Abstract Title Page

Title:

Individualizing Student Literacy Instruction: Implications of Child Characteristics by Instruction Interactions on Students' Reading Skill Growth

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Background/context:

Many children fail to reach proficient levels in reading only because they do not receive the amount and type of instruction they need (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Morrison, Bachman, & Connor, 2005 2005; Vellutino, Scanlon, Sipay, Small, Pratt, Chen, & Denckla, 1996). Early literacy instruction that is balanced between phonics, or code-based instruction, and meaning-based reading experiences has been shown to be more effective than instruction that focuses on one to the exclusion of the other (Mathes, Denton, Fletcher, Anthony, Francis, & Schatschneider, 2005; Xue & Meisels, 2004). However, providing effective instruction may be more complex than many of the current models of instruction and learning imply. Accumulating evidence reveals that the effect of any particular instructional strategy will vary with each child's language and literacy skills (Connor, Morrison, & Katch, 2004a 2004; Foorman et al., 1998 Schatschneider, & Mehta, 1998; Juel & Minden-Cupp, 2000). We have called these *child characteristic by instruction (child X instruction) interactions* (Connor et al., 2004a 2004). They have also been called *aptitude X treatment* interactions (Cronbach & Snow, 1977). Child X instruction interaction research is beginning to demonstrate that relations among instruction, child characteristics, and outcomes are non-linear, transactional, and dynamic (Connor, Piasta, Fishman, Glasney, Schatschneider, Crowe, Underwood, & Morrison, 2009).

Purpose/objective/research question/focus of study:

The purpose of this study was to test whether child X instruction interactions are causally implicated in the widely varying achievement observed within and between classrooms. Individualized student instruction (ISI) operationalizes ecological and transactional theories of child development, which, as Yoshikawa and Hsueh (2001) note, are dynamic system theories. In ISI, tailored amounts and types of reading instruction are computed for each student using algorithms that consider the dynamic and non-linear relations among child characteristics and key types of literacy instruction. In essence, the algorithms translate empirically derived projections of what comprises optimal reading instruction and provide recommendations that teachers can implement in the classroom.

Elements of complex systems, such as the teaching of reading, are inter-related and these relations may be non-linear. Small changes can have large effects and large changes can have small effects (Buell & Cassidy, 2001). For example, small differences in the beginning (e.g., child slightly below grade level at the beginning of first grade) can have large effects in the end (e.g., child must repeat first grade, or unable to read proficiently in fourth grade). As Buell and Cassidy (Buell & Cassidy) note, one-time snapshot approaches to data collection will not assess the manner in which complex systems function; nor will linear or benchmark solutions capture the complexity of ensuring proficient reading. Plus, instruction in the classsroom is not a closed system that is isolated from and independent of their environment (Yoshikawa & Hsueh, 2001). Rather, instruction is conducted in a classroom with a teacher (and sometimes an aide) and an average of twenty students, all of whom are interacting – in the case of this study – around the teaching and learning of a basic skill, reading. Moreover, the classroom is situated within a school and the school is in a community. Children's reading skills are directly and indirectly affected by home and community influences (Connor, Son, Hindman, & Morrison, 2005; NICHD-ECCRN, 2004). Thus, we suggest that reading instruction is multidimensional (Connor et al., 2004a 2004), essentially transactional (Morrison & Connor, in press; Sameroff & MacKenzie, 2003), with multiple proximal and distal sources of influence (Bronfenbrenner, 1986). It it part of a system which may be better understood within a dynamic (or complex) systems framework (Yoshikawa & Hsueh, 2001). By using this more complex view of reading instruction, we hypothesize that we can design and implement more effective reading instruction.

We asked the following research questions: (1) What was the effect of individualizing student literacy instruction (i.e., the ISI intervention) compared to high quality literacy instruction that was not individualized (control group); and (2) was the ISI intervention more or less effective based on child characteristics, specifically initial vocabulary and reading skills? We hypothesized that if a dynamic forecasting intervention, taking into account child X instruction interactions, was applicable to the design and implementation of reading instruction, then children in the treatment schools and classrooms should demonstrate greater gains in reading skills compared to children in the control schools and classrooms. Additionally, because the essence of the ISI intervention was that a plan was provided for all children, we anticipated no child X ISI interactions.

Setting:

This study was conducted in a economically and ethnically diverse school district in north Florida.

Population/Participants/Subjects:

Three hundred sixty-nine children in 25 classrooms from 7 schools participated in this cluster randomized control field trial. Schools were located in an ethnically and economically diverse North Florida district. All but one school used Open Court (https://www.sraonline.com/oc_home.html) as their principal core literacy curriculum while the remaining school used the Houghton-Mifflin curriculum (http://www.eduplace.com/) (Crowe, Connor, & Petscher, 2008 2008). All participating teachers were fully certified and had, at a minimum, a BA or BS degree. No schools or teachers withdrew from the study. All of the first grade teachers at the participating schools were invited to join the study, with over 90% actually participating.

All of the students in participating teachers' classrooms were invited to join the study and we were able to recruit approximately 86% of the students. Notably, 15% of children in the control and 14% of children in the treatment group were identified as eligible for special or exceptional student education (e.g., speech impairment, language impairment, developmental disability, etc.). For this reason, we included their status in our models with 1 = identified and 0 = not indentified for exceptional student education (ESE), excluding children identified as gifted. Across groups, students were similar demographically. Fifty-four percent of the control and 51% of the treatment group were girls; 26% of the control and 32% of the treatment group were African American; 45% of both groups were White, and the remaining children across groups represented other ethnic groups (e.g., Hispanic, multiracial); 49% of the control students and 44% of the treatment students qualified for free or reduced price lunch. Ten percent student attrition, which is in line with mobility for the participating schools, was equally divided between treatment and control classrooms.

Intervention/Program/Practice:

The Individualizing Student Instruction (ISI) intervention relied on Assessment to Instruction (A2i) software that computed, using complex algorithms, amounts of teacher/child-managed (TCM) code-focused and child-managed (CM) meaning-focused instruction for each child in the classroom. Using a set target outcome, which was defined as end of first grade achievement according to district norms (grade equivalent [GE] = 2.1), children's assessed word reading and vocabulary skills, and the month of the school year (where September = 1, October = 2, etc.), the algorithms solved for each type of reading instruction. The function for TCM code-focused instruction by word reading GE is provided in Figure 1. Note that this is the September (month = 1) function for children who have typical vocabulary skills. Changing either parameter would result in a different trajectory.

TCM meaning-focused and CM code-focused instruction were set at the means observed in the Connor, Morrison, and Katch (2004) study. The recommendations for each student are displayed in the ISI online classroom view. The ISI website also includes progress monitoring charts, children's test scores, classroom planning and lesson planning features. The website is http://isi.fcrr.org and the log in for the demonstration classroom is A2idemo; the password is isi06! (include the exclamation point).

The ISI intervention lasted the entire school year. Teachers received professional development, including online resources, to help them meet the targets for each child in their classroom. In addition to a fall half-day workshop, teachers attended monthly school-level meetings and received classroom-based support bi-weekly. Their core reading curriculum and Florida Center for Reading Research (FCRR) center activities (http://fcrr.org/Curriculum/SCAindex.htm) were indexed to the four types of instruction (i.e., TCM code-focused, CM meaning-focused, etc.). Thus, the ISI intervention was not a new curriculum but rather was intended to provide a way to implement reading instruction more effectively for each child using the available school resources. The treatment group teachers received professional development beginning in August 2006 and first gained access to algorithm recommendations and assessment information provided by A2i software in September 2006. They received training and used the software continuously through May 2007. The control group teachers were provided written reports of the assessments results for their students in the fall, winter, and spring of the study year.

Research Design:

This was a cluster randomized control field trial using a wait-list control design. Schools were matched on percentage of students qualifying for free/reduced price lunch, Reading First status, and 3rd grade state mandated reading assessment scores and then one member of each matched pair was randomly assigned to the treatment group. The middle unmatched school was then randomly assigned. Thus, 4 schools, 11 teachers, and 174 students were assigned to the control condition whereas 3 schools, 13 teachers, and 222 students were assigned to the treatment condition. Schools ranged in percentage of children qualifying for free or reduced price lunch from 4 to 87% and two schools were participating in Reading First.

Data Collection and Analysis:

Students' language and literacy skills were assessed in the fall, and again in the winter and spring using a battery of language and literacy assessments, including tests from the *Woodcock-Johnson Tests of Achievement-III* (Woodcock, McGrew, & Mather, 2001). The WJ-III was selected because it is widely used in schools and for research. It is psychometrically strong for this age group (reliabilities on the tests used ranged from .81 to .94), and subtests are brief. All assessments were administered to children individually by a trained researcher in a quiet location near the students' classrooms. We assessed students' letter and word reading skills using the WJ-III *Letter-Word Identification* subtest, which asks children to recognize and name increasingly unfamiliar letters and words out of context. Expressive vocabulary was assessed using the WJ-III *Picture Vocabulary* subtest, which asks children to name pictures of increasingly unfamiliar objects. W scores, which are a variation of the Rasch score and thus have equal intervals, were used in models to evaluate the efficacy of the ISI intervention.

Whereas students were nested in classrooms and classrooms were, in turn, nested in schools, we used hierarchical linear modeling (HLM, Raudenbush & Bryk, 2002). Because of the nested design, standard errors may be misestimated if shared classroom and school level variance among students is not considered.

Findings/Results:

Three-level HLM models with fall scores as the outcome revealed that there were no significant differences between groups in students' fall reading and vocabulary scores (see Table 1 for means and standard deviations by group). Moreover, examining standard scores (standardized mean = 100, SD = 15) for fall and spring revealed that, on average, both groups demonstrated generally grade-appropriate gains in word reading and vocabulary scores (see Table 1). Notably, ranges for spring word reading standard scores were wide, ranging from 63 (very low) to 141 (very high) for both groups. Examining the unconditional model with spring word reading W score as the outcome and no predictor variables revealed that the intraclass correlation (ICC), the proportion of explained between-school variance, was .06 [school-level variance = 38.05, $X^2 = 30.77(6)$, $p < .001$]. There was no significant classroom-level variance [variance = .78, $X^2 = 18.97(18)$, $p = .393$]. Student-level variance in the unconditional model was 641.19. To build the final model, we added fall word reading and vocabulary W scores as covariates, centered at the grand mean for the sample. Adding covariates was not done to control for group differences but rather to remove variance in the outcome variable that was not of primary interest. This increases power to find differences between groups (Venter, Maxwell, & Bolig, 2002 2002). Additionally, by controlling for initial status, we could compare group gains (i.e., residualized change). The treatment variable (assignment to the treatment condition = 1; assignment to the control condition = 0) was added at the school level. The coefficient for the treatment variable represents the fitted mean difference between school groups in students' word reading W scores.

There was a significant effect of treatment. That is, students whose teachers (within schools) implemented the ISI intervention demonstrated significantly greater gains in word reading scores than did students whose teachers and schools were in the control group and conducted literacy instruction as usual. The effect size (*d* = treatment coefficient/standard deviation at the student level) was .27, which is a small to moderate effect (Rosenthal & Rosnow, 1984). Considered another way, the more than 4 point difference between the ISI intervention and control group represents a two month difference in grade level, based on equating the fitted mean for the control group students (460 = 2.6 GE) and the intervention group students (464 = 2.8 GE) where .9 represents a nine-month school year.

Conclusions:

The A2i algorithms follow the main principles of dynamic systems forecasting. A set of complex non-linear equations (see Figure 1), the algorithms use information from multiple sources to predict specific amounts and types of reading instruction that should, theoretically, lead to stronger student reading skills. The multiple sources include children's assessed reading and vocabulary skills, target outcomes based on societal norms for acceptable levels of end of first grade reading, predicted reading skill growth (implicit assumptions about limitations to gains), and the kinds of reading instruction strategies that are empirically recognized to promote stronger student reading outcomes. Moreover, key to the ISI intervention is the implicit understanding that human interactions are better described within a transactional, bidirectional framework (Bronfenbrenner & Morris, 2006; Connor et al., 2008a; Morrison & Connor, in press; Pianta & Rimm-Kaufman, 2006; Tudge, Odero, Hogan, & Etz, 2003). Thus, the skills and aptitudes (Kyllonen & Lajoie, 2003) children bring to the classroom (including additional aptitudes not discussed here) and how they interact with the classroom environment more generally are crucial information for dynamic forecasting interventions.

There are clear challenges to implementing ISI, in addition to the well documented challenges teachers face, such as lack of time and resources (Cohen, Raudenbush, & Ball, 2003 2003). Implementing ISI requires: (a) enhanced responsiveness to students' instructional needs based on assessment results, (b) masterful classroom planning and organization, and (c) a firm and fluent grasp of how to teach reading effectively. Although analyses of classroom observation video are ongoing, preliminary results along with results from Study 1 suggest that breakdowns in any one of these skills are associated with less teacher fidelity and weaker student reading outcomes.

Summary

Multidimensional views of the classroom environment coupled with a dynamic forecasting intervention model of instruction help us understand how child X instruction interactions might operate to affect students' achievement and how research can inform the design and implementation of more effective instruction. Incorporated into the model, transactional theories indicate that children are active agents in their development, ecological theory justifies multiple sources of influence, including the classroom, and dynamic systems theories suggest that we can predict student outcomes but that multiple and changing functions are complex and non-linear. With more data, we can refine dynamic forecasting intervention models and, theoretically, design better instructional regimes. For example, using data from this study and Study 1, we developed and are currently testing A2i algorithms for TCM meaning-focused and CM code-focused instruction. Data from these and other studies will be used to further refine and improve the algorithms from kindergarten through third grade.

Given the importance of academic success to children's well-being and ultimate success in life (Reynolds & Ou, 2004), over-simplifying our views of children's reading acquisition and the ways in which it interacts with and responds to the instruction children receive will limit our understanding of the complex classroom environment and how to design more effective instruction for all children. Instead, viewing the process of learning as the complex process it is (Robinson, 1993; Yoshikawa & Hsueh, 2001), impacted by child and environmental factors, not the least of which is instruction itself, will lead to more useful models of learning and, ultimately, to designing and implementing more effective classroom environments for all children.

Appendixes

Appendix A. References

A2i. *A teacher version of A2i will be available after August 1, 2008. More information about A2i is available at http://know.soe.umich.edu/A2I/login.asp. The login is A2idemo and the password is ISI06!. The software and protocol are currently freely available to other researchers upon request.*

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Appendix B. Tables and Figures
Table 1

Fall and Spring W and Standard Scores by Treatment and Control Condition

Treatment	*Mean*		*Std. Deviation*		*Minimum*		*Maximum*	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
WJ letter Word W	417.41	464.86	29.64	24.98	340	371	511	514
WJ letter Word SS	107	112	16	14	67	66	150	141
WJ Vocabulary W	481.39	486.48	9.23	9.38	456	463	506	520
Control								
WJ Letter Word W	417.61	461.20	32.01	27.45	314	345	507	512
WJ letter Word SS	108	112	15	14	64	63	144	141
WJ Vocabulary W	481.59	487.66	14.87	10.44	448	463	510	517
Total (used in HLM)								
WJ letter Word W	416.68	463.22	30.84	26.09				
WJ Vocabulary W	481.19		9.55					

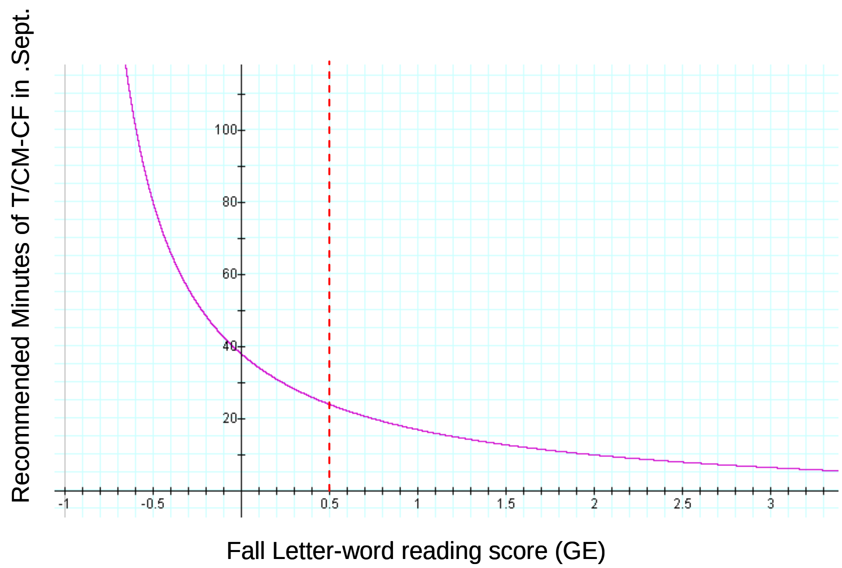

Figure 1.
A2i algorithm TCM-code focused instruction recommended amounts as a function of children's reading grade equivalent (GE) in September assuming vocabulary scores falling at the mean age equivalent (AE). The vertical dotted line indicates the level at which a child might qualify for Tier 2 intervention in an RTI model. A grade equivalent (GE) of 1.0 corresponds to beginning of first grade reading achievement. A GE of 0 corresponds to a beginning of kindergarten level, and so on.