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Early Lessons Learned in Designing an Adaptive Shared Reading Intervention for Preschoolers With Autism

Veronica P. Fleury[1] and Jacqueline A. Towson[2]

Abstract

Project START (Students and Teachers Actively Reading Together) is an adaptive shared reading intervention designed to address the varied learning needs of preschool children with autism spectrum disorder (ASD). This report summarizes procedures and results of the developmental year of the project, which focused primarily on evaluating implementation fidelity and social validity of the intervention. The final sample consisted of four classrooms with 10 students with ASD (M_{age} = 4.32 years) and their teachers (N = 4). Classrooms were randomized to either a 4- or an 8-week first-stage small-group dialogic reading condition. Children who were early responders continued with the initial intervention; those who were slower to respond were randomized to one of two intensified reading conditions. Results indicate that teachers perceived the intervention as feasible and child outcomes as acceptable. Implementation fidelity was low during initial weeks (33%–50%), improving to 67% to 83% by the last weeks of the study. Neither children's engagement nor vocabulary growth differed between treatment levels or conditions. We discuss lessons learned from the study's developmental year and changes that will be made in subsequent years to improve implementation and feasibility.

The Simple View of Reading is a well-evidenced model of reading development (Catts, 2018; Hogan et al., 2011) that maintains reading is the product of both decoding and language comprehension (Gough & Tunmer, 1986). Effective readers apply code-focused skills (i.e., alphabet knowledge, phonological awareness) that support the mechanics of reading text and meaning-focused skills that support their ability to comprehend text. Emerging research suggests that learners with autism spectrum disorder (ASD) often demonstrate particular strength in code-focused skills, namely, alphabet knowledge. Other code-focused skills—print concept knowledge and phonological awareness—reveal great heterogeneity (Davidson & Weismer, 2014; Dynia et al., 2014; Lanter et al., 2012; Westerveld et al., 2017). Despite highly variable performance on code-focused skills, most school-age learners with ASD consistently struggle to understand what they read (i.e., meaning-focused skills; Grimm et al., 2018; McIntyre et al., 2018). It is, therefore, important that learners with ASD receive instruction, and ample opportunities, to develop skills that support comprehension.

Several models to explain the comprehension process have been proposed (Cain & Barnes, 2017; van Dijk, & Kintsch, 1983). A common feature of these models requires that readers generate a situational model of text. This is a complex process that involves applying one's understanding of language—including narrative structure, grammatical

[1]Florida State University
[2]University of Central Florida

Corresponding Author:
Veronica P. Fleury, Florida State University, 1114 W. Call Street, Tallahassee, FL 32306-4450, USA.
Email: vpfleury@fsu.edu

skills, and vocabulary knowledge—and higher-order language-processing tasks, such as inference making and memory retrieval. Many children with ASD as young as preschool age show deficits in oral narrative understanding and production skills (Westerveld et al., 2017) as well as in depth of vocabulary knowledge (Dynia et al., 2014; Fleury & Lease, 2018). These difficulties adversely influence children's ability to understand language in narrative text. Regarding higher-order language processing, deficits in making inferences are well established in the ASD research (McIntyre et al., 2018; Norbury & Nation, 2011). Scholars have attributed difficulty with drawing inferences, in part, to underdeveloped theory-of-mind skills and to lessened ability to recognize and understand the mental states of self and others to explain and predict behavior (Begeer et al., 2003; McIntyre et al., 2018). Additional cognitive difficulties with executive functioning and memory retrieval places learners with ASD at further risk for comprehension failure. The memory challenges experienced by individuals with ASD include difficulty recalling words, stories, and sentences (Williams et al., 2006). Individuals with ASD also commonly demonstrate executive functioning impairments, particularly with metacognitive tasks, which include monitoring one's own comprehension of language and employing strategies to remedy errors in understanding (Williamson et al., 2012).

Comprehension difficulties may emerge as early as preschool (Fleury & Lease, 2018; Westerveld et al., 2017). These early skill deficits persist once learners with ASD enter school, and they influence reading development (Wei et al., 2011). Experts advocate for early intervention to include language and emergent literacy instruction to influence the trajectory of reading development for children at risk for reading difficulties (Kaiser et al., 2011; Whalon et al., 2009). One developmentally appropriate approach used to build emergent literacy skills in the preschool years is interactive shared reading (Hogan et al., 2011). Shared reading activities with young children are social by design and provide a context for rich language interactions. High-quality shared reading typically involves children and adults asking questions, posing comments, and directing others' attention to story elements. Interactions during shared reading help children develop skills associated with future reading success, including improved oral language skills (i.e., vocabulary, listening comprehension) and other areas of emergent literacy (i.e., print concepts, alphabetic knowledge; Schickedanz & McGee, 2010).

Dialogic reading (DR) is an interactive shared reading approach in which adults use specific question prompts to encourage children to converse with them about the story (Whitehurst et al., 1988; Whitehurst, Epstein, et al., 1994). There is preliminary evidence that DR is a promising approach for children with ASD. Fleury and Schwartz (2017) examined the effect of a modified DR intervention on levels of verbal participation and vocabulary growth in nine preschool children with ASD. Baseline book reading in which the adults read as they typically would resulted in consistently low levels of verbal participation. DR reading sessions produced an immediate increase in verbal participation during DR sessions for all children and also produced greater gains in book-specific vocabulary for all children, as compared with baseline book-reading sessions.

Previous research that included children with ASD used single-subject experimental design methods in which participants were relatively homogenous in age, language, and cognitive ability. The design of these studies limits the extent to which we can make claims about the effectiveness of shared reading for a broader, heterogeneous population. A "one size fits all" approach likely will not suffice in addressing the varied needs of children with ASD. Thus, although traditional shared reading interventions may be effective for some students with ASD, educators may need alternatives for students who do not respond as intended to traditional instruction. The current research base does not enable us to determine for whom interventions are likely to be effective and, importantly, what, if any, modifica-

tions or adaptations will lead to improved learning outcomes for children with ASD.

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Designing an Adaptive Intervention for Emergent Literacy Instruction

Adaptive interventions (AIs) provide clinicians with decision rules that recommend when, how, and for whom treatments should be applied (Collins et al., 2004; Lavori et al., 2000; Lavori & Dawson, 2000; Murphy, 2005). AIs have the potential to improve student outcomes while conserving educational resources. Intensified instruction, though potentially more effective, can be burdensome to teachers in terms of time and training involved. They are, therefore, delivered only when and for whom they will do the most good. In this article, we summarize the efforts of the 1st year of a 4-year developmental project called Project START (Students and Teachers Actively Reading Together), an adaptive shared reading intervention that is modeled from a tiered intervention approach, in which instruction is systematically intensified based on the student's needs (response to intervention, positive behavior intervention support). Readers should refer to Figure 1 for a diagram of the study design.

First-Stage Intervention: Small-Group DR

We selected DR as the initial intervention in the AI based on a robust body of evidence supporting its effectiveness (U.S. Department of Education, 2007), including preliminary studies that have included children with ASD (Fleury et al., 2014; Fleury & Schwartz, 2017). There is, however, considerable variability across studies in both the instructional arrangement and overall intervention duration (Towson et al., 2017). Experts recommend reading to children in small groups of three or four children (Lonigan & Whitehurst, 1998); however, this recommendation is based on work with typically developing and at-risk populations. Notably, most DR studies that included children with disabilities featured a 1:1 reading arrangement (Fleury et al., 2014; Hargrave & Sénéchal, 2000; Rahn et al., 2016), whereas relatively fewer studies used a group format (Towson et al., 2016). We used a small-group instructional arrangement during the first intervention stage, as it is less burdensome to teachers.

Our next design decision focused on the overall duration of the first-stage intervention. We drew from previous classroom-based DR studies to identify decision points. The overall intervention dosage in published DR studies ranges widely, from nine sessions (Fleury et al., 2014) to over 90 sessions (Zevenbergen et al., 2003). The most commonly used intervention dosages were 16 sessions (Fleury & Schwartz, 2017; Lever & Sénéchal, 2011) and 30 sessions (Lonigan et al., 1999; Valdez-Menchaca & Whitehurst, 1992; Whitehurst, Arnold, et al., 1994). Assuming that teachers would conduct reading sessions four times per week in this study, we selected an early decision point at 4 weeks (16 sessions) and a late decision point at 8 weeks (30 sessions). The research team randomized classrooms to a first-stage intervention condition: early decision point (4 weeks) or late decision point (8 weeks). Comparing different AIs embedded within the study design will provide empirical guidance for the preferred intervention dosage, which has practical importance for teachers who will need to decide when to change the instructional strategy for students who are not responding to instruction.

Selecting the tailoring variable. Tailoring variables are a crucial feature of AIs because they guide practitioners' instructional decisions. In selecting the tailoring variable for this AI, we needed an assessment measure sensitive to detecting proximal change in children's skills resulting from DR instruction, one that researchers could easily administer at repeated times throughout the intervention. On the basis of existing literature, we identified vocabulary growth as a child outcome that commonly results from DR. Vocabulary knowledge is also a meaningful outcome for

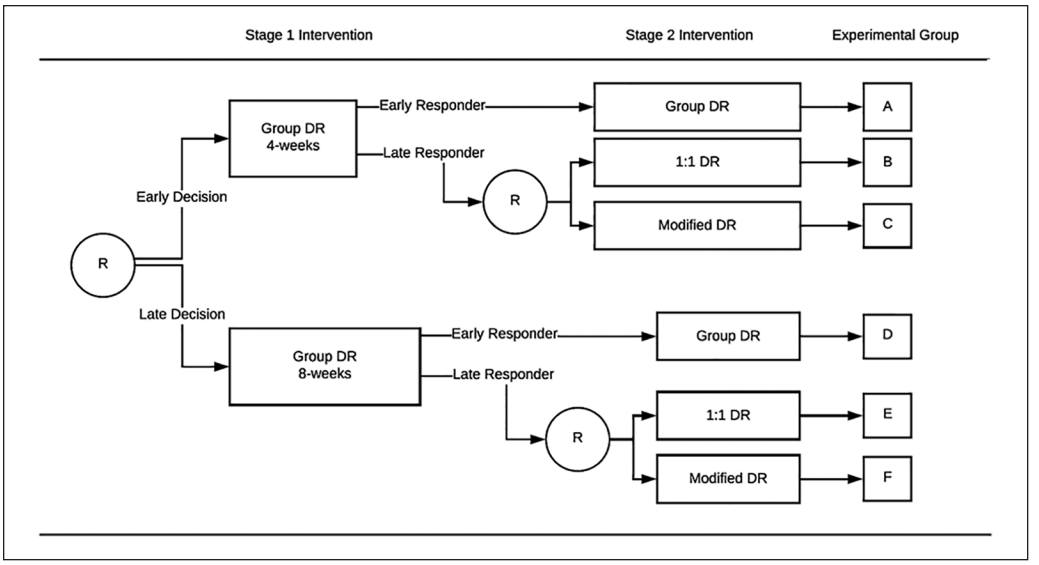

Figure 1. Pilot sequential multiple-assignment randomized trial study diagram. R = randomization; DR = dialogic reading. The four adaptive interventions (AIs) considered in this pilot study are as follows: (a) AI 1: First instruct with daily group DR for the initial 4 weeks (16 sessions). If at Week 4 the child is not either a "high performer" or a "fast grower" (i.e., the child is a "slow responder"), augment instruction by reading daily using DR strategy in a 1:1 instructional arrangement for the next 16 weeks. Otherwise, if the child is an early responder, maintain in group DR instruction. (b) AI 2: First instruct with daily group DR for the initial 4 weeks (16 sessions). If at Week 4 the child is not either a high performer or a fast grower (i.e., the child is a slow responder), augment instruction by using a modified dialogic reading (M-DR) technique for the next 16 weeks. Otherwise, if the child is an early responder, maintain group DR instruction. (c) AI 3: First instruct with daily group DR for the initial 8 weeks (30 sessions). If at Week 8 the child is not either a high performer or a fast grower (i.e., the child is a slow responder), augment instruction by reading daily using DR strategy in a 1:1 instructional arrangement for the remaining 12 weeks. Otherwise, if the child is an early responder, maintain group DR instruction. (d) AI 4: First instruct with daily group DR for the initial 8 weeks (30 sessions). If at Week 8 the child is Not either a high performer or a fast grower (i.e., the child is a slow responder), augment instruction by using an M-DR technique for the next 12 weeks. Otherwise, if the child is an early responder, maintain group DR instruction.

children with ASD as it supports language comprehension (Hogan et al., 2011). We initially considered commercially available curriculum-based measures that include a vocabulary measure, specifically the Individual Growth Developmental Indicators–Early Literacy (IGDI-EL; McConnell et al., 2012). The IGDI-EL provides a measure of gross vocabulary skill development and may lack the sensitivity in identifying improvement that children in our study would make during the intervention. A developer of the IGDI-EL recommended we develop our own measure using vocabulary targeted in the books used as part of the intervention (S. McConnell, personal communication, June 20, 2017). This assessment is described in the Method section.

Second-Stage Intervention: Modify Instruction for Students as Needed

Given the great heterogeneity of ASD, we expect that a proportion of children will be unresponsive to DR as it is traditionally implemented. This study's design allows us to intensify instruction for children who demonstrate insufficient responses to traditional group DR. One intensification option is switching from group to 1:1 book reading. Individual book readings would provide children with more opportunities to participate

than would be afforded in group reading sessions (Hindman et al., 2008). Previous shared reading intervention studies that included children with ASD typically use a 1:1 reading arrangement, with positive outcomes (Fleury et al., 2014; Hargrave & Sénéchal, 2000; Rahn et al., 2016). Another method for intensifying instruction involves modifying procedures. Focused intervention strategies—instructional practices implemented for a relatively short time with the clear objective of changing targeted behaviors or skills—may prove especially useful in developing intervention packages for students with ASD because they can be combined and embedded within academic instruction (Steinbrenner et al., 2020). Referring to the existing single-subject experimental design studies on shared reading, we identified strategies to augment DR instruction for students who require additional supports, specifically, visual cues (Whalon et al., 2015) and a prompting hierarchy (Fleury & Schwartz, 2017; Whalon et al., 2015).

This study's design allows us to intensify instruction for children who demonstrate insufficient responses to traditional group DR.

Focus of the Current Study

The long-term goal of Project START is to develop an AI for emergent literacy that will guide teachers as they adapt their reading instruction to better serve their diverse student populations. It will thus be important to evaluate the extent to which school personnel can feasibly implement the AI in classroom settings. The extent to which interventionists implement DR as designed, however, is not well established. Though most studies that form the DR research base include estimates of overall implementation fidelity, it is unclear how researchers calculated these estimates. DR involves a clear instructional sequence (i.e., prompt, evaluate, expand, repeat [PEER]) and specific question prompts (i.e., completion, recall, open-ended, *wh*- questions, distancing [CROWD]), yet many researchers do not consistently report implementation fidelity for each instructional component (Towson et al., 2017). It has been found that interventionists often have difficulty implementing the full instructional sequence with children with disabilities (Fleury & Schwartz, 2017; Towson & Gallagher, 2014). The extent to which educators can implement DR, and any required modifications, should be evaluated if teachers are to use the intervention in their classrooms.

Another key consideration is social validity—the extent to which teachers perceive the AI procedures and student outcomes as acceptable. Social validation is crucial in applied research and will guide programming decisions respectful of teachers' values and constraints imposed by the learning environment (Schwartz & Baer, 1991). The existing DR research with students with ASD has yielded encouraging social-validity data (Fleury et al., 2014; Fleury & Schwartz, 2017). In these studies, school personnel were trained to implement one set of procedures. The intervention in this study, however, differs in that teachers change their instruction for particular students depending on their responsiveness to initial instruction. Teachers' evaluative feedback regarding their experience with the AI will inform any necessary changes to the procedures, improving the likelihood that teachers will adopt the intervention in their classroom beyond the research purposes.

The components of the AI will be developed and refined within the context of a sequential multiple-assignment randomized trial (SMART; Almirall et al., 2014) in which we randomize children throughout the intervention at crucial decision points (Figure 1). The results of the SMART can then define decision rules that make up the AIs. Crucial decision rules in the current project are (a) How long should teachers initially use DR techniques before determining if students need an instructional change? and (b) What is the best way to modify DR for students slow to respond to the initial instruction? Our ability to answer these questions requires adequate sample size to power analyses (Almirall et al., 2012). Though the current study will not be adequately powered to answer these questions, it will provide preliminary data that can

inform the development of a full-scale SMART.

We will use these data to refine our intervention procedures for the subsequent years of the project. The research questions for the first year of the study are as follows:

1. To what extent do school personnel implement the AI in their classrooms after training and coaching?
2. To what extent do school personnel perceive the AI procedures as feasible and the child outcomes as acceptable?
3. What percentage of students respond to the initial small-group DR instruction at the 4- and 8-week decision points?
4. How does children's (a) engagement during book reading and (b) knowledge of vocabulary targeted in books compare across intervention stages?

Method

The institutional review board at Florida State University and cooperating school district partners approved all study procedures. Informed consent was obtained from all study participants.

Participants

We recruited preschool students and their teachers from school districts throughout northern and central Florida. Participating teachers identified students who met the following inclusion criteria: (a) are between the ages of 4 years 0 months and 5 years 11 months; (b) have some language facility, routinely using three or more independent units to communicate in English (e.g., "baby fall down"; "go yellow truck"); (c) regularly attend educational programming as reported by the teacher; and (d) have a clinical diagnosis or educational determination of ASD. The research team confirmed children's ASD status using the Autism Diagnostic Observation Schedule (Lord et al., 2012). Children with significant visual, hearing, or physical impairment were excluded.

Eighteen students (15 male, three female) returned consent forms. Seven of these students were found ineligible after the initial screening (see Figure 2). Two teachers and classrooms were excluded after the screening phase because they no longer had eligible students in their classes. Eleven children across five classrooms were initially enrolled in the study. The research team withdrew one child because of prolonged school absence. As a result, one classroom was removed from the study as the student was the only participant in the class. Ten students across four classrooms completed the full study. Child participants were an average of 4.32 years of age ($SD = 0.44$) at the start of the study. Eighty percent of the students ($n = 8$) were male. Fifty percent of child participants identified their ethnicity as Hispanic, Latino, or Spanish origin. Children's receptive language and emergent literacy skills were assessed using the Peabody Picture Vocabulary Test, Fifth Edition (PPVT-5; Dunn, 2018) and the Test of Preschool Early Literacy (TOPEL; Lonigan et al., 2007), respectively. Children's median standard score on the PPVT-5 was within normal range ($Mdn = 75.5$, $SD = 12.85$) marked by high variability, with standard scores ranging from 54 to 103. Children's performance on the TOPEL early literacy index varied from 61 to 85 ($Mdn = 74$, $SD = 8.47$).

School personnel serving as study interventionists were all female with a modal age range of 26 to 30 years, and all were serving as lead teacher in their classrooms. Of the four teachers who completed the study, three (75%) identified as Caucasian and one (25%) as Black. Each of the teachers held a bachelor's degree. Three teachers held a teaching certificate in special education, and one was a certified voluntary prekindergarten instructor. The modal range of teaching experience was 4 to 6 years. School personnel earned $325 for participating.

Study Overview

Four AIs are being considered in this study (see Figure 1). The total duration of the intervention was 20 weeks. We randomized

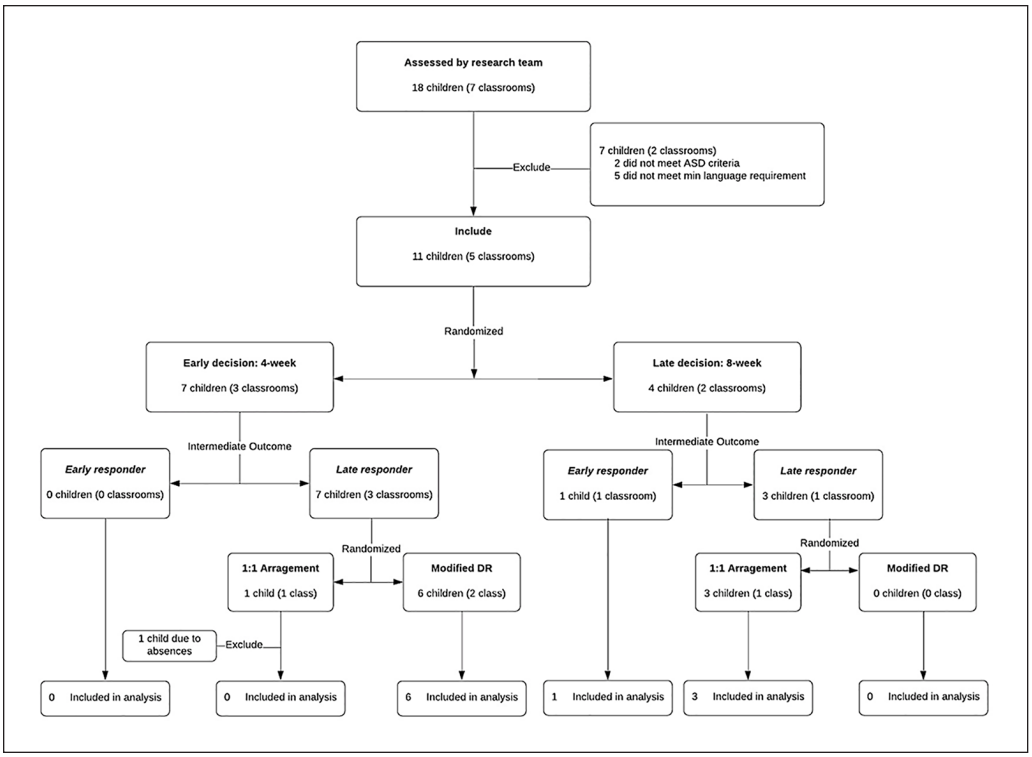

Figure 2. CONSORT diagram.

classrooms at the start of the study to an early decision point (Week 4) or late decision point (Week 8) for identifying students slow to respond to small-group DR (G-DR). Students classified as slow to respond were randomized a second time to either (a) DR conducted in 1:1 instructional arrangement or (b) modified DR. Randomization occurred at the classroom level. Thus, students who were early responders continued with G-DR, whereas all students classified as slow to respond within a classroom were assigned to the same Stage 2 condition (e.g., 1:1 reading or modified DR). We chose to randomize at the classroom level, as opposed to matched teacher–child pairs, for two main reasons. First, we wanted to control for carryover effects that would compromise experimental control. It is probable that the school personnel, once trained to use an intensified strategy, would unintentionally apply it broadly to all reading sessions regardless of assignment. Second, we considered the feasibility of implementing this intervention in the classroom. All reading sessions were embedded into the classroom routine with school personnel serving as interventionists. For various practical reasons, we elected to train classroom personnel in one intensified strategy. This means that, at most, teachers may have a group of students continuing G-DR and students in one intensified second-stage condition.

Researchers provided all books used in the study. All books were published, narrative texts obtainable through commercial retailers. We used the Advantage-TASA Open Standard (ATOS; School Renaissance Institute, 2000) readability formula to control for text complexity in books used during shared readings. The ATOS readability formula accounts for various predictors of text complexity, such as average sentence length, average word length, and word difficulty level. All books used were within the 2.3-to-2.4 ATOS classification consistent with Common Core State Standards for children in lower grades.

Training and Coaching Procedures. School personnel implemented the AI in their classrooms. The principal investigator conducted an in-person, 2-hr training at the start of the academic year. This initial workshop served as an introduction to the study and the intervention procedures. During this training, the research team described study requirements and distributed books and instructional materials. The team described the Stage 1 DR protocol, using video examples to model each component of the DR instructional sequence. School personnel worked in small groups to role-play implementing DR with books to be used in the study. Members of the research team observed school personnel and provided feedback on their implementation. At the conclusion of the training, a team member informally assessed each teacher's understanding of the DR protocol by asking them to (a) describe the steps of the PEER instructional sequence, (b) provide examples of CROWD question prompts, and (c) demonstrate the instructional sequence in a book. All participating teachers were able to describe the DR protocol and use the PEER instructional sequence accurately for at least one question prompt. An additional 2-hr workshop with the same format was conducted at the midpoint to train teachers in Stage 2 intervention procedures.

During intervention, teachers received weekly coaching and feedback from the research team on their use of the intervention strategies. Teacher–coach dyad assignments remained consistent throughout the duration of the study. Coaches observed teachers implementing a reading session at least once per week. Coaches used a researcher-developed fidelity checklist to evaluate the extent to which teachers implemented the reading protocol. Following the observation, coach and teacher met for a 20-min debrief in which the coach provided feedback about what went well and areas for improvement. The coach identified one or two specific areas for the teacher to focus on during the following week's book-reading sessions. The coach shared this feedback during the debrief session and provided a written summary via email.

First-Stage Intervention. Classroom teachers implemented G-DR in small-group arrangements comprising three or four students for either 4 weeks (early decision) or 8 weeks (late decision). Teachers read one book four times per week, adhering to the DR instructional sequence. Teachers prompted children in the reading every two to three pages by asking questions about the content. The questions asked were consistent with previous DR studies and included CROWD prompts (e.g., Whitehurst, Arnold, et al., 1994). Once the child responded to the adult's question, teachers completed the DR instructional sequence through evaluating, expanding, and requesting the child to repeat the phrase.

Tailoring variable. Children's performance on a researcher-developed vocabulary measure determined Stage 2 treatment. A full description of the vocabulary assessment is detailed in the Measures section. The research team administered the vocabulary assessment prior to the intervention (pretest), at midpoint (4 weeks for early decision, 8 weeks for late decision), and at the completion of the study (posttest). Performance during the midtest progress assessment was used to differentiate "early responders" from "slow responders." For the study, early responders are either (a) "high achievers," defined as correctly identifying $>80\%$ of items or (b) "fast growers," defined as students whose rate of growth averaged of 1.8 vocabulary words per book (Fleury & Schwartz, 2017). We established these criteria to reflect that intervention responsiveness may look differently across learners. One benchmark of success is for students to develop a breadth of vocabulary, hence the criteria of correctly labeling 80% or more of the book vocabulary. Intensified intervention would not be warranted for these students given their current vocabulary breadth. Other students who have lower vocabulary baselines may not reach the target of 80% by the end of the first-stage intervention given the duration of the study timeline. Nonetheless, these students may show responsiveness to the first-stage procedures as evidenced by a rapid rate of vocabulary growth. We referred to previous intervention research

to identify a metric of vocabulary growth. Fleury and Schwartz (2017) trained paraeducators to implement DR strategies to preschoolers with ASD using the same inclusion criteria used in the present study. The average rate of vocabulary growth during the DR sessions was 1.8 words per book. We established this rate of growth in the present study as the criteria for a fast responder. Children who did not meet the criteria for high achiever or fast grower were categorized as slow responders.

Second-Stage Intervention. Children identified as early responders continued with G-DR instruction for the rest of the study period. We made no changes to the instructional procedures. Children identified as slow to respond were assigned to one of two instructional intensification conditions, described as follows. All children in the same classroom who were slow to respond were randomized to the same condition.

1:1 DR. Teachers of slow responders randomized to a 1:1 condition continued to read books using the DR strategy as described in the earlier section, with one alteration. Discontinuing the small-group format, teachers read with children in a 1:1 instructional arrangement to allow the teacher to provide behavioral supports (e.g., reinforcement) and afford the child more opportunities to respond to question prompts.

Modified DR. Classrooms containing children slow to respond continued to read books in a small group, with modifications to the instruction delivered during reading sessions. The research team taught the teachers to intensify the instruction in three ways. First, the team created visual supports representing key vocabulary, which school personnel used when teaching target vocabulary prior to each session (Spencer et al., 2012). Second, teachers posed questions during the reading to elicit responses containing the key vocabulary. Third, a follow-up error-correction procedure was implemented when the student answered incorrectly or failed to respond. If the child failed to respond to a question, teachers used specific follow-up prompts (e.g., yes or no, choice stems, request to point) in a least-to-most prompt hierarchy (Fleury & Schwartz, 2017; Whalon et al., 2015).

Measures

Implementation Fidelity. The extent to which the teachers implemented the intervention procedures was evaluated twice per month. Research personnel evaluated implementation for 14 behaviors across three general areas: materials and arrangement (MA), DR strategies, and other adult behaviors (OAB). Individual items used to assess implementation fidelity can be found in Supplemental Table 1. The research team coded approximately 30% of reading sessions to establish interobserver agreement (IOA). Interobserver estimates were 100% for both MA and OAB categories and 93% (range 83%–100%) for DR strategies items using a point-by-point agreement in which the number of agreements was divided by total items.

Social Validity. Evaluative feedback from teachers was used to assess the extent to which they viewed the intervention procedures as feasible and child outcomes as acceptable. All teachers completed a social validity survey through Qualtrics upon conclusion of the study. The survey comprised nine statements reflecting experiences or attitudes on training and support provided by the research team, feasibility of the intervention, and intent to continue the intervention. In addition, teachers provided input about the extent to which they believed children benefited from the intervention at each stage. Teachers indicated the extent to which they agreed to each statement using a scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

Children's Engagement During Reading. We assessed the quality and quantity of children's engagement during book reading through direct observation. A researcher observed the teacher reading with target students six times during the study (three times

in each intervention stage) using a momentary-time-sampling procedure at 10-s intervals. The observation began when the teacher read the title of the story, made a comment about the book, or asked a question about the book. Every 10 s, the observer was auditorily cued to record the engagement state of the target child. *Unengaged* was coded if the child was not looking at the book or reader or was actively disrupting the session (e.g., lying on the ground, walking away). *Passive engagement* was used when the child was listening to the reader and attending to the book (e.g., eyes and body oriented to the reader). *Active engagement* included moments when the child was asking a question, making a comment, or responding to a question. Recording stopped when the teacher closed the book or when the last question or comment was made. An overall percentage of time during each engagement state was calculated for each observation.

The research team coded approximately 30% of the engagement assessments to establish IOA using a point-by-point agreement in which the number of agreements was divided by total intervals observed. Interobserver estimates were 87% for Stage 1 (range = 78%–92%) and 92.5% for Stage 2 observations (range 83%–98%).

Children's Vocabulary Growth. The research team identified target key vocabulary words in books used in each week of the study. Included words occurred at least twice during the reading and were accompanied by an illustration. Between four and six vocabulary terms were selected for each book, comprising both nouns and verbs. Symbolstix software was used to create images that corresponded with each vocabulary term; thus the illustration was not the same as that used in the book. The assessor presented each image and asked the child to provide its expressive label. Children scored 1 point for each correct response; no credit was given for an incorrect response. An overall total of correct responses and a percentage (number correct divided by total) were calculated for each student.

This process generated a proximal measure of children's knowledge of vocabulary presented in books. We created two versions of the vocabulary assessment. One form contained vocabulary that was targeted in books used in Stage 1 procedures. A second form contained vocabulary presented in Stage 2 books. The research team assessed children's vocabulary knowledge at three points during the study: prior to Stage 1 intervention (pretest), after 4 weeks for the early-decision group and 8 weeks for the late-decision group (midtest), and at the completion of the study (posttest). Both forms of the assessment were administered at each time point to allow researchers to differentiate whether growth in vocabulary was attributed to the intervention or natural maturation. We expected that children's vocabulary knowledge would improve at a faster rate for vocabulary presented in books used during the corresponding intervention stage compared with vocabulary in books that were not used in the current intervention stage. In Stage 1, for instance, children should show faster vocabulary growth for words used in Stage 1 books than for words in Stage 2 books. During Stage 2, we expect a growth in Stage 2 words while knowledge of Stage 1 vocabulary would remain constant or slower developing.

Results

No student randomized to the early-decision (Week 4) condition showed an early response. Among children randomized to the late-decision (Week 8) condition, one student (25% of the sample) showed an early response and continued with the G-DR sessions (see Figure 1).

Implementation Fidelity

Median implementation was high for all teachers in the areas of MA and OAB, adhering to 100% of MA and OAB items every observation during Stage 1. Scores were low and variable for teacher implementation of DR strategies. Teachers assigned to the early-decision (4-week) condition demonstrated a median implementation rate of 67% (range 33%–100%). Teachers assigned to the

late-decision (8-week) condition demonstrated a median implementation rate of 50% (range 50%–67%). Implementation of MA and OAB items remained high during Stage 2 (*Mdn* = 100% for all conditions). Scores for DR implementation varied across Stage 2 conditions but were higher compared with the previous phase: continue G-DR (*Mdn* = 67%, range 67%—67%), 1:1 reading (*Mdn* = 83%, range 83%–83%) and modified DR (*Mdn* = 71%; range 38%–100%). Teachers who had students randomized to the modified-DR condition ($n = 2$) included instructional components in addition to DR, specifically, (a) preteaching key vocabulary prior to book reading and (b) asking questions during book reading that targeted key vocabulary words. Data on implementation fidelity were mixed. One teacher implemented the systematic instruction procedures with a median rate of 100% fidelity on all observations; the other teacher performed the instruction with 66% fidelity (median). Data on implementation are disaggregated by teacher in Supplemental Figure 3.

Scores were low and variable for teacher implementation of DR strategies.

We analyzed the data further to assess the extent to which teachers implemented specific components of DR. Teachers consistently prompted students to take part in the reading sessions by asking questions (Phase 1, *Mdn* = 100%, range 50%–100%; Phase 2, *Mdn* = 87.5%, range 75%–100%) but did not consistently follow through with the entire PEER sequence. Teachers less often explicitly evaluated students' responses (Phase 1, *Mdn* = 55%, range 47%–67%; Phase 2, *Mdn* = 68.5%, range 58.5%–78.5%) and demonstrated low levels of expanding student responses (Phase 1, *Mdn* = 25.5%, range 10%–40.5%; Phase 2, *Mdn* = 36%, range 11%–57%) and of asking the student to repeat the expanded phrase (Phase 1, *Mdn* = 21%, range 0%–36%; Phase 2, *Mdn* = 21.3%, range 0%–41.5%).

Evaluative Feedback on Social Validity

All teachers believed that the initial in-service training conducted by the research team was sufficient (mean = 4.5) and "strongly agreed" that they received sufficient support from the coaches during the study (mean = 5). In addition, teachers "strongly agreed" with the following statements: (a) "Strategies were easy to incorporate into daily book reading," (b) "I will continue to use these strategies," and (c) "Interactive reading should be included in educational programming for all students." Teachers' perception of the acceptability of child outcomes was also assessed and disaggregated by study phase. Teachers reported more favorable outcomes from Phase 2 procedures, strongly agreeing that their students talked more during reading, enjoyed reading, and attended during book-reading sessions (see Supplemental Figure 4).

Child Outcomes

Engagement During Reading. A Wilcoxon signed rank test was applied to compare children's engagement during book reading sessions. Effect sizes (r) were calculated by dividing the z value that is used for a normal approximation test by the square root of the number of observations and interpreted along the guidelines of Cohen's d (.10 = small effect, .30 = medium effect, .50 = large effect; Pallant, 2007). An evaluation of median values revealed that the proportion of time children actively engaged in book reading increased between Stage 1 (*Mdn* = .16) and Stage 2 (*Mdn* = .24), though the difference was not statistically significant, $z = 1.02$, $p = .38$, with a small effect size ($r = .23$). We found no statistical difference for the proportion of time children passively engaged in book reading in Stage 1 (*Mdn* = .39) compared with Stage 2 (*Mdn* = .40), $z = .56$, $p = .57$, with a small effect size ($r = .12$). The proportion of time children were unengaged decreased from Stage 1 (*Mdn* = .47) to Stage

2 (*Mdn* = .28). This difference was not statistically significant, $z = 1.02$, $p = .38$, with a medium effect size ($r = .33$). Data disaggregated by child can be found in Table 1.

Vocabulary Knowledge. Data on children's vocabulary knowledge failed to meet several assumptions needed to apply inferential statistics. We instead provide descriptive information of median values of performance on the vocabulary probe assessment by intervention stage and treatment condition. A rate of vocabulary growth was calculated for each child by treatment condition. The rate of growth for Stage 1 treatment conditions was calculated by subtracting the number of words correctly labeled at pretest score from the midtest score (e.g., after 4 weeks for early decision or 8 weeks for late decision) divided by the number of weeks children received intervention. We reached a vocabulary improvement rate for Stage 2 treatment conditions by subtracting the midtest score obtained prior to the Stage 2 intervention from the posttest score at the end of the study. This value was divided by the number of weeks children received Stage 2 intervention.

Stage 1. Children assigned to the early-decision 4-week condition identified a median of 28% of target vocabulary words at the beginning of Stage 1 (pretest; range 0%–42%) compared with a median of 32% at the end of Stage 1 (midtest; range 9%–45%). The median rate of vocabulary change from pretest to midtest was 0.31 words per week (range 0–0.79 words per week). Children assigned to the late-decision 8-week condition identified a median of 12% of target vocabulary words at pretest (range 0%–20%) compared with a median of 20% at midtest (range 16%–40%). The median rate of vocabulary change from pretest to midtest was 0.50 words per week (range 0–0.63 words per week). Children were also assessed for vocabulary knowledge contained in books that were not used in the current intervention condition as a control measure. Children correctly identified a median of 20% of vocabulary at pretest (range 10%–40%) compared with 28% at midtest (range 16%–56%) for median growth of 0.31 words per week (range 0–1.0 words per week).

Stage 2. Slow responders assigned to a Stage 2 1:1 reading condition identified a median of 24% of target vocabulary words at the beginning of Stage 2 (midtest; range 16%–28%) compared with a median of 28% at the end of Stage 2 (posttest; range 12%–28%). The median rate of vocabulary change was 0.0 words per week (range 0–0.1 words per week). Children who were slow to respond and assigned to a Stage 2 explicit-instruction condition identified a median of 30% of target vocabulary words at midtest (range 16%–56%) compared with a median of 44% at posttest (range 20%–52%). The median rate of vocabulary change was 0.15 words per week (range 0–0.3 words per week). We also assessed children for vocabulary knowledge contained in books that were not used in the Stage 2 intervention condition as a control measure. Children correctly identified a median of 23% of vocabulary at midtest (range 9%–41%) compared with 25% at posttest (range 14%–55%) for median vocabulary growth rate of .08 words per week (range 0.0–0.18 words per week).

Discussion

The purpose of Project START is to create an adaptive reading intervention to support the development of early language and literacy skills that are foundational to future reading achievement. Though the sample size of the developmental year of this study prevents us from drawing conclusions about the effect of the AIs on child language and literacy outcomes, we gain preliminary insight of directions that the intervention may have on children's engagement and vocabulary growth. Specifically, we found that children with ASD spent approximately 48% of the time unengaged in book reading in Stage 1. This represents a meaningful proportion time in which children are not learning from the activity. This proportion decreases to 28% during Stage 2 activities, which suggests that changing instruction relates to children's engagement. The benefit of improved engagement on children's vocabulary growth, however, is not clearly established in these data.

Table 1. Child Vocabulary and Engagement Across Intervention Stages (in percentages).

	Stage 1							Stage 2						
		Book Vocabulary (% correct)			Engagement (% per state)				Book Vocabulary (% correct)			Engagement (% per state)		
Class/Child	Condition	Pretest	Midtest	Posttest	Active	Passive	Unengaged	Condition	Pretest	Midtest	Posttest	Active	Passive	Unengaged
A/1	4 week	8	23	27	28	46	26	M-DR	25	32	52	29	43	24
A/2	4 week	0	9	14	13	60	27	M-DR	15	20	20	18	47	29
A/3	4 week	42	41	45	19	33	48	M-DR	25	28	52	22	52	28
A/4	4 week	17	23	18	18	24	59	M-DR	20	16	36	13	34	53
B/5	4 week	40	45	55	14	38	48	M-DR	40	56	48	7	35	58
B/6	4 week	42	41	41	21	32	46	M-DR	25	40	40	15	36	49
C/7	8 week	0	16	24	3	40	57	1:1 DR	10	24	28	26	56	17
C/8	8 week	8	24	16	6	40	55	1:1 DR	15	16	12	56	10	35
C/9	8 week	17	16	16	9	44	48	1:1 DR	20	28	28	39	51	10
D/10	8 week	20	40	52	77	20	3	Cont DR	25	40	56	79	21	1

Note. The research team assessed children's vocabulary knowledge of words presented in books used in the intervention at three points during the study: prior to Stage 1 intervention (pretest), after 4 weeks for the early-decision group and 8 weeks for the late-decision group (midtest), and at the completion of the study (posttest). Stage 1 vocabulary words are presented in books used between pretest and midtest. Stage 2 vocabulary words are presented in books used between midtest and posttest. DR = dialogic reading; M-DR = modified DR; Cont DR = DEFINITION; Cont DR = Continue Group DR.

Though data indicate that children are learning new vocabulary words, the rate of growth is slow. Moreover, we do not detect meaningful changes in the rate of vocabulary growth across different stages and treatment conditions. This may be due, in part, to limitations of our sample size as well as the sensitivity of the researcher-developed assessment that was used to measure vocabulary growth. We discuss these limitations later in this section.

Our efforts during the 1st year of the study primarily focused on evaluating the feasibility and acceptability of the AI in anticipation that modifications would need to be made during the subsequent years of the study. Teachers' attitudes about the intervention not only are valuable to us as applied researchers but also have implications for whether they will adopt interventions beyond the life of the study. Teachers' responses to the social validity questionnaire are supportive of the intervention procedures, the training they received from the research team, and perceived benefits to their students. Although teachers' impressions of the intervention and their experiences delivering instruction were overall favorable, several issues emerged during the developmental year that will need to be addressed. We describe those issues, along with the proposed means of addressing them, in the following section, with a summary in Table 2.

Several issues emerged during the developmental year that will need to be addressed.

Future Directions

Expand Recruitment. We drew our sample from urban-area schools that held existing partnerships with the university, which may introduce bias. This is consistent with the larger body of autism intervention research, in which participants from families that are more educated and more advantaged than families in the broader population are overrepresented (West et al., 2016). Because our aim is to develop and test the feasibility of the intervention in a broad range of schools that serve students with ASD, we will need to expand our recruitment efforts. In addition, we found approximately 38% of children whose caregivers expressed interest in the study ineligible to take part in the study. This poses a significant burden on the assessment team, teachers, and students whose routines are disrupted by the testing schedule. It is apparent the research team will need to review and clarify the basic child criteria for study inclusion.

Identify Early and Slow Responders. Identifying specific crucial decision points is a necessary first step for developing adaptive strategies to determine when a change is warranted (Murphy et al., 2007). This development year provided us with an opportunity to gather estimates of the proportion of students who would show an early response to Stage 1 intervention at the different decision points. There was a 0% response rate in the Stage 1 early-decision (4-week) group compared with 25% in the late-decision (8-week) group. It is thus unlikely we will have sufficient numbers in each AI subgroup for analytical purposes. We will enact several changes to address this issue.

First, we will revise the timing of Stage 2 decision points to increase the probability that children will respond to the Stage 1 intervention. The early-decision time point will be changed to 8 weeks; the late-decision time point will be changed to 12 weeks. Given a Stage 1 response rate of 25%, we estimate we will need 64 children to take part in the pilot SMART. We used the applet program created by the Methodology Center at Pennsylvania State University to calculate the minimum sample size required for a pilot SMART (https://methodology.psu.edu/publications/news/sample-size-smart-applet). The estimate is based on having a minimum of six students in each subgroup, assuming a .70 minimum probability of observing this many participants in each subgroup.

Second, we will modify the format of the book-specific vocabulary assessment that is being used as a tailoring variable to identify the Stage 2 intervention. Researchers noted anecdotally that many students used the target vocabulary during reading sessions yet did not identify the target word(s) accurately when assessed at midpoint. Assessors also observed that children often provided a label

Table 2. Issues Identified in the Development Year and Changes to the Subsequent Pilot SMART.

Topic	Issues discovered in development year	Changes in preparation for pilot SMART
Recruitment	Our sample was drawn from urban-area schools. Although it is common for research to be conducted at sites conveniently located near universities and ASD clinics, our aim is to develop and evaluate the feasibility of the intervention in a broad range of schools that serve students with ASD. Approximately 38% of children failed to meet minimum criterion for study inclusion.	Changes in recruitment efforts will be made as follows: 1. Greater effort will be made to recruit from a wider range of schools to increase the diversity of the sample. 2. The research team will recruit a larger sample initially with the expectation that a percentage of the students will not meet criteria to be included in the full study. We will also be more explicit in verbal and written communication with teachers about the inclusion criteria so that consent forms are sent home with students who are likely to meet the inclusion criteria.
Identification of early and slow responders	There was a 0% response rate in the Stage 1 early-decision (4-week) group. Twenty-five percent of children assigned to the late-decision (8-week) group were categorized as an early responder. Based on these estimates, the probability of having a sufficient number of children in the AI1 category is unlikely. Students used the target vocabulary during reading sessions yet did not identify the target word(s) accurately when assessed at the decision point. Assessors also observed that children commonly provided a label that, although sensible, was not the exact target vocabulary word so was marked as an error (e.g., "hop" vs. "bounce").	Two major changes will be made in an effort to increase the number of children identified as early responders: 1. The early-decision time point will be delayed from 4 weeks to 8 weeks. The late-decision time point will be changed from 8 weeks to 12 weeks. 2. To improve the sensitivity of the tailoring variable assessment, the format of the tailoring variable will change from an expressive identification task to a receptive task. The assessor will read the target word, and the child will respond by pointing to the image that corresponds with the target word from an array of four images.
Identification of additional tailoring variables	Teachers reported improved vocabulary performance demonstrated by their students, which supports the use of a vocabulary measure as one tailoring variable. Teachers who study also commented on other areas of skill improvement they observed, primarily in children's attention and participation in reading.	In the subsequent years of the pilot SMART, we will include an additional tailoring variable related to behavioral engagement. Thus, children who show growth in book-specific vocabulary or high levels of active engagement during reading sessions will be identified as early responders.
Implementation fidelity	In assessments, teachers' fidelity of implementation was low. Although improvements were observed as the intervention progress, the overall percentage of steps implemented as designed was generally below research standards.	The following changes will be made to the training and coaching protocol: 1. The initial training will be conducted in a hybrid format, consisting of face-to-face instruction and online supplemental supports and videos. Teachers will be able to refer back to the videos and supports as needed throughout the school year. 2. Coaches will continue to observe and provide feedback to teachers weekly. If after 3 weeks there is no improvement, coaches will video reading sessions. The coaches will use software to annotate their feedback during the video and review with teachers. 3. The frequency of coaching sessions will be gradually faded for teachers who demonstrate adequate implementation (e.g., 80% or better).
Feasibility	The coaches reported that a common barrier teachers faced was maintaining a consistent reading schedule. Often, teachers or their support staff were pulled from the classroom to attend to other matters, or team members were out sick without substitutes.	In subsequent years, we will take a team approach and request that at least two members of the classroom team be trained in the study procedures. This will support that readings are done, even in the event that the lead teacher is not available to lead the book reading session.

Note. SMART = sequential multiple-assignment randomized trial; ASD = autism spectrum disorder; AI = adaptive intervention.

that, though sensible, was not the exact target vocabulary word and was considered an error (e.g., "hop" vs. "jump"). We can use this information, though anecdotal, to improve the sensitivity of the tailoring variable. We will change the assessment from relying on expressive identification of target vocabulary to receptive identification, as children commonly learn words receptively before they produce them expressively.

Identify Additional Tailoring Variables. Children's knowledge of vocabulary presented in books served as the sole tailoring variable in the intervention. The choice to use vocabulary as a tailoring variable was supported by teachers' reports that they perceived their students learned new vocabulary as a result of participating in the intervention. We also believe that targeting vocabulary skills is a meaningful outcome for children with ASD given that vocabulary knowledge is foundational to supporting children's ability to draw meaning from language (NELP, 2008). For these reasons, we will continue to use assessments of book-specific vocabulary knowledge as a tailoring variable.

Teachers also reported improvement in children's attention and participation in reading. Joint attention, the visual sharing of attention with a social partner in reference to an object or event (Carpenter et al., 1998) is a deficit for many children with ASD (Adamson et al., 2004) but is an important intervention target as it is related to children's language development (Adamson et al., 2004) and reading comprehension (Dickinson & Porche, 2011). Given the important role that joint attention has on learning, we will create an additional tailoring variable focused on the quality and quantity of children's engagement during reading sessions.

Improve Implementation Fidelity. Teachers' DR implementation was lower than desirable research standards and varied across instructional components. Teachers were consistent with prompting participation by asking questions but were less likely to follow through with the remaining steps of the instructional sequence. This finding is consistent with previous research using DR strategies in classrooms with learners with ASD (Fleury & Schwartz, 2017) but is particularly concerning given the benefit to this population of hearing expanded language and practicing their use of language. For this reason, we will make several modifications to the training and coaching protocol to better support teachers to implement the intervention with greater fidelity.

First, we will continue to offer an initial workshop followed by coaching. Research shows that training supplemented with coaching is more effective in enacting change in teacher behavior than workshops alone and is especially important for educators working with children with ASD (Franzone et al., 2012; Wilson et al., 2012). We will, however, change the initial workshop to include a traditional face-to-face training combined with online supplemental supports and videos. Adding the online component will allow teachers to refer to the supplemental materials as needed throughout the intervention. Second, under a tiered approach, coaches will continue to observe teachers weekly to provide feedback and guidance on their implementation as originally designed. Teachers progressing adequately on implementation assessments will continue to receive coaching weekly, following the same format. But if teachers do not show adequate improvement within the first 3 weeks of the intervention, the coaches will intensify their support by recording video of the reading sessions. The coaches will use software that lets them annotate the videos and review them with the teachers. Coaches will gradually fade their support once teachers show mastery of the intervention procedures.

Improve AI Feasibility. The coaches reported that maintaining a consistent reading schedule was difficult for teachers. Often, teachers or their support staff left the classroom to attend to other matters, or team members were out sick without substitutes. Maintaining a consistent reading schedule is beneficial not only from a classroom management perspective

but also considering the tendency of children with ASD to benefit from predictable routines. In subsequent years, we will request that at least two members of the classroom team receive training in the study procedures. Including at least two adults to lead the reading sessions has an added benefit of supporting skill generalization, an essential feature of quality ASD programming (Foxx, 2008).

Conclusion

In sum, we learned much from the developmental year of this project. Data regarding the feasibility and acceptability of the intervention will improve the intervention for the subsequent 3 years of the project. Social validity—the extent to which teachers viewed the procedures as feasible and outcomes as acceptable—is a major strength of the intervention. Though teachers believed that the intervention was feasible, our direct observations revealed that teachers will need additional training and support to deliver the intervention as designed. This developmental year also provided data that we will use to change our recruitment strategy, modify the timing of decision points, and adapt our tailoring variable. After incorporating these changes, we are well positioned to launch the subsequent study with a larger sample of children with ASD that will inform the direction of the AI's effects on emergent literacy and language outcomes.

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ORCID iD

Veronica P. Fleury https://orcid.org/0000-0002-3247-234X

Supplemental Material

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