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Can Brain Research and Computers Improve Literacy? A Randomized Field Trial of the Fast ForWord Language Computer-Based Training Program[1]

Geoffrey D. Borman and James Benson

This article describes the methods and results of an independent assessment of the Fast ForWord Language computer-based training program developed by Scientific Learning Corporation. The study assessed the language and reading outcomes for second- and seventh-grade students served by a pilot program in eight schools in the Baltimore City Public School System (BCPSS). Data collected included a pretest and posttest of students' language and reading comprehension skills using (a) the Comprehensive Test of Basic Skills, Fifth Edition (CTBS/5) Terra Nova; (b) teacher-reported information regarding each child's language skills prior to the intervention; and (c) descriptive data regarding the implementation of the program at the school sites. We implemented an experimental design that involved within-school random assignment of students to the program or a control group condition. This randomized field trial across eight BCPSS schools yielded a study with strong internal validity that also provided good external validity for assessing whether Fast ForWord programs can be expected to help academically at-risk students from an urban locale learn literacy skills that are commonly measured in school accountability programs across the nation.

Background

Since Scientific Learning Corporation launched its first product in 1997, its Fast ForWord programs have served over 120,000 students across the United States (Scientific Learning Corporation, 2002). The programs are based on the theory that children experiencing reading and language difficulties have a general auditory processing deficit that stems from their difficulties detecting rapidly presented and changing stimuli. For instance, though consonant-vowel pairs (e.g., /ba/ and /da/) mainly differ in the first 40 ms of the speech signal (Reed, 1989), children experiencing language difficulties require hundreds of milliseconds to discriminate such speech signals. As a result, these children process rapid and successive incoming sensory information too slowly to discriminate among the brief and weak acoustic cues that are needed to learn the phonemes of language. According to Tallal (1980), these difficulties may impede a child's ability to understand and use language, read, perform at a satisfactory level in school, and participate successfully in many aspects of the home and school environment.

Using computer technology, the Fast ForWord programs' mathematical algorithms change many of the features of sounds, including volume, pitch, and duration. The programs selectively stretch and emphasize important acoustic differences in the sounds of language so that individuals recognize the acoustic "signature" of each phoneme. Both the stretching and the enhancement are varied systematically in degree and intensity over the course of training. The programs are adaptive, in that they respond to each participant's incoming skill level and

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ongoing progress by gradually moving speech sounds closer and closer together with less and less modification until the student is eventually learning with more natural speech acoustics. Data from the child's daily exercises are uploaded via an Internet connection to Scientific Learning, and weekly reports are generated to summarize the child's progress.

The family of Fast ForWord products includes three programs: (a) Fast ForWord Language (available in both elementary and middle/high school versions); (b) Fast ForWord Language to Reading; and (c) Fast ForWord Reading. Fast ForWord Language is designed to build oral language comprehension skills such as phonemic awareness, auditory processing speed, phonological awareness, working memory, syntax, grammar, sequencing, and other critical skills necessary to learn to read or become a better reader. The elementary and middle/high school versions of the Fast ForWord Language program are similar, but the middle/high school software contains graphics and content tailored to older students. Language to Reading focuses on making the connection between spoken and written language and attends to skills such as sound/letter recognition, decoding, vocabulary, syntax and grammar, listening comprehension, and word recognition. Finally, Fast ForWord Reading helps children build reading skills such as word recognition and fluency, decoding, vocabulary, spelling, and passage comprehension.

The Fast ForWord Language program, which is the focus of this study, consists of 100 minutes of training per day, 5 days per week, for a minimum of 20 training days under the supervision of Fast ForWord–trained clinicians or educators.[2] The developer requires this high degree of intensity and frequency to sustain a level of practice that develops skills to the extent that they become automatic, or learned. The exercises are provided in a game-like computerized environment, with animations to help maintain the child's interest. On-screen rewards for successful completion of training segments are supplemented with token economy rewards, which are awarded for achievement of point goals determined in conjunction with the participant. Points are awarded for a combination of correct answers and attentiveness to instruction. All children start at the same basic level and advance only after attaining a predetermined level of proficiency. The rate at which a child progresses through the program is therefore determined by the child. On average, children complete Fast ForWord Language in 6 to 8 weeks.

The Fast ForWord Evidence Base

The initial research on the prototype that would ultimately become the Fast ForWord Language program revealed that children with language-based learning impairments (i.e., major deficits in their recognition of some rapidly successive phonetic elements and nonspeech stimuli) improved markedly in their abilities to recognize brief and fast sequences of nonspeech and speech stimuli with approximately 20 hours of computer-based training per week over a 4-week period (Merzenich et al., 1996; Tallal et al., 1996).

Additional research used functional magnetic resonance imaging to analyze the brain activity of 20 dyslexic children and 12 children with normal reading abilities while they

[2] The Fast ForWord Language program for middle and high school students has a recommended schedule of 90 minutes per day, 5 days per week, for a minimum of 20 days.

performed a simple rhyming task (Temple et al., 2003). After the initial scans, the 20 dyslexic children used the Fast ForWord Language training program for 8 weeks as part of their regular school day. At the end of the 8 weeks, brain scans revealed increased activity in the brains of the dyslexic children that represented a partial amelioration of the disrupted responses found prior to Fast ForWord training. The authors, who also found improved language and reading test scores for the Fast ForWord group, concluded that the program may have changed brain areas related to the sound structure of language, which in turn led to improved language and reading outcomes.

These early studies yielded impressive results suggesting that Fast ForWord Language could hold considerable promise for improving students' language and reading outcomes. However, the ability to generalize from these small and tightly controlled laboratory experiments to typical implementations of Fast ForWord Language in school-based settings may be limited. Cronbach et al. (1980) characterized such small-scale evaluations of promising new programs implemented under optimal conditions as the "superrealization" stage of program development. These types of studies demonstrate the optimal effects that can be expected of an intervention but generally do not provide realistic estimates of what can be expected from the intervention when it is implemented on a broader scale in schools, classrooms, and other field-based settings.

Further, the applicability of early findings on Fast ForWord Language may be modest because the studies targeted very small samples of children who had specific language-based impairments that occur at a rate of only about 5% to 8% in the U.S. population. Nevertheless, in the years since this initial research, the developer has disseminated Fast ForWord Language to other student subgroups beyond the specialized groups of language-impaired children originally targeted by the intervention. These groups have included children with developmental problems or classifications, such as pervasive developmental disorder (PDD), attention deficit disorder (ADD), and central auditory processing disorder (CAPD) (Gillam, 1999). Further, various pretest-to-posttest outcome data presented at the developer's Web site suggest that a variety of other children may benefit, including students at risk for reading failure, students from low socioeconomic status backgrounds, at-risk African American students, and English language learners (see www.scientificlearning.com/scie/index.php3?main=graphs& cartid=).

These data and other information provided by the Fast ForWord Web site suggest that a broad school-based population of students can benefit from the Scientific Learning products (see www.scilearn.com/prod2/ffwd_l/main=home). Yet, we are aware of only one randomized field trial that has assessed the impacts of Fast ForWord Language in school-based settings with a more general sample of students struggling with reading. Rouse and Krueger (2004) found that the programs improved some aspects of students' language skills, but they did not find that these gains translated into impacts on broader measures of language acquisition or actual reading skills, at least as measured by commonly used standardized tests. Though Rouse and Krueger acknowledged that their sample sizes were too small to detect small effects of Fast ForWord Language of less than 0.10 *SD*s with statistical precision, they noted that such impacts are considerably smaller than those of approximately 0.80 *SD*s that have been promoted by the developer.

Therefore, there is some anecdotal and non-experimental information from the developer that suggests that a wider variety of students than previously assumed may achieve important improvements on a range of literacy skills as a result of training with Fast ForWord Language.

Only Rouse and Krueger (2004), though, have provided rigorous experimental evidence concerning such effects. In this respect, the true impacts of Fast ForWord Language implemented in school-based settings and targeting students generally at risk for poor literacy performance do not appear to be well understood.

Objectives and Hypotheses

The goal of the current study was to examine the overall effects of the Fast ForWord Language program on at-risk students' reading and language outcomes. The children participating in the study were predominantly African American, of low socioeconomic status, and performing below national averages on norm-referenced reading achievement tests. An additional objective of the study was to investigate two potential Aptitude × Treatment interaction (ATI) effects related to the following baseline student characteristics:

- The degree of pre-intervention speech and language difficulties experienced by the child; and
- The degree of pre-intervention reading difficulties experienced by the child.

That is, we designed the study in such a way as to be able to pose the question, Do students with more severe language and speech problems and/or those with more difficulty reading realize stronger language and reading achievement gains from Fast ForWord than students with less profound language/speech and reading problems? This design allowed us to test how well the major theory behind the program generalizes to an at-risk student sample and to identify those for whom the intervention may be most helpful.

The Fast ForWord program is intended primarily to improve the skills that are key predictors of reading success: phonemic awareness; phonological awareness; and language skills. Our study assessed the effects of the Fast ForWord intervention on two outcomes—language skills and reading comprehension skills—as measured by the BCPSS CTBS/5 Terra Nova testing program.

As suggested by our review of the Fast ForWord research base, the strongest connection between the theory behind the program and its potential promise seems to be for children experiencing speech and language difficulties in the classroom. Further, although there is the potential for Fast ForWord Language to improve reading skills, the theory would seem to suggest that students, in general, should achieve more direct and stronger improvements in language outcomes than in reading outcomes, at least in the short term. Accordingly, we hypothesized that all students participating in the program would achieve greater academic gains in language than in reading comprehension and that students with more severe pre-program language difficulties would experience the greatest overall benefits from the intervention.

Finally, because the intervention was implemented in school-based settings rather than the more tightly controlled clinical or laboratory settings of earlier studies (e.g., Merzenich et al., 1996; Tallal et al., 1996), we suspected that student compliance with the demanding treatment regimen would vary.[3] Thus, it was important to collect data that could differentiate between the treatment that participants received as a result of random assignment and the treatment that they received in reality. To understand the intention-to-treat (ITT) effect and the effect of treatment on the treated, we applied two classes of analytical methods to the resulting data.

The effects estimated through the ITT analysis provide educators and policymakers with an indication of the impacts that can be expected in typical school settings in which full school and student compliance is not achieved. To complement the ITT analysis, we used an instrumental variables approach to estimate the expected impact when students do receive the full treatment. In a randomized experiment with full treatment compliance, analyzing this result is simply a matter of comparing the treatment and control groups' outcome measures as in an ITT analysis. In most field-based studies—including the current one—assignment to treatment and control conditions is random, but treatment compliance is not perfect (Borman, 2003). In these cases, the instrumental variables approach described by Angrist, Imbens, and Rubins (1996) can provide a useful analytical framework for estimating the causal effects of treatment compliance and participation.

Method

Sample

The Fast ForWord Language intervention was offered to students from eight BCPSS schools: two elementary schools; three middle schools; and three elementary/middle schools. The student sample included a total of 415 children from two grade-specific cohorts: 141 second-grade students and 274 seventh-grade students. These grade levels were selected to represent the elementary and middle school levels.

In an attempt to define a sample that was similar to Fast ForWord's typical school-based target population, second- and seventh-grade students from the eight schools were deemed eligible for the intervention if they had scored below national norms (i.e., the 50th percentile) on the Total Reading outcome for the district-administered CTBS/5 during the spring of 2000. The 415 students selected to participate in the study had a spring 2000 CTBS/5 Total Reading national percentile score of 16.11—far below the national average. In addition to below-average CTBS/5 Total Reading outcomes, these students also tended to have below-average outcomes on language skills. The 415 students in the sample had a mean spring 2000 CTBS/5 Language Expression national percentile score of 22.13.

Measures

Student achievement. Pretest data on experimental and control students' reading comprehension and language skills were obtained from the spring 2001 administration of the CTBS/5, Form B, by BCPSS. These data were collected just prior to the start of the Fast ForWord program on April 17, 2001. Upon completion of the Fast ForWord program on June 15,

[3] The hypothesized greater variability in school-based settings than in laboratory settings is also consistent with the study by Rouse and Krueger (2004), which found notable variation in student compliance with the Fast ForWord training schedule when the program was implemented in an urban school district.

2001, experimental and control students' reading comprehension and language skills were retested using Form A of the CTBS/5. Thus, the April and June tests represented the pretest and posttest, respectively.

The CTBS/5, published by CTB/McGraw-Hill, is a widely used and highly regarded achievement test. Prior analyses of national norming sample data have indicated high item and scale reliabilities, absence of ceiling and floor effects, absence of obvious cultural biases, and a low error of measurement. The CTBS/5 is vertically equated, and it provides normal curve equivalent (NCE) scores that are appropriate for analysis of longitudinal achievement gains.[4] The test items from the CTBS/5 reflect the educational objectives that are commonly found in state and district curriculum guides and in major textbooks, basal series, and instructional programs.

Student background data. In addition to test scores, we collected demographic data on the students based on information abstracted from the BCPSS Pupil Information File (PIF). Data abstracted from the district-compiled PIF included gender, race/ethnicity, federal free-lunch program eligibility status, and 1999–2000 school year attendance rate. These data were used to describe the characteristics of the sample and to confirm that the process of random assignment elicited treatment and control groups that were from statistically similar backgrounds.

Language and speech skills observational survey. Prior to random assignment and the start of the Fast ForWord intervention, the classroom teacher who was most familiar with each of the 415 eligible children was asked to complete a 20-item questionnaire regarding the child's language and reading skills. This survey, which was developed by Scientific Learning Corporation, included instructions to teachers stating that the questions "help to indicate whether an individual has difficulty with learning language and reading skills. . . . If you mark 'sometimes' or 'frequently' to many of the questions, the individual may be a candidate for a Scientific Learning training program." Though Scientific Leaning Corporation provides no evidence of the reliability or validity of the instrument, the fact that the company constructed this survey to determine whether a student is experiencing difficulty with language and reading and that it suggests using it to determine which students may be in need of the training program indicates some degree of content validity.[5]

Students were assigned a value of 1 when teachers indicated that the problem behavior occurred "rarely," a value of 2 when the teacher indicated that the behavior occurred "sometimes," and a score of 3 when the teacher indicated that the behavior occurred "frequently." Thus, the survey had a range of 20 to 60, with higher scores representing a greater prevalence of behaviors indicating difficulties with speech, auditory, language, and reading skills. The mean score for the sample was 34.60 with a standard deviation of 9.99. To facilitate

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[4] NCEs, which have a mean of 50 and standard deviation of 21.06, are equal to percentile scores at 99, 50, and 1. Unlike percentiles, though, the NCE metric is an equal-interval scale that is appropriate for measuring change from one testing time to another.

[5] Although we know of no empirical studies of the reliability and validity of the language and speech skills observational survey, the survey score was consistently a statistically significant predictor of reading comprehension and language posttest outcomes across all regression models tabulated in Tables 4, 5, 7, and 8. Thus, in the current study, the instrument exhibited good criterion-related validity.

interpretation of the survey scores, we employed a standardized score, with a mean of 0 and standard deviation of 1, in the analyses of Fast ForWord treatment effects.

Procedure

Random assignment. We conducted the randomization process separately within each school and grade level, with an equal selection probability of approximately 50% in all cases. As shown in Table 1, this combination of Grade Level × School clusters resulted in a total of 11 randomization pools. Within each of the 11 Grade Level × School randomization pools, approximately 50% of the students eligible for the intervention were assigned at random to the experimental group, and 50% were assigned at random to the control group. This method of assignment was both fair and ethical, in that there were more eligible students than slots available in the program and the intervention was, strictly speaking, of unproven educational value. Table 1 presents summary data on the numbers of eligible students, the selection probabilities used, and the resulting experimental and control sample sizes.

We conducted experimental-control comparisons of family background characteristics, pre-treatment language and speech skills survey data, and the CTBS/5 pretest scores to examine the extent to which the randomization process yielded statistically equivalent control and treatment groups. Table 2 shows the family background and baseline school participation and language skills of students randomized into the treatment and control conditions. The baseline characteristics of the total sample, as originally randomized, and the analytic samples, as used in the final analyses of treatment effects, are displayed for the second-grade sample and the seventh-grade sample. As the table shows, the participating students were predominantly African American and poor, as indicated by eligibility for the federal free-lunch program. The data displayed for the baseline samples revealed that randomization produced experimental and control groups that were roughly equivalent on all pre-intervention measures. Statistical comparisons of experimental-control differences for regular school year attendance rates, *t*-tests of baseline survey outcomes, and χ^2 analyses of the experimental-control differences on gender, ethnicity, and free-lunch status revealed no differences at $p < .05$.

Listwise deletion of student cases with missing pretest-posttest data did not cause differential attrition rates by program condition for the second-grade cohort, $\chi^2(1, N = 141) = 2.25$, $p = 0.13$, leaving 60 (85%) of the 71 treatment students from the baseline sample and 52 (74%) of the 70 baseline controls, for a total of 112 students for the impact analyses. Data attrition for the seventh-grade sample also was statistically equivalent across treatment and control, $\chi^2(1, N = 274) = 1.96$, $p = 0.16$, leaving 90 (65%) of the 139 treatment students from the baseline sample and 98 (73%) of the 135 baseline controls, for a total of 188 students for the impact analyses. Furthermore, the pretest scores, regular school year attendance rates, baseline survey outcomes, and gender, ethnicity, and free-lunch status of treatment and control students retained for the analyses were statistically equivalent. In this respect, the equivalence of the experimental and control samples produced through randomization was not undermined by pretest-to-posttest data attrition.

Finally, to assess the external validity of the study, we looked at whether treatment and control students lost from the sample due to data attrition systematically differed from students who remained in the sample in their (a) background characteristics, (b) 1999–2000 school attendance, and (c) teacher-appraised language skills. The results revealed two differences between seventh-grade students with complete and incomplete data. First, the average teacher survey score for seventh-grade students with complete data was lower ($M = 32.20$, $SD = 9.91$) than that for students with incomplete data ($M = 36.81$, $SD = 9.28$). This difference was statistically significant, $t(272) = 3.64$, $p < .001$ (two-tailed), indicating that those who remained in the seventh-grade analytical sample were more skilled at language than their counterparts who were omitted from the analytic sample due to incomplete data. Similarly, the seventh-grade students with complete data had attended school at a higher rate ($M = 0.92$, $SD = .07$) than students with incomplete data ($M = 0.85$, $SD = 0.11$) during the preceding school year, $t(272) = -6.94$, $p < .001$ (two-tailed). We found no statistically significant differences between second-grade students with complete and incomplete pretest-posttest data.

Though the differences for the seventh-grade sample may compromise the external validity of our analysis to some extent, there is no conflict in this experiment between random assignment of treatment and missing at random. That is, among the complete data observations, the covariate distributions of students assigned to treatment are similar to those of students assigned to control. As noted by Rubin (1976) and Little and Rubin (1987), the missing data process is *ignorable* if, conditional on treatment and fully observed covariates, the data are *missing at random* (MAR).

Implementation of the intervention. After randomization, students selected for treatment were offered the Fast ForWord Language program in school resource rooms designed to accommodate the students, computers, and software. Treatment students attended Fast ForWord training as a targeted pullout program offered during the regular school day. In general, while treatment students were pulled out of their regular classrooms for the Fast ForWord training, control students received non-literacy instruction or participated in special activities and classes, such as art and gym. In this way, Fast ForWord typically supplemented the regular classroom literacy instruction afforded treatment students.

We conducted three brief site visits, during the 1st, 3rd, and 5th weeks of the program, at each of the eight schools implementing Fast ForWord Language. We used a checklist based on the Scientific Learning Corporation's Site Compliance Guide to ascertain the quality of the program implementation at each site.[6] Following the protocols established in the Site Compliance Guide, we ensured that the computers and training rooms complied with the requirements specified by Scientific Learning. By noting each site's compliance with the requirements, we were able to ascertain that each school had achieved a basic level of program implementation. Additional questions on our Fast ForWord Site Observation Form targeted (a) the level of overall support for implementation that school personnel received from Scientific Learning and the school system, (b) particular problems with the implementation, and (c) if problems occurred, the remedies undertaken to address them.

Before the start of the program, Scientific Learning provided a thorough training session for all teachers operating the programs at the eight BCPSS schools. Each of the computer labs

[6] We consulted the Site Compliance Guide dated May 25, 2001, which is available from the developer, Scientific Learning.

was well equipped with online computers containing adequate memory and RAM. Each training room had adequate lighting and presented limited visual and auditory distractions. At each school, there were more than adequate numbers of headphones for all students and teachers. The headphones had padded headbands and ear cups that covered the entire ear to maximize hearing. Although each computer did not necessarily have a Y-adapter to facilitate listening in by the Fast ForWord trainer, multiple adapters were available for trainers to use as the need arose. In two schools, Y-adapters were not necessary, as the computers had connections for more than one set of headphones. All of the teachers reported success in connecting to Scientific Learning servers to receive the daily updated student portfolios.

A representative from Scientific Learning had visited each of the eight schools to oversee the initial implementation. None of the teachers expressed anything negative about the level of the support they were receiving from the district or from Scientific Learning, and only a few implementation problems were reported during our site visits. At one elementary school, a temporary problem with the sound related to a software malfunction occurred on six of the computers. At one of the middle schools, implementation started a week later than scheduled because of problems with the Internet connection; in that instance, the staff from Scientific Learning, in cooperation with the technical staff from the district, were eventually successful in getting the computers online. At another school, the Fast ForWord demonstration program had to be used during the first week of implementation. Also, due to a corrupted file on one of the computers, the trainer had to access the exercises for the students manually. Aside from these minor and temporary problems, the software and Internet connections functioned properly.

Fast ForWord attendance, compliance, and completion data. We obtained data from the Scientific Learning Corporation regarding the progress each student was making in the Fast ForWord program. The company measures progress in three ways: (a) the overall number of training sessions attended by the student; (b) the student's compliance with the suggested program schedule; and (c) the student's exercise completion rate. As noted earlier, Scientific Learning recommends that elementary students train on Fast ForWord Language for 100 minutes per day, 5 days per week, for a minimum of 20 days, and that middle and high school students train for 90 minutes per day, 5 days per week, for a minimum of 20 days.

The Fast ForWord compliance measure provides a single value that indicates how closely a student is following the recommended training schedule. It is calculated by dividing the total minutes a student has trained by the total minutes a student should have trained, as recommended by the developer. For example, a student who trains 100 minutes per day 4 days a week will have a compliance percentage of 80%, and a student who trains 5 days a week but leaves the Fast ForWord Language classroom 30 minutes early every day will have a compliance rate of 70%. Thus, compliance provides an important estimate of how diligently the students and the school are following the suggested training schedule.

In addition, the completion percentage is provided for each exercise. For exercises that have processed speech, a completion percentage of 80% or more indicates normal speech. As a summary measure of each student's mastery of the program content, the completion percentage is averaged across all of the exercises. According to data provided by the developer, the national average completion percentage across nearly 30,000 students was 70%.

Results

Data analysis began with a screening of students' pretest and posttest data. This analysis revealed substantial drops in some students' scores from pretest to posttest. These achievement losses fell outside the bounds of what one might expect, given the reliability of the tests being used and the rather short time between the pretests and the posttests. To identify outliers for removal from the analytic sample, we regressed posttest scores on the key variables in the analyses (i.e., pretest score; teacher survey score; gender, race, and free-lunch status), with the exception of the treatment and compliance variables. After obtaining the regression coefficients, we computed Cook's Distance statistic, *D*, for each observation from the two analyses of language and reading comprehension outcomes. Cook's *D* expresses both distance from the mean and leverage exerted upon regression coefficients. A case is considered a highly influential outlier if the value of *D* exceeds 4/*n* (Cook, 1977).

The study participants who exceeded this threshold tended to be students with average to slightly above-average skills, as indicated by the teacher survey, who experienced precipitous pretest-to-posttest declines in their achievement scores. When the *D* exceeded 4/*n* for either or both of the analyses, we eliminated the observation from the analytic sample. This procedure resulted in the elimination of 6 second-grade students, 2 from the experimental group and 4 from the control group, and 13 seventh-grade students, 8 from the experimental group and 5 from the control group. The outlier analysis removed students from the sample whose performance on the posttest was not credible, given their pretest performance, but making these changes to our sample had little effect on our findings.[7]

Our primary estimates of the Fast ForWord program impacts were derived from intention-to-treat analyses. Regardless of the experimental students' actual compliance with the Fast ForWord schedule and exercise completion rate, these analyses compared all students assigned to the experimental condition—those who were intended to receive the treatment—to all those assigned to the control condition. In experiments with imperfect compliance with the intervention's regimen, such as this one, the ITT effect represents only the impact of *assignment* to the treatment. This ITT effect provides a reasonable estimate of the overall effects on achievement that can be expected in the field when schools implement a Fast ForWord program with the typical less-than-perfect student attendance and participation.

Additional analyses specifically addressed program attendance, compliance, and completion and the ways in which they may have influenced students' achievement outcomes. These analyses utilized an instrumental variables approach for estimating the treatment effect for the treated (Angrist et al., 1996). In this formulation, assignment to treatment was modeled as an instrument for actual participation. Assignment to the Fast ForWord treatment, although determined randomly, did co-vary with actual participation in the program, but was not correlated with the error term in the outcome equation because it was determined randomly. Under reasonable assumptions, the instrumental variables model yields a precise and consistent estimate of the effect of "treatment on the treated." In our analyses, the second-stage, or

[7] All regression analyses were run with and without the outliers, for both the language and reading comprehension outcomes. In general, regressions run prior to the removal of outliers produced coefficients equivalent in sign and similar in size to those presented in Tables 4 and 5.

outcome, equation was represented by models that included the following three mediator variables measuring actual participation and compliance with the treatment: (a) the number of days trained in the Fast ForWord classroom; (b) the student's compliance rate; and (c) the completion rate.

Analyses of Intention-to-Treat Effects

Table 3 summarizes the pretest-to-posttest performance of control and Fast ForWord students on the reading comprehension and language assessments. This table presents simple pretest-posttest change scores expressed in NCE points. These change scores represent the number of NCE points students gained or lost from the pretest to the posttest. The impacts on language gains for the second-grade sample and on reading comprehension gains for the seventh-grade sample were positive and modest in magnitude. For second graders, treatment students outperformed the controls by approximately one quarter of a standard deviation, and for seventh graders, the Fast ForWord students gained nearly one fifth of a standard deviation more than controls. To test for statistically significant treatment-control differences on the outcomes, we calculated one- and two-tailed independent sample *t*-tests for each set of change scores. These small differences favoring the treatment group did not attain conventional levels of statistical significance.

Tables 4 and 5 summarize a series of ordinary least squares regression models that tested main effects and interaction effects of treatment assignment on achievement. Table 4 presents results for the second-grade cohort, and Table 5, for the seventh-grade cohort. These models included measures of student background as covariates, which helped improve the precision of the Fast ForWord impact estimates, and they applied Huber-White robust covariance matrices and standard errors for all model estimates and statistical tests of significance (White, 1980). Typical statistical methods assume that observations are obtained from a simple or probability sample, but due to our initial sampling and randomization of students from within the school-specific clusters, White's method was appropriate.

Model I regressed language and reading posttest scores on the following set of covariates: pretest; teacher-rated speech/auditory/language difficulties; grade level; gender; free-lunch status; African American; and a series of dummy codes representing fixed effects for each school. Model II included these covariates along with an indicator of treatment assignment (i.e., Fast ForWord or control). Models III and IV added interaction terms for, respectively, Treatment × Pretest and Treatment × Teacher-Rated Speech/Auditory/Language Difficulties.

In Table 4, the regression models showed no statistically significant differences between second-grade experimental and control students' language and reading comprehension outcomes and revealed no interaction effects. As indicated by the results for Model II, there were small but non–statistically significant differences for treatment assignment that favored the Fast ForWord group with respect to the language outcome, 1.11 NCE points, but that favored the control group by 2.18 NCEs for reading comprehension. Models III and IV in Table 4 showed no interaction effects for, respectively, Treatment × Pretest and Treatment × Teacher Survey.

The results for seventh-grade students displayed in Table 5 revealed no statistically significant main effects of treatment assignment. As shown in Model II, the effect of Fast

ForWord assignment on language outcomes was 0.38 NCE points, and the impact estimate of 2.96 NCEs for reading comprehension was slightly less than twice its standard error. Model III indicated no Treatment × Pretest interaction, and the results for Model V indicated no Treatment × Teacher Survey interaction.[8]

Fast ForWord Attendance, Compliance, and Completion Data

Two keys to the success of the Fast ForWord program are, of course, diligent attendance by the students in the program and successful completion of the program's exercises. Table 6 documents attendance, compliance, and completion data for the second- and seventh-grade treatment samples. The column labeled "Attended Fast ForWord program" reports the percentage of treatment students who attended at least one day of the program. These data show that turnout for the program was close to 100%.

The next column in Table 6 documents the average number of days of training that students received. With an average of more than 23 days of training for second graders and more than 20 days for seventh graders, both cohorts exceeded the minimum standard of 20 days recommended by the developer. The next columns present the compliance and completion data for Fast ForWord students. Compliance was reasonably high, as both second- and seventh-grade students trained for approximately 77% of their allotted minutes, on average. Finally, second graders, on average, completed fewer exercises, 61%, than seventh graders, 71%. Thus, in this case, seventh graders met the national average of 70% cited by Fast ForWord, but second graders did not.

In addition to the means and standard deviations reported for days of training, compliance, and completion, Table 6 indicates the number and percentage of students achieving the Fast ForWord standards for each of these outcomes. As suggested by the data presented in Table 6, the clear majority of students met or exceeded the Fast ForWord standards of 20 days of training, a compliance rate of over 70%, and a completion rate of over 70%. The one exception was for second-grade students, of whom only 30% met the standard for the Fast ForWord completion rate. Therefore, in general, student attendance, completion, and compliance were sufficient to meet Fast ForWord standards. Most students attended the program, persevered for the required number of weekly minutes, and successfully completed the exercises. Despite generally high attendance and compliance, though, many second-grade students experienced difficulty meeting the exercise completion standard of 70%.

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[8] Statistical power analyses showed that the second- and seventh-grade sample sizes were more than adequate to detect an effect equivalent to one quarter of one standard deviation or greater. With the covariates in our model accounting for a minimum of one third of the variability on the posttest, an alpha level of $p < .05$, and assuming an effect size of $d = 0.25$, power exceeded 0.80 with a total sample of $n = 100$, with 50 treatment students and 50 controls. Although the effect size standard we have chosen is relatively small, it has generally been deemed of practical educational importance (Slavin, 1990). It is also considerably smaller than the effect of approximately $d = 0.80$ that was claimed by the Fast ForWord developer (Rouse & Krueger, 2004).

Causal Effects of Program Participation

Tables 7 and 8 summarize the outcomes from a series of two-stage least squares regression models estimated with Huber-White robust standard errors, which corrected for the clustering associated with sampling and randomizing students from within the four elementary school clusters and seven middle school clusters. In these models, assignment to treatment was modeled as an instrument for actual participation, with participation measured by (a) days of training; (b) compliance rate; and (c) completion rate. We employed the same set of covariates as in the previous regression models for the ITT effects.

Table 7 presents the results for second-grade students across all three treatment definitions: days of training, compliance rate, and completion rate. The coefficients estimated across the reading comprehension and language measures and across all three definitions of treatment did not reach conventional levels of statistical significance. Therefore, second-grade students who received more treatment did not show statistically detectable literacy effects as measured by the CTBS/5.

The results for seventh graders shown in Table 8 indicated statistically significant effects of participation on reading comprehension for each of the three treatment definitions. For each additional 7 days of training attended, students gained approximately 1 NCE point (1.05 NCEs). Similarly, an advantage of approximately 1 NCE point was linked to each increase of 25 percentage points in the compliance rate (0.97 NCEs) and completion rate (1.05 NCEs).

Discussion

In some ways, the results of this study are perplexing. From the beginning, the implementation of the program and the level of support from within the school system and from the program developer, Scientific Learning Corporation, were exemplary. Site visits, observations of the training, communications with Scientific Learning, and communications with the teachers and principals implementing Fast ForWord revealed a consistent level of commitment and support across district leadership, school-level leaders, the schools' teaching staff, and representatives from Scientific Learning. Nevertheless, impact analyses of assignment to the Fast ForWord program revealed few encouraging signs of academic benefits approaching those claimed by the program's developer. Thus, the results raise several questions regarding the potential and the appropriateness of Fast ForWord for improving reading and language outcomes for non-clinical, at-risk student populations served in school-based settings.

There are several plausible explanations for our findings. First, and most important, although the majority of students who were served by the program met the developer's standards for Fast ForWord attendance, compliance, and completion, a sizeable proportion did not. These outcomes are consistent with those reported by Rouse and Krueger (2004), the authors of the only other randomized evaluation of Fast ForWord conducted independently of the Scientific Learning Corporation. Rouse and Krueger also evaluated school-based implementations of the program within a large urban school district in the Northeast. Across two successive waves of implementation, the authors noted that only 67% to 76% of students attended the requisite 20 days of training and only 38% to 51% completed a sufficient proportion of the exercises. Though we observed somewhat higher attendance and completion rates, this result is likely a function of the fact that students in our study had 8 weeks of potential training days as compared with 7 weeks in the Rouse and Krueger (2004) study.

One of the most common difficulties at the schools in our study, and particularly the middle schools, was student scheduling for Fast ForWord training. At one school, for instance, it took nearly 2 weeks before all regular classroom teachers fully understood the new schedule and consistently sent students to Fast ForWord at the appointed time. In addition, students at times resisted attending when it meant missing physical education or other electives.

A final challenge for the Fast ForWord teachers in our study was simply motivating the students to come to the resource room and do the work. In four of the eight schools, teachers reported that students were initially excited about the training but soon complained of being bored by the repetitive nature of the activities. This pattern was most prevalent among the seventh-grade students. At one middle school, some students complained that the computer graphics were “babyish” and that their assignment to the program made them feel “stupid.” The token economy rewards and consistent words of encouragement from teachers were important sources of external motivation that helped students remain fairly motivated and on task.

The null effect of Fast ForWord Language for elementary and middle school students is certainly policy-relevant in its own right, but this average effect of the intent to treat is best understood as an amalgam of treatment effects for those who completed the training with greater and lesser success. Our supplementary analyses, which examined the causal effects of participation, revealed that when the middle school teachers and students remained committed and more faithfully achieved the participation standards set by Scientific Learning Corporation, the students exhibited statistically significant improvements in reading comprehension. Though evidence from this study and from the study conducted by Rouse and Krueger (2004) suggests that the demanding Fast ForWord training regimen can be difficult to schedule and implement in school-based settings, our results provide some evidence to suggest that when the program is successfully carried out, students’ literacy outcomes can improve.

A second explanation for the null results from our ITT analyses may be that Fast ForWord Language is designed to help students with very specific and profound learning problems, and our more generally at-risk sample included relatively few such students. The real strength of the Fast ForWord research base and the theory behind the program lies in the program’s application to children with speech, auditory, and language difficulties. The program’s potential impact on a more general population of educationally at-risk students is less well established. On the one hand, the Aptitude × Treatment interaction effects that we tested revealed no reliable differences in program impacts across students with varying levels of pre-program reading achievement and language difficulties. On the other hand, the language-impaired students who experienced large effects in past studies by Merzenich et al. (1996) and Temple et al. (2003) represent a very small subpopulation from this larger population of students at risk for poor literacy outcomes.

The final explanation for our findings relates to the outcomes we elected to measure. This study examined program effects on achievement tests typically used by school systems for accountability purposes, rather than effects on oral language competencies, which may be most directly affected by Fast ForWord Language. It is possible that the treatment students in our sample realized some important improvements in their language skills that the CTBS/5 was not sensitive enough to measure. However, the expectation that Fast ForWord Language can improve students' outcomes on state assessments and standardized norm-referenced tests of various literacy outcomes—including comprehension, language, oral reading fluency, and vocabulary—is supported by the results presented on the developer's Web site (see www.scilearn.com/results/main=home/rd). Indeed, BCPSS leaders, who provided input into the design of our study, were most interested in Fast ForWord's effects on achievement assessments such as the CTBS/5, which had important consequences for students and schools in the district.

Conclusion

The above alternative explanations notwithstanding, the results from this experimental study suggest that the Fast ForWord Language program did not, in general, help students in the eight participating BCPSS schools improve their language and reading comprehension outcomes. This finding raises questions about the appropriateness of Fast ForWord Language training for school-based populations of educationally at-risk students, especially if the key outcome of interest is improvement on district- or state-administered standardized tests used for accountability purposes.

Our results also raise questions about the viability of scheduling and implementing the demanding training schedule of 90–100 minutes per day, five times per week in an urban school setting. In most respects, ours was an exemplary implementation of a school-based educational program. However, as the positive achievement results for those seventh graders with better Fast ForWord participation rates suggest, only a high level of day-to-day perseverance by teachers and students is likely to pay dividends in improved literacy outcomes.

Finally, though those students assigned to Fast ForWord Language in our study did not realize reliable achievement advantages over controls in the short term, we do not know whether these students will realize gains in the longer term. We also do not know what, if any, other skills Fast ForWord students may have improved. Are there more specific subgroups of students for which the program is especially well suited? Is it possible for BCPSS schools, and other urban schools in general, to achieve more consistent student participation in the program and higher completion rates? While these questions merit further research, we find reasons to be skeptical about the applicability of this program to the broad population of students experiencing difficulties with reading and language skills.

References

Angrist, J. D., Imbens, G. W., & Rubins, D. B. (1996). Identification of causal effects using instrumental variables (with discussion). *Journal of the American Statistical Association, 91,* 444–472.

Borman, G. D. (2003). Experiments for educational evaluation and improvement. *Peabody Journal of Education, 77*(4), 7–27.

Cook, R. D. (1977). Detection of influential observations in linear regression. *Technometrics, 19,* 15–18.

Cronbach, L. J., Ambron, S. R., Dornbusch, S. M., Hess, R. D., Hornik, R. C., Phillips, D. C., et al. (1980). *Toward reform of program evaluation: Aims, methods, and institutional arrangements.* San Francisco: Jossey-Bass.

Gillam, R. B. (1999). Computer-assisted language intervention using Fast ForWord: Theoretical and empirical considerations for clinical decision-making. *Language, Speech, and Hearing Services in Schools, 30,* 363–370.

Little, R. J. A., & Rubin, D. B. (1987). *Statistical analysis with missing data.* New York: John Wiley.

Merzenich, M. M., Jenkins, W. M., Johnston, P., Schreiner, C., Miller, S. L., & Tallal, P. (1996). Temporal processing deficits of language-learning impaired children ameliorated by training. *Science, 271,* 77–81.

Reed, M. A. (1989). Speech perception and the discrimination of brief auditory cues in reading disabled children. *Journal of Experimental Child Psychology, 48,* 270–292.

Rouse, C. E., & Krueger, A. B. (2004). Putting computerized instruction to the test: A randomized evaluation of a "scientifically-based" reading program. *Economics of Education Review, 23,* 323–338.

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

Scientific Learning Corporation. (2002). *2001 annual report*. Oakland, CA: Author.

Slavin, R. E. (1990). IBM's Writing to Read: Is it right for reading? *Phi Delta Kappan, 72*(3), 214–216.

Tallal, P. (1980). Auditory temporal perception, phonics, and reading disabilities in children. *Brain and Language, 9,* 182–198.

Tallal, P., Miller, S. L., Bedi, G., Byma, G., Wang, X., Nagarajan, S. S., et al.(1996). Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science, 271,* 81–84.

Temple, E., Deutsch, G., Poldrack, R., Miller, S., Tallal, P., Merzenich, M., et al. (2003). Neural deficits in children with dyslexia ameliorated by behavioral remediation: Evidence from functional MRI. *Proceedings from the National Academy of Sciences*, *100,* 2860–2865.

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica*, *48,* 817–830.

Table 1

Summary of Sampling Frame

	Second grade		Seventh grade					
School	Eligible students	Selected for program	Eligible students	Selected for program	Selection probability	Total eligible	Total selected for program	Total controls
A	66	33			0.50	66	33	33
B			39	20	0.51	39	20	19
C			54	27	0.50	54	27	27
D	28	14	32	16	0.50	60	30	30
E	25	13	33	17	0.52	58	30	28
F			20	10	0.50	20	10	10
G	22	11	33	17	0.52	58	30	28
H			63	32	0.51	63	32	31
Total	141	71	274	139	0.51	415	210	205

Table 2
Comparison of Background Data for Students in Experimental and Control Groups

		Family background							School participation & skills	
	n	Male %	Nat Am[a] %	Asian %	Af Am[b] %	White %	Latino %	Free lunch %	Attend *M* (*SD*)	Survey *M* (*SD*)
Second grade										
Total sample										
Experimental	71	52.1	0.0	0.0	88.7	11.3	0.0	73.2	0.93 (0.07)	35.87 (10.31)
Control	70	51.4	0.0	0.0	90.0	8.6	1.4	74.3	0.93 (0.06)	37.01 (9.40)
Analytic sample										
Experimental	60	51.7	0.0	0.0	91.7	8.3	0.0	75.0	0.93 (0.06)	35.50 (10.40)
Control	52	55.8	0.0	0.0	94.2	5.8	0.0	75.0	0.93 (0.06)	36.20 (8.37)
Seventh grade										
Total sample										
Experimental	139	50.4	0.7	0.7	66.9	30.2	1.4	79.1	0.90 (0.09)	33.74 (9.91)
Control	135	48.2	1.5	1.5	68.2	27.4	1.5	83.0	0.90 (0.09)	33.56 (10.00)
Analytic sample										
Experimental	90	45.6	0.0	1.1	63.3	34.4	1.1	73.3	0.93 (0.07)	32.67 (10.24)
Control	98	45.9	2.0	1.0	66.3	29.6	1.0	84.7	0.92 (0.07)	31.78 (9.64)

[a]Nat Am = Native American. [b]Af Am = African American.

Table 3
Pretest, Posttest, and Pre-Post Change Scores for Language and Reading Comprehension Outcomes for Second-Grade (n = 112) and Seventh-Grade (n = 188) Students

Outcome		Second grade		Seventh grade	
		Fast ForWord	Control	Fast ForWord	Control
Language NCE scores					
Pretest	*M*	42.78	44.52	33.42	33.16
	(*SD*)	(17.88)	(15.05)	(18.04)	(17.24)
Posttest	*M*	36.53	35.26	40.67	40.14
	(*SD*)	(11.04)	(12.07)	(11.22)	(11.59)
Change score	*M*	-6.25	-9.25	7.24	6.98
	(*SD*)	(15.13)	(14.24)	(17.45)	(14.23)
Effect size	*d*	0.26		0.02	
Reading NCE scores					
Pretest	*M*	41.98	41.12	38.06	36.73
	(*SD*)	(16.39)	(12.54)	(12.26)	(13.75)
Posttest	*M*	33.41	34.56	38.12	34.03
	(*SD*)	(15.90)	(12.44)	(14.11)	(14.92)
Change score	*M*	-8.57	-6.55	0.06	-2.70
	(*SD*)	(15.91)	(13.66)	(11.78)	(11.18)
Effect size	*d*	-0.14		0.19	

Table 4

Summary of Regression Analyses of the Effects of Assignment to Fast ForWord Treatment on Language and Reading Comprehension Outcomes for Second-Grade Students (n = 112)

	Model I		Model II		Model III		Model IV	
	Language	Reading	Language	Reading	Language	Reading	Language	Reading
Constant	26.52***	24.48***	25.72***	25.73***	23.99***	25.66***	25.71***	26.20***
	(4.47)[a]	(5.85)	(4.69)	(5.70)	(6.02)	(6.98)	(4.77)	(5.65)
Pretest	0.28***	0.35***	0.29***	0.35***	0.33**	0.29*	0.29***	0.35***
	(0.06)	(0.07)	(0.06)	(0.07)	(0.11)	(0.14)	(0.06)	(0.07)
Teacher survey	-2.77**	-4.21**	-2.72*	-4.25**	-2.75*	-4.31**	-2.70	-5.33*
	(1.04)	(1.38)	(1.05)	(1.39)	(1.06)	(1.42)	(1.71)	(2.24)
Gender (male = 1)	-0.34	0.30	-0.29	0.21	-0.26	0.38	-0.30	0.43
	(1.77)	(2.39)	(1.77)	(2.37)	(1.77)	(2.37)	(1.82)	(2.35)
Free lunch eligible	4.14	3.15	4.08	3.26	4.06	3.44	4.09	2.96
	(2.41)	(3.37)	(2.43)	(3.41)	(2.42)	(3.49)	(2.49)	(3.48)
African American	-9.06**	-8.99*	-8.96**	-9.19*	-9.32**	-8.84*	-8.96**	-9.22*
	(3.03)	(3.89)	(3.06)	(3.91)	(3.12)	(3.90)	(3.08)	(3.91)
Treatment			1.11	-2.18	4.52	-5.79	1.11	-2.39
			(1.76)	(2.29)	(5.94)	(6.86)	(1.77)	(2.17)
Treatment × pretest					-0.08	0.09		
					(0.12)	(0.15)		
Treatment × teacher survey							-0.04	1.66
							(2.02)	(2.64)
School 2	5.33	4.49	5.29	4.61	5.25	4.61	5.29	4.55
	(2.91)	(4.25)	(2.91)	(4.20)	(2.90)	(4.25)	(2.94)	(4.16)
School 3	4.18	-0.11	4.19	-0.09	4.07	-0.23	4.20	-0.49
	(2.28)	(2.88)	(2.31)	(2.84)	(2.29)	(2.85)	(2.44)	(2.85)
School 4	7.80*	3.87	7.73*	3.98	7.62*	4.16	7.73*	3.69
	(3.12)	(3.20)	(3.16)	(3.31)	(3.16)	(3.35)	(3.20)	(3.33)
R^2	0.40	0.33	0.41	0.34	0.41	0.34	0.41	0.34

[a]Robust *SE*s in parentheses.
***$p < .001$. **$p < .01$. *$p < .05$.

Table 5

Summary of Regression Analyses of the Effects of Assignment to Fast ForWord Treatment on Language and Reading Comprehension Outcomes for Seventh-Grade Students (n = 188)

	Model I		Model II		Model III		Model IV	
	Language	Reading	Language	Reading	Language	Reading	Language	Reading
Constant	33.72***	14.62***	33.47***	12.88***	31.70***	12.00**	33.39***	12.68***
	(2.46)[a]	(3.38)	(2.47)	(3.40)	(2.60)	(3.85)	(2.49)	(3.37)
Pretest	0.15**	0.62***	0.15**	0.61***	0.21***	0.64***	0.15**	0.62***
	(0.04)	(0.07)	(0.04)	(0.07)	(0.05)	(0.08)	(0.04)	(0.06)
Teacher survey	-3.96***	-2.24**	-3.97***	-2.33**	-3.84***	-2.31**	-3.50**	-1.38**
	(0.87)	(0.84)	(0.87)	(0.84)	(0.88)	(0.84)	(1.16)	(1.27)
Gender (male = 1)	-4.64**	-3.75*	-4.63**	-3.70*	-4.62**	-3.68*	-4.63**	-3.70*
	(1.39)	(1.47)	(1.39)	(1.46)	(1.38)	(1.46)	(1.40)	(1.46)
Free lunch eligible	-0.97	-4.21*	-0.90	-3.73*	-0.97	-3.84*	-0.85	-3.64*
	(1.73)	(1.61)	(1.74)	(1.65)	(1.72)	(1.61)	(1.75)	(1.66)
African American	1.00	-1.30	1.03	-1.11	0.88	-1.13	1.06	-1.09
	(1.34)	(1.86)	(1.34)	(1.84)	(1.35)	(1.86)	(1.36)	(1.84)
Treatment			0.38	2.96	3.83	5.14	0.18	2.53
			(1.27)	(1.51)	(2.87)	(4.65)	(1.37)	(1.63)
Treatment × pretest					-0.10	-0.06		
					(0.08)	(0.11)		
Treatment × teacher survey							-0.86	-1.76
							(1.51)	(1.54)
School 2	-2.40	2.69	-2.38	2.82	-2.13	2.94	-2.35	2.89
	(2.01)	(2.52)	(2.01)	(2.47)	(2.02)	(2.46)	(2.03)	(2.50)
School 3	-0.91	-5.22	-0.95	-5.50	-0.72	-5.38	-0.89	-5.40
	(2.84)	(3.23)	(2.84)	(3.14)	(2.90)	(3.17)	(2.84)	(3.17)
School 4	2.50	6.72*	2.45	6.36*	2.72	6.40*	2.50	6.45*
	(2.42)	(2.83)	(2.43)	(2.85)	(2.44)	(2.86)	(2.45)	(2.81)
School 5	13.26***	9.61**	13.27***	9.78**	13.22***	9.81**	13.26***	9.75**
	(2.24)	(2.89)	(2.25)	(2.85)	(2.26)	(2.84)	(2.23)	(2.84)
School 6	5.94	9.59*	5.92	9.43*	6.14*	9.60*	5.96	9.51*
	(3.20)	(4.63)	(3.18)	(4.72)	(3.10)	(4.81)	(3.20)	(4.66)
School 7	3.46	4.84	3.44	4.68	3.56	4.69	3.54	4.91
	(1.92)	(2.79)	(1.92)	(2.71)	(1.95)	(2.73)	(1.90)	(2.66)
R^2	0.45	0.55	0.45	0.56	0.46	0.56	0.45	0.56

[a]Robust *SE*s in parentheses.
***$p < .001$. **$p < .01$. *$p < .05$.

Table 6

Summary of Fast ForWord Attendance, Compliance, and Completion Data

		Attended Fast ForWord program	Days of Fast ForWord training		Fast ForWord compliance rate		Fast ForWord completion rate	
				Met standard		Met standard		Met standard
	N	*N* %	*M* (*SD*)	*N* %	*M* (*SD*)	*N* %	*M* (*SD*)	*N* %
Second grade	60	60 100%	23.2 (3.75)	51 85.0%	77.4 (15.0)	43 71.7%	61.0 (16.8)	18 30.0%
Seventh grade	90	89 98.9%	20.2 (5.79)	58 64.4%	76.2 (15.8)	63 70.0%	71.1 (16.6)	65 72.2%

Table 7

Summary of Two-Stage Least Squares Regression Estimates of the Effects of Alternative Treatment Definitions on Language and Reading Comprehension Outcomes for Second-Grade Students (n = 112)

	Days of training		Compliance rate		Completion rate	
	Language	Reading	Language	Reading	Language	Reading
Constant	25.85***	25.54***	25.84***	25.44***	26.00***	25.48***
	(4.65)[a]	(5.71)	(4.66)	(5.67)	(4.62)	(5.70)
Pretest	0.29***	0.35***	0.28***	0.35***	0.28***	0.35***
	(0.06)	(0.08)	(0.06)	(0.08)	(0.06)	(0.08)
Teacher survey	-2.71*	-4.28**	-2.72***	-4.26**	-2.73*	-4.29**
	(1.05)	(1.39)	(1.05)	(1.40)	(1.05)	(1.39)
Gender (male = 1)	-0.30	0.22	-0.30	0.22	-0.34	0.28
	(1.77)	(2.37)	(1.78)	(2.36)	(1.79)	(2.38)
Free lunch eligible	4.09	3.24	4.07	3.26	4.09	3.21
	(2.44)	(3.39)	(2.44)	(3.39)	(2.42)	(3.42)
African American	-9.00**	-9.11*	-8.97*	-9.17*	-8.96**	-9.20*
	(3.06)	(3.90)	(3.07)	(3.87)	(3.06)	(3.92)
Training	0.05	-0.09				
	(0.08)	(0.10)				
Compliance			1.43	-2.83		
			(2.29)	(2.97)		
Completion					1.80	-2.83
					(2.88)	(2.97)
School 2	5.26	4.65	5.14*	4.90	5.21	4.69
	(2.91)	(4.20)	(2.89)	(4.22)	(2.89)	(4.21)
School 3	4.16	-0.04	4.06	0.18	4.12	0.01
	(2.31)	(2.84)	(2.29)	(2.83)	(2.29)	(2.84)
School 4	7.64*	4.13	7.65*	4.11	7.62*	4.20
	(3.17)	(3.35)	(3.17)	(3.34)	(3.19)	(3.40)
R^2	0.40	0.34	0.40	0.42	0.40	0.33

[a]Robust *SE*s in parentheses.
****p* < .001. ***p* < .01. **p* < .05.

Table 8

Summary of Two-Stage Least Squares Regression Estimates of the Effects of Alternative Treatment Definitions on Language and Reading Comprehension Outcomes for Seventh-Grade Students (n = 188)

	Days of training		Compliance rate		Completion rate	
	Language	Reading	Language	Reading	Language	Reading
Constant	33.46***	12.81***	33.45***	12.91***	33.44***	12.79***
	(2.48)[a]	(3.43)	(2.48)	(3.41)	(2.49)	(3.42)
Pretest	0.15***	0.61***	0.15***	0.61***	0.15***	0.61***
	(0.04)	(0.07)	(0.04)	(0.07)	(0.04)	(0.07)
Teacher survey	-3.98***	-2.40**	-3.97***	-2.39**	-3.97***	-2.38**
	(0.88)	(0.85)	(0.87)	(0.84)	(0.88)	(0.85)
Gender (male = 1)	-4.63***	-3.72*	-4.62***	-3.61*	-4.63***	-3.70*
	(1.39)	(1.47)	(1.39)	(1.47)	(1.39)	(1.46)
Free lunch eligible	-0.88	-3.55*	-0.90	-3.73*	-0.87	-3.51*
	(1.74)	(1.67)	(1.74)	(1.66)	(1.74)	(1.67)
African American	1.02	-1.24	1.03	-1.17	1.03	-1.14
	(1.35)	(1.84)	(1.34)	(1.84)	(1.34)	(1.83)
Training	0.02	0.15*				
	(0.06)	(0.07)				
Compliance			0.50	3.88*		
			(1.67)	(1.98)		
Completion					0.54	4.21*
					(1.81)	(2.14)
School 2	-2.39	2.80	-2.39	2.79	-2.36	3.03
	(2.02)	(2.47)	(2.01)	(2.45)	(2.01)	(2.46)
School 3	-0.94	-5.39	-0.94	-5.43	-0.94	-5.41
	(2.85)	(3.13)	(2.84)	(3.14)	(2.85)	(3.11)
School 4	2.50	6.82*	2.45	6.42*	2.49	6.71*
	(2.41)	(2.83)	(2.42)	(2.85)	(2.41)	(2.83)
School 5	13.26***	9.73***	13.26***	9.81***	13.27***	9.85***
	(2.25)	(2.87)	(2.24)	(2.86)	(2.25)	(2.85)
School 6	5.98	9.95*	5.96	9.74*	5.96	9.74*
	(3.23)	(4.79)	(3.19)	(4.75)	(3.20)	(4.78)
School 7	3.48	5.03	3.45	4.83	3.42	4.56
	(1.92)	(2.72)	(1.92)	(2.71)	(1.93)	(2.70)
R^2	0.45	0.56	0.45	0.56	0.45	0.56

[a]Robust *SE*s in parentheses.
***$p < .001$. **$p < .01$. *$p < .05$.