferences (e.g., resolving pronouns) to more sophisticated inferences (e.g., bridging, elaborative, and evaluative). Children were encouraged to use and discuss their prior knowledge to aid their understanding. In the final component, children explored aspects of written narrative (e.g., narrative structure, sequencing, character profiling) and applied this knowledge to produce their own written narratives.

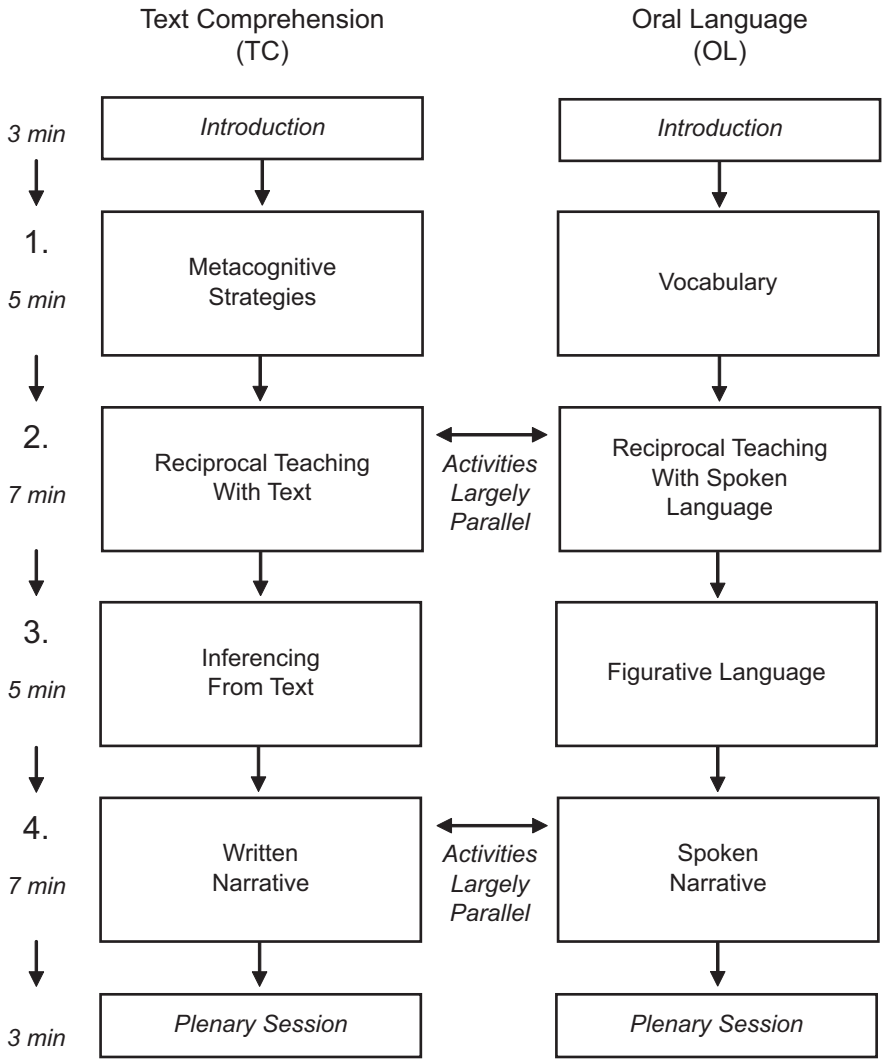

Fig. 1. Overview of the text-comprehension (TC) and oral-language (OL) intervention programs. In the TC program, children were taught using written texts; in the OL program, children were taught using spoken language. The flow charts indicate the sequence and duration of the components in each program.

OL program. The OL program also comprised four components (see Fig. 1): vocabulary, reciprocal teaching with spoken language, figurative language, and spoken narrative. All teaching in this program involved working with spoken language. In the first component, a typical session began with a "word of the day," which was taught primarily using the multiple-context learning approach (Beck et al., 2002). This approach emphasizes the dialogue between children and tutor and encourages children to use new words in relevant and familiar contexts. It equips children with strategies they can use to decipher the meanings of new words and enhance their representations of known words. The multiple-context learning approach was supplemented with other activities, including graphic organizers, verbal reasoning, visual and physical mnemonics, and illustrations. Sixty new words were taught (one per session).

In the second component, children listened to a passage and completed an activity utilizing the four key reciprocal-teaching skills in the spoken-language domain. In the third component, children explored figurative language, including idioms, riddles, jokes, similes, and metaphors. In the fourth component, children completed spoken narrative activities (largely paralleling those in the TC program) and applied their learning to record their spoken stories onto CDs.

COM program. The COM program integrated all eight components from the TC and OL programs. Within each session, children performed reading and listening activities and completed activities from five components. Across the 20 weeks, children spent 50% of their time completing TC components and 50% completing OL components. To incorporate all the activities used in the TC and OL programs, we moved children

through the training components at a faster rate for the COM group than for the TC and OL groups.

Results

Children's performance in each condition on the pretest and screening assessments is shown in Table S1 in the Supplemental Material available online. As might be expected given the random assignment of children to groups, there were no statistically significant differences among the four groups on any of the key screening and selection measures.

Effectiveness of the interventions

A summary of the data obtained at all time points for the primary and secondary outcome measures is given in Table 1. In general, all groups showed gains immediately following intervention on measures of comprehension, although the waiting-list control group actually showed a decrease in WIAT II standard scores between Times 1 and 3. (Such a pattern of decreasing attainment compared to peers is common in children with educational difficulties who are not receiving intervention.) At Time 4, 11 months after the intervention finished, the OL group showed further gains in reading comprehension (particularly on the WIAT II) compared with other groups.

For each of our outcome measures, we report the extent to which postintervention gains in performance were greater for each of the intervention groups than for the waiting-list control group. These analyses (which are equivalent to analyses of covariance) were implemented as regression models with group dummy-coded and performance on the same measure at Time 1 and gender entered as covariates. All analyses were conducted in Mplus (Version 5.2; Muthén & Muthén, 2008); missing data were estimated using full-information maximum-likelihood, and robust standard errors (Huber-White) were used to allow for the nonindependence of observations from children nested within schools. Figures 2 through 4 show the results of these analyses.

The top panel of Figure 2 shows that at both Times 3 and 4, all three intervention groups made significant gains relative to the control group on the WIAT II measure of reading

Table 1. Mean Scores for the Primary and Secondary Outcome Measures for All Groups at Each Time Point

Measure and time of assessment	Oral-language group	Text-comprehension group	Combined group	Waiting-list control group
NARA II reading comprehension				
Time 1	16.13 (4.70)	16.15 (4.89)	16.15 (4.12)	16.55 (5.37)
Time 2	20.95 (6.00)	20.25 (5.39)	20.00 (5.11)	19.86 (5.59)
Time 3	24.00 (5.51)	24.46 (5.86)	24.54 (5.36)	23.79 (5.79)
Time 4	28.17 (6.68)	27.27 (5.84)	28.11 (6.00)	26.45 (7.34)
WIAT II Reading Comprehension				
Time 1	95.43 (7.38)	96.38 (6.98)	94.08 (8.34)	97.77 (6.06)
Time 3	98.46 (7.05)	98.66 (7.92)	99.23 (7.66)	95.79 (7.55)
Time 4	100.80 (8.81)	98.14 (10.29)	96.83 (9.53)	94.18 (10.13)
WASI Vocabulary				
Time 1	23.84 (5.77)	23.62 (5.15)	22.69 (5.53)	23.03 (5.36)
Time 3	29.43 (6.14)	27.67 (5.97)	28.55 (6.41)	27.11 (6.22)
Time 4	33.43 (5.35)	32.30 (6.16)	31.47 (6.00)	30.95 (6.79)
Bespoke vocabulary taught words				
Time 1	0.85 (1.15)	0.68 (0.97)	0.72 (0.94)	0.95 (1.93)
Time 3	6.89 (5.88)	2.50 (2.89)	4.92 (0.81)	2.03 (2.31)
Bespoke vocabulary nontaught words				
Time 1	1.02 (1.05)	1.05 (1.15)	0.90 (1.02)	0.92 (1.05)
Time 3	2.92 (3.36)	1.45 (1.29)	1.63 (1.85)	1.47 (1.62)
WIAT II Numerical Operations				
Time 1	16.98 (2.97)	16.72 (2.75)	16.65 (3.04)	16.38 (3.07)
Time 2	18.36 (3.09)	18.33 (2.67)	18.06 (3.05)	17.38 (3.00)
Time 3	19.95 (3.22)	19.87 (2.86)	20.15 (3.54)	18.82 (3.53)
Time 4	21.86 (3.24)	21.38 (3.35)	21.77 (3.41)	21.37 (3.46)

Note: Maximum raw scores for the measures were as follows—Neale Analysis of Reading Ability: Second Revised British Edition (NARA II; Neale, 1997) reading comprehension: 44; Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) Vocabulary: 64; bespoke vocabulary taught words: 16; bespoke vocabulary nontaught words: 8; and Wechsler Individual Achievement Test 2nd Edition (WIAT II; Wechsler, 2005) Numerical Operations: 28. Standard scores are reported for the WIAT II Reading Comprehension measure because it was not possible to extract meaningful raw scores from the test. Children's performance was assessed at pretest (Time 1), after 10 weeks of intervention (Time 2), following 20 weeks of intervention (Time 3), and at a delayed follow-up approximately 11 months after the intervention finished (Time 4). Standard deviations are given in parentheses.

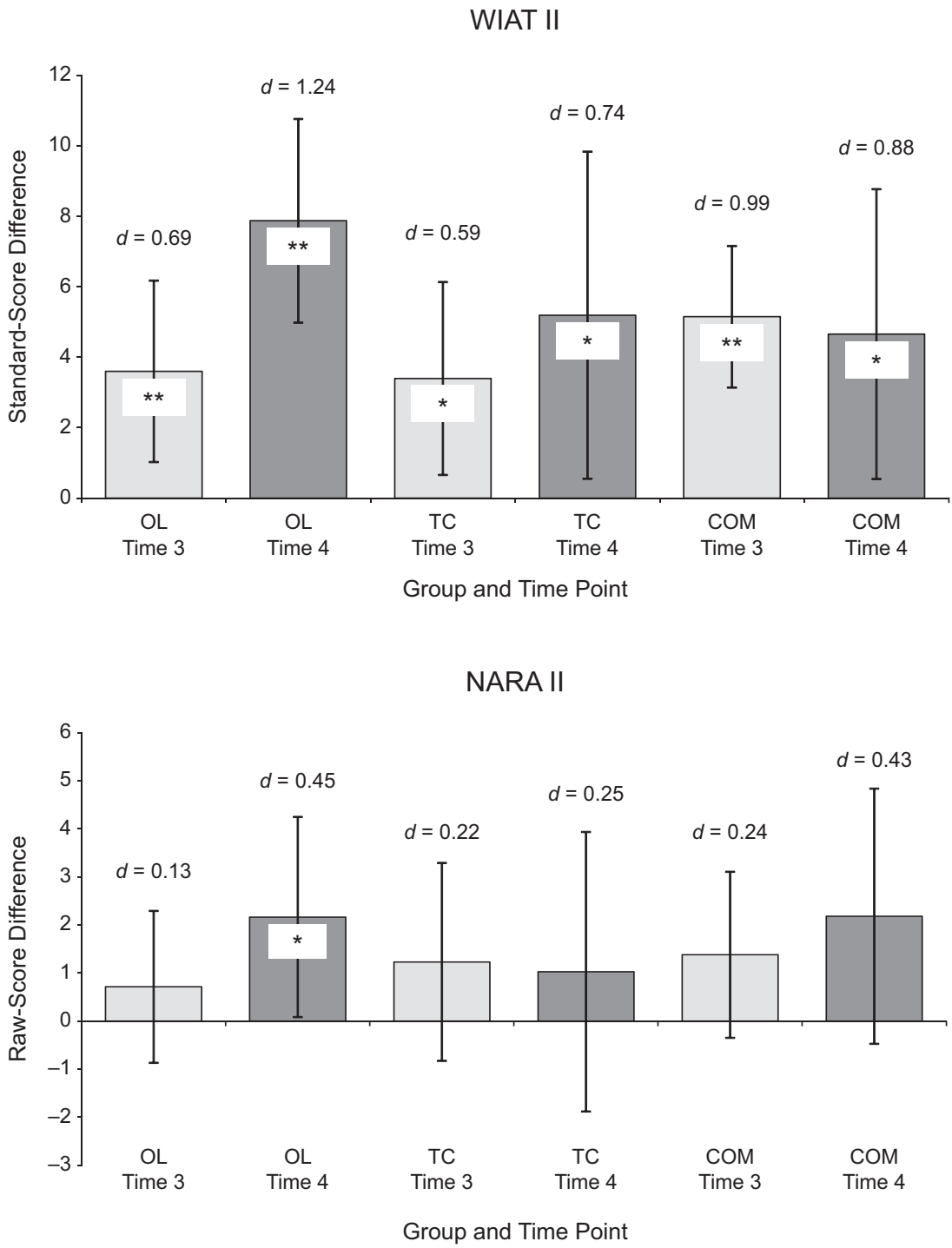

Fig. 2. Relative changes in reading-comprehension scores on the Wechsler Individual Achievement Test 2nd Edition (WIAT II; Wechsler, 2005; top panel) and the Neale Analysis of Reading Ability: Second Revised British Edition (NARA II, Form B; Neale, 1997; bottom panel). The height of each bar shows the difference in gains between one of the intervention groups and the waiting-list control group at either Time 3 or Time 4 (*$p < .05$, **$p < .01$). Error bars show robust 95% confidence intervals. Cohen's *d* was calculated for each group by taking the difference in progress between that group and the waiting-list control group and dividing this value by the pooled Time 1 standard deviation. OL = oral-language group; TC = text-comprehension group; COM = OL-and-TC-combined group.

comprehension. It is also clear from the confidence intervals (CIs) in this figure that the relative gain of the OL group actually increased significantly between Times 3 and 4. In contrast, the relative gain of the other two groups showed no reliable change. (The CIs get wider at Time 4 for these two groups; this reflects increased variability in scores.)

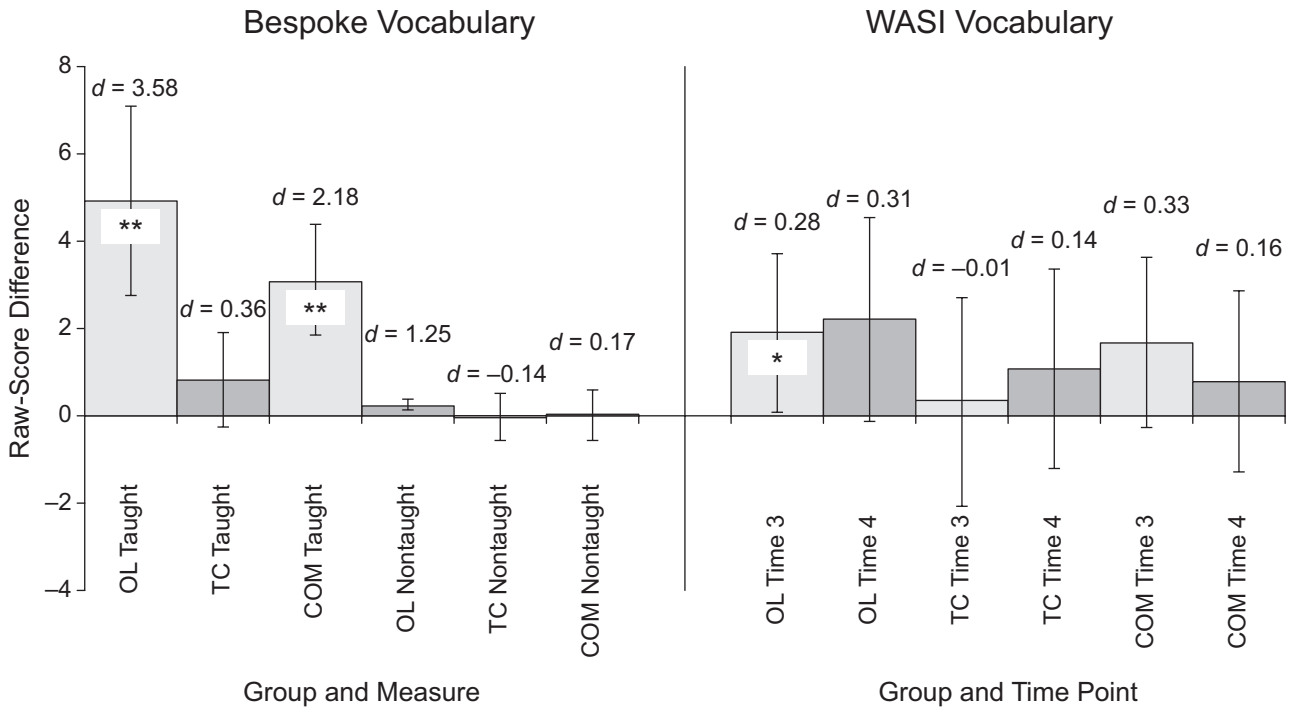

Fig. 3. Differences in raw-score changes between the oral-language (OL), text-comprehension (TC), and OL-and-TC-combined (COM) intervention groups and the waiting-list control group on the secondary outcome measures. Scores for taught and nontaught bespoke vocabulary (left panel) and Wechsler Abbreviated Scale of Intelligence (WASI) Vocabulary scores (Wechsler, 1999; right panel) were obtained at Times 3 and 4 for each group. Error bars show robust 95% confidence intervals. Cohen's *d* was calculated for each group by taking the difference in progress between that group and the waiting-list control group and dividing this value by the pooled Time 1 standard deviation. Asterisks indicate significant differences from the control group (*$p < .05$, **$p < .01$).

The bottom panel of Figure 2 shows the gains of the intervention groups relative to the control group on the NARA II measure of reading comprehension. The gains here are smaller than for the WIAT, and at Time 3, none of the intervention groups made significant gains relative to the control group. However, by Time 4, the gain made by the OL group was significant and moderate in size. (The gain in the COM group was of a similar size and almost significant.)

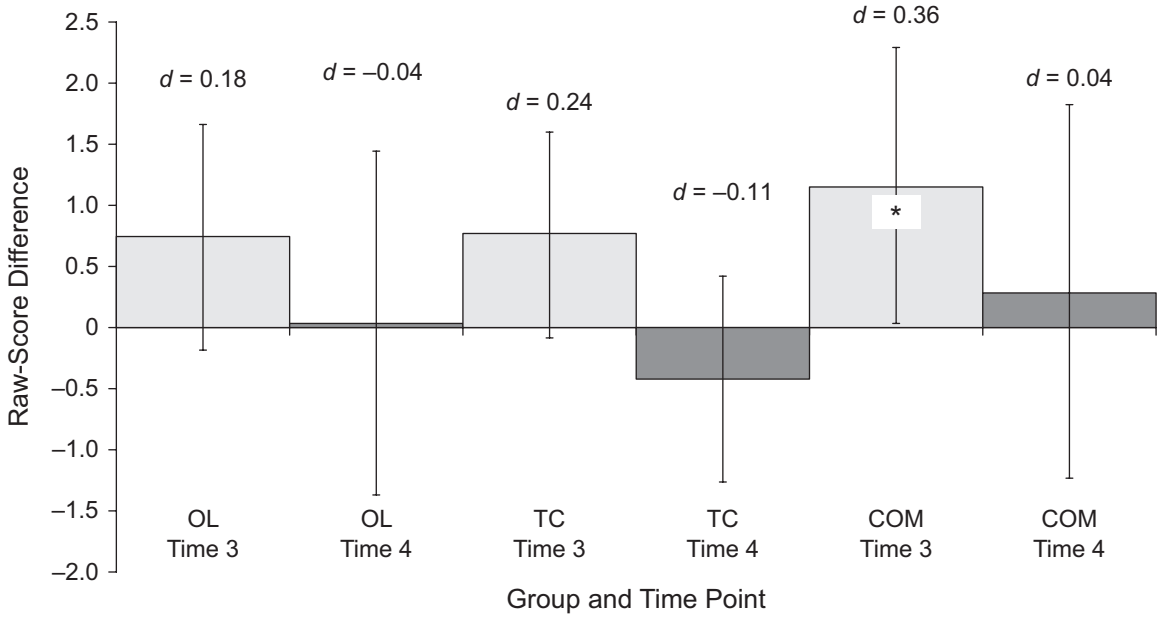

Fig. 4. Differences in raw-score changes between the oral-language (OL), text-comprehension (TC), and OL-and-TC-combined (COM) intervention groups and the waiting-list control group on the Wechsler Individual Achievement Test 2nd Edition Numerical Operations control task (Wechsler, 2005). Scores were obtained at Times 3 and 4. Error bars show robust 95% confidence intervals. Cohen's *d* was calculated for each group by taking the difference in progress between that group and the waiting-list control group and dividing this value by the pooled Time 1 standard deviation. An asterisk indicates a significant difference from the control group (*$p < .05$).

The differences in results from our two measures of reading comprehension (NARA II and WIAT II) are difficult to explain. It is notable that the control group made large improvements in raw scores on the NARA II between Times 1 and 4 (equivalent to a 5-point increase in standard scores from 93 to 98; see Table 1), whereas, conversely, over the same period, the control group showed a decline of roughly 4 standard-score points (from 98 to 94) on the WIAT. This suggests that results of the NARA are particularly susceptible to practice effects (which may have served to inflate the estimates of gains in the control group). Regardless of how the discrepancy between these measures is interpreted, it is clear that the OL and COM groups showed gains in comprehension scores that reflect medium-to-large effect sizes.

Figure 3 shows the gains on measures of vocabulary. At Time 3, the gains relative to the control group on the bespoke vocabulary test were significant for the OL group on the taught and nontaught words and for the COM group on the taught words only. On the standardized vocabulary measure (WASI), the OL group also showed a significant gain compared with the control group at Time 3; this gain fell to just nonsignificant levels at Time 4. (Neither of the other two intervention groups showed a reliable gain.)

Figure 4 shows that on the WIAT II Numerical Operations test, there were small and similar-sized improvements in all three intervention groups compared with the control group at Time 3. The improvement was just significant in the COM group but not in either of the other groups, and these effects dissipated by Time 4. It seems clear, therefore, that the intervention effects found for reading comprehension and vocabulary cannot be explained simply as a general effect that translates to other skills that have not been directly taught.

Vocabulary as a mediator of intervention effects on reading comprehension

The two interventions that included oral-language training (OL and COM programs) produced reliable increases in both reading comprehension and vocabulary knowledge in children with reading-comprehension difficulties. It is a plausible argument that at least some of the effects of intervention on reading comprehension might be produced by increases in vocabulary knowledge. To assess this idea, we constructed a mediation model in which we focused on the long-term outcome of the intervention (Time 4 reading comprehension), with Time 3 vocabulary as a mediator. In this model, the effects of the putative cause (earlier changes in vocabulary) were operating forward in time (affecting later reading-comprehension skills). Vocabulary at Time 3 was assessed by combining scores from the taught and nontaught items on the bespoke vocabulary measure. Reading comprehension (Time 4) was assessed using the WIAT II. (We chose the WIAT II measure because it revealed the largest effects of our interventions; essentially, equivalent results were also obtained for a combined measure of reading comprehension, formed by summing Time 4 WIAT II and Time 4 NARA II standardized scores).

A basic analysis of covariance model without vocabulary as a mediator (Fig. 5a) showed that all three intervention groups achieved significantly greater gains in reading comprehension than the waiting-list control group. In addition, both the OL and the COM programs produced significant gains in vocabulary knowledge at Time 3 relative to the control group (Fig. 5b). Variations in Time 3 vocabulary scores completely accounted for the effects of the COM program and partly accounted for the effects of the OL program on reading comprehension (WIAT II, Time 4). The indirect effects of these two programs on reading comprehension, via Time 3 vocabulary, were reliable. The effects of the TC intervention on vocabulary were not statistically reliable (as expected, given that this group did not receive any vocabulary instruction).

Discussion

This was the first randomized controlled trial investigating whether educationally realistic, evidence-based interventions can ameliorate children's reading-comprehension difficulties. We have shown that three interventions (OL, TC, and COM) can produce statistically and educationally significant improvements in reading comprehension in these children. This is a result with important educational implications for large numbers of children. It is perhaps surprising that long-term gains in reading comprehension were largest for children who received the OL rather than the COM intervention, and this suggests that the total amount of time devoted to oral-language training (which is approximately double in the OL group compared to the COM group) is crucial. Moreover, the improvements in reading comprehension in the OL and COM groups were wholly or partially mediated by improvements in children's oral-vocabulary knowledge. This finding supports the idea that deficits in oral vocabulary may be one important underlying cause of children's reading-comprehension problems. More broadly, our findings lend support to theories that view children's reading-comprehension problems as one facet of a broader oral-language comprehension problem.

The nature and causes of specific reading-comprehension impairments in children

Children with specific reading-comprehension impairments are relatively common (7.5% of the current sample is a conservative estimate). They form an important group to study because their difficulties have serious educational consequences that often go unnoticed because such children read aloud accurately. It is clear that these children have difficulties with a wide range of oral-language skills (Hulme & Snowling, 2009, chap. 3). Their difficulties in comprehending written texts might also reflect processes specific to reading (such as problems in comprehension monitoring). An ongoing tension in theoretical accounts of this disorder is the extent to which these children's reading-comprehension impairments can be reduced to an oral-language deficit. Our study provides a powerful test of this issue by comparing the relative effectiveness

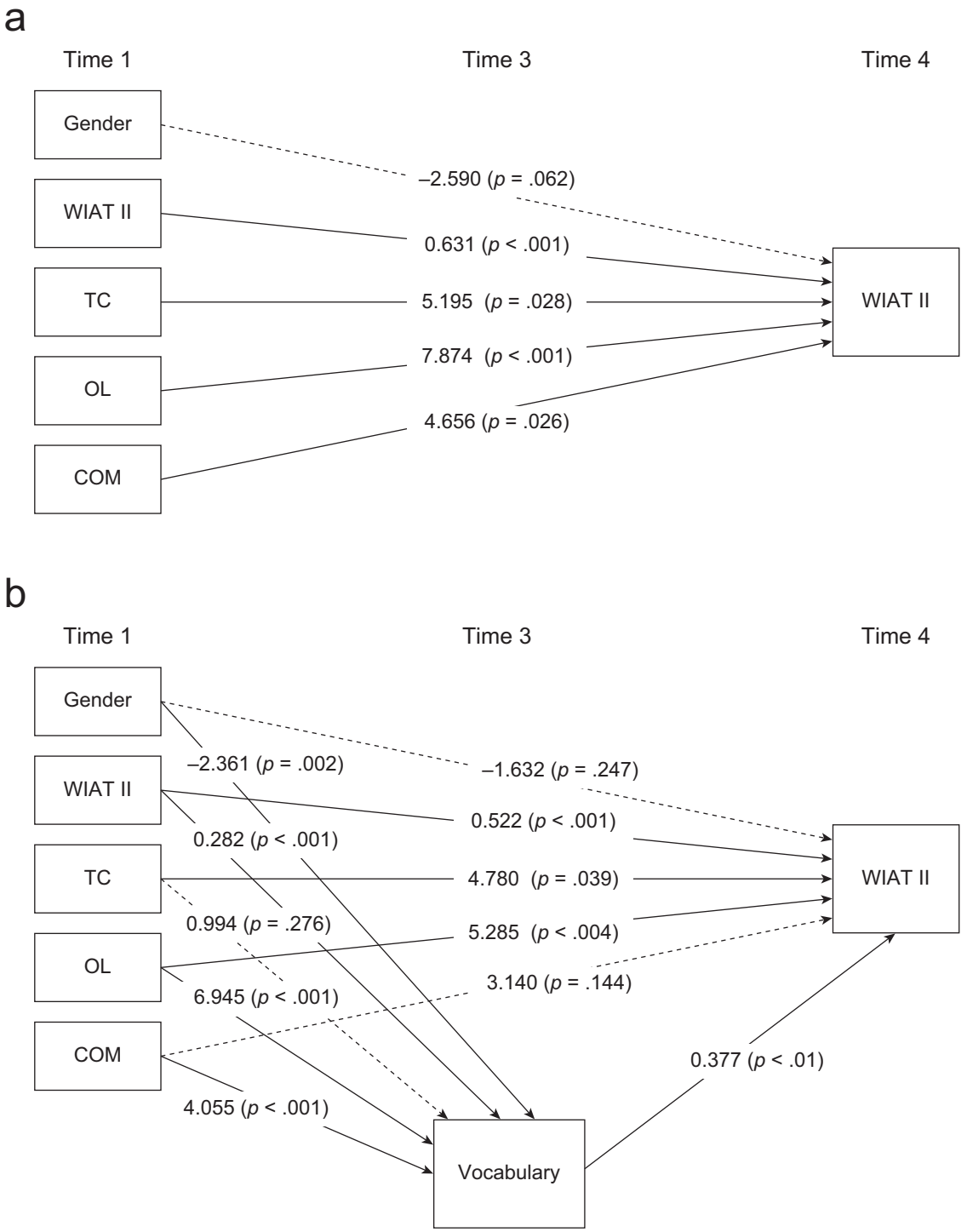

Fig. 5. Two models assessing reading-comprehension performance of the oral-language (OL), text-comprehension (TC), and OL-and-TC-combined (COM) intervention groups relative to the control group on the Wechsler Individual Achievement Test 2nd Edition (WIAT II; Wechsler, 2005). An analysis of covariance model in which WIAT II Reading Comprehension scores at Time 4 are predicted from WIAT II scores at Time 1 and gender is shown in (a). Dummy variables represent the difference in scores between each of the intervention groups and the control group. Unstandardized slope values are shown; these values can be interpreted as the difference (in standard-score points) on the WIAT II between each of the intervention groups and the waiting-list control group (after controlling for Time 1 differences on the WIAT II and gender). A mediation model assessing the extent to which the effects of the three interventions on reading comprehension (WIAT II at Time 4) were mediated by changes in vocabulary knowledge at the end of the intervention (Time 3) is shown in (b). Solid lines represent statistically significant paths, and dashed lines represent statistically nonsignificant paths.

of an OL and a TC remediation program. Although our results do not completely settle the issue, we believe that the strength of improvements seen in the OL group supports the idea that oral-language deficits are one critical causal factor underlying these children's reading-comprehension difficulties. More specifically, the mediation analysis provides support for a critical role of oral-vocabulary knowledge as one cause of these children's reading comprehension difficulties.

Two of our intervention groups (OL and COM) showed improvements in oral-vocabulary knowledge. For the children in the OL group, which received the most vocabulary instruction, these improvements not only were reliable for words that they had been directly taught, but also generalized to untaught words (resulting in increased WASI Vocabulary scores). These increases in vocabulary knowledge might be seen as akin to an improvement in verbal IQ in these children and are likely to be of educational significance irrespective of their effects on reading comprehension. The nature of the gains on nontaught vocabulary items shown in this group are important and deserve further study. We speculate that these children developed some enhanced metacognitive skills as a result of the language intervention and that these skills resulted in greater engagement with language learning and possibly the more active use of a range of strategies (such as contextual strategies) that support vocabulary learning and reading comprehension.

Educational implications

Our findings show that specific reading-comprehension impairments in children are relatively common, easily identifiable, and effectively remediable. Children with such impairments could easily be identified by the routine use of measures of reading accuracy and reading comprehension. In addition, the gains shown in our study are of a magnitude that is likely to be of real educational significance. It is also likely that intervention programs of the sort evaluated here have the potential to be highly cost-effective in relation to their long-term educational benefits. More broadly, we believe that one implication of this study is that researchers should be seeking to identify and remediate children's early oral-language weaknesses, which are important in their own right and appear to be one cause of reading-comprehension difficulties.

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Declaration of Conflicting Interests

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Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

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