THE EARLY YEARS

Algorithm-Guided Individualized Reading Instruction

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Reading instruction benefits from a computerized intervention.

Reading and writing are among the most important skills in today's information-driven world. Yet, according to the National Assessment of Educational Progress (*1*), more than one-third of children in the United States lack fundamental reading skills. This rate is even higher for children living in poverty. Illiteracy is a society-wide and costly problem and is associated with increased rates of grade retention, referral to special education, high school dropout, and juvenile delinquency (*2*). Many children fail to reach proficient levels in reading only because they do not receive the amount and type of instruction they need (*3*–*5*).

Much of the controversy regarding the best way to teach children how to read has focused on whether instruction should be code-based, such as phonics, or based on whole language and meaning (*6*–*8*), but this debate may miss the point. Although most children develop stronger reading skills when they receive a balance of explicit decoding instruction in combination with meaningful reading activities (*7*, *9*–*12*), even a balanced approach theory assumes that one approach, if it is the right one, will be equally effective for all children (*13*, *14*). Instead, the efficacy of any particular instructional practice may depend on the skill level of the student. Instructional strategies that help one student may be ineffective when applied to another student with different skills (*15*–*21*).

About the Intervention

In a previous study, children who began first grade with below-average letter-word reading skills demonstrated greater improvement with greater amounts of time in explicit teacher-managed code-focused instruction (table S1) (*16*). For students who began with above-average reading skills, greater growth in letter-word reading skills was actually related to less time in teacher-managed code-focused activities. We also found an interaction between vocabulary and instruction. Children with above-average vocabulary scores at the start of the school year made greater gains in word reading when they spent more time throughout the year in child-managed meaning-focused instruction (such as independent reading). In contrast, children who began with below-average vocabulary scores achieved the strongest growth in word reading skills with a combination of instruction patterns: Their reading skills grew more when they initially spent more time on code-based activities, with increased child-managed meaning-focused instruction as the school year progressed.

Reading instruction. Lessons are tailored to individual students.

Algorithms used by Assessment to Instruction (A2i) Web-based software (*22*) incorporate these child-by-instruction interactions and, for each child, provide recommendations updated monthly regarding amounts and types of instruction (figs. S1 and S2).

Individualizing instruction with the use of A2i does not represent a new reading curriculum but rather a new way of implementing current reading programs. All literacy activities are indexed to dimensions of instruction: code- versus meaning-focused, teacher- versus child-managed, and change over time (*16*) (table S1). The dimension that describes code- versus meaning-focused instruction captures the content of the activity. Code-focused instruction includes those activities designed to help students achieve proficient phonological decoding and word reading skills (*14*). Meaning-focused instruction is designed to teach children how to extract and construct meaning from text (*23*). The dimension teacher- versus child-managed instruction identifies who is responsible for focusing the students' attention on the learning activities at hand—the teacher or the student (*4*, *16*). Teacher-managed instruction may be highly interactive, such as when the teacher is leading a discussion. Child-managed instruction includes activities in which students are expected to work independently (see photograph, left) or with peers. Change over time captures the impact of changing the focus or instruction time through the school year (*16*).

These dimensions operate simultaneously so that any language arts activity falls in one of four sectors (table S1). For example, children reading together in the library are participating in a child-managed, meaning-focused activity. The teacher instructing the children in how to segment or blend phonemes in words is leading a teacher-managed, code-focused activity.

In addition to recommending amounts and types of instruction, A2i algorithms use children's reading scores to help teachers effectively group the children for instruction. Lesson planning software helps teachers implement this individualized instruction on a daily basis (appendix SA and fig. S2).

The individualizing instruction intervention asked teachers to teach reading for at least 90 minutes a day during a dedicated block of time, to provide instruction to children with similar reading skills in small groups, and to follow the A2i recommended amounts and specific types of instruction. Control teachers were also expected to have a dedicated daily reading block (of 90 minutes) and to use small groups according to school policies. Assessment results were shared with all teachers (appendices SA and SB). All teachers in the treatment group received the same amount of training on how to plan and implement individualized reading instruction using A2i. Control teachers received no professional development from our program during this

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experimental phase. Thus, expectations for amount and structure of reading instruction were similar across groups, whereas the access to A2i recommendations and professional development was different.

Methods

This cluster-randomized field trial asked whether providing individualized reading instruction (as guided by A2i algorithms) would cause stronger student reading outcomes. The study was conducted in an ethnically and economically diverse school district in Florida, in 10 schools, with 47 teachers and 616 first-grade students. Schools were matched and paired on key indicators, with one randomly assigned to the treatment group (n = 22 teachers) and the other to the control group (n = 25 teachers). All participating schools had students living in poverty (table S2 and appendix SB).

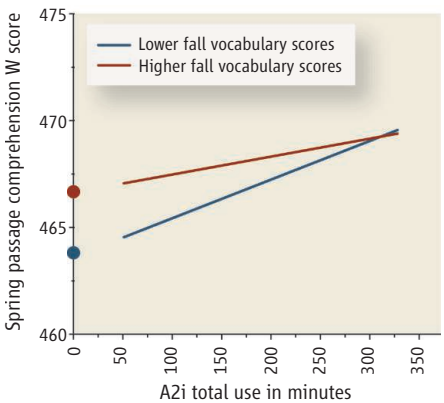
Students' language and literacy skills were assessed in August 2005 and in January and May 2006 with the use of the *Woodcock Johnson Tests of Achievement-III* (*24*), which are predictive of performance on state and federal achievement tests (*1*) (table S3).

Results and Implications

Our results revealed that individualized instruction, guided by A2i and supported by professional development, promoted stronger student reading growth compared with that of the control group, controlling for fall reading and vocabulary scores as well as child and school characteristics (residualized mean difference = 2.63, 95% confidence interval = 0.37 to 4.90; appendices SB and SC and table S5).

However, individualizing student instruction using A2i software, even with professional development, proved challenging for some of the teachers in the study. We captured fidelity of treatment in two ways, through classroom observations and by recording time spent using A2i (appendix SC). Based on classroom observations, by February, nine teachers (41%) implemented the intervention with moderate to high fidelity (table S4). Two teachers (9%) did not implement the intervention until toward the end of the year. Teachers' use of A2i software also varied. On average, they used A2i for 180 minutes from 1 September to 31 May (range 15 to 374 minutes, median = 191 minutes). Six teachers used the software for less than 100 minutes, whereas 11 teachers used the software for more than 200 minutes. Teachers who used A2i more frequently also tended to better implement individualized instruction in the classroom (correlation, r = 0.34, P = 0.014).

Although it is not possible to fully disentangle the impact of individualizing instruction using A2i and the professional development teachers received, it is unlikely that the reading outcomes were due to teacher training alone. The treatment teachers all received the same amount of training, yet varied in the number of minutes they used A2i and the extent to which they individualized instruction. Thus, we could examine these two markers of fidelity as they related to children's reading outcomes, holding the amount of training constant. We found that the more time teachers spent using A2i, the stronger were their students' reading skills by the end of the year (a 1-point increase in W score for every additional 50 minutes teachers used A2i, $t(20)$ = 2.97, P = 0.008; table S6). There was also an interaction with students' initial vocabulary scores. When teachers used A2i more frequently, on average, their students demonstrated stronger outcomes compared with children who had similar initial vocabulary scores in the control classrooms. Additionally, in higher fidelity classrooms, students with below-average initial vocabulary skills (including many children from high-poverty families) achieved reading scores that were generally comparable to students with higher initial vocabulary scores (tables S7 and S8, fig. S3, and the figure shown below). Taken together, using A2i and implementing A2i recommendations in the classroom appear to contribute to stronger student outcomes over and above the training teachers received, although no doubt both aspects contribute to better reading results.



Interaction between A2i use and vocabulary. Spring scores for first graders who started the year with below-average vocabulary (blue) (25th percentile; W score = 474; age equivalent, 6 years) and above-average vocabulary (red) (75th percentile; W score = 486; age equivalent, 8 years). Mean terminal scores are shown for children in the control group (circles) and the treatment group (lines); treatment group results vary depending on teachers' A2i use (table S6).

Thus, individualized reading instruction guided by the A2i algorithm and coupled with professional development supports teachers in their efforts to provide optimally effective reading instruction for all children.

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Supporting Online Material

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