NBER WORKING PAPER SERIES

ONE STEP AT A TIME:
THE EFFECTS OF AN EARLY LITERACY TEXT MESSAGING PROGRAM FOR PARENTS OF PRESCHOOLERS

Benjamin N. York
Susanna Loeb

Working Paper 20659
http://www.nber.org/papers/w20659

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 2014

We give special thanks to Carla Bryant, Chief of Early Education of San Francisco Unified School District, and her team, for the many ways in which they supported this study. We are grateful to the Silver Giving Foundation and the Evelyn and Walter Haas, Jr. Fund for their generous financial support. We also thank Helen Maniates, Assistant Professor of Teacher Education at the University of San Francisco, Molly Wertz, Executive Director of Raising A Reader in San Francisco, Alameda and Contra Costa Counties, and various team members of Jumpstart Northern California, including Jennifer Curran and Catherine Aranda, for their feedback on our text messages. This research was also supported by the Institute of Education Sciences (IES), United States (U.S.) Department of Education, through Grant R305B090016 to Stanford University. The opinions expressed herein are those of the authors and do not reflect the views of the Silver Giving Foundation, the Evelyn and Walter Haas, Jr. Fund, IES, the U.S. Department of Education, or the National Bureau of Economic Research. This randomized controlled trial (RCT) was registered in the American Economic Association Registry for RCTs (RCT ID AEARCTR-0000536).

One Step at a Time: The Effects of an Early Literacy Text Messaging Program for Parents of Preschoolers

Benjamin N. York and Susanna Loeb

NBER Working Paper No. 20659
November 2014
JEL No. I1,I10,I12,I2,I20,I25

ABSTRACT

Substantial systematic differences exist in children's home learning experiences. The few existing parenting programs that have shown promise often are not widely accessible, either due to the demands they place on parents' time and effort or cost. In this study, we evaluate the effects of READY4K!, a text messaging program for parents of preschoolers designed to help them support their children's literacy development. The program targets the behavioral barriers to good parenting by breaking down the complexity of parenting into small steps that are easy-to-achieve and providing continuous support for an entire school year. We find that READY4K! positively affected the extent to which parents engaged in home literacy activities with their children by 0.22 to 0.34 standard deviations, as well as parental involvement at school by 0.13 to 0.19 standard deviations. Increases in parental activity at home and school translated into student learning gains in some areas of early literacy, ranging from approximately 0.21 to 0.34 standard deviations. The widespread use, low cost, and ease of scalability of text messaging make texting an attractive approach to supporting parenting practices.

Benjamin N. York
520 Galvez Mall, Room 511
Stanford University
Stanford, CA 94305
byork@stanford.edu

Susanna Loeb
524 CERAS, 520 Galvez Mall
Stanford University
Stanford, CA 94305
and NBER
sloeb@stanford.edu

Introduction

The home learning experiences of young children vary dramatically (Bradley, Corwyn, McAdoo & García Coll, 2001). Hart and Risley (1995), for example, finds that by the age of four, children in "welfare families" hear about 30 million fewer words than children in "professional families." Parenting interventions represent one strategy for addressing such differences, yet to date, only a small number of programs have had positive effects on parents or their children (Duncan, Ludwig & Magnuson, 2010). Even the most promising interventions, including pediatric clinic-based programs (Mendelsohn et al., 2001) and home visitation programs (Olds et al., 1997), have meaningful limitations such as access (Prinz & Miller, 1994) and cost (Aos, Lieb, Mayfield, Miller & Pennucci, 2004). Many existing interventions try to rapidly change complex parenting behaviors through a small number of time- and information-intensive parent education sessions.

A promising alternative to existing programs is to break down the complexity of parenting into small steps that are easy-to-achieve, and draw on widely-used technology to provide continuous encouragement, support, and reinforcement to parents over extended periods of time. Given its widespread use, extremely low cost, and ease of scalability, text messaging ("texting") is an ideal vehicle for putting this strategy to work. Eighty-eight percent of American adults have cell phones, 98 percent of cell phone owners can access texts, and text messages have a 95 percent open rate (Ehrlich, 2013; Zickuhr & Smith, 2012). Black and Hispanic adults, who often exhibit the highest dropout rates in parenting programs, send or receive texts more frequently than their white counterparts (Zickuhr & Smith, 2012).

Texting has been proven to be effective in similar behavior change applications. For instance, a growing body of experimental research in healthcare shows that the frequent

provision of well-designed texts can improve weight loss (Patrick et al., 2009), medication regimen adherence (Petrie, Perry, Broadbent & Weinman, 2012), glycemic control (Yoon & Kim, 2008), and smoking cessation rates (Rodgers et al., 2005). In education, Castleman and Page (2013) finds positive effects of a texting program for recent high-school graduates designed to curb summer "melt," which occurs when college-intending graduates fail to matriculate in college the year after high school. Similarly, Bergman (2014) finds that high school students whose parents received messages about their missing work and grades had, on average, a grade point average that was 0.19 standard deviations higher than students whose parents did not receive text messages.

This study adds to research on both parenting and texting interventions by evaluating the effects of READY4K!, an eight-month-long text messaging program for parents of preschoolers designed to help them support their children's literacy development. During the 2013-14 school year, we conducted a randomized controlled trial (RCT) of the program in San Francisco Unifed School District (SFUSD). Five hundred and nineteen parents and gaurdians agreed to participate in the study, and we randomly selected half of them to receive READY4K! texts. Every week, these parents received three texts about a particular early literacy skill or set of skills: a "FACT" text designed to generate buy-in from parents; a "TIP" text that aimed to enhance parents' self-efficacy; and a "GROWTH" text, which provided parents with encouragement and reinforcement as well as a follow-up tip. READY4K! texts are linked to the California Preschool Learning Foundations and they have a defined scope and sequence. About every two weeks, we sent one "placebo" text to parents in the control group, often pertaining to the district's kindergarten enrollment requirements or required vaccinations.

We find strong evidence that parents in the treatment group read the texts, used the tips, and in general found READY4K! helpful. More importantly, the program positively affected parents and their children. For example, the intervention increased the frequency with which parents told stories, pointed out two words that begin with the same sound, pointed out two words that rhyme, recited nursery rhymes, looked at pictures in a book, showed the different parts of a book, and played games or worked on puzzles with their children – effects of up to 0.34 standard deviations. According to teachers, READY4K! parents more frequently asked questions about their children's learning than control group parents – effects of up to 0.19 standard deviations. Increases in parental activity and involvement translated into learning gains for children, as students whose parents received READY4K! texts scored approximately 0.21 and 0.34 standard deviations higher on spring lower-case alphabet knowledge and letter sounds sub-tests than students whose parents received placebo texts. We find some evidence that the program was particularly beneficial for black and Hispanic parents and their children, and that texts targeting highly-specific home literacy activities were more effective than texts that address more general practices.

One of the most compelling features of READY4K! is its low cost. For the entire school year, we spent less than one dollar per family to send text messages. Moreover, fixed program expenses such as content development and program administration costs trend towards zero as the program scales. Most importantly, READY4K! imposes minimal costs on parents. Despite the fact that nearly all of the parents in the study received financial assistance for preschool tuition costs, about 80 percent of them had an unlimited texting plan. The program also places few demands on parents' time and effort as READY4K! tips are short and easy to implement. In

contrast, most existing parenting interventions require much more from parents and are far more expensive. The Nurse Home Visitation Program, for instance, costs over 9,000 dollars per family.

The remainder of this paper proceeds as follows. In the next section, we review research on parenting and text messaging interventions. The subsequent section describes study procedures. In the section after that, we present study results. We conclude this paper with a discussion of the findings.

Background

Virtually all parents want their children to succeed in school. Yet some parents provide their children with more support than others. For example, economically-disadvantaged and wealthy parents exhibit large and systematic differences in parenting practices. From birth to age two, non-poor children are more likely than poor children to be caressed, kissed, or hugged by their mother, and they are less likely to be spanked (Bradley, Corwyn, McAdoo & García Coll, 2001). Non-poor birth-to-two-year-olds also have greater access to children's books and are more likely to be read to than their poor counterparts (Bradley, Corwyn, McAdoo & García Coll, 2001). These disparities likely have significant consequences, as children who experience responsive and stimulating parental care tend to score higher on assessments of motor, social, emotional, literacy, and numeracy skills than those who do not (Anderson, 2006; Bradley, Corwyn, Burchinal, McAdoo & García Coll, 2001; Melhuish et al., 2008).

Given that most parents want their children to succeed in school, why are some parents more involved in their children's learning than others? Overall resource availability is undoubtedly part of the answer to this question (Riccio, et al., 2013; Costello et al., 2003); however, there are likely other contributing factors which may be easier and more cost effective

to address through educational policies or interventions. One such factor is a lack of information. Some parents may not have good information about the importance of parenting or productive parenting practices, and as a result, fail to provide their children with an optimal level of support. Information deficiency has been studied in other educational contexts with mixed results. Avery and Kane (2004) and Grodsky and Jones (2007), for example, find little evidence that a lack of information by students or their parents about the costs and benefits of college explains the socioeconomic stratification of college attendance. However, other studies find that information affects school choices and subsequent student outcomes (Hastings & Weinstein, 2008; Valant & Loeb, 2014).

While information likely plays a role in parenting, even when parents know what steps to take to support their children and genuinely want to take these steps, they do not always do so. Behavioral factors might provide insights into this phenomenon. For instance, the complexity of parenting may overwhelm some parents, leading them to underinvest in their children. Each day, parents must make near countless decisions – choices about what to say, do, and provide to their children in every situation. The sheer volume of decisions might bewilder and inhibit parents. Making choices about activities to support their children's learning may be particularly daunting for parents, given that many of the skills required to be successful in school are outside of parents' area of expertise (such as literacy, numeracy, and socio-emotional skills). The importance of task complexity has strong empirical support in education. As an example, a random assignment study of simplifying the college enrollment process finds that students of low- to moderate-income families who received assistance filling out the Free Application for Federal Student Aid (FAFSA), along with information about their eligibility for aid and local post-secondary options, were substantially more likely to submit the aid application and enroll in

college the following fall than students in families that only received information (Bettinger, Long, Oreopoulos & Sanbonmatsu, 2012).

Delayed gratification is another behavioral barrier that parents must overcome to take an active role in their children's learning. Since children do not immediately exhibit the benefits of parental involvement, parents must wait for the satisfaction that they receive from supporting their children's education. As such, parenting has potentially-significant opportunity costs and requires self-control. For example, when a mother reads a book to her child, she cannot simultaneously engage in another activity that has more immediate rewards, such as watching her favorite television program, talking to a friend or relative on the phone, or going on a walk. Parenting is perhaps an extreme example of a delayed gratification activity – not only are the benefits of parenting delayed but they are also extra-personal. Most people tend to do too little when dealing with delayed gratification activities (Thaler & Sunstein, 2008).

Adopting positive parenting practices also requires changing behaviors that have become routine, or interrupting the status quo (Samuelson & Zeckhauser, 1988). Interrupting the status quo is difficult. The best-known status quo bias research addresses retirement savings plans. Madrian and Shea (2000) examines the savings behavior of employees of a large corporation that adopted automatic enrollment into its 401(k) plan. The study finds that a substantial fraction of employees hired after the adoption of automatic enrollment retained the corporation's pre-set contribution rate and fund allocation, while employees hired prior to automatic enrollment made different choices. This finding demonstrates the power of defaults to influence behavior. In the context of parenting, status quo bias may lead parents to maintain historical parenting behaviors even when they know that changing their practices would be in the best interest of their children.

A final potential behavioral barrier to effective parenting is limited attention (Karlan, McConnell, Mullainathan & Zinman, 2010). Sometimes individuals lack the attention to regularly work towards a goal (e.g., because life is busy), and when they reach their goal deadline, they have underinvested in the process for achieving the goal. For example, a father might have the goal of helping his child prepare for an assessment in a month. However, he is preoccupied by life's stressors and lacks the attention to provide his child with daily test preparation. The father does not remember his child's test until the days leading up to it, and as a result, only helps his child cram for the assessment. In this case, he has underinvested in his child's learning relative to what he had planned to do. A series of randomized experiments finds that sending regular reminders to new savings account holders improves their saving behavior, providing evidence for the saliency of limited attention (Karlan, McConnell, Mullainathan & Zinman, 2010).

A substantial amount of effort has gone into developing programs that aim to improve parents' practices. Many existing interventions try to quickly change parenting through a short series of parenting information sessions. Unfortunately, this strategy has proven to be largely ineffective, especially over the long run (Duncan, Ludwig & Magnuson, 2010). An alternative approach that has shown more promise is to target parents' home literacy practices. For example, a number of programs leverage children's visits to the doctor by providing parents with information on the importance of literacy development as well as books and other resources. These relatively inexpensive interventions have been correlated with improvements in literacy practices among low-income, black, and Hispanic parents (Blom-Hoffman, O'Neil-Pirozzi, Volpe, Cutting & Bissinger, 2007; Golova, Alario, Vivier, Rodriguez & High, 1999; Needlman,

Toker, Dreyer, Klass & Mendelsohn, 2005; Zuckerman, 2009), and program participation predicts children's early language development (Sharif, Rieber & Ozuah, 2002).

The Reach out and Read (ROR) program has received a particularly high level of attention in the literature. It involves reading to children in the clinic waiting room, giving children developmentally-appropriate books to take home, and having pediatricians discuss the benefits of reading during the appointment. Mendelsohn et al. (2001) examines the effectiveness of ROR by comparing the vocabulary development of children in two similar inner-city pediatric clinics. One clinic had had the ROR program for three years, while the other had only recently introduced the intervention. Results of multivariate regressions show that children who had been visiting the first clinic had significantly higher scores on measures of both receptive and expressive language than those who had been visiting the second clinic.

Some childcare centers and elementary schools have carried out similar family-based literacy-specific interventions (e.g., Jordan, Snow & Porche, 2000; and, Whitehurst et al., 1994). Recent meta-analyses of these programs find that they are associated with small but significant short-term gains for young children (Manz, Hughes, Barnabas, Bracaliello & Ginsburg-Block, 2010; Reese, Sparks, & Leyva 2010). In one random assignment study, Whitehurst et al. (1994) evaluates the effect of a reading program that teaches parents dialogic reading techniques such as asking open-ended questions and asks parents read the same book to their child as their child's teacher. Program participation had a positive impact on children's writing, language, and print concepts skills.

While clinic- and school-based programs show promise, they have a number of limitations. Many of the benefits of clinic-based interventions occur during visits, which are often infrequent. School-based programs have even greater access problems, largely driven by

the time and effort demands they place on parents. For instance, the overall participation rate in study of ParentCorps, which consists of 13 school-based, two hour-long parent and child sessions, was 42 percent (Brotman et al., 2011). The average number of ParentCorps sessions attended by treatment group parents was less than six. Dropout rates in center-based programs can be as high as 50 percent, and it is often the parents who could benefit the most from support who drop out (Prinz & Miller, 1994). Finally, to the best of our knowledge, there are no experimental studies demonstrating long-term benefits of parent literacy interventions.

Another alternative to parenting information sessions that has shown some positive effects involves providing parents with intensive support on a broad array of topics through in-home visits. The Nurse Home Visitation Program (NHVP) is a program that has been rigorously examined. One random assignment study of NHVP began in a semi-rural area of New York in 1978 and followed five hundred predominantly white, low-income, and unmarried pregnant women through the time that their children were adolescents. Women in the treatment group received regular home visits that focused on maternal health, positive parenting, and personal development. The control group received developmental screenings for their children at 12 and 24 months of age, but no additional maternal support services. A 15-year follow-up of the intervention showed that program participants were less likely to be perpetrators of child abuse and neglect (Olds et al., 1997). The subgroup of mothers who were unmarried and low-income at the time of their pregnancy also experienced fewer subsequent births, months on welfare, and arrests (Olds et al., 1997). Further, the children of this subgroup had meaningful social and health benefits, with lower levels of arrests, fewer incidents of running away, fewer sexual partners, and less regular alcohol consumption (Olds et al., 1998). A more recent replication

study of NHVP that draws upon a primarily black, urban sample also found significant benefits for the children of treatment recipients (Olds, et al., 2010).

While the results of NHVP studies are encouraging, findings from the growing body of research on home visitation more broadly are mixed, and arguably underwhelming (Astuto & Allen, 2009; Azzi-Lessing, 2011; Gomby, 2005). Some home visitation programs result in improvements in parenting practices, yet they often yield few measured effects on children's development. As Gomby, Culross, and Behrman (1999) points out, it may be unrealistic to expect programs involving 20 to 40 hours of direct contact over several years to have such significant impacts on parental behaviors that children's outcomes are affected in a meaningful way. Finally, home visitation programs are expensive and thus difficult to scale. The Nurse Home Visitation Program, for example, costs over 9,000 dollars per family (Aos, Lieb, Mayfield, Miller & Pennucci, 2004).

Overall, only a small number of parenting programs have shown positive effects on parents or children. Even the most promising programs – namely, literacy-specific and home visitation programs – have significant limitations such as access and cost. Moreover, many programs try to rapidly change parenting during a small number of informational sessions.

READY4K! takes an alternative approach to supporting parenting practices by breaking down the complexity of parenting into small, easy-to-achieve steps and providing continuous encouragement and reinforcement over a long period of time. Text messaging is an ideal vehicle for such a strategy given its low cost, widespread use, and ease of scalability. More importantly, a rapidly-growing body of experimental research indicates that texting is an effective way to change complex behaviors. As described above, the regular provision of well-crafted texts messages has led to meaningful improvements in healthcare. For example, an experimental study

of a personalized and interactive text messaging program designed to help individuals in New Zealand quit smoking finds that 28 percent of the treatment group quit smoking, compared to 13 percent of the control group (Rodgers et al., 2005).

Texting in education is relatively new but initial findings are encouraging. Castleman and Page (2013) evaluates a texting program for recent high school graduates designed encourage college enrollment. The program, which was delivered between early June and mid-August, consists of a series of 10 texts messages to students (and their parents, where possible), sent roughly over five-day intervals. The messages remind students and their parents about tasks required by the students' intended college such as completing important paperwork, and they prompt students and parents to ask for additional assistance if needed. The study finds that students in the treatment group we roughly three percentage points more likely to enroll at two-year institutions than control group students and that texting was particularly effective for students with low access to college-planning supports. Another notable experimental texting study sent parents or guardians of high schools students several messages over six months about students' missing assignments (including homework, classwork, projects, essays, and exams) and grades (Bergman, 2014). The study finds positive treatment effects on class attendance, assignment completion, student behavior, and grade point average, and there is some evidence of positive effects on students' math test scores.

Studies in health and education provide evidence that text messaging can be an effective way to change complex, continuous, and long-term behaviors, underscoring the potential of texting to promote parental involvement. We build on the nascent educational texting literature by evaluating the impact of READY4K!, an early literacy-focused text messaging program for parents of preschoolers.

Procedures

The Intervention

READY4K! is an eight-month-long text messaging program for parents of four year olds designed to help them support their children's literacy development. It draws on research on literacy development (e.g., Lonigan & Shanahan, 2009), parenting practices (e.g., Reese, Sparks & Leyva, 2010), and behavior change strategies (e.g., Abraham & Michie, 2008). The program is linked to the California Preschool Learning Foundations and is structured as a spiral curriculum – it starts simple and gets progressively more advanced over time, and topics are re-introduced throughout the year for reinforcement. For example, the first week of the program focuses on parent-child conversations, while the last few weeks concentrate on developing high-quality parent-child book reading routines (see Appendix A for a description of the text development process). READY4K! is available in English, Spanish, and Chinese.

In the present study, parents who were randomly assigned to the treatment group received three READY4K! texts messages each week during the school year about a particular early literacy skill or set of skills (starting in October and ending in May). On Mondays, they received "FACT" texts, designed to generate buy-in by highlighting the importance of a particular skill or set of skills. On Wednesdays, they received "TIP" texts, designed to maximize parents' self-efficacy in supporting their children's literacy development by minimizing the costs associated with adopting beneficial practices. These texts include short, simple, and highly-specific activities for parents to do with their children. On Fridays, parents received "GROWTH" texts, which provide encouragement and reinforcement and extend the tips from Wednesdays. The following example week of texts focuses on beginning sound awareness:

FACT: Beginning word sounds are essential for reading. You can help your child learn to read by saying the beginning sound of words. “Read” starts w/ “rrr.”

TIP: Say two words to your child that start with the same sound, like happy & healthy. Ask: can you hear the “hhh” sound in happy & healthy?

GROWTH: By saying beginning word sounds, like “ttt” in taco & tomato, you’re preparing your child 4K. Now, have your child make the “ttt” sound.

Overall, READY4K! covers a wide range of early literacy skills and related parenting practices, including: alphabet knowledge, letter sounds, beginning sound awareness, rhyme awareness, nursery rhyme awareness, name writing, concepts of print, story comprehension, vocabulary development, elaborative reminiscing, parent-child conversations, listening to and singing songs, and establishing high-quality parent-child book reading routines.

Throughout the program, text messages emphasized parental involvement at the school. The following text, which we sent during a week about concepts of print, is one example of how we addressed parental involvement:

TIP: Ask the teacher about your child’s knowledge of concepts of print. Concepts of print include knowing how book are organized & that words have meaning.

We also included messages about SFUSD’s Raising A Reader (RAR) program, which regularly sends books home to children in both the treatment and control group. In particular, we coupled reading activity texts with texts about RAR. We worried that families without children’s books would not uptake suggested reading activities. Highlighting the district’s book program was one way to address this concern:

TIP: Use the RAR red book bag to build your routine. Let your child hold the book. Ask what it is about. Follow the words with your finger as your read.

To the extent possible, READY4K! texts build on activities that parents already do with their children. By adding to pre-existing family routines, the program's messages further reduce the costs of adopting good home literacy practices – parents do not have to take up a new activity they just have to make the most of something that they already do with their children. For example, the following "spiral" week of texts – which covers a wide range of early literacy skills including answering open-ended questions, concepts of print, letter identification, letters sounds, and vocabulary building – focuses on making the most of bath time:

> FACT: Bath time is great for teaching your child important skills for K. Start by asking your child: what are the things we need for bath time? Why?
>
> TIP: When you're bathing your child, point out the letters on the shampoo bottles. Ask your child to name them & tell you the sounds that they make.
>
> GROWTH: By teaching at bath time, you're preparing your child for K. Next time, ask questions about body parts. Where are your elbows? What do they do?

While parents in the treatment group received multiple READY4K! texts per week, parents in the control group received one placebo text about every two weeks during the 2013-14 school year. These messages generally pertained to the district's kindergarten enrollment requirements or required vaccinations. Here are two examples:

> READY4K: Students new to SFUSD are required to have a TB Skin Test. Children entering K need: 5 DTaP, 4 Polio, 3 Hepatitis B, 2 MMR and 1 Varicella vaccines.
>
> READY4K: Immunization forms are available at any San Francisco Health Center & SFUSD's Educational Placement Center at 555 Franklin St., Room 100.

Study Participants

During the 2013-14 school year, we conducted a large-scale study of READY4K! with parents of four year old preschoolers in SFUSD. SFUSD's preschool program is run by its Early Education Department (EED), which has a substantial amount of operational autonomy. EED serves roughly one-third of San Francisco's preschool market, operating 21 stand-alone sites and 13 sites that are co-located at elementary schools. Stand-alone and co-located sites function somewhat differently and have different sets of supports.

To recruit parents at stand-alone sites, we built on EED's existing enrollment processes by distributing READY4K! enrollment forms to the department's enrollment clerks and offering them 10 dollars for each family that they enrolled. In SFUSD, parents of preschoolers must turn in a completed enrollment form to an enrollment clerk prior to the start of the school year. To further encourage participation, we offered parents a 10 dollar Target gift card for enrolling in the program; and, since we did not want texting costs to represent a barrier to program participation, we also offered 10 dollars per month or a 12 dollar monthly Amazon.com gift card to both treatment and control group parents for participating.

Unlike stand-alone sites, early education sites that are co-located at elementary schools do not have an EED enrollment clerk. Therefore, we could not use the strategy described above to recruit parents at these sites. Instead, we sent home information to eligible parents about the program along with our enrollment form. We also called some of these families and opted them into the study in over the phone. The incentive structure was the same for these families.

We began program enrollment in early June and completed it in late September of 2013, about six weeks after the start of the school year (many parents enrolled their children in preschool during the first few weeks of school). In total, 519 of 874 eligible families at 31 of 34

sites enrolled in the study. EED clerks enrolled 455 families, 38 families sent in enrollment forms through the mail, and 16 opted into the study over the phone. The three sites in which there was no participation are all co-located at elementary schools.

Of the 519 families that enrolled in the study, 51 left SFUSD prior to the start of the school year, 19 left the district during the year, and nine opted out of the study, leaving an effective sample of 440 families. Mobility is high in early education and we were therefore not surprised by the level of attrition from the district. For example, during the 2012-13 school year, only 76 percent of children who enrolled in an SFUSD preschool attended for the entire year. Assuming that READY4K! did not affect initial enrollment or mid-year exit decisions, only nine out of 440 families intentionally left the study – an opt-out rate of only two percent.

The district offers both subsidized and tuition-based care; however, nearly all families receive some financial aid for preschool enrollment costs (and most receive a lot of aid). During the 2012-13 school year, only 12 percent of families paid full tuition for sending their child to a district preschool. While the families in our sample are similar from a socioeconomic standpoint, they are diverse in other ways. As shown in Table 1, roughly 47 percent of children in the sample are Hispanic, 29 percent are Chinese, and 15 percent are black. The youngest parent in the sample is 20 years old, while the oldest is 57 (the average age of parents is 34.24 years). While most of the parents in the sample lack a bachelor's degree (78 percent), there is meaningful variation in how often parents read for pleasure as well as in other parenting activities as reported on the enrollment forms. On average, parents indicated that they read to their child about three to six times per week, but there is a substantial amount of variation around this average. More than half of the parents, 54 percent, chose to receive texts in English, while 25 percent chose Spanish

and 22 percent chose Chinese texts. Most parents (80 percent) had an unlimited texting plan at the start of the study.

Table 1 also describes children in the sample. The average age of children at the start of the school year was 4.33 years. The youngest child was nearly four and the oldest child was nearly five when the study started. According to parents, there is a high degree of variation in children's pre-treatment early literacy skills. While on average, parents indicated that their children know most of the letters and can produce letter sounds and rhyme somewhat well, the variation around these averages is quite large. Similarly, the average frequency with which children asked to be read to is roughly three to six times per week, yet there is substantial variation around this average.

Randomization Strategy and Minimum Detectable Effect Size

To assign families to treatment and control, we employed a multi-site person-level randomized controlled trial design, blocking on early education site (Spybrook et al., 2011). Within each site, we randomly selected half of the parents to join the treatment group and half to join the control group. While individuals within sites tend to be similar with respect to background characteristics, individuals between sites are often very different. By blocking, the variation between sites does not affect the standard error of the treatment effect estimate, which can increase statistical power if such variation is large (Spybrook et al., 2011).

A minimum detectable effect is the smallest true effect that can be detected from an experimental study for a specified level of statistical power, statistical significance, and sample size (Bloom, 1995). To calculate the minimum detectable effect size (MDES), we used standard assumptions, including a statistical significance level of 0.05 and statistical power of 0.80. In prior unpublished work with SFUSD four year olds, we found that sites explain approximately

35 percent of the variation in spring test scores. We used this figure in our MDES estimation, and we also assumed that our robust set of pre-treatment covariates explains another 15 percent of the variation in outcomes. Based on these assumptions and our sample of 440 parents across 31 sites, we estimate that we can detect effects of approximately 0.20 standard deviations.

Data

This study uses multiple sources of data describing four year olds in SFUSD and their parents. Information on parents comes three sources: the READY4K! enrollment form, an end-of-year survey of parents, and an end-of-year survey of teachers. In the enrollment form, we collected relevant information from parents including their home address, cell phone number, cell phone service provider, whether or not they have unlimited texting, and their level of education. We also asked parents to tell us about their early literacy-related parenting practices and their children's early literacy skills. For example, we asked parents to indicate the number of times per week they read to and sing songs with their child and about their child's knowledge of letters and letter sounds. We collected these data prior to the start of the intervention and all parents partially or fully completed the form.

At the end of the 2013-14 school year, we mailed home surveys to parents about their experiences participating in the study (we also sent a text message to parents with a link to an on-line version of the survey). We asked both treatment and control group parents about the extent to which they felt supported by the district, their experiences receiving texts messages (such as the helpfulness of the texts), and the activities they engaged in to help develop their children's early literacy skills. For example, we asked parents to indicate how many times in the last week they looked at pictures in a book with their child. We also asked parents questions about their involvement in their children's education. We offered parents 50 dollars for completing the

survey, and in total, 287 of the 440 families in our sample completed surveys – a response rate of roughly 65 percent.

We also surveyed teachers about parental involvement. We asked them about the frequency with which both treatment and control group parents ask questions about their child's interests, what their child is learning in school, and things they can do to help their child learn to read. Teachers did not know which parents were in the treatment group and which were in the control group. As with parents, we offered teachers 50 dollars for completing the survey. We used SFUSD's inter-office mail to send surveys to teachers' school mailboxes. Within a few weeks of sending the surveys, 63 teachers covering 254 of 440 families completed and returned them – a response rate of about 58 percent.

To describe students, we use two additional sources of information: SFUSD's administrative records and students' spring scores on the district's early literacy assessment. SFUSD's administrative records contain demographic information on students. We used these data to check the accuracy of the information collected on the program enrollment form and for additional information such as the names of students' teachers. In the spring of each school year, the district assesses the early literacy skills of four years olds using Phonological Awareness Literacy Screening (PALS).[1] PALS, which was developed and validated at the University of Virginia (Invernizzi, Sullivan, Meier & Swank, 2004), is a one-on-one assessment that takes about 20 to 30 minutes to complete.[2] It includes tests of children's name writing skills, alphabet knowledge, beginning sound awareness, print and word awareness, rhyme awareness, and nursery rhyme awareness. The assessment has a leveled component: in the alphabet knowledge sub-test, children who correctly identify 16 or more upper-case letters move on to be assessed in

[1] The 2014 assessment window was March 17th to April 11th.
[2] In SFUSD, outside assessors administer PALS.

lower-case letters; and, children who correctly identify nine or more lower-case letters move on to letter sounds. All of the students in this study were assessed with the English-language version of PALS.

Randomization Checks

In expectation, the only difference between the treatment group and the control group in a randomized experiment is treatment status – one group receives the treatment and the other does not. On average, all other characteristics of treatment and control group members, such as race, should be balanced. However, if by chance the randomization process used to generate the two groups fails, and there is imbalance across the groups, then treatment effect estimates could be biased.

Since we randomized READY4K! within sites, we estimate a set of site fixed effects models to examine treatment-control group balance. These models take the following form:

$$X_{is} = \beta_1 T_{is} + \gamma_s + \varepsilon_{is} \quad [1]$$

where X_{is} is a pre-treatment covariate of child *i* (or his or her parent) in site *s*, T_{is} is the treatment status of the parent of child *i* in site *s*, γ_s is a site fixed effect, and ε_{is} is a child-level (or parent-level) error term. Results of these models tell us whether or not pre-treatment covariates such as child race are balanced across the treatment and control groups within sites. We examine the balance of several pre-treatment covariates, including: child age, race, and gender; parents' ratings of children's pre-treatment early literacy skills; parents' age, educational attainment, cell phone service provider, texting language, and whether or not parents have unlimited texts; and, parents' self-reports of their early literacy-related parenting activities.

The vast majority of analyses show no detectable differences between the treatment and control group (see Table 2). The only statistically-significant difference we find is in parents'

ratings of how many times per week their children ask to be read to. On average within sites, parents in the control group indicated that their children ask to be read to in excess of three to six times per week, while parents in the treatment group indicated that their children asked to be read to slightly less than three to six times per week. As described below, we make a statistical adjustment for this imbalance when we estimate treatment effects.

Estimating Treatment Effects

This study evaluates the impact of READY4K! on parents' text messaging attitudes and behaviors, home literacy practices, and involvement at the school, as well as children's early literacy skills. To assess the effect of the program on parents, we start by examining end-of-year parent survey data. The survey asked parents to indicate how many times during the last week they engaged in various home literacy activities, such as helping their children write their name, reciting nursery rhymes, and reading to their children. Our first step in analyzing the data is to conduct a factor analysis. Results of this analysis indicate that one underlying early literacy parenting factor explains approximately 38 percent of the variance in the data. Based on this result, we use principal components analysis to create a global early literacy parenting composite variable. The weighting for the element variables of this composite appears in Appendix Table 1A in Appendix B.

While factor analysis results indicate that a global composite explains a substantial part of the variation in parent responses, we also created relative-focus measures by rotating the loading matrix to generate orthogonal factors. When we impose the orthogonality restriction, we see that the data decomposes into two parenting factors. The first factor loads on general early literacy parenting activities such as reading and looking at pictures in a book, while the second loads on specific activities such as pointing out two words that sound the same and pointing out

two words that rhyme. We use principal components analysis to create two additional composite variables based on this analysis: a general early literacy activities variable and a specific early literacy activities variable. The weighting for the element variables of these addition composites appears in Appendix Tables 1B and 1C in Appendix B.

To evaluate the effects of the program on parents' home literacy practices, we estimate four sets of models. In the first set of unadjusted models, we simply regress parenting practices on treatment status. We add site fixed effects to the second set of models to account for our randomization strategy. The third set of models controls for treatment-control imbalance in parents' ratings of how many times per week their children ask to be read to. In the fourth set of models, we add additional pre-treatment covariates. Taking this step can increase the precision of effect estimates. The fourth set of models takes the following form:

$$Y_{is} = \beta_1 T_{is} + \gamma_s + \beta_2 Z_{is} + X_{is}\beta_3 + \varepsilon_{is} \quad [2]$$

where Y_{is} indicates the frequency with which the parent of child *i* in site *s* engaged in a particular early literacy activity with the child during the week prior to being surveyed, T_{is} is the parent's treatment status, γ_s is a site fixed effect, Z_{is} controls for randomization imbalance, X_{is} is a vector of pre-treatment covariates (including child gender, race, and age, as well as parent race and educational attainment), and ε_{is} is a parent-level error term. Home literacy activities include activities that target developing specific skills such as pointing out two words that rhyme, activities that target literacy development more broadly like reading and singing songs, and literacy-building experiences such as taking the child to the library. We also estimate the effects of READY4K! on the global early literacy parenting composite variable and the general and specific activities composites, as well as parents' attitudes toward texting and their use of the texts.

We use the same four-model approach to evaluate the effects of the treatment on parental involvement at the school and children's early literacy development. The outcomes for our analysis of parental involvement are teachers' end-of-year ratings of how often parents ask questions about their children's development, including questions about: their child's interests and friends; how their child gets along with others; what their child is doing and learning in school; their child's understanding of early literacy skills; things they can do at home to help their child learn to read; and children's book recommendations.

To evaluate the effects of READY4K! on children's literacy development, we use children's spring PALS scores. We examine the impact of the program on both children's sub-test scores and their summed scores on PALS. Given that PALS has a leveled component, we estimate treatment effects for three groups of children: all children, children who progressed to lower-case alphabet knowledge sub-test, and those who progressed to the letter sounds sub-test.

In addition to estimating main effects, we also test for heterogeneous effects in all of our parent and child outcomes. This analysis allows us to identify whether or not READY4K! was differentially effective for particular types of parents or children. We are especially interested in differences by race because the wording of READY4K! texts might be differentially inviting for families with different racial backgrounds. To test for heterogeneous effects, we add interactions terms to our fully-specified models. For example, to test whether or not READY4K! had a particularly strong effect on the practices of Hispanic parents, we estimate the following model:

$$Y_{is} = \beta_1 T_{is} + \beta_2 H_{is} + \beta_3 T_{is} * H_{is} + \gamma_s + \beta_4 Z_{is} + X_{is}\beta_5 + \varepsilon_{is} \quad [3]$$

where Y_{is} indicates the frequency with which the parent of child *i* in site *s* engaged in a particular home literacy activity, T_{is} is the parent's treatment status, H_{is} equals one if the parent of child *i* in site *s* is Hispanic, $T_{is} * H_{is}$ is an interaction of treatment status and whether or not the parent is

Hispanic, and the rest of the terms are the same as those described in equation [2] above. The coefficient on β_3 indicates the difference in the size of the average treatment effect among Hispanic and non-Hispanic parents. Given the statistical power of this study and our interests, we test for race heterogeneous effects only.

Attrition Analysis

As in many preschools, there is a significant amount of attrition in this study. Not including the families who left the district before or during the school year, 9 families opted out of the study, leaving 440 participating families. The children of 54 of these families were not tested in spring, in large part due to absences from school on the day of testing. As a result, we only have spring test score data on 386 children (86 percent of the 449 who did not leave SFUSD). We have even less data on parents. 287 parents filled out the parent survey and 63 teachers provided information on the parental involvement of 254 parents (64 and 57 percent of the 449, respectively).

The biggest concern with study attrition pertains to bias. If the types of treatment group families who attrited are systematically different than the type of control group families who attrited in a way that is related to study outcomes, then results are likely biased. For example, if extremely poor families leave the treatment group at a higher rate than they leave the control group, and family income is positively related to study outcomes, than results are likely biased upward.

We analyze attrition in the parent survey data, teacher survey data, and child outcome data. To begin, we test whether attrition differs by treatment status. In particular, we regress a binary variable that equals one if a family attrited on treatment status, controlling for site fixed

effects. Then, we test for differential attrition by treatment status by estimating a series of models that take the following form:

$$A_{is} = \beta_1 T_{is} + \beta_2 X_{is} + \beta_3 T_{is} * X_{is} + \gamma_s + \varepsilon_{is} \quad [4]$$

where A_{is} equals one if the family of child *i* in site *s* attrited from the sample, T_{is} is the treatment status of the parent of child *i* in site *s*, X_{is} is a pre-treatment covariate of child *i* or his or her parent, $T_{is} * X_{is}$ is an interaction of treatment status and the covariate, γ_s is a site fixed effect, and ε_{is} is a child-level error term. The coefficient on β_3 indicates whether or not there is differential attrition with respect to X across the treatment and control groups.

Results

Main Effects

We find strong evidence that parents in the treatment group read READY4K! texts, used the tips, and in general found the prorgram helpful.[3] More importantly, treatment parents group reported engaging far more frequently in home literacy activities with their children than parents in the control group. As Table 3 indicates, READY4K! positively affected the frequency with which parents told stories, pointed out two words that begin with the same sound, pointed out rhyming words, recited nursery rhymes, looked at pictures in a book, showed the different parts

[3]As Appendix Table 2 in Appendix B indicates, parents who received READY4K! texts exhibited more active texting behavior and had more positive attitudes towards receiving text messages than parents who received placebo texts. For example, the extent to which parents in the treatment group read, used, and shared texts with other parents ranged from about 0.26 to 0.53 standard deviations higher than the extent to which parents in the control group engaged in these texting behaviors (all results are statistically-significant at the 0.05 level or higher). Moreover, the difference in the extent to which treatment and control group parents found the texts helpful is roughly 0.59 standard deviations (significant at the 0.01 level). Finally, the difference in the extent to which READY4K! and non-READY4K! parents would recommend texts is about 0.25 standard deviations units (significant at conventional levels). Of note, if parents in the treatment group shared texts with parents in the control group, then results are likely biased. Unfortunately, we do not have a way to test for experimental contamination; however, this type of contamination would have the effect of negatively biasing our estimates. Therefore, our estimates can be viewed as lower-bound estimates of the effects of READY4K!.

of a book, and played games or worked on a puzzle with their children during the week prior to being surveyed (see Model 4). The size of these effects range from about 0.22 standard deviations to about 0.34 standard deviations and all results are significant at conventional levels. Similarly, READY4K! led to improvements on the global early literacy parenting composite variable of roughly 0.29 standard deviations (significant at the 0.05 level).

READY4K! texts appear to have had a greater impact on parents' specific home literacy practices (e.g., saying two words that start with the same sound) than on general practices such are reading books. In particular, the effect of the treatment on the specific activities composite variable is about 0.24 standard deviations (significant at the 0.10 level), while the intervention had no statistically-significant impact on the general activities composite variable (see Model 4 in Table 3).

According to teachers, parents in the intervention group were significantly more likely to ask them questions about their children's learning than control group parents. We summarize the effects of READY4K! on parental involvement in Table 4. For example, the frequency with which treatment group parents asked the teacher about how their children get along with others and what their children are doing in school is approximately 0.16 to 0.19 standard deviations greater than the frequency with which control group parents asked these questions (results are significant at conventional levels). In addition, the difference between how often READY4K! and non-READY4K! parents asked the teacher about what they can do at home to help their children learn to read is approximately 0.13 standard deviations (significant at the 0.10 level).

In Table 5, we summarize the effect of the intervention on children's early literacy test scores. Results indicate that the intervention had a positive effect on children's literacy development. When considering all students in the sample, those whose parents received

READY4K! texts scored about 0.21 and 0.34 standard deviations higher on the PALS lower-case alphabet knowledge and letter sounds sub-tests than those whose parents received placebo texts (results significant at conventional levels; see Panel A). READY4K! had additional positive effects on students who progressed to the second and third levels of the alphabet knowledge sub-test. In particular, the treatment had a positive impact on the upper-case alphabet knowledge and PALS summed scores of these students of about 0.26 to 0.29 standard deviations (significant at the 0.05 level; see Panels B and C).

Heterogeneous Effects

We find limited evidence that READY4K! was differentially effective for particular types of families. As Table 6 illustrates, there is weak directional evidence that READY4K! was particularly effective for black and Hispanic parents – the treatment had a positive though insignificant differential effect on the global early literacy composite score of these parents of about 0.05 standard deviations. Interestingly, the program seems to have affected the two groups of parents in different ways. READY4K! had a large though insignificant negative effect on black parents' general home literacy activities but a large insignificant positive effect on their specific activities. The opposite is true for Hispanic parents. The clearest evidence of this difference comes from the point estimate of the heterogeneous treatment effect on Hispanic parents' specific home literacy activities of about -0.67 standard deviations (significant at the 0.05 level). READY4K! also had positive differential effects on Hispanic parents' involvement at the school. For instance, the effect of the program on the extent to which parents asked about how their child is doing in school is about 0.50 standard deviations greater for Hispanic parents than non-Hispanic parents (significant at the 0.05 level).

The intervention appears least effective for Chinese parents. Nearly all of the heterogeneous effect point estimates for Chinese parents are negative, and two are highly significant – those pertaining to the frequency with which parents ask the teacher about how their child gets along with others and about how their child is doing in school (approximately -0.45 and -0.42 standard deviations, respectively; both results are significant at conventional levels). These effects may be due to shortcomings in the texting technology. In order to receive texts in Chinese, parents had to enable their phones to show Chinese characters. We had no way on knowing which parents would take this extra step so we sent Chinese-speaking parents texts in English as well as in Chinese. Some parents may not have been able to read any of the texts we sent (if, for example, they did not enable their phones and could not read English). Other parents may have been deterred by having to take an extra step to receive texts in Chinese or by receiving duplicates of each text in two languages. A final possibility is that the texts may not have been written in a way that was as helpful for Chines parents as it was for others.

Table 7 summarizes the heterogeneous effects of READY4K! on student outcomes. We find some evidence that READY4K! was especially beneficial for black and Hispanic students. Many of the heterogeneous effect point estimates for black students are positive (particularly for those who progressed beyond the first level of the alphabet knowledge sub-test), and the difference in the size of the average letter sounds treatment effect between black and non-black students is about 0.57 standard deviations (marginally significant at the 0.10 level). Similarly, the difference in the size of the average upper-case letter knowledge treatment effect between Hispanic and non-Hispanic students who progressed to the second level of the alphabet knowledge sub-test is about 0.48 standard deviations (marginally significant at the 0.10 level). In keeping with the parenting results, we find some evidence that the program was least effective

for Chinese students. For example, the difference in the size of the average upper- and lower-case letter knowledge treatment effect estimates between Chinese and non-Chinese students who progressed to the lower-case letters sub-test are about -0.51 and -0.59 standard deviations, respectively (significant at the 0.05 level).

Results of the Attrition Analysis and a Robustness Test

Across the parent survey, teacher survey, and child outcome data, we find no evidence that the rate of attrition differs between the treatment and control groups (see Table 8). Nor do we find any evidence that treatment and control group attriters in the teacher survey data vary systematically (see Table 9). We do however find modest evidence of differential attrition in the parent survey data. As Table 10 illustrates, fewer white families and more Chinese left the control group than the treatment group.[4] To assess the direction of potential bias driven by differential attrition in the parent survey data, we examine whether or not racial status is correlated with the outcomes measured in the data. First, we estimate a set of site fixed effects models in which we regress parents' self reports of particular home literacy practices on a binary variable that equals one if the family is white. We then repeat the process using a binary variable that equals one if the family is Chinese. Among all of the activities affected by READY4K! (see Table 3), we only find two instances of a statistically-significant relationship with racial status: the relationship between being white and playing games or working on puzzles with a child is approximately 0.45 standard deviations; and, the relationship between being Chinese and saying two words that rhyme to a child is approximately -0.39 standard deviations (both results are

[4] In particular, the odds that a treatment group family who attrited from the parent survey sample is white are over six times as great as the odds that a control group family who attrited from this sample is white. While this difference seems large, it is driven by a small number of families. In particular, four of 121 control group families who attrited are white, compared to nine of 111 treatment group attriters. The odds that a treatment group family who attrited from the parent survey sample is Chinese are 0.43 times as great as the odds that a control group family who attrited from this sample is Chinese. In terms of raw numbers, 17 Chinese families attrited from the treatment group while 27 attrited from the control group.

significant at the 0.05 level). These results suggest that differential attrition in the parent survey data likely biases the effects of READY4K! on parenting practices downward – true effects could be larger.[5]

We also find limited evidence of differential attrition in the child outcome data. As shown in Table 11, the odds that a treatment group family who attrited chose to receive texts in English are about 0.43 times as large as the odds that a control group family who attrited chose English language texts. In terms of raw numbers, 46 of the 64 control group families who attrited chose to receive texts in English, compared to 41 of 69 attriting treatment group families.

Based on the fact that we find that treatment and control group attriters in the child outcome data only differ in one of 15 tested dimension (and that this difference is quite small in terms of raw numbers of families), the impact of differential attrition on the unbiasedness of our treatment effect estimates is likely small. Nonetheless, we assess potential bias resulting from differential attrition by examining whether or not receiving texts in English is correlated with child outcomes. First, we estimate a set of site fixed effects models in which we regress children's PALS sub-test and summed scores on a binary variable that equals one if the child's parent received texts in English. We find some evidence of a positive association between receiving texts in English and children's test scores, suggesting that if differential attrition in the child outcome data biases treatment effect estimates, the bias is likely upward.[6]

To gauge the magnitude of such bias, we conduct a robustness test in which we re-estimate the effects of READY4K! on children's spring early literacy assessment scores using

[5] Because more Chinese and fewer White families left the control group, and being Chinese and being white are negatively and positively correlated with parents' home literacy activities, respectively.

[6] Receiving texts in English is most strongly related to print and word awareness and rhyme awareness scores, which READY4K! did not affect. Among the skills affected by PALS, we only find one positive relationship: the average upper-case letter knowledge of children of parents who received texts in English about 0.22 standard deviations higher that of others (significant at the 0.05 level).

the entire sample, including attriters and non-attriters. In particular, we use non-attriters' spring test scores and our rich set of pre-treatment covariates to generate predicted values of attriting children's assessment scores, which we input in the model we use to estimate the effects of READ4K! on the total sample. We find that effect estimates marginally contract but that all effects persist. For example, as Table 12 illustrates, READY4K! continues to have a positive effect on all students' lower-case alphabet knowledge and letter sounds knowledge; however, the size of these effects decreases to roughly 0.18 and 0.26 standard deviations from approximately 0.21 and 0.34 standard deviations, respectively (see also Table 5).

Discussion

The substantial differences in the home learning experiences of wealthy and economically-disadvantaged young children are troubling. Young children with few learning opportunities at home exhibit fewer skills across a broad range of developmental domains – skills which are critical for economic success later in life (Heckman, 2006). Traditional parenting information sessions often do little to affect differences in children's at-home experiences. Interventions that target parents' literacy skills and in-home visitations show more promise; however, access to these programs is a significant issue. Moreover, some parents who acquire the skills necessary to support their children's learning fail to stay involved over the long term, in part due to behavioral barriers.

This study examines the effectiveness of an early literacy text messaging program that targets the behavioral barriers to good parenting by breaking down the complexity of parenting into bite-sized pieces and proving continuous encouragement and support over long periods of time. We find that the texting program approach positively affected parents and their children.

Receiving READY4K! texts increased the extent to which parents engaged in numerous home literacy activities with their children, with effect sizes ranging from about 0.22 to 0.34 standard deviations. The intervention also positively affected parental involvement at school, as teachers indicated that treatment group parents asked questions about their child's learning about 0.13 to 0.19 standard deviations more often than control group parents. Increases in parental activity and involvement led to learning gains among children. The effects of READY4K! on children's lower-case alphabet knowledge and letter sounds spring assessment scores are roughly 0.21 and 0.34 standard deviations, respectively. We find additional treatment effects for students who progressed beyond the first level of the alphabet knowledge sub-test, and there is some evidence that the program was differentially effective for black and Hispanic families.

READY4K! had a greater effect on highly-specific home literacy activities (such as saying two words that begin with the same sound) than on general home literacy activities like reading. By construction, tip texts that address specific skills provide parents with more detailed instructions than tip texts that address general skills. Therefore, it seems that specifically-worded text messages are better than generally-worded texts. This interpretation is in keeping with our overall theory of action underlying the program – highly-specific messages break down the complexity of parenting more than general messages, making them easier to act on.

Perhaps the most compelling implication of this study's findings is that text messaging represents an extremely viable strategy for promoting parental involvement. The vast majority of American adults have cell phones, nearly all cell phone owners already send and receive texts, and texting rates are particularly high in black and Hispanic populations. Moreover, virtually all text messages are opened (by comparison, the e-mail open rate in education is about 36 percent). Last year, we spent less than one dollar per family to send text messages, and fixed program

expenses such as content development costs trend towards zero as the program scales. Scaling READY4K! is easy, as adding parents to the program requires little administration work. Based on its widespread use, low cost, and sacalability, text messaging is an attractive alternative to other parenting interventions which place significant demands on parents' time and effort and can cost upwards of 10,000 per family.

References

Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology*, *27*(3), 379.

Anderson, N. B. (2006). Child-care effect sizes for the NICHD study of early child care and youth development. National Institute of Child Health and Human Development Early Child Care Research Network.

Aos, S., Lieb, R., Mayfield, J., Miller, M., & Pennucci, A. (2004). *Benefits and costs of prevention and early intervention programs for youth* (No. 04-07, p. 3901). Olympia, WA: Washington State Institute for Public Policy.

Astuto, J., & Allen, L. (2009). Home Visitation and Young Children: An Approach Worth Investing In? Social Policy Report. Volume XXIII, Number IV. *Society for Research in Child Development*.

Avery, C., & Kane, T.J. (2004). Student perceptions of college opportunities. The Boston COACH program. In *College choices: The economics of where to go, when to go, and how to pay for it* (pp. 355-394). University of Chicago Press.

Azzi-Lessing, L. (2011). Home visitation programs: critical issues and future directions. *Early Childhood Research Quarterly*, *26*(4), 387-398.

Bergman, P. (2014). Parent-child information frictions and human capital investment: Evidence from a field experiment. Working paper.

Bettinger, E.P., Long, B.T., Oreopoulos, P., & Sanbonmatsu, L. (2012). The role of application assistance and information in college decisions: Results from the H&R Block FAFSA experiment. *The Quarterly Journal of Economics*, *127*(3), 1205-1242.

Blom-Hoffman, J., O'Neil-Pirozzi, T., Volpe, R., Cutting, J., & Bissinger, E. (2007). Instructing parents to use dialogic reading strategies with preschool children: Impact of a video-based training program on caregiver reading behaviors and children's related verbalizations. *Journal of Applied School Psychology, 23*(1), 117-131.

Bloom, H.S. (1995). Minimum detectable effects: A simple way to report the statistical power of experimental designs. *Evaluation Review, 19*(5), 547-556.

Bradley, R.H., Corwyn, R.F., McAdoo, H.P., & García Coll, C. (2001). The home environments of children in the United States part I: Variations by age, ethnicity, and poverty status. *Child Development, 72*(6), 1844-1867.

Bradley, R.H., Corwyn, R.F., Burchinal, M., McAdoo, H.P., & García Coll, C. (2001). The home environments of children in the United States Part II: Relations with behavioral development through age thirteen. *Child Development, 72*(6), 1868-1886.

Brotman, L.M., Calzada, E., Huang, K.Y., Kingston, S., Dawson-McClure, S., Kamboukos, D., Rosenfelt, A., Schwab, A., & Petkova, E. (2011). Promoting effective parenting practices and preventing child behavior problems in school among ethnically diverse families from underserved, urban communities. *Child Development, 82*(1), 258-276.

Castleman, B.L., & Page, L.C. (2013). Summer Nudging: Can Personalized Text Messages and Peer Mentor Outreach Increase College Going Among Low-Income High School Graduates?. *Center for Education Policy and Workforce Competitiveness Working Paper*, (9).

Costello, E.J., Compton, S.N., Keeler, G., & Angold, A. (2003). Relationships between poverty and psychopathology: A natural experiment. *Journal of the American Medical Association, 290*(15), 2023-2029.

Duncan, G.J., Ludwig, J., & Magnuson, K.A. (2010). Child development. In P.B. Levine & D.J. Zimmerman (Eds.), *Targeting investments in children: Fighting poverty when resources are limited* (27-58). Chicago: The University of Chicago Press.

Ehrlich, S. (2013, February 27). Mogreet releases best practices guide for successfully navigating text marketing rules and regulations. *The Wall Street Journal.* Retrieved from http://online.wsj.com/article/PR-CO-20130227-908303.html

Golova, N., Alario, A.J., Vivier, P.M., Rodriguez, M., & High, P.C. (1999). Literacy promotion for Hispanic families in a primary care setting: a randomized, controlled trial. *Pediatrics*, *103*(5), 993-997.

Gomby, D.S. (2005). Home visitation in 2005: Outcomes for children and parents. *Washington, DC: Committee on Economic Development*.

Gomby, D.S., Culross, P.L., & Behrman, R. E. (1999). Home visiting: Recent program evaluations: Analysis and recommendations. *The Future of Children,* 4-26.

Grodsky, E., & Jones, M. T. (2007). Real and imagined barriers to college entry: Perceptions of cost. *Social Science Research, 36*(2), 745-766.

Hart, B., & Risley, T.R. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore, MD: Brookes Publishing.

Hastings, J.S., & Weinstein, J.M. (2007). *Information, school choice, and academic achievement: Evidence from two experiments* (No. w13623). National Bureau of Economic Research.

Heckman, J.J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science, 312*(5782), 1900-1902.

Invernizzi, Sullivan, Meier & Swank (2004). *Phonological Awareness Literacy Screening (PALS) prek teacher's manual.* University of Virginia.

Jordan, G.E., Snow, C.E., & Porche, M. V. (2000). Project EASE: The effect of a family literacy project on kindergarten students' early literacy skills. *Reading Research Quarterly*, *35*(4), 524-546.

Karlan, D., McConnell, M., Mullainathan, S., & Zinman, J. (2010). *Getting to the top of mind: How reminders increase saving* (No. w16205). National Bureau of Economic Research.

Lonigan, C.J., & Shanahan, T. (2009). Developing Early Literacy: Report of the National Early Literacy Panel. Executive Summary. A Scientific Synthesis of Early Literacy Development and Implications for Intervention. *National Institute for Literacy*.

Madrian, B.C., & Shea, D.F. (2000). *The power of suggestion: Inertia in 401 (k) participation and savings behavior* (No. w7682). National Bureau of Economic Research.

Manz, P.H., Hughes, C., Barnabas, E., Bracaliello, C., & Ginsburg-Block, M. (2010). A descriptive review and meta-analysis of family-based emergent literacy interventions: To what extent is the research applicable to low-income, ethnic-minority or linguistically-diverse young children?. *Early Childhood Research Quarterly*, *25*(4), 409-431.

Melhuish, E.C., Phan, M. B., Sylva, K., Sammons, P., Siraj-Blatchford, I., & Taggart, B. (2008). Effects of the home learning environment and preschool center experience upon literacy and numeracy development in early primary school. *Journal of Social Issues*, *64*(1), 95-114.

Mendelsohn, A.L., Mogilner, L.N., Dreyer, B.P., Forman, J.A., Weinstein, S.C., Broderick, M., Cheng, K., Magloire, T., Moore, T., & Napier, C. (2001). The impact of a clinic-based literacy intervention on language development in inner-city preschool children. *Pediatrics*, *107*(1), 130-134.

Needlman, R., Toker, K.H., Dreyer, B.P., Klass, P., & Mendelsohn, A.L. (2005). Effectiveness of a primary care intervention to support reading aloud: a multicenter evaluation. *Ambulatory Pediatrics*, *5*(4), 209-215.

Olds, D.L., Eckenrode, J., Henderson, C.R., Kitzman, H., Powers, J., Cole, R., Sidora, K., Morris, P., Pettitt, L.M., & Luckey, D. (1997). Long-term effects of home visitation on maternal life course and child abuse and neglect: fifteen-year follow-up of a randomized trial. *Journal of the American Medical Association*, *278*(8), 637-643.

Olds, D., Henderson Jr, C.R., Cole, R., Eckenrode, J., Kitzman, H., Luckey, D., Pettitt, L., Sidora, K., Morris, P., & Powers, J. (1998). Long-term effects of nurse home visitation on children's criminal and antisocial behavior: 15-year follow-up of a randomized controlled trial. *Journal of the American Medical Association*, *280*(14), 1238-1244.

Patrick, K., Raab, F., Adams, M.A., Dillon, L., Zabinski, M., Rock, C.L., Griswold, W.G., & Norman, G. J. (2009). A text message–based intervention for weight loss: randomized controlled trial. *Journal of Medical Internet Research*, *11*(1).

Petrie, K.J., Perry, K., Broadbent, E., & Weinman, J. (2012). A text message programme designed to modify patients' illness and treatment beliefs improves self-reported adherence to asthma preventer medication. *British Journal of Health Psychology*, *17*(1), 74-84.

Prinz, R.J., & Miller, G.E. (1994). Family-based treatment for childhood antisocial behavior: Experimental influences on dropout and engagement. *Journal of Consulting and Clinical Psychology*, *62*(3), 645.

Reese, E., Sparks, A., & Leyva, D. (2010). A review of parent interventions for preschool children's language and emergent literacy. *Journal of Early Childhood Literacy*, *10*(1), 97-117.

Riccio, J., Dechausay, N., Miller, C., Nunez, S., Verma, N., & Yang, E. (2013). *Conditional cash transfers in New York City: The continuing story of the Opportunity NYC-Family Rewards demonstration.* New York: MDRC.

Rodgers, A., Corbett, T., Bramley, D., Riddell, T., Wills, M., Lin, R.B., & Jones, M. (2005). Do u smoke after txt? Results of a randomised trial of smoking cessation using mobile phone text messaging. *Tobacco Control*, *14*(4), 255-261.

Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*, *1*(1), 7-59.

Sharif, I., Rieber, S., Ozuah, P.O., & Reiber, S. (2002). Exposure to Reach Out and Read and vocabulary outcomes in inner city preschoolers. *Journal of the National Medical Association*, *94*(3), 171.

Spybrook, J., Bloom, H., Congdon, R., Hill, C., Martinez, A., & Raudenbush, S.(2011). Optimal design plus empirical evidence: Documentation for the "Optimal Design" software. *William T. Grant Foundation. Retrieved on 7/1/*2013.

Thaler, R.H., & Sunstein, C.R. (2008). *Nudge: Improving decisions about health, wealth, and happiness*. New Haven, CT: Yale University Press.

United States Department of Health and Human Services. (1996). *Physical activity and health: a report of the Surgeon General*. Darby, PA: DIANE Publishing.

Valant, J., & Loeb, S. (2014). Information, choice, and decision-making: Field experiments with adult and student school choosers. Working Paper.

Whitehurst, G.J., Epstein, J.N., Angell, A.L., Payne, A.C., Crone, D.A., & Fischel, J. E. (1994). Outcomes of an emergent literacy intervention in Head Start. *Journal of Educational Psychology*, *86*(4), 542.

Yoon, K.H., & Kim, H.S. (2008). A short message service by cellular phone in type 2 diabetic patients for 12 months. *Diabetes Research and Clinical Practice*, *79*(2), 256-261.

Zickuhr, K., & Smith, A. (2012). Digital differences. *Pew Internet & American Life Project*, *13*.

Zuckerman, B. (2009). Promoting early literacy in pediatric practice: twenty years of Reach Out and Read. *Pediatrics*, *124*(6), 1660-1665.

Tables and Figures

Table 1
Sample summary statistics

Panel A: Children	Mean	Std. Dev.	Min	Max
Female	0.47	-	-	-
Hispanic	0.34	-	-	-
Chinese	0.29	-	-	-
Black	0.15	-	-	-
White	0.10	-	-	-
Age in years (fall)	4.33	0.29	3.84	4.88
Parent rating of letter knowledge (fall)	2.88	0.92	1	4
Parent rating of letter sounds knowledge (fall)	3.05	1.15	1	5
Parent rating of rhyming skills (fall)	2.90	1.19	1	5
Parent rating of how often child ask to be read to per week (fall)	2.96	0.89	1	4
N=	440			
Panel B: Parents				
Age in years (fall)	34.24	5.53	20	57
Has less than a bachelor's degree	0.78	-	-	-
Received texts in English	0.54	-	-	-
Received texts in Spanish	0.25	-	-	-
Received texts in Chinese	0.22	-	-	-
Has an unlimited text messaging plan	0.80	-	-	-
How many times per week parent reads for pleasure (fall)	2.55	0.87	1	4
How many times per week parent tells a story to child (fall)	2.85	0.84	1	4
How many times per week parent sings to child (fall)	2.92	0.82	1	4
How many times per week parent reads to child (fall)	2.98	0.82	1	4
N=	440			

Notes. Parents rated the letter knowledge of their child in one of four categories: 1=The child knows no letters, 2=Some, 3=Most, 4=All. Parents rated how well their child can produce letter sounds and rhyme in one of five categories: 1=Not at all, 2=Not very well, 3=Somewhat well, 4=Well, 5=Very Well. Answer options for weekly parental activities and how often the child asks to be read to include: 1=Not at all, 2=Once or twice per week, 3=Three to six times, 4=Every day. Missing values set at the sample average.

Table 2

Randomization checks: the effect of treatment status on pre-treatment covariates (estimates reported in standard deviation units)

	Treatment effect estimates
Panel A: Child covariates	
Female	1.047
	(0.240)
Hispanic	0.748
	(1.090)
Chinese	1.307
	(0.960)
Black	1.340
	(0.890)
White	0.772
	(0.740)
Age in years (fall)	0.013
	(0.027)
Parent rating of letter knowledge (fall)	0.095
	(0.088)
Parent rating of letter sounds knowledge (fall)	-0.034
	(0.115)
Parent rating of rhyming skills (fall)	-0.069
	(0.122)
Parent rating of how often child ask to be read to per week (fall)	-0.205**
	(0.090)
Panel B: Parent covariates	
Age in years (fall)	-0.475
	(0.620)
Has less than a bachelor's degree	0.889
	(0.450)
Received texts in English	1.195
	(0.790)
Received texts in Spanish	0.744
	(1.050)
Received texts in Chinese	1.019
	(0.070)
Has an unlimited text messaging plan	0.768
	(1.000)
How many times per week parent reads for pleasure (fall)	-0.002
	(0.088)
How many times per week parent tells a story to child (fall)	-0.008
	(0.082)
How many times per week parent sings to child (fall)	0.026
	(0.082)
How many times per week parent reads to child (fall)	-0.032
	(0.082)
N=	440
Model inclusions:	
Site fixed effects	X

Notes. Estimates for binary variables such as female are reported as odds ratios (with z-statistics in parentheses). Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 3

The effects of READY4K! on parents' home literacy activities (estimates reported in standard deviation units)

	Treatment effect estimates			
Panel A: Home literacy activities	Model 1	Model 2	Model 3	Model 4
Told your child a story	0.035	0.100	0.198	0.221*
	(0.118)	(0.124)	(0.121)	(0.126)
Pointed out two words that begin with the same sound to your child	0.180	0.141	0.186	0.219*
	(0.118)	(0.122)	(0.122)	(0.127)
Pointed out two words that rhyme to your child	0.184	0.158	0.227*	0.234*
	(0.119)	(0.122)	(0.122)	(0.125)
Recited a nursery rhyme to your child	0.198*	0.174	0.231*	0.305**
	(0.118)	(0.122)	(0.123)	(0.122)
Looked at pictures in a book with your child	0.227*	0.240*	0.331***	0.340***
	(0.118)	(0.124)	(0.120)	(0.123)
Showed your child the different parts of a book (e.g., cover, title, author, and pages)	0.202*	0.165	0.243**	0.276**
	(0.118)	(0.118)	(0.117)	(0.120)
Played games or worked on puzzles with your child	0.176	0.205*	0.256**	0.293**
	(0.118)	(0.124)	(0.125)	(0.130)
Panel B: Home literacy activity composite variables				
Global early literacy parenting composite variable	0.166	0.167	0.249**	0.294**
	(0.125)	(0.128)	(0.123)	(0.127)
General early literacy activities composite variable	0.050	0.076	0.169	0.180
	(0.125)	(0.129)	(0.122)	(0.125)
Specific early literacy activities composite variable	0.157	0.192	0.205	0.243*
	(0.125)	(0.125)	(0.127)	(0.128)
N=	287	287	287	287
Model inclusions:				
Site fixed effects		X	X	X
Imbalanced pre-treatment covariates			X	X
Additional pre-treatment covariates				X

Note. Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 4

The effects of READY4K! on parental involvement (estimates reported in standard deviation units)

	Treatment effect estimates			
Teachers' ratings of how often parents ask them about:	Model 1	Model 2	Model 3	Model 4
How the child gets along with others	0.119	0.224**	0.226**	0.192*
	(0.109)	(0.092)	(0.092)	(0.098)
What their child is doing in school	0.031	0.168*	0.166*	0.160*
	(0.107)	(0.086)	(0.089)	(0.091)
What they can do at home to help the child learn to read	-0.009	0.129*	0.132*	0.129*
	(0.096)	(0.075)	(0.074)	(0.074)
N=	254	254	254	254
Model inclusions:				
Site fixed effects		X	X	X
Imbalanced pre-treatment covariates			X	X
Additional pre-treatment covariates				X

Notes. Standard errors clustered at the teacher level. Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 5

The effects of READY4K! on children's spring early literacy assessment scores (estimates reported in standard deviation units)

Panel A: All students	Name Writing	Upper-case letters	Lower-case letters	Letter sounds	Beginning word sounds	Print & word awareness	Rhyme awareness	Summed Score
Treatment effect estimate	-0.042	-0.007	0.205*	0.344***	-0.067	0.067	-0.052	-0.045
	(0.104)	(0.088)	(0.122)	(0.113)	(0.100)	(0.099)	(0.095)	(0.091)
N=	382	383	286	272	368	373	365	344
Panel B: Students who progressed to lower-case letters								
Treatment effect estimate	0.054	0.291**	0.205*	0.344***	0.023	0.153	-0.035	0.260**
	(0.109)	(0.121)	(0.122)	(0.113)	(0.126)	(0.120)	(0.114)	(0.117)
N=	284	286	286	272	272	278	272	256
Panel C: Students who progressed to letter sounds								
Treatment effect estimate	0.025	0.263**	0.130	0.344***	0.023	0.172	-0.003	0.260**
	(0.112)	(0.124)	(0.126)	(0.113)	(0.128)	(0.125)	(0.117)	(0.117)
N=	270	272	272	272	267	265	261	256
Model inclusions:								
Site fixed effects	X	X	X	X	X	X	X	X
Imbalanced pre-treatment covariates	X	X	X	X	X	X	X	X
Additional pre-treatment covariates	X	X	X	X	X	X	X	X

Note. Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 6

The heterogeneous effects of READY4K! on different types of parents (estimates reported in standard deviation units)

Heterogeneous treatment effect estimates:	Global early literacy parenting composite variable	General early literacy activities composite	Specific early literacy activities composite	Asks teacher how child gets along with others	Asks teacher what child is doing in school	Asks teacher for tips on helping child learn to read
Black parent x treatment status	0.051	-0.514	0.276	-0.015	-0.014	-0.161
	(0.328)	(0.328)	(0.322)	(0.349)	(0.320)	(0.309)
Hispanic parent x treatment status	0.055	0.372	-0.665**	0.378**	0.496**	0.154
	(0.296)	(0.296)	(0.287)	(0.180)	(0.192)	(0.194)
Chinese parent x treatment status	-0.237	-0.158	0.063	-0.446*	-0.419**	-0.244
	(0.275)	(0.277)	(0.271)	(0.245)	(0.193)	(0.192)
N=	287	287	287	287	287	287
Model inclusions:						
Site fixed effects	X	X	X	X	X	X
Imbalanced pre-treatment covariates	X	X	X	X	X	X
Additional pre-treatment covariates	X	X	X	X	X	X

Notes. The coefficients on interaction terms come from separate models. We estimated a different model for each heterogeneous effect of interest. Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 7

The heterogeneous effects of READY4K! on different types of students (estimates reported in standard deviation units)

	Name Writing	Upper-case letters	Lower-case letters	Letter sounds	Beginning word sounds	Print & word awareness	Rhyme awareness	Summed Score
Panel A: All students								
Black x treatment status	-0.105	-0.024	0.299	0.568*	0.193	0.032	-0.135	-0.032
	(0.319)	(0.277)	(0.367)	(0.342)	(0.315)	(0.323)	(0.309)	(0.299)
Hispanic x treatment status	0.242	0.019	0.269	-0.275	-0.178	-0.108	0.257	-0.078
	(0.216)	(0.187)	(0.275)	(0.258)	(0.212)	(0.214)	(0.201)	(0.191)
Chinese x treatment status	-0.174	0.017	-0.589**	0.292	0.028	0.293	-0.053	0.184
	(0.220)	(0.192)	(0.241)	(0.232)	(0.218)	(0.216)	(0.207)	(0.203)
N=	382	383	286	272	368	373	365	344
Panel B: Students who progressed to lower-case letters								
Black x treatment status	-0.364	0.193	0.299	0.568*	0.465	0.231	-0.051	0.395
	(0.332)	(0.368)	(0.367)	(0.342)	(0.386)	(0.373)	(0.352)	(0.356)
Hispanic x treatment status	0.374	0.480*	0.269	-0.275	-0.301	-0.178	0.341	-0.050
	(0.245)	(0.275)	(0.275)	(0.258)	(0.286)	(0.275)	(0.259)	(0.262)
Chinese x treatment status	-0.335	-0.512**	-0.589**	0.292	-0.055	0.233	-0.156	-0.207
	(0.219)	(0.243)	(0.241)	(0.232)	(0.257)	(0.245)	(0.233)	(0.240)
N=	284	286	286	272	272	278	272	256
Panel C: Students who progressed to letter sounds								
Black x treatment status	-0.444	0.089	0.144	0.568*	0.506	0.262	-0.068	0.395
	(0.337)	(0.373)	(0.376)	(0.342)	(0.388)	(0.380)	(0.357)	(0.356)
Hispanic x treatment status	0.336	0.284	0.166	-0.275	-0.328	-0.221	0.337	-0.050
	(0.250)	(0.280)	(0.282)	(0.258)	(0.286)	(0.283)	(0.264)	(0.262)
Chinese x treatment status	-0.290	-0.296	-0.254	0.292	0.011	0.233	-0.137	-0.207
	(0.226)	(0.250)	(0.252)	(0.232)	(0.259)	(0.256)	(0.242)	(0.240)
N=	270	272	272	272	267	265	261	256
Model inclusions:								
Site fixed effects	X	X	X	X	X	X	X	X
Imbalanced pre-treatment covariates	X	X	X	X	X	X	X	X
Additional pre-treatment covariates	X	X	X	X	X	X	X	X

Note. The coefficients on interaction terms come from separate models. We estimated a different model for each heterogeneous effect of interest. Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 8

The effects of treatment status on study attrition (estimates reported as odds ratios with z-statistics in parentheses)

Parent survey data	0.822
	(1.070)
Teacher survey data on parental involvement	0.993
	(0.030)
Child outcome data	1.098
	(0.450)
N=	508
Model inclusions:	
Site fixed effects	X

Notes. We are missing site information for 11 students who left the district before the start of the school year. Since we estimate logit models using site fixed effects, the sample size drops to 508 from 519 (the total number of study participants). Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 9

The differential effects of treatment status on attrition in teacher survey data on parental involvement (estimates reported as odds ratios with z-statistics in parentheses)

Parent age x treatment status	1.040
	(1.010)
Parent education x treatment status	1.041
	(0.240)
Received texts in English x treatment status	0.988
	(0.030)
Received texts in Spanish x treatment status	0.828
	(0.360)
Received texts in Chinese x treatment status	1.212
	(0.360)
Parent has unlimited texts x treatment status	1.419
	(0.580)
Child is female x treatment status	1.194
	(0.340)
White x treatment status	0.653
	(0.510)
Black x treatment status	0.375
	(1.380)
Hispanic x treatment status	0.618
	(0.910)
Chinese x treatment status	1.555
	(0.850)
How many times per week parent reads for pleasure (fall) x treatment status	0.714
	(1.270)
How many times per week parent tells a story to child (fall) x treatment status	0.851
	(0.570)
How many times per week parent sings to child (fall) x treatment status	0.715
	(1.230)
How many times per week parent reads to child (fall) x treatment status	0.802
	(0.800)
N=	508
Model inclusions:	
Site fixed effects	X

Notes. We are missing site information for 11 students who left the district before the start of the school year. Since we estimate logit models using site fixed effects, the sample size drops to 508 from 519 (the total number of study participants). Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 10

The differential effects of treatment status on attrition in parent survey data (estimates reported as odds ratios with z-statistics in parentheses)

Parent age x treatment status	1.022
	(0.650)
Parent education x treatment status	0.849
	(1.190)
Received texts in English x treatment status	1.012
	(0.030)
Received texts in Spanish x treatment status	1.599
	(1.090)
Received texts in Chinese x treatment status	0.597
	(1.130)
Parent has unlimited texts x treatment status	1.093
	(0.180)
Child is female x treatment status	0.687
	(0.940)
White x treatment status	6.09**
	(2.400)
Black x treatment status	0.822
	(0.360)
Hispanic x treatment status	1.166
	(0.380)
Chinese x treatment status	0.430**
	(1.970)
How many times per week parent reads for pleasure (fall) x treatment status	1.101
	(0.450)
How many times per week parent tells a story to child (fall) x treatment status	1.224
	(0.900)
How many times per week parent sings to child (fall) x treatment status	0.916
	(0.390)
How many times per week parent reads to child (fall) x treatment status	0.835
	(0.800)
N=	508
Model inclusions:	
Site fixed effects	X

Notes. We are missing site information for 11 students who left the district before the start of the school year. Since we estimate logit models using site fixed effects, the sample size drops to 508 from 519 (the total number of study participants). Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 11

The differential effects of treatment status on attrition in child outcome data (estimates reported as odds ratios with z-statistics in parentheses)

Parent age x treatment status	0.973
	(0.730)
Parent education x treatment status	0.765
	(1.540)
Received texts in English x treatment status	0.432*
	(1.900)
Received texts in Spanish x treatment status	1.503
	(0.810)
Received texts in Chinese x treatment status	2.690
	(1.600)
Parent has unlimited texts x treatment status	1.506
	(0.710)
Female x treatment status	1.438
	(0.690)
White x treatment status	0.526
	(0.670)
Black x treatment status	0.641
	(0.790)
Hispanic x treatment status	1.150
	(0.270)
Chinese x treatment status	1.854
	(0.990)
Parent rating of child's letter knowledge (fall) x treatment status	0.926
	(0.300)
Parent rating of child's letter sounds knowledge (fall) x treatment status	0.913
	(0.450)
Parent rating of child's rhyming skills (fall) x treatment status	1.019
	(0.100)
Parent rating of how often child ask to be read to per week (fall) x treatment status	0.782
	(1.030)
N=	508
Model inclusions:	
Site fixed effects	X

Notes. We are missing site information for 11 students who left the district before the start of the school year. Since we estimate logit models using site fixed effects, the sample size drops to 508 from 519 (the total number of study participants). Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Table 12

Robustness check: the effects of READY4K! on attriting and non-attriting students' spring early literacy assessment scores using predicted values for attriters (estimates reported in standard deviation units)

Panel A: All students	Name Writing	Upper-case letters	Lower-case letters	Letter sounds	Beginning word sounds	Print & word awareness	Rhyme awareness	Summed Score
Treatment effect estimate	0.010	0.046	0.175*	0.255***	-0.016	0.049	-0.001	0.029
	(0.087)	(0.076)	(0.092)	(0.086)	(0.068)	(0.062)	(0.076)	(0.077)
N=	510	511	414	400	496	501	493	472
Panel B: Students who progressed to lower-case letters								
Treatment effect estimate	0.021	0.178**	0.175*	0.255***	0.029	0.079	0.019	0.182**
	(0.093)	(0.086)	(0.092)	(0.086)	(0.066)	(0.063)	(0.087)	(0.082)
N=	412	414	414	400	400	406	400	384
Panel C: Students who progressed to letter sounds								
Treatment effect estimate	0.003	0.173**	0.120	0.255***	0.030	0.086	0.042	0.182**
	(0.095)	(0.087)	(0.093)	(0.086)	(0.066)	(0.064)	(0.089)	(0.082)
N=	398	400	400	400	395	393	389	384
Model inclusions:								
Site fixed effects	X	X	X	X	X	X	X	X
Imbalanced pre-treatment covariates	X	X	X	X	X	X	X	X
Additional pre-treatment covariates	X	X	X	X	X	X	X	X

Note. Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01

Appendices

Appendix A: The Development of READY4K!

We began developing READY4K! in early 2013. Our first step in program development was to generate a list of potential texting topics. To create this list, we consulted the California Preschool Learning Foundations, The National Early Literacy Panel's report on developing early literacy skills (Lonigan & Shanahan, 2009), experimental studies of interventions designed to help parents support their preschooler's literacy development (for a review, see Reese, Sparks & Leyva, 2010), and the websites of nationally-recognized literacy programs (such as Reach Out and Read, Reading Rockets, and Reading Is Fundamental) and the U.S. and state departments of education.

The initial list of list of topics that we generated was far too long to cover in eight months of weekly texts and it lacked a logical ordering. Therefore, our next step in developing READY4K! was to establish a scope and sequence for the program. In determining which topics to include in the program, we prioritized those with a strong research base as well as topics identified by multiple organizations as important. Since we piloted READY4K! in SFUSD, we gave additional weight to the early literacy skills in the California Preschool Learning Foundations as well as those assessed by the district. To set the program's sequence, we drew heavily on the behavior change principle of shaping, or incrementally increasing the difficulty of tasks over time. We also re-introduced or "spiraled" topics during the year to reinforce key concepts.

Our next step was to turn our scope and sequence into a text messaging program. As a starting point, we reviewed research on behavior change theories in an attempt to identify the characteristics of an effective message. While these theories have subtle differences, many of

them emphasize similar strategies such as highlighting the benefits or perceived outcomes of the target behavior, identifying and minimizing barriers to the behavior, goal setting, and reinforcement, which includes repetition and intrinsic rewards (for reviews, see Abraham & Michie, 2008; and, U.S. Department of Health and Human Services, 1996). Using these techniques, we adopted the three-texts-per-week model described above. "FACT" texts highlight perceived outcomes, "TIP" texts are designed to build self-efficacy, and "GROWTH" texts provide reinforcement both through repetition and the intrinsic reward of supporting the child's learning. "GROWTH" texts also serve a goal-setting function. All of them start by highlighting the program's overarching goal of preparing children for kindergarten: "GROWTH: By [taking up the activity of the week], you're preparing your child 4K." Behavior change principles are also integrated in each individual text. For example, READY4K! texts are as specific as possible so as minimize the costs of uptake.

Throughout the development of READY4K!, Molly Wertz, Executive Director of Raising A Reader in San Francisco, Alameda and Contra Costa Counties, Jennifer Curran and Catherine Aranda of Jumpstart Northern California, and Helen Maniates, Assistant Professor of Teacher Education at the University of San Francisco, provided us with valuable feedback on the program.

After we developed texts for an entire school year, we conducted a mini pilot study of READY4K!. Over two days in the summer of 2013, we surveyed and conducted focus groups with parents and caregivers of three to five year olds at Redwood City Public Library. In total, we got feedback from 44 parents and caregivers, which we used to make final programmatic adjustments.

During the middle of the 2013-14 pilot of READY4K! (in January of 2014), we surveyed parents in the program about their experiences receiving texts. Based on their feedback, we augmented the program by including links to websites with additional resources for supporting children's development of early literacy skills. Throughout the year, we ran a READY4K! hotline to provide parents in the intervention group with technical assistance (e.g., if they changed their cell phone number).

To send text messages, we used a commercially-available blast short message service (SMS) provider as well as email. We sent English- and Spanish-language texts to the intervention group via the SMS service provider. In particular, we provided the service provider with the cell phone numbers of English- and Spanish-speaking parents in the treatment group, which it uploaded into its system. Once cell phone numbers were in the system, we began texting parents using the service provider's web interface. We sent messages to all parents at the same time, but there was the option to text parents individually.

To text Chinese-speaking treatment group parents and all control group parents, we used an e-mail account. One can send text messages over e-mail if she has the cell phone number and the name of the cell phone service provider (and the service provider's "SMS gateway") of the intended recipient. For example, if the recipient's service provider is Verizon Wireless, you can send him a text message by typing in hisnumber@vtext.com in the "To:" field (@vtext.com is Verizon's SMS gateway). We sent messages in Chinese over e-mail because our blast SMS service provider did not have the technology to send Chinese characters. We sent messages to the control group over e-mail to save money.

Appendix B: Additional Tables

Appendix Table 1A

Global early literacy parenting composite variable

Components:	Scoring coefficient
Told your child a story	0.09825
Asked your child questions about school	0.05899
Played "I Spy" with your child	0.08223
Sang or listened to songs with your child	0.08351
Read to your child	0.10088
Looked at pictures in a book with your child	0.10201
Gave a book to your child to look at on his/her own	0.08658
Helped your child write his/her name	0.09175
Pointed out two words that begin with the same sound	0.11500
Pointed out two words to your child that rhyme	0.11770
Showed your child the different parts of a book (e.g., cover, title, author, and pages)	0.11325
Pointed out letters on shampoo bottles during bath time	0.10792
Said and explained a new word to your child while in the kitchen	0.09666
Recited a nursery rhyme to your child	0.10022
Took your child to the library	0.08516
Took your child to a museum	0.08560
Played games or worked on puzzles with your child	0.08118

Eigenvalue: 6.43206 (37.84% of variance explained)

Appendix Table 1B

General early literacy activities composite variable

Components:	Scoring coefficient
Told your child a story	0.24527
Asked your child questions about school	0.07617
Played "I Spy" with your child	-0.07560
Sang or listened to songs with your child	0.06784
Read to your child	0.38226
Looked at pictures in a book with your child	0.33758
Gave a book to your child to look at on his/her own	0.32259
Helped your child write his/her name	-0.01788
Pointed out two words that begin with the same sound	-0.04639
Pointed out two words to your child that rhyme	-0.04910
Showed your child the different parts of a book (e.g., cover, title, author, and pages)	0.01733
Pointed out letters on shampoo bottles during bath time	-0.14745
Said and explained a new word to your child while in the kitchen	-0.07293
Recited a nursery rhyme to your child	-0.06504
Took your child to the library	-0.01939
Took your child to a museum	0.03942
Played games or worked on puzzles with your child	-0.03560

Eigenvalue: 3.13788 (18.46% of variance explained)

Appendix Table 1C

Specific early literacy activities composite variable

Components:	Scoring coefficient
Told your child a story	-0.06211
Asked your child questions about school	0.21581
Played "I Spy" with your child	0.01646
Sang or listened to songs with your child	0.13990
Read to your child	-0.15472
Looked at pictures in a book with your child	-0.08894
Gave a book to your child to look at on his/her own	-0.17403
Helped your child write his/her name	0.16304
Pointed out two words that begin with the same sound	0.28436
Pointed out two words to your child that rhyme	0.25903
Showed your child the different parts of a book (e.g., cover, title, author, and pages)	0.10263
Pointed out letters on shampoo bottles during bath time	0.18664
Said and explained a new word to your child while in the kitchen	0.25154
Recited a nursery rhyme to your child	0.11853
Took your child to the library	-0.12417
Took your child to a museum	-0.19553
Played games or worked on puzzles with your child	0.12671

Eigenvalue: 3.78306 (22.25% of variance explained)

Appendix Table 2

The effects of READY4K! on parents' texting behaviors and attitudes (estimates reported in standard deviation units)

	Treatment effect estimates			
Texting behaviors and attitudes:	Model 1	Model 2	Model 3	Model 4
Parent read text messages	0.195	0.202	0.213	0.262**
	(0.120)	(0.127)	(0.129)	(0.131)
Parent used text messages	0.494***	0.504***	0.499***	0.532***
	(0.116)	(0.117)	(0.119)	(0.123)
Parent found text messages helpful	0.515***	0.523***	0.528***	0.591***
	(0.116)	(0.118)	(0.120)	(0.118)
Parent shared texts with other parents	0.285**	0.248**	0.276**	0.266**
	(0.118)	(0.122)	(0.123)	(0.127)
Parent would recommend texts	0.242**	0.238**	0.244**	0.236*
	(0.119)	(0.119)	(0.121)	(0.123)
N=	287	287	287	287
Model inclusions:				
Site fixed effects		X	X	X
Imbalanced pre-treatment covariates			X	X
Additional pre-treatment covariates				X

Note. Statistical significance levels: *p<0.10; **p<0.05; ***p<0.01