

Supplement Article

Designing Caregiver-Implemented Shared-Reading Interventions to Overcome Implementation Barriers

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Purpose: This study presents an application of the theoretical domains framework (TDF; Michie et al., 2005), an integrative framework drawing on behavior-change theories, to speech-language pathology.

Methods: A multistep procedure was used to identify barriers affecting caregivers' implementation of shared-reading interventions with their children with language impairment (LI). The authors examined caregiver-level data corresponding to implementation issues from two randomized controlled trials and mapped these to domains in the TDF as well as empirically validated behavior-change techniques.

Results: Four barriers to implementation were identified as potentially affecting caregivers' implementation: time pressures, reading difficulties, discomfort with reading, and

lack of awareness of benefits. These were mapped to 3 TDF domains: intentions, beliefs about capabilities, and skills. In turn, 4 behavior-change techniques were identified as potential vehicles for affecting these domains: reward, feedback, model, and encourage. An ongoing study is described that is determining the effects of these techniques for improving caregivers' implementation of a shared-reading intervention.

Conclusions: A description of the steps to identifying barriers to implementation, in conjunction with an ongoing experiment that will explicitly determine whether behavior-change techniques affect these barriers, provides a model for how implementation science can be used to identify and overcome implementation barriers in the treatment of communication disorders.

Children with language impairment (LI) are highly susceptible to reading difficulties (RD; see Catts, Fey, Tomblin, & Zhang, 2002). For some children, this susceptibility is evidenced during the preschool years by deficits in early-literacy skills that are causally associated with future reading achievement, such as print knowledge, phonological awareness, and vocabulary skills (Cabell et al., 2010). For instance, one recent report showed that 55% of 3- to 5-year-olds with LI exhibited significant deficits in these early-literacy skills (Justice et al., 2013), and this figure generally corresponds with the number of children with LI who experience RD in the later primary grades (Catts et al., 2002). Identifying effective ways to prevent RD among children with LI is a priority within national research agendas (Lonigan & Shanahan, 2009), with efforts

typically focused on improving those early-literacy skills that are causally relevant to future reading achievement.

To this end, a number of researchers have studied avenues for improving the early-literacy skills of young children with LI, with many studies finding positive short-term effects (Gillon, 2002; Justice, Chow, Capellini, Flanigan, & Colton, 2003; Justice, Kaderavek, Bowles, & Grimm, 2005; Lovelace & Stewart, 2007; van Bysterveldt, Gillon, & Moran, 2006). The prevailing approach to improving early-literacy skills, as applied to children with LI and children at risk more generally, involves systematic manipulation of shared-reading routines so as to make early-literacy learning opportunities more salient and intensive for children. For instance, a commonly used intervention approach involves training caregivers and educators to read storybooks with children in a way that promotes the quality and quantity of adult-child oral exchanges during read-alouds, typically termed *interactive* or *dialogic* reading (see Mol, Bus, & de Jong, 2009). Several meta-analyses aggregating results from studies featuring variations of interactive reading have provided generally strong support for shared-reading interventions as an avenue for improving children's early-literacy skills (Bus, Van IJzendoorn, & Pellegrini, 1995;

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Mol et al., 2009). It is interesting, however, that a meta-analysis examining the effects of interactive reading on children's vocabulary skills, in particular, found attenuated effects for children who were considered at risk due to poverty; that is, compared with children not at risk ($d = 0.53$), those who were at risk benefited significantly less ($d = 0.13$) from exposure to interactive reading (Mol, Bus, de Jong, & Smeets, 2008). The authors suggested that the attenuated effects for children at risk may be due to the way in which caregivers implement the book-reading interventions. They pointed out, however, that this cannot be explicitly tested, given that there are no studies that have carefully determined how the interventions are "actually realized" for children who are and are not at risk (Mol et al., 2008, p. 22).

It is most certainly true that implementation of shared-reading interventions by caregivers within the home environment does not always reach the levels intended by the intervention developers. For instance, caregivers may implement fewer intervention sessions than is recommended, may not maintain adequate records detailing implementation, or may cease implementation altogether (Justice, Skibbe, McGinty, Piasta, & Petrill, 2011; Lonigan & Whitehurst, 1998). As examples, Justice et al. (2011) reported that nearly one in four caregivers implementing home-based book-reading interventions with their children with LI dropped out of their study, whereas Lonigan and Whitehurst (1998) reported that only 60% of caregivers maintained logs of home reading sessions that were a required part of intervention implementation. The field of implementation science can provide guidance for how researchers can improve understanding of why interventions are not implemented as intended, theoretically and empirically. Implementation science is a scientific field focused on understanding the translation of research into the field, to include generating theories of how research is translated effectively and guiding research designed to enhance translation (Eccles & Mittman, 2006).

In this supplement article, we discuss a framework generated within the field of implementation science that can serve to improve understanding of why caregivers may not implement shared-reading interventions at the levels intended by developers. The supplement article is organized to discuss this framework and present some examples of how it has been used previously. We then discuss how the framework was applied to caregiver-implemented shared-reading interventions. The supplement article closes with a description of an ongoing research study in which the application is being explicitly tested to determine whether caregivers' implementation of a shared-reading intervention can be positively affected.

The Theoretical Domains Framework From the Field of Implementation Science

When implementers of an intervention do not deliver it as intended (in this case, caregivers who we want to read regularly to their children), implementation scientists propose that it is important to identify behavioral determinants

that affect implementation and examine how techniques that target these behavioral determinants may remove barriers and improve implementation (Francis, O'Connor, & Curran, 2012). That is, to identify why individuals are not implementing something that is desirable (or the converse, why individuals are doing something that is undesirable), it is necessary to carefully identify what is determining the behavior (nonimplementation). By way of example, a recent study sought to identify determinants of a behavior often seen among surgeons—namely, ordering preoperative tests in healthy patients for whom such tests are not indicated (McSherry et al., 2012). Given that there are clear guidelines available to guide implementation of preoperative tests, it is unclear why these guidelines are not being followed. McSherry et al. (2012) conducted interviews with surgeons to identify determinants of their behaviors, specifically to find out why they were not following clinical guidelines governing preoperative tests. By empirically identifying determinants of the surgeons' behaviors (e.g., fear of missing an underlying condition that could complicate surgery, belief that such tests are relatively inexpensive, concerns about colleagues' perceptions if they do not do such tests), researchers can seek to improve implementation by explicitly seeking to affect these determinants. Such work is necessary for changing the behaviors that contribute to implementation issues and reducing the gaps between implementation as intended and as achieved.

The theoretical domains framework (TDF; Cane, O'Connor, & Michie, 2012; Michie et al., 2005; Michie, Johnston, Francis, Hardeman, & Eccles, 2008) is a tool that has emerged in the field of implementation science to guide efforts to identify determinants of behaviors with respect to intervention implementation. There have been numerous efforts over time to identify the determinants of human behavior, and the TDF seeks to catalog these into a framework that can be used to understand how these determinants (e.g., a surgeon's fear of missing an underlying condition) can affect the implementation of an intervention (e.g., a surgeon's adherence to clinical guidelines regarding the use of preoperative tests). The TDF is an integrative framework used in implementation-science research to identify salient behavioral determinants, referred to as *domains*, that serve as barriers to intervention implementation as drawn from behavior-change theories. The TDF identifies 14 distinct domains that affect implementation of interventions or other evidence-based practices; the domains appear in Table 1.

The TDF has been applied almost exclusively to the health science fields, with a 2012 synthesis showing it to have 133 references in the literature (Francis et al., 2012). The synthesis provided evidence of its application to implementation issues related to weight management, tobacco use prevention, hand hygiene, pain management, and human papilloma virus vaccination, to name a few. As an example of its application, French et al. (2012) sought to identify the behavioral determinants that prevent physicians from using an evidence-based clinical guideline designed to restrict use of plain film x-rays when contraindicated. The behavior of interest was lack of adherence to the clinical guideline. For

Table 1. Behavioral determinants (domains) within the theoretical domain framework.

No.	Domain	Description
1	Knowledge	An awareness of the existence of something
2	Skills	An ability or proficiency acquired through practice
3	Social/professional role and identity	A coherent set of behaviors and displayed personal qualities of an individual in a social or work setting
4	Beliefs about capabilities	Acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use
5	Optimism	The confidence that things will happen for the best or that desired goals will be attained
6	Beliefs about consequences	Acceptance of the truth, reality, or validity about outcomes of a behavior in a given situation
7	Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus
8	Intentions	A conscious decision to perform a behavior or a resolve to act in a certain way
9	Goals	Mental representations of outcomes or end states that an individual wants to achieve
10	Memory, attention, and decision processes	The ability to retain information, focus selectively on aspects of the environment, and choose between two or more alternatives
11	Environmental context and resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behavior
12	Social influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviors
13	Emotion	A complex reaction pattern, involving experiential, behavioral, and physiological elements, by which the individual attempts to deal with a personally significant matter or event
14	Behavioral regulation	Anything aimed at managing or changing objectively observed or measured actions

Source. Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behavior change and implementation research. *Implementation Science, 7*, 37.

some physicians, the researchers found that knowledge served as a significant determiner of their behavior—that is, the physicians had limited awareness of why x-rays are contraindicated in some circumstances. In the TDF, knowledge is identified as a key determinant of behavior (No. 1 in Table 1). Of note, by identifying that physicians' knowledge is determining their behavior, it is then possible to identify specific behavior-change techniques that can affect that domain (French et al., 2012). For instance, for the knowledge domain, a behavior-change technique that can address lack of knowledge is the explicit provision of information, which can take a variety of forms such as providing physicians with a workbook or a workshop. By addressing the behavioral determinant (lack of knowledge) that was affecting physicians' implementation of this evidence-based guideline, via implementation of an effective behavior-change technique (provision of information), the barrier can be overcome and implementation can improve.

The TDF has been used extensively in the health sciences literature (Francis et al., 2012), as noted previously, yet we have seen few applications to the field of communication disorders or the social sciences in general. Thus, in the remainder of this supplement article, we present an application of the TDF to the field of speech-language pathology, specifically, to the implementation of book-reading intervention by caregivers of children with LI. An empirically supported approach to improving the early-literacy skills of children with elevated risk for RD (see Mol et al., 2009), speech-language pathologists (SLPs) may recommend use of this practice to the caregivers of children

on their caseloads. However, given evidence we will provide in detail the following sections, it is foreseeable that many caregivers will have issues with implementing the intervention as recommended. Thus, clinicians need to work to identify why some caregivers have difficulty with implementing this practice, so they can apply behavior-change techniques that will effectively improve implementation.

Caregiver-Implemented Shared-Reading Interventions: Implementation Barriers

For children with LI, efforts to improve their early-literacy skills and reduce their risk for future RD often feature caregiver-implemented shared-reading interventions in the home environment (Crain-Thoreson & Dale, 1999; Dale, Crain-Thoreson, Notari-Syverson, & Cole, 1996; Ezell, Justice, & Parsons, 2000; Justice et al., 2005, 2011; van Bysterveldt et al., 2006). Doing so provides an avenue for actively involving caregivers in their children's intervention, improving the home literacy environment that children experience, and using an empirically validated practice to address children's risk for RD. For example, in one study, van Bysterveldt et al. (2006) described an investigation involving seven caregivers of children with Down syndrome, all of whom had LI and were considered to be at risk for future RD. In this study, caregivers were instructed to implement read-alouds four times weekly with their children for a 6-week period, corresponding to a 24-session intervention. The caregivers were trained to embed explicit

conversations about print and sound structures into the repeated read-aloud sessions, which represents an empirically validated practice for improving the early-literacy skills of children with LI (Justice et al., 2005, 2011). The children showed significant growth on four early-literacy measures over the 6-week period, and the gains were generally larger than those seen in an untreated control group of typically developing peers for the duration of the intervention. The results of this work converge with other studies showing that caregiver-implemented book-reading interventions can enhance the early-literacy skills of children with LI and, consequently, can be considered an evidence-based practice for SLPs to utilize.

Nonetheless, the accumulated evidence, if studied closely, also raises concerns regarding whether an ordinary caregiver can implement the intervention as intended, particularly with the frequency of shared-reading interactions required. In nearly all studies of caregiver-implemented book-reading interventions, caregivers are required to read with their children on a regular basis for a sustained period of time. In the study by van Bysterveldt et al. (2006), the caregivers had to implement 24 shared-reading sessions with their children with Down syndrome. In this study, the caregivers had no challenges implementing the intervention as designed; however, it is important to recognize that all of the caregivers enrolled into the study were already reading with their children on a regular basis, as shown on logs they maintained for 2 weeks prior to the intervention. On average, the caregivers typically read books with their children 10 min per day, and thus the intervention was compatible with preexisting home literacy activities of the caregivers involved.

For many caregivers, however, implementation of interventions requiring frequent and sustained read-alouds with their children may be incompatible with their current home literacy practices. A considerable body of research has shown substantial variability in how often caregivers read with their children as well as their comfort with and beliefs about the value of this routine (Curenton & Justice, 2008; Roberts, Jurgens, & Burchinal, 2005). National data collected as part of the National Household Education Survey ($n = 7,566$) have shown that about one fourth of caregivers of young children report seldom reading with their young children (reading books with them on two or fewer occasions per week; Yarosz & Barnett, 2001). The frequency of reading aloud correlates with a range of sociodemographic factors, such as how many children are in the home (negatively associated with frequency of home reading) and maternal level of education (positively associated with frequency of reading). Frequency of reading aloud can also relate to one's ethnic or racial background; for instance, among low-income families, White mothers read more often to their young children than Hispanic and African American mothers do (Raikes et al., 2006). Phillips and Lonigan (2009) examined the home reading practices of about 1,000 caregivers of young children in Florida. On average, caregivers reported reading to children about five times per week, but there was wide variability in this practice,

ranging from 0 to 7 days of reading per week. These researchers used cluster analysis to determine whether certain profiles of caregivers were associated with home reading practices and other home literacy routines. Of note, two thirds of caregivers in this sample reported low levels of adult-child reading in the home and were less educated, less advantaged, and more highly stressed, on average, compared with caregivers who reported high levels of adult-child home reading.

Therefore, it is not surprising that two recent studies of shared-reading interventions involving relatively large and diverse samples of caregivers of children with LI found considerable variability in the extent to which caregivers implemented the intervention, particularly with respect to implementation intensity (Justice, Logan, Kaderavek, & Dynia, 2015; Justice et al., 2011). *Implementation intensity* is a function of the number and length of sessions over time (i.e., *intervention frequency*) and the frequency of instructional routines to be embedded within each session (i.e., *intervention dose*). Both studies featured caregiver implementation of print-focused read-alouds over an extended period of time (12 weeks or 30 weeks). *Print-focused read-alouds* represent an empirically supported book-reading intervention designed to improve children's print knowledge in the short term (Justice, Kaderavek, Fan, Sofka, & Hunt, 2009; Justice et al., 2011; Lovelace & Stewart, 2007; Piasta, Justice, McGinty, & Kaderavek, 2012), with recent work showing positive longer-term effects on reading achievement (Piasta et al., 2012).

Investigations of caregiver-child interactions during print-focused read-alouds have shown that the primary active ingredient of this intervention is the adult's explicit references to print, which in turn serve as a mechanism for directing children's visual and verbal attention toward specific, explicit information about print within the books being read (Evans & Saint-Aubin, 2005; Evans, Williamson, & Pursoo, 2008; Justice, Pullen, & Pence, 2008). Interventions featuring print-focused read-alouds "manualize" this active ingredient by specifying the number of adult explicit references to print to occur within a given reading session, corresponding to intervention dose, as well as the number of reading sessions to occur over time, corresponding to intervention frequency. Both intervention dose and frequency represent important mechanisms for bringing about change in children's print knowledge, with higher within-session dose offsetting lower frequency implementations (McGinty, Breit-Smith, Fan, Justice, & Kaderavek, 2011). The most thorough treatment manual available to guide clinical use of print-focused read-alouds recommends an intervention intensity of two to four shared-reading sessions per week and within-session dosage of about four to five print references per each of two print-knowledge objectives (Justice & Sofka, 2013). The treatment manual and all related materials to guide implementation are freely available online (<http://ccec.ehe.osu.edu/practice/ccec-curricula/star2/materials/>).

Two recent randomized controlled trials examining the effects of print-focused read-alouds for children with LI, as implemented by relatively large and diverse samples

of caregivers, illustrate the extent to which caregivers can achieve implementation goals with respect to intervention intensity and dose (Justice et al., 2011, 2015). For our purposes, we will simply refer to these studies as Study 1 (Justice et al., 2011) and Study 2 (Justice et al., 2015). In both studies, caregivers implemented print-focused read-alouds following an assigned schedule of dose and frequency so that children would be exposed to a comprehensive scope and sequence of print knowledge objectives. Also in both studies, caregivers received the following: a new storybook each week to read with their children, recording media for audio- or videotaping their home reading sessions and sending these to project staff on a specific schedule, and written logs they were to return by mail every 2 weeks to project staff. With respect to dosage and intensity of implementation, there were slight variations in the intervention, as manualized across the two studies. In Study 1, caregivers read to their children four times per week for 12 weeks, for an overall intensity of 48 sessions. For dosage, within each session, caregivers were to engage in print-focused discussion nine times, and small scripts for these discussions were pasted within the books themselves. In Study 2, caregivers read to their children two times per week for 30 weeks, for an overall intensity of 60 sessions. For dosage, within each session, caregivers were to engage in print-focused discussions four to six times, and a card placed within each book provided a general guide for these discussions.

In Study 1 and Study 2, examining caregiver implementation of intervention intensity and dose was not a primary focus of the work. Rather, the goals of these studies were focused on determining the causal relations between treatment exposure and children's gains in print knowledge; the results of both studies showed positive effects on children's print knowledge that can be attributable to exposure to print-focused read-alouds. However, both studies also indicated that a nontrivial number of caregivers could not implement the intervention as it was intended. It is no surprise that the effects seen for children's outcomes are attenuated compared with those seen in carefully controlled efficacy studies in which implementation more closely resembles what is intended by intervention developers (e.g., Justice & Ezell, 2002; Lovelace & Stewart, 2007).

In Study 1, a total of 62 caregivers of children with LI implemented print-focused read-alouds for 12 weeks (four sessions per week) or an alternative (control) shared-reading program that featured regular shared reading of the same frequency (Justice et al., 2011). In the control condition, caregivers read at the same intensity as those in the treatment condition, but they were asked to read with their children using their normal reading style. Caregivers were recruited into the study largely via referral by their children's SLPs, who were treating the children in a range of settings, including outpatient clinics and preschool/child-care programs. SLPs across the state in which the study was conducted were provided information about the study, the desired characteristics of child participants, and how to refer children/families to the study. Consequently, the children enrolled in the study were relatively diverse with respect to their

socioeconomic status, which was based on maternal education, with about half of the mothers having high school as their highest education level. Consequently, the caregivers showed greater variability in their socioeconomic background than that seen in other studies of caregiver-implemented shared-reading interventions (e.g., van Bysterveldt et al., 2006). The children were relatively diverse with respect to race and ethnicity as well (76% White, 11% African American, 6% multiracial, 3% Hispanic, 3% other, 2% unreported). We refer readers to the study report for further details of the sample (Justice et al., 2011).

In this study, caregivers participated in a one-on-one orientation session with staff, received all materials necessary to implement the intervention, and received weekly phone calls from project staff as a general support for implementation and participant incentives (12 storybooks plus \$100). Of the 62 caregivers who consented to and began the intervention, only three fourths participated for the entire 12-week period, with 25% of caregivers dropping out of the study. Attrition was not differential by condition, with 32% of caregivers dropping out of the control condition, which featured implementation of four read-alouds per week. Thus, dropout from the study seemed to have less to do with the implementation of print-focused read-alouds and more to do with the required intensity of the home reading program, at four caregiver-child sessions per week.

In Study 2, participants were 291 children with LI whose caregivers and early childhood special education (ECSE) teachers implemented print-focused read-alouds simultaneously for 30 weeks or a control condition featuring regular reading. That is, children were exposed to the shared-reading intervention as implemented by both their ECSE teachers and their caregivers at the same time. Caregivers were recruited into the study via their children's enrollment in ECSE programs and were highly variable in their socioeconomic status on the basis of maternal highest level of education. Specifically, about half of the mothers had a high school diploma as their highest education level, with the other half having college or university credentials. The children were predominantly White (71%) or African American (12%), with 25% Asian, mixed race, Hispanic, or other. We refer readers to the primary report of this study for further details about the sample and recruitment procedures.

In this study, teachers and caregivers received a new storybook each week for 30 weeks; teachers were asked to read the book to their students four times per week, whereas caregivers were asked to read the book twice per week. The effects on children's print knowledge were compared with two alternative conditions: a school-only condition (teachers implement print-focused shared readings, caregivers implement regular reading), and a control condition (teachers and caregivers implement regular reading). For all conditions, caregivers completed a comprehensive entrance questionnaire about their background (including home literacy activities) and received an introductory orientation, monthly phone reminders plus home visits over

9 months to support implementation, and financial incentives to complete the program (30 storybooks plus gift cards). An important part of the intervention was caregiver completion of weekly logs on preprinted stamped/addressed postcards that they were to submit via mail to project staff at the end of each week. At the end of the 30-week interventions, an exit interview was also scheduled for all caregivers. Caregivers could not drop out of the study because their children were enrolled in a participating ECSE program and thus were maintained in the study through that relationship. However, many caregivers did not implement the program as intended, on the basis of an analysis of the logs they submitted over the course of the 30-week intervention. Although it is not entirely satisfying to use caregiver logs as an index of treatment intensity, we used these data to explore whether there were specific discernable patterns of implementation that characterized groups of caregivers.

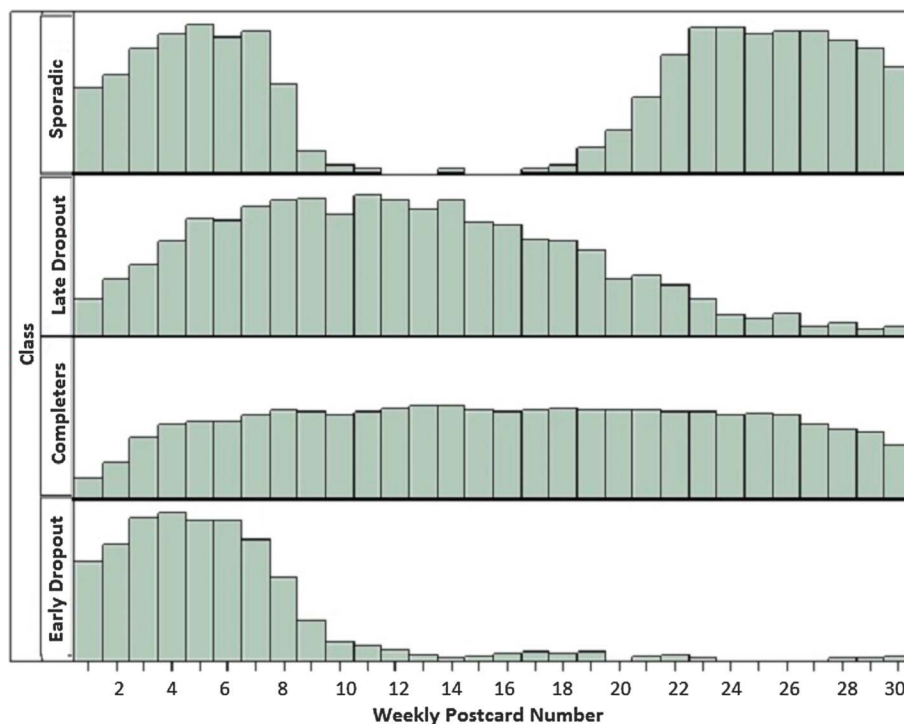
Specifically, we analyzed patterns of log submissions using latent class analysis, with the results shown in Figure 1. The latent class analysis results showed there to be four distinct profiles of caregivers with respect to their treatment intensity, on the basis of the logs submitted. The caregivers in Group 1 showed a pattern of implementation in which intensity was high only at the start and at the end of the intervention; however, between weeks 10 and 20, caregivers implemented little of it, so we refer to this as the “sporadic” group ($n = 117$; 15%). Group 2, referred to as the “late dropout” group ($n = 54$; 7%), showed high return rates until about three fourths of the way through the intervention,

and then they stopped it. Those in Group 3 demonstrated a high level of intensity throughout the course of the intervention, and thus we refer to these caregivers as the “completers” ($n = 264$; 34%). Finally, those in Group 4 ($n = 337$; 44%) are referred to as “nonstarters” because they appeared to implement none of the intervention. We found it interesting that the percentage of caregivers who failed to maintain any records of participation (Group 4: 44% of sample) is almost identical to that seen in Lonigan and Whitehurst (1998; 40% of sample) in their study of a caregiver-implemented book-reading intervention for children from low-income households.

Applying the TDF to Caregivers of Children With LI

In Study 1 and Study 2, a number of caregivers did not implement the book-reading intervention as intended. Given the orientations provided to caregivers, the efforts to maintain contact and provide support to caregivers via weekly phone calls (Study 1) or monthly calls plus home visits (Study 2) and the provision of generous incentives, we anticipated that implementation would be high. Indeed, the implementation issues we observed were hinted at in several prior studies of shared-reading interventions in the literature. Lonigan and Whitehurst (1998) reported that 40% of low-income caregivers failed to maintain implementation logs when conducting a 6-week home reading

Figure 1. Average participant rate of return (y , range 0 to 1) for each week’s postcard (x) across the four identified classes in Study 2.



program with their children. Crain-Thoreson and Dale (1999) reported that 14% of caregivers of children with LI implementing an 8-week home reading program dropped out of the study before completion. In contrast, Arnold and colleagues reported that 94% of caregivers submitted reading logs documenting implementation for every week of a 5-week book-reading intervention involving middle- and high-income families. Thus, it seems that attrition and implementation is not an issue in studies that involve small, homogeneous, and relatively advantaged samples of caregivers (e.g., Justice & Ezell, 2002; Lovelace & Stewart, 2007); however, when larger and/or more diverse samples of caregivers are used, as in our Study 1 and Study 2, there appear to be significant barriers affecting implementation. Identifying determinants of these implementation barriers and investigating techniques that can circumvent these determinants has become an unanticipated aim of our intervention work.

To address this aim, we examined the data available to our team to explore barriers that correlated with implementation failures among caregivers in our studies and did so within the framework of the TDF. To apply the TDF to this particular realm of clinical practice, we followed the four-step approach described by French et al. (2012) for developing theory-informed behavior-change interventions for the target population (caregivers of children with LI) with respect to the intervention being implemented (print-focused read-alouds). The results of the application of this approach are discussed here and are summarized in Table 2. Note that in applying the TDF to identify behavioral determinants that affect implementation, it is recommended that one use qualitative and quantitative data if possible in this effort (see French et al., 2012). We therefore examined the data referenced previously, available from Study 1 and Study 2, to identify four potential barriers that may be negatively affecting caregiver implementation of home-based shared-reading intervention.

Step 1

Step 1 involves identifying the problem that needs to be addressed, which generally corresponds to the research-

practice gap. In the current application, the problem we identified is that a significant number of caregivers of children with LI did not appear to implement an evidence-based intervention as intended. From caregivers' own records, we see in Study 1 that one fourth of caregivers dropped out of the intervention, whereas in Study 2, it seems 56% of caregivers did not implement the intervention at all. For these caregivers, we want to identify how we might enable them to be more successful implementing this intervention or, conversely, to remove those barriers that are restricting their implementation.

Step 2

Step 2 involves identifying which barriers and enablers need to be addressed from within the context of a theoretical framework that identifies behavioral determinants that may affect implementation. To identify barriers to implementation, we examined data available from Study 1 and 2 that might help us understand why caregivers cease or maintain implementation; data included caregiver surveys, interviews, and questionnaires.

From Study 1, two data sources were available. First was an exit interview conducted with each nonimplementing caregiver ($n = 14$) to identify why they dropped out of the study. Two caregivers cited illness-related issues; six cited time-related constraints (going back to school, taking a second job, or preparing for a birth); one cited child-custody issues; and two cited personal difficulties with reading. (In three instances, caregivers did not provide a reason.) The second data source was a comparison of caregiver- and child-level characteristics of implementers ($n = 48$) and nonimplementers ($n = 14$) with respect to caregiver age, maternal and paternal educational attainment, maternal reading ability, and several child-level characteristics (e.g., child language skills, child age). Table 3 provides a comparison of implementers and nonimplementers on the caregiver-level variables. Results of analyses of variance showed statistically significant differences between implementers and nonimplementers for maternal age ($d = 0.73$), maternal education ($d = 0.88$), and paternal education ($d = 0.62$). For maternal and paternal education, we found

Table 2. Process followed to develop theory-informed behavior change interventions (from French et al., 2012).

Step 2	Step 3	Step 4
Identify which barriers (behavioral determinants) need to be addressed for caregivers	Determine within which theoretical domain the barriers operate from the theoretical domain framework	Identify which empirically supported behavior-change technique is likely to overcome the barrier
Caregivers do not have time to complete the intervention; caregivers do not have time to complete implementation documentation	Intentions (stability of intentions)	Provide rewards for completion of tasks (reward technique)
Caregivers themselves have difficulties reading	Beliefs about capabilities (self-confidence)	Receive supportive and corrective feedback (feedback technique)
Caregivers are not comfortable with reading and may not view it as enjoyable	Skills (skills development)	Model/demonstrate behavior by others (model technique)
Caregivers have limited understanding of the benefits of reading to their children	Beliefs about capabilities (empowerment)	Encourage, support (encourage technique)

Table 3. Comparison of implementing and nonimplementing caregivers in Study 1.

Variable	Implementers (<i>n</i> = 48)	Nonimplementers (<i>n</i> = 14)
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Maternal age (in years)	35.2 (7.1)*	30.3 (4.7)
Maternal education	5.4 (1.1)*	4.4 (1.2)
Paternal education	5.0 (1.4)*	4.1 (1.5)
Maternal reading	49.1 (6.9)	46.5 (6.5)

Note. Maternal and paternal education based on a categorical scale to represent highest grade completed (1 = < 7th grade, 2 = 7th–8th grade, 3 = some high school, 4 = high school diploma, 5 = some college, 6 = university degree, 7 = postgraduate training). Maternal reading level was based on raw score of the Wide Range Achievement Test (Wilkinson, 1993).

**p* < .05.

that the probability of nonimplementation was elevated significantly if either had not completed high school. It is interesting that mothers' reading skill was not significantly associated with implementation. Results generally suggested that if mothers were young and the caregivers had not completed high school, implementation issues were likely to arise.

From Study 2, recall that we categorized caregivers with respect to implementation into four profiles using latent class analysis: sporadic (15%), late dropouts (7%), completers (34%), and nonstarters (44%). A comprehensive caregiver questionnaire was completed by caregivers at the start of the investigation, providing information about socioeconomic status (maternal education), home reading habits, household chaos, and the Parent Reading Belief Inventory (PRBI; DeBaryshe & Binder, 1994). The PRBI examines caregivers' perceptions about the value and benefits of reading with their children.

Table 4 provides a sample of descriptive data drawn from the questionnaire as a function of the four implementation profiles. These data indicate that certain caregiver- and

household-level characteristics seem associated with implementation profiles. For instance, maternal education varied significantly across the profiles, on the basis of an analysis of variance. The completers had significantly higher levels of educational attainment than all three of the other profiles. Likewise, the frequency of caregiver–child reading in the home also varied (see the reading frequency variable in Table 4). Completers read significantly more often to their children each week than those in the sporadic and nonstarter profiles. Completers were less likely to have a history of reading difficulty than those in the late dropout, sporadic, and nonstarter profiles. In addition, completers had less chaotic homes than those in the nonstarter profile.

In analyzing these data across Study 1 and Study 2, our team sought to identify the most salient and probable behavioral determinants (i.e., barriers) corresponding to issues with intervention implementation across the caregivers in these studies. The first barrier identified was that of time pressure. In Study 1, we found that six of the 11 interviewed nonimplementers cited time-related constraints as contributing to their attrition from the study. In Study 2, completers reported having the least pressures on time to read with their children (*M* = 1.59, with lower scores corresponding to lower time pressures) than those in the other profiles (see Table 4). As can also be seen in Table 4, sporadics and nonstarters reported higher levels of household chaos than completers. (Late dropouts also had relatively low levels of household chaos).

The second barrier identified was reading difficulties, as identified via the caregiver questionnaire data collected in Study 1. Caregivers were asked whether they had a history of reading difficulties in elementary and high school, specifically, whether they had ever received formal help for reading difficulties. These caregiver questions were included in the study given the heritability of reading and language problems (Olson, Wise, Connors, Rack, & Fulker, 1989) and the potential that some caregivers of children with LI would have reading difficulties themselves. In this sample,

Table 4. Comparison of implementation profiles in Study 2 for caregiver characteristics.

Variable	Sporadic	Late Dropouts	Completers	Nonstarters
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Profile percentage	15%	7%	34%	44%
Maternal education	5.84 (2.5)	5.86 (3.0)	6.64 (2.2)	5.46 (2.5)
Reading beliefs				
Don't have time to read (reverse)	1.70 (1.3)	2.50 (1.3)	1.59 (1.2)	1.75 (1.2)
Don't enjoy reading (reverse)	0.70 (0.9)	0.50 (0.6)	0.69 (0.8)	0.81 (0.9)
Reading is fun	3.54 (0.8)	2.00 (1.8)	3.52 (0.9)	3.44 (0.7)
Household chaos	10.27 (4.9)	7.75 (4.9)	9.82 (4.8)	11.34 (5.2)
Caregiver reading difficulty	19%	50%	10%	25%
Reading frequency	5.07 (2.2)	5.00 (3.6)	5.67 (2.1)	4.60 (2.3)

Note. Maternal education based on a categorical scale to represent highest grade completed (1 = < 7th grade, 2 = 7th–8th grade, 3 = some high school, 4 = high school diploma, 5 = some college, 6 = university degree, 7 = postgraduate training). Reading belief items are from the Parent Reading Belief Inventory (DeBaryshe & Binder, 1994) and scored on a 1–4 scale (“reverse” items are reverse-scored, 1 = higher value); household chaos from the Chaos, Hubbub, and Order Scale (higher scores = more chaos; Matheny et al., 1995); Caregiver reading difficulty represents percentage of caregivers who reported receiving extra help for reading in high school; Reading frequency represents caregiver reported reading to child during a week, range of 0 (never read) to 8 (7+ sessions).

about 20% of caregivers reported having reading difficulties, and this was disproportionate across the profiles: Whereas only 10% of completers reported a history of reading difficulties, 19%, 25%, and 50% of sporadics, nonstarters, and late dropouts, respectively, reported a history of reading difficulties. Consequently, it seems that a salient barrier to caregivers' implementation of shared-reading sessions with their children is that they themselves struggle with reading.

The third barrier identified was discomfort with reading, also identified via the caregiver questionnaires from Study 2. Caregivers responded to two questions/statements for which we saw discernable patterns across the four profiles. First, caregivers were asked to identify how often they read to their children each week; completers read more often with their children compared with any other profile. The difference in reading frequency was statistically significant when comparing completers ($M = 5.67$) with sporadics ($M = 5.07$) and nonstarters ($M = 4.6$). Second, caregivers were asked to respond to a series of statements concerning their shared-reading beliefs and perceptions. To the statement "Reading together (with my child) is fun" (1 = *strongly disagree*, 5 = *strongly agree*), completers had slightly higher scores ($M = 3.52$) than nonstarters ($M = 3.44$) and late dropouts ($M = 2.0$); the latter was a statistically significant difference. On the basis of these findings, we propose that a barrier to caregiver implementation of home reading sessions with their children is that it may be an activity with which they are not very familiar or from which they may not derive substantial enjoyment.

Finally, the fourth barrier identified was limited understanding of benefits, in that some caregivers may have limited knowledge of the benefits of shared book-reading with their children. We made this inference on the basis of caregiver questionnaire responses collected in Study 2, namely, their responses to some items on the PRBI that allow caregivers to identify barriers to reading with their children, such as "Reading is not a priority" (1 = *strongly disagree*, 5 = *strongly agree*). As can be seen in Table 4, nonstarters (44% of caregivers) had higher scores on this item compared with completers. Perhaps the nonstarters did not start the book-reading program because they did not understand the benefits their children may derive.

Step 3

Step 3 involves mapping each identified barrier (time pressure, reading difficulties, discomfort with reading, limited understanding of benefits) to one of the 14 domains within the TDF, which appear in Table 1. Though a barrier can map to more than one domain in the TDF, for our purposes, we mapped each barrier to a single domain within the TDF, as follows. Time pressure was mapped to the TDF domain of intentions (see No. 8 in Table 1) because this TDF domain serves to capture the lack of congruence between a caregiver establishing the goal of reading regularly with her child and not achieving that goal (see Cane et al., 2012). The domain of reading difficulties was mapped to the domain of beliefs about capabilities (No. 6) because this

domain represents the issues with self-confidence that caregivers may have in implementing a book-reading intervention, should they have reading difficulties themselves. Caregiver discomfort with reading was mapped to the TDF domain of skills (No. 2) because we surmised that caregivers who seldom read may not feel or be proficient, given their limited practice with the skill. Finally, limited understanding of benefits was mapped to the TDF domain of beliefs about capabilities (as was reading difficulties) because this domain captures the possibility that caregivers do not implement book-reading interventions with their children because they do not understand their own capabilities in affecting change. We should note that publications describing the TDF and its applications provide numerous examples and exemplars to assist in linking barriers/behavioral determinants to TDF domains, and we referred to these heavily (see Cane et al., 2012; French et al., 2012).

Step 4

Step 4 involves mapping the identified domains to specific behavior-change techniques, for which we relied on Michie et al. (2008) and their explicit mapping of behavioral determinants (from the TDF) to empirically supported techniques that will change these behaviors. Michie et al. conducted a comprehensive evaluation of the literature to identify effective techniques that bring about change in behaviors, coupling meta-analyses and textbook review to identify 137 techniques that can be used to address implementation barriers. We used their compendium to link each behavioral determinant and barrier identified at Step 3 to an effective behavior-change technique, as shown in Table 2. For instance, the barrier of time pressures was mapped to the TDF domain of intentions, which was in turn aligned to the behavioral change technique of reward (see Michie et al., 2008). That is, the provision of a reward ("a contingent, valued consequence that is provided if and only if a behavior is performed"; Michie et al., 2008, p. 674) is an effective technique for addressing the barrier of time pressures. Table 2, referenced previously, provides a map of the barriers we speculate are affecting caregiver implementation of shared-reading interventions, the TDF domain we identified for that barrier, and a sample behavior-change technique.

Designing Research to Test Theoretically Informed Behavior-Change Techniques to Improve Caregivers' Implementation

Caregiver implementation of book-reading interventions in the home environment, an empirically supported practice, is often not implemented at the levels intended by intervention developers; of particular concern is the disparity of implementation among caregivers. In our analyses of data from two randomized controlled trials involving caregivers of children with LI (Study 1 and Study 2), we identified four potential behavioral determinants that may serve as barriers to their intervention implementation: time

pressure, reading difficulties, discomfort with reading, limited understanding of benefits. We subsequently identified evidence-based behavior-change techniques that may address each of these behavioral determinants (Michie et al., 2008). To determine the extent to which each of these techniques may affect these behavioral determinants and improve caregiver implementation of shared-reading interventions, our team designed an experimental study that is currently under way. We provide the details of this in-progress study, funded by the National Institutes of Health (Grant 1R21DC013599), which shows how a factorial experiment can be used to test the unique and interactive effects of four behavioral-change techniques on caregiver implementation (see Table 2): reward, feedback, model, and encourage.

To examine the effects of these four techniques, the study will involve 128 caregivers and their 4- and 5-year-old children with LI in a factorial experiment. Currently, there are 23 dyads enrolled (and 10 pending) via a partnership with speech-language pathology outpatient clinics. Caregivers of children who meet study criteria on the basis of age (48 to 671 months), general diagnosis (primary impairment of language), and absence of exclusionary conditions (autism, hearing loss, severe intellectual disability) are referred to contact study personnel and may self-select into the study after receiving information, including informed consent protocols.

At enrollment, children's caregivers are randomly assigned to one of 16 conditions ($n = 8$ per condition), on the basis of the factorial design shown in Table 5. As seen in Table 5, each condition receives one or more behavior-change techniques. By using a factorial experimental design, we can isolate each behavior-change technique for its unique influence on caregiver implementation (controlling for the other techniques) as well as the main effect of each technique (ignoring the other techniques). The four identified techniques will be either present or absent in a given condition, thus the full factorial experimental design ($2 \times 2 \times 2 \times 2$) includes 16 conditions. Conditions 1, 2, 3, and 4 will involve receipt of a single technique; Conditions 7, 8, 9, and 10 will involve receipt of two techniques; Conditions 11, 12, 13, and 14 will involve receipt of three techniques; Condition 15 will involve receipt of all techniques; and Condition 16 will remain untreated. Note that the research design is balanced, such that equal numbers of participants will receive and not receive each technique (see Table 5). This allows for treatment effects on caregivers and children to be

estimated with maximum power. Though a fractional factorial design could be used, it is unknown how the combinations of techniques may relate to the outcomes; thus, best practice suggests that all possible combinations be included (such that no interactions will be aliased with main effects).

General Procedures

In this study, all 128 caregivers implement print-focused read-alouds with their children for a 15-week period at the intensity of four sessions per week (60 total sessions) and dosage of two objectives per session, each targeted four to five times, as specified in the treatment manual (Justice & Sofka, 2013). Each caregiver-child reading session features a commercial storybook, with a new book provided for each week of the intervention. Caregivers read the book four times in the week it is assigned, using any schedule they choose. Accompanying each book is a double-sided implementation guide designed to support the caregiver in adhering to the dosage. Attached to the back cover of each book is a postcard on which caregivers log each session and submit at the end of the week.

To conduct this study, all caregivers complete an initial 1-hour orientation session that involves provision of educational information about children's early-literacy development, explicit description of the book-reading intervention via an interactive web-based presentation on an iPad with embedded videos, and role-playing and practice. At the close of orientation, caregivers receive all materials to implement print-focused read-alouds for an initial 3-week period as well as a digital recorder with memory card. Caregivers are asked to audio-record one book-reading session per week, with the specific session identified so that recordings are uniform across caregivers. Every 3 weeks, caregivers meet with staff to trade the memory card for intervention materials for the next 3-week period.

Testing Theoretically Informed Behavior-Change Techniques

Caregivers receive one or more behavior-change techniques over the 15-week intervention, on the basis of random assignment. Descriptions of the techniques and the specific conditions to which they are assigned are as follows.

Reward Technique (Conditions 1, 5, 6, 7, 11, 12, 13, 15)

Caregivers in the reward condition receive a small reward for each of the target behaviors implemented, such that reinforcement is contingent on effective implementation. For each session conducted and recorded on logs (up to 60 sessions) and for each videotaped session submitted that achieves the target dosage (up to 15 submissions), caregivers receive credit of \$0.50 (toward a gift card at week 15), with maximum value of \$37.50. Financial incentives are effective in other behavior-change milieus, including smoking cessation and weight loss (Giuffrida & Torgerson,

Table 5. The 16 conditions used in factorial experiment to test effects of four behavior-change techniques.

Technique	Conditions in Full Factorial Design															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Reward	1	0	0	0	1	1	1	0	0	0	1	1	1	0	1	0
Feedback	0	1	0	0	1	0	0	1	1	0	1	1	0	1	1	0
Model	0	0	1	0	0	1	0	1	0	1	1	0	1	1	1	0
Encourage	0	0	0	1	0	0	1	0	1	1	0	1	1	1	1	0

1997; Volpp et al., 2008) and are included as a possible behavior-change technique for caregivers.

Feedback Technique (Conditions 2, 5, 8, 9, 11, 12, 14, 15)

Caregivers in the feedback condition receive feedback that is based on analysis of weekly logs and videos submitted at Weeks 3, 6, 9, and 12. Staff analyze these with respect to intensity and dosage to generate supportive feedback (positive examples) and corrective feedback (areas for improvement) on the basis of empirically supported protocols (Hemmeter, Snyder, Kinder, & Artman, 2011). Over the 15-week intervention, caregivers participate in four 20-min face-to-face individualized feedback sessions with research staff. Prior research has effectively used feedback with caregivers of children with LI to support their implementation of language interventions in the home environment (Fey, Cleave, Long, & Hughes, 1993).

Model Technique (Conditions 3, 6, 8, 10, 11, 13, 14, 15)

Caregivers in the model condition participate in four 20-min one-on-one sessions with research staff over the 15-week intervention in which they watch videos of caregivers implementing print-focused read-alouds with their children. The videos provide salient models of the targeted behaviors. Prior work training caregivers in using print-focused read-alouds has used video modeling and observational learning (Ezell & Justice, 2000), which are serving as protocols in this study.

Encourage Technique (Condition 4, 7, 9, 10, 12, 13, 14, 15)

Caregivers in the encourage condition receive general gain-based encouraging and persuasive messages that emphasize the value of implementing the intervention as intended (Abraham & Michie, 2008). These are delivered every 2 weeks via phone, email, or text per caregiver preference, for a total of seven messages over the intervention course. The messages, delivered by research staff, are tailored to the caregiver, child, and week of intervention (e.g., “Ian, be sure to read *David Gets in Trouble* four times this week. By reading this book and talking about print as you read, you are helping Addie learn to read!”).

Combination (Conditions 5–15) and Untreated (Condition 16) Conditions

A majority of caregivers receive more than one behavior-change technique (see Table 4). For instance, caregivers in Condition 13 receive reward, feedback, and encourage and thus (a) receive financial incentives, (b) participate in four individualized feedback sessions, and (c) receive encouraging messages every 2 weeks. Caregivers assigned to Condition 16 (untreated) receive no behavior-change interventions over the 15 weeks of implementation. Using the factorial design allows only a modest number of caregivers to be in a true control condition, which is a benefit of this design.

Identifying Effective Behavior-Change Techniques

Caregivers’ implementation of the book-reading intervention is being carefully monitored in two key ways. First, to index implementation intensity, caregivers submit weekly logs (contained within each book), documenting occurrence and length of each session and targeted goals for each. Upon receipt, these preaddressed, postage-paid postcards are entered continually into the project database. This approach is similar to collection of time diaries, which have been used successfully in large-scale studies to document reading and other activities in the home (Hofferth & Sandberg, 2001) and provide a valid index of in-home reading activities (Allen, Cipielewski, & Stanovich, 1992). Reading logs are reviewed with caregivers at each 3-week interval, when forthcoming intervention materials are provided to them.

Second, to index dosage, caregivers submit audio-recordings of one book-reading session per week, for a total of 15 submissions. All caregiver audiotapes are analyzed using a fidelity coding checklist (FCC), a reliable event-based coding system that captures the volume of explicit targeting of print-related objectives during print-focused read-aloud sessions (Piasta et al., 2010). The FCC identifies the volume of talk about print within each reading session, and FCC data have been linked to children’s gains during this intervention in prior studies (McGinty et al., 2011).

The intensity and dosage data will be analyzed at study completion to determine the extent to which specific behavior-change techniques affected caregivers’ implementation of the 15-week book-reading intervention. Analytically, we will use a regression framework to examine the two implementation outcomes as dependent variables in relation to the various behavior-change techniques evaluated. To estimate the impact of each technique, in isolation and in combination with others, the 16 conditions are coded with an effect-coding scheme applied to factorial experiments. Effect coding ($-1 = \textit{absence}$, $1 = \textit{presence}$) offers many advantages over dummy coding ($0 = \textit{absence}$, $1 = \textit{presence}$), the latter of which essentially eliminates all observations that are set to “0” in a given contrast such that they do not contribute to the estimated coefficient. To the contrary, effect coding expresses the average difference between caregivers who do and do not receive the technique across all levels of the second technique. For instance, half of the caregivers will be randomly assigned to reward conditions (see Table 5), whereas half will not. To estimate the main effect of reward, those caregivers who do not receive rewards (even if they do receive other techniques) will serve as the control group for those who do. Because we use a balanced factorial design, each coefficient can be treated as orthogonal in analyses, such that main effects can be interpreted even if significant two-, three-, or even four-way interactions are found. With respect to power, we designed the experiment to detect an average-sized effect ($d = 0.50$), for which a full factorial experiment with 16 conditions and eight participants per condition (total $n = 128$) has a power of .80 to detect an effect for each technique.

A Preliminary Look at Caregivers' Implementation

It would be premature to examine intensity and/or dosage data for any of the caregivers currently enrolled, given that only about 20% of the total sample required for the study has been ascertained. However, it is interesting to note that a nontrivial number of caregivers who are enrolled presently are having difficulties implementing this intervention, which involves reading to their children four times per week for 15 weeks. Recall that the caregivers receive a new storybook each week and read it repeatedly during the week it is scheduled. To date, 12 caregivers are more than two weeks into the intervention, and of these, one third ($n = 4$) have had major issues with implementation. Two of the caregivers dropped out of the study (one after Week 3 and the other after Week 7), and two of the caregivers have implemented less than 50% of intervention sessions but have not formally dropped. The preliminary data confirm that a number of caregivers of children with LI do have difficulty implementing shared-reading interventions and that perhaps other avenues for improving implementation than those being investigated in the current work will need to be examined.

Conclusions and Applications

In this supplement article, we describe an empirically supported intervention—caregiver-implemented book reading—that clinicians may utilize to improve the early-literacy skills of children with LI. Caregivers show disparities in their implementation of this intervention, however, and it is important to identify why these disparities occur. Application of the TDF, a tool used in implementation science research to link behavioral determinants to empirically validated behavior-change techniques, provides a means to identify and test avenues for improving implementation. In this application, we identified four potential barriers to caregivers' implementation: time-related pressures, difficulties with reading, discomfort with reading, and lack of awareness of reading benefits. Ongoing work is helping us to determine whether application of behavior-change techniques to these barriers can result in implementation improvements when caregivers implement a 15-week book-reading intervention. The steps followed here can be applied to a variety of implementation issues seen within the treatment of communication disorders.

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