Multi-sensory Structured Reading Instruction for Spanish-speaking First Grade Students in Buenos Aires Public Schools

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Abstract

A multi-sensory structured language reading program was deployed in six first grade public school classrooms (n=150 students) in Buenos Aires, Argentina. Six control rooms used business-as-usual, whole language, instruction (n=178 students). Control and treatment rooms were well-matched in initial status. Students' abilities and progress were recorded 3 times over 27 weeks using a test battery covering basic pre-reading and reading skills: phonological awareness, decoding, vocabulary, rapid automatized naming, and executive function. At the start of 1st grade, most students have no measurable capacity for decoding. Many struggle with phonological awareness and letter naming. Very high rates of absenteeism and school closures (similar in both groups) meant that planned treatment dosage was not achieved. However, at the endpoint of the study, students in MSL classrooms show an advantage over those in control classrooms in sentence reading comprehension, but the groups remain at parity in other measured skills.

keywords: Spanish language, grade school children, reading skills, multi-sensory structured learning, education, public policy

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Introduction & Overview

The Project

This efficacy trial provides an evaluation of evidence-based, multi-sensory structured language (MSL) reading instruction, in the form of the *Aprendo Leyendo* reading program, on first grade student achievement. The trial was carried out in the 2019 school year in twelve 1st grade classrooms in the Province of Buenos Aires, Argentina. Six ‘treatment’ rooms received the MSL program. Six ‘control’ rooms used business-as-usual reading instruction.

In 2017, the Ministry of Education in the Province of Buenos Aires – Dirección General de Cultura y Educación – invited public schools in the district to participate in an initiative called the *Red de Escuelas de Aprendizaje* (the Red). The Red de Escuelas is an innovative priority program of the government of the Province of Buenos Aires. It seeks to establish strong processes of improvement for schools and educators, especially in regard to motivation and professional qualifications. The program is built around a novel format designed to scale to a large number of schools (more than 2000), while cultivating relationships with each school institution and each educator involved (Dirección General de Evaluación y Planeamiento, Ministerio de Cultura y Educación de la Provincia de Buenos Aires 2019). The Red has four principal goals. The first is to strengthen leadership qualities and pedagogical knowledge in school principals. Second, it seeks to improve the climate for learning within participating schools. The third goal is to improve student learning outcomes in language arts and math. Finally, the Red pursues improvements in graduation rates and reduction in grade repetition.

In 2019, to advance its third goal of improved learning outcomes for students, the Red implemented several experimental pedagogical models in some of its schools. The intent was that these would provide information to inform models that could lead to improvements in school outcomes. One of those projects deployed the *Aprendo Leyendo* program of professional development for 1st and 2nd grade teachers in 68 schools across 10 school districts and provided classroom materials for 9000 children. It also included an efficacy trial of MSL reading instruction, which was carried out in 6 classrooms selected from among those 68 schools (together with 6 control classrooms, selected from schools participating in the Red, but not among the 68 *Aprendo Leyendo* PD schools).

All twelve schools in this study were selected from those participating in the Red. The six treatment classrooms for the present study were selected from among a subset of those schools, including over 400 teachers and principals, received training in the multi-sensory structured language (MSL) approach to reading instruction. The six control classrooms were also chosen from schools participating in the Red, but MSL training and materials had not (yet) been made available to them. Teachers and principals at the control schools received no special training in reading instruction, and control classrooms had no supplementary visits from MSL master teachers.

In addition to MSL training provided to their regular classroom teachers, treatment rooms also received regular visits from MSL master teachers who both delivered instruction to students and modeled MSL methods to teachers of record. Students in the control classrooms received business-as-usual reading instruction from their regular classroom teachers.

Students’ baseline abilities and progress in all 12 classrooms (treatment and control) are recorded using a test battery, described in more detail below, covering basic pre-reading and reading skills, vocabulary, rapid automatized naming (RAN), and executive function. Testing took place three times during the 2019 school year. Data for the first measurement point were collected at the

beginning (fall) of the 2019 school year to establish a baseline before any intervention had begun. Subsequent testing took place about mid-year (winter) and near the end of the school year (spring), after about 27 weeks of instruction, which differed for treatment and control rooms.

Teacher professional development and supplementary classroom instruction was performed by Intelexia personnel, under contract with the *Red*. Student evaluation, scoring, and tabulation were accomplished by staff and graduate students from the Universidad Favaloro, together with data on teacher absences and school closures, all under the direction of F. Salvarezza. Intelexia also generated qualitative summaries of school environments and teacher attributes for participating schools/rooms. These data were tabulated following advice from Haskins Laboratories, and then sent to Haskins for analysis.

This Report

This report has been prepared by Haskins Laboratories using quantitative and qualitative data provided by Universidad Favaloro and Intelexia. The report is divided into five major sections plus appendices. In this introductory section we provide a brief overview of the project. The next section provides details of **Design and Method** specification. The third section describes **Implementation** of the project, as it occurred. Section four presents **Results** of the project, to date. Finally, section five summarizes **Key Findings and Limitations**, and proposes future directions.

Design & Method

This project consists of a research trial contrasting reading acquisition for first grade students who receive evidence-based multi-sensory reading instruction vs. first grade students who receive business-as-usual instruction. The MSL treatment is provided via a specific reading curriculum (*Aprendo Leyendo*) delivered primarily by visiting master teachers, with supplementation by regular classroom teachers. The business-as-usual curriculum is guided by the whole language philosophy toward teaching reading. Student achievement in this project is measured using a set of standardized measures, most administered at three time points in the school year. Additionally, a pair of novel word and sentence reading comprehension measures, designed for this project, is included in the post-test.

Overall Design

Multi-sensory Structured Language Reading Instruction

Multi-sensory structured language reading instruction has several general characteristics. It is *multi-sensory* in nature, which is to say it includes visual, auditory, and kinesthetic components of instruction (Vickery, Reynolds, and Cochran 1987). It is *structured* in that it makes use of direct, systematic instruction of learning targets (Foorman et al. 1998). It includes systematic instruction in mappings between speech sounds and letters (systematic phonics). Finally, it recognizes that *language* skills and linguistic knowledge are a necessary part of the foundation for skilled reading (Braze and Gong 2018).

Aprendo Leyendo (AL) is a Spanish language multi-sensory structured reading program designed for children in the early stages of reading acquisition through an explicit, sequential and multi-sensory approach. It is developed and published by Intellexia, LLC. AL is based on Preventing Academic Failure, a U.S. early reading program with a 40 year track record. AL is designed to help beginning students to achieve automaticity in decoding and fluency in reading connected text. It also includes systematic instruction in reading comprehension strategies, vocabulary, and handwriting.

There is emerging evidence that reading engages similar cognitive and neural mechanisms, regardless of orthographic depth, or details of the mapping from speech to print (Rueckl et al. 2015). Most work on MSL approaches to reading instruction has been done with English speaking children, and English has a notably deep orthography. Nonetheless, there is good reason to believe that the same principles will be effective in an orthographically shallow language like Spanish (Caravolas et al. 2012, 2013). A central aim of this project is to test that possibility.

The program includes integrated professional development (PD) for teachers, which is a crucial design feature to provide teachers with the tools they need to help students develop into independent readers. The PD curriculum includes 16 hours of in-person training, with continued support throughout the school year, and both print and online teacher and student materials. Teachers in the six ‘treatment’ schools received the standard *Aprendo Leyendo* PD training as part of a cohort of more than 400 teachers that were trained by Intellexia, all from schools participating in the *Red*.

The intention was that an experienced MSL master teacher visit each treatment classroom three times a week for 35 weeks and deliver 45 minute AL lessons. Classroom teachers would then teach at least one additional 45 minute AL lesson per week. Thus, AL instruction would span most of a full academic year. On this schedule, classrooms would complete 46 AL units during the school year, or

nearly half of the complete set of 96 units in the full AL program. These 46 units cover a range of content, including: phonemic awareness; the letters [c,s,m,l,p,t,g,n,d,a,v,r,j,f,ñ,e,y,b,z,o] and their grapheme–phoneme correspondences; blending phonemes to read syllables, words, phrases, and connected text. Further, there are lessons in handwriting, spelling, grammar (including verb conjugations, pronouns and noun/adjective correspondences, synonyms and antonyms), and reading comprehension strategies.

The use of experienced MSL master teachers in the treatment classrooms serves two purposes. First, it maximizes instructional fidelity and dosage as delivered to students. Further, it serves to model high-quality AL lessons for regular classroom teachers to enhance their command of the program. Both of these are important because early grades teachers in Argentina are trained in a whole language approach wherein they are told that it is largely unnecessary to explicitly teach reading. The three master teachers employed by Intelectia to deliver the program are all highly experienced elementary school teachers. See Appendix E for a summary of their backgrounds and experience.

Teachers in the six control schools received no special training and students in these classrooms received business-as-usual reading instruction. These rooms served as a comparison group against which to evaluate effectiveness of the MSL program as implemented in the treatment schools. The general approach to reading instruction in Argentina can be characterized as “whole language.” It is based on the premise that learning to read and write comes as naturally to young children as learning to speak and to understand speech. A key element of the whole language approach is that teaching and learning should be driven by engagement and exposure to the printed word. In such an environment, it is surmised, that children will acquire the ability to read without direct instruction. In fact, in materials designed for teachers of reading, the Dirección de Formación Continua de la Provincia de Buenos Aires [Directorate of Continuing Education of the Province of Buenos Aires] asserts that (Dirección General de Evaluación y Planeamiento de la Provincia de Buenos Aires 2018):

Beginning with their own names, children learn how the writing system works and its various social uses. In this way, children familiarize themselves with social aspects of reading and writing in different language contexts. The children construct hypotheses about what would be in the written text through being exposed to different texts that their teachers read to them.

Further,

... different reflections around reading and writing, developed through listening to texts read by their teachers, allow children to gradually infer the basic nature of the alphabetic system as a model for comprehension and cultural immersion.

It is important to note that the whole language approach stands in opposition to systematic teaching of component skills that is broadly supported by modern reading research, and is a key aspect of multi-sensory structured language approaches to early literacy instruction. But, beginning in 2018 school year, changes were introduced to the curriculum in Buenos Aires schools to allow for instruction in decoding, in an attempt to balance pedagogical approaches to reading (Dirección General de Evaluación y Planeamiento de la Provincia de Buenos Aires 2018).

As an incentive to participate in this project, teachers and administrators in the comparison schools were promised that their schools would receive *Aprendo Leyendo* training and materials the following year.

Student Assessment Instruments

Students in all 12 participating schools are assessed with a set of conventional published measures, whose strengths and limitations are well-known to researchers and educators, as well as two word and sentence reading comprehension measures designed specifically for this project by Intelexia with advice from Haskins Laboratories. The published tests used are: Indicadores Dinámicos del Éxito en la Lectura (IDEL; Spanish language adaptation of DIBELS); Head, Toes, Knees, Shoulders (HTKS; executive function); Test de Vocabulario en Imágenes Peabody (TVIP; picture vocabulary); Rapid Automatized Naming for objects and colors (RAN). This task set was chosen to evaluate the range of pre-reading and reading-related skills that would be expected of nascent and early-stage readers, and predictive of their future reading achievement.

Unfortunately, good normative samples, relative to the population under study, are simply not available for these tasks. Further, some tasks were adapted to local conditions (TVIP, RAN, and IDEL letter naming fluency). Therefore, all student assessment data is recorded and analyzed as raw scores. A side benefit of this project will be to acquire estimates of “typical” performance of first grade students in Buenos Aires public schools on these reading, language, and cognitive measures. The task set is as follows.

Indicadores Dinámicos del Éxito en la Lectura: IDEL is a Spanish language adaptation of the DIBELS formative assessment (Good et al. 2003). The assessment includes three subtests intended for first grade students:

- **Fluidez en Nombrar Letras (FNL)** is a test of letter naming fluency. Score is the number of letter names that can be produced correctly in 1 minute (`idel_fnl`). Note that standard practice for this test is to use mixed case materials. We deviated from that practice and used all uppercase materials. In Argentina, most printed material for beginning readers is written using uppercase letters only.
- **Fluidez en la Segmentación de Fonemas (FSF)** is a phoneme segmentation test of phonemic awareness. Two scoring rubrics provide separate scores for the task, one based on phonemes (`idel_fsf_tlp`) and another based on syllables (`idel_fsf_sil`).
- **Fluidez en las Palabras sin Sentido (FPS)** measures fluency in nonsense word reading. Two scoring rubrics provide scores for number of letter sounds correct per minute (`idel_fps_tsl`) and number of (non)words pronounced correctly (`idel_fps_npc`).

Test de Vocabulario en Imágenes Peabody: TVIP is a Spanish language adaptation of the Peabody Picture Vocabulary Test (Dunn et al. 1986). It appears as `tvip_raw` in the following data summaries. Note that nine items in the published test are problematic in that they do not align well with the *Rioplatense* dialect of Spanish spoken by study participants. The words in these items were replaced with more locally appropriate terms. See Appendix G for details. Further, the normative sample for the TVIP was collected c1985 in Spain and so is unlikely to be of much value here. For both these reasons, we report only raw scores in this study.

Head, Toes, Knees, Shoulders: We used a Spanish language adaptation of the HTKS task to assess inhibitory control (executive function) in participating students (Ponitz et al. 2009; McClelland et al. 2014; Cameron and McClelland 2011). It appears as `htks_total` in the following data summaries.

Rapid Automatized Naming: RAN is a well-established correlate of reading skill. We chose to use RAN tasks for object naming (`ran_objects`) and color naming (`ran_colors`) with this cohort of nascent readers (Denckla and Wolf 2005). The published test was designed for English speakers; participants in this study named items in Spanish. We report naming times per trial in seconds. All trials with more than 5 errors are considered spoiled, so their durations are not included in summaries or analyses.

Word and Sentence Reading Comprehension: In the Word Reading Comprehension (WRC) task, students must match a given picture to one of a set of printed words. Part A of the task consists of 6 items, each with one picture and two printed words. Part B of the task consists of 12 items each with a single picture and three printed words. Scores reported here are the sum of parts A and B. For all items, students are asked to point to the printed word that best matches the picture.

For each of 12 items in the Sentence Reading Comprehension (SRC) task, students must match a given printed sentence to one of two pictures. Students are asked to point to the picture that best matches the meaning of the printed sentence.

Participating Schools

All twelve of these rooms were selected from schools participating in the *Red de Escuelas de Aprendizaje de la Provincia de Buenos Aires* (the *Red*). A subset of schools participating in the *Red*, more than 68 schools in all, received training in the multi-sensory structured language (MSL) approach to reading instruction. This included training for more than 400 teachers and principals. These schools were also provided with the *Aprendo Leyendo* curriculum and classroom materials, which are designed specifically to support MSL reading instruction. The six treatment schools/rooms for the present study were selected from among these. In addition to training and materials for regular teachers, these rooms also received regular visits from MSL master teachers who both delivered instruction to students and modeled MSL methods to teachers of record.

The six schools that control classrooms were drawn from were also participating in the *Red*, but the MSL training and materials had not (yet) been made available to them. Teachers and principals at the control schools received no special training in reading instruction, and no supplementary visits from MSL master teachers. Students in these classrooms received business-as-usual reading instruction. These rooms served as a control group against which to evaluate effectiveness of the MSL instructional program as implemented in the treatment schools. As an incentive to participate, teachers and administrators in the control schools were promised that their teachers would receive *Aprendo Leyendo* training and materials the following year.

In order that treatment and control schools be as similar as possible, state education administrators used school-level demographic data to generate a set (28 pairs) of matched treatment/control schools. Matching was done using a Mahalanobis distance metric (Gu and Rosenbaum 1993; Rubin 1980). Note that allocation of schools to receive MSL training or not in 2019 was established prior

to the matching process. Final selection of 6 pairs of schools/rooms for participation in the present study was based on quality of the pair match and on logistical considerations. Most schools included more than 1 first grade classroom and the specific room chosen for participation was selected based on logistical considerations and classroom size (the latter ensured rooms of sufficient size). Note that, since only one classroom was chosen per school, we refer to classrooms/schools using the same label. See Appendix F for a list of participating schools.

Testing Schedule

Three testing periods were planned for the 2019 school year. The initial test period occurs in the fall, before delivery of the *Aprendo Leyendo* program begins, but about 1 month after the beginning of the school year. This serves to establish baseline performance for both sets of schools. It allows verification that average performance for children in schools slated for immediate treatment is similar to those in control schools. At this initial test period, all measures except for the word reading comprehension and sentence reading comprehension measures were collected.

The second test period, conducted about mid-year, serves to monitor progress of all students. Here, an abbreviated test suite was used, including only IDEL and RAN tasks. The third test period, in spring near the end of the school year, included the full set of measures listed in Student Assessment Instruments. Word reading comprehension and sentence reading comprehension are administered in spring for the first time. A difference in performance between treatment and control schools at this time point serves as a critical test of program impact.

Testing Procedures

Student assessment is carried out by two teams of graduate student examiners from the Universidad Favaloro. Examiners were trained and supervised by university faculty under the direction of F. Salvarezza. Children were tested at each school's premises, in space assigned by the principal dedicated to that purpose. For maximum efficiency the team planned to test 3-5 children at a time in different rooms, but given space constraints at participating schools, it was not possible to gain access to that many rooms. Therefore, testing would be carried out in one room as follows. For most tests (except for HTKS) 3 to 4 children were to be tested at the same time in the same room, each by one member of the assessment team. Each child would be seated in a corner facing the wall, the assessor faced the center of the room. This ensured that children could not see the others in the room and minimized distractions. For the HSKT, children were tested individually in a different room.

Data Management & Sources

All data are collected and tabulated by the Universidad Favaloro team. Intalexia managed cloud-based storage and tools for data entry and warehousing. Quantitative data are transmitted to Haskins Laboratories in the form of Google Sheets files. Qualitative and descriptive information is provided by Intalexia to Haskins as Google Docs files. Analyses in this report are based on these data files.

Analyses

Primary analyses adopt an intent-to-treat approach (Hollis and Campbell 1999). Therefore, all treatment participants are included in primary analyses according to their assigned treatment group, regardless of fidelity of protocol delivery, of protocol adherence, or of dosage received. ITT has the advantage of reducing chances of false positive outcomes. It also provides information about benefits arising from treatment-in-practice, in contrast to potential or idealized benefits.

First, we examine differences in word reading comprehension and sentence reading comprehension scores by treatment group at year end. Here we use *multi-level models* (Snijders and Bosker 2012) with random intercepts for classrooms. Student Age at intake and absenteeism are included as covariates. Comprehension of the printed word is, of course, the goal of skilled reading. These outcome measures allow us to assess whether our MSL approach to reading instruction provides clear benefits to comprehension.

Second, we look at possible group differences in TVIP (vocabulary) from fall to spring (by intervention group). Here we apply *growth curve models* (Singer and Willett 2003) with random intercepts for student within classroom. This is important because one challenge to those pedagogical approaches to early reading that place a heavy emphasis on systematic phonics instruction, as is the case with our MSL approach, is that they may retard vocabulary acquisition. That is not our view. We predict either no difference or a benefit to the treatment group (due to increased reading abilities). An outcome where the control classrooms showed greater vocabulary growth than the treatment classrooms would contradict our prediction.

Third, we use growth curve models to look for possible group differences in improvements to executive function (HTKS), RAN Objects and Colors, and letter naming Fluency (IDEL FNL) from fall to spring. Again, models include random intercepts for student within classroom. While we do expect student improvement in all these measures over the academic year, there is no compelling reason to expect group differences in rate of improvement.

Implementation

Teacher Training

Aprendo Leyendo MSL training was delivered to a cohort of 432 teachers and principals, drawn from 68 schools in 10 districts participating in the *Red*, starting in April, 2019. Teachers in participating treatment classrooms were a part of this cohort; teachers in control classrooms were not. The complete training program consisted of four sessions of four hours each, covering the science of reading, MSL principles, and the AL program. These sessions happened during the 2019 school year from April to November. See Appendix D for summary of training sessions. One hundred forty one (33%) of teaching professionals attended all 4 training sessions and another twenty-two percent attended three. The remaining attended one or two of the sessions. The training was generally very well received by attendees. In the final session, attendees completed a survey about the training and their attitudes toward it.

Two hundred thirty five trainees completed the 74 item questionnaire. It gathered information about: teachers' professional trajectories; current classroom information; use of best practices from the science of reading in their teaching; perceptions of the *Aprendo Leyendo* program of training; implementation of the AL program in their classrooms; and reading and motivation outcomes. Ninety-two percent of teachers agreed that they would recommend the training course to their colleagues. Eighty-eight percent of them believe that their students are learning to read better than in previous years. Seventy-seven percent believe their students improved their comprehension skills better than previous years. Eighty-three percent of respondents believe that their students were more motivated to learn than in previous years. Ninety-two percent agree it is necessary to deepen their knowledge of phonological awareness. See Appendix D "Fourth Session" for more information on the survey.

Treatment Delivery

Classroom Teachers

Four of six classroom teachers in treatment rooms attended all four days of the MSL professional development seminar (rooms sf2, sf36, t18, and t37). One teacher attended two days (sf4), and one attended three days (sf21). As it turns out, both of these latter teachers were replaced by substitutes partway through the school year due to illness or other reason. The substitute who took over in sf21 had attended 1 day of PD, and the substitute who took over in sf4 had attended 2 days of PD. We also note that one of the control classrooms (q1) had three different teachers over the school year.

A significant challenge that confronted this project is that classroom teachers in treatment rooms made little use of MSL teaching strategies and AL materials (based on observations of visiting master teachers). The research team's sense of it is that a shift in teacher acceptance of the new pedagogical approach will require further professional development and enculturation in new ways of thinking. A step forward would be to work toward building formal and informal structures in support of effective and rigorous research-based teaching methods for early literacy. Critical components of that process include establishing trust with teachers and cultivating buy-in from practitioners and administrators alike (Bean and Ippolito 2016).

Master Teachers & Classroom Visits

Description of each Master Teacher’s professional qualifications can be found in Appendix E. Treatment classrooms received between 50 and 65 visits from master teachers over the study period, with one AL lessons delivered in each visit. The number of lessons and AL units delivered to each room is shown in Table 1, along with the number of AL units.

Table 1: Number of MSL lessons and units completed.

classroom	N Lessons	N AL Units
sf36	57	28
sf21	65	24
sf4	50	21
t37	55	23
t18	63	32
sf2	63	27

This is significantly fewer than the approx 100 master teacher visits that were planned. The difference is attributable to scheduling conflicts and school closings. This, together with the fact that regular classroom teachers made little use of the MSL curriculum, entailed that only 32 AL units were completed, at most, in contrast to the 46 that were planned for the first year of this project (96 were planned over two years). The school that went furthest in the AL program (t18) got through AL unit 32. These units cover a range of content, including: phonemic awareness; the letters [c,s,m,l,p,t,g,n,d,a,v,r,j,f,ñ,e] and their grapheme–phoneme correspondences; blending phonemes to read syllables, words, phrases, and connected text. Further, there are lessons in handwriting, spelling, grammar, and reading comprehension strategies.

Students & Assessment

Assessment of school children was carried out by faculty and graduate students from the Universidad Favaloro, under the direction of F. Salvarezza. Graduate student assessors received, 35 hours of training in assessment theory and practice before the school year began. Between the fall and winter test periods, they participated in an additional 6 hours of debriefing and training, and between winter and spring periods the assessment team participated in 8 hours of debriefing and training.

Children were tested on-site, at their schools, in a classroom dedicated to the purpose. Four to eight assessors tested children at each school, but separate rooms for each child were not available, so the testing was carried out in one room as follows. For most tests (except for HTKS) 3 to 4 children were tested at the same time in the same room, each by one member of the assessment team. Each child was seated in a corner facing the wall, the assessor faced the center of the room. This ensured that children could not see the others in the room and minimized distractions. For the HTKS, children were tested individually in a different room, 2 assessors per group were exclusively dedicated to administering the HTKS task.

Tests were administered in the following order:

- Indicadores Dinámicos del Éxito en la Lectura (F, W, S)

- Fluency at naming letters
- Fluency at phoneme segmentation
- Fluency at reading nonsense words
- Rapid Automatized Naming (F, W, S)
 - objects
 - colors
- Test de Vocabulario en Imágenes Peabody (F, S)
- Head, Toes, Knees, Shoulders (F, S)
- Word Reading Comprehension (S)
- Sentence Reading Comprehension (S)

Over the course of the 2019 school year, the project tested 328 students in at least one assessment period. A total of 193 students were tested at all three test periods. Treatment and Control groups were similar in age, gender make-up, and rates of absenteeism. See Table 2. Students in the treatment classrooms received up to sixty-four forty-five minute sessions of MSL instruction from visiting Master Teachers over a 26 week period, but this number varied considerably and the typical number of sessions was lower.

Table 2: Group Average Student Characteristics.

Group	N	Age (months)	% Female	Attendance (days)	Master Classes
Treatment	150	73.6	47	111	41
Control	178	74.1	47	113	NA

Attendance & Intervention Dosage

Here we summarize attendance, taking into account school closures and student attendance, and treatment dosage (number of AL lessons), taking into account student presence in intervention sessions (applies to treatment schools only).

School and Classroom Closures

The length of school year for each school in the project includes 173 statutory school days. Schools may be closed on some regular school days for a variety of reasons (e.g., building malfunction, teacher strike). Further, if a teacher is absent on a school day, standard practice is to dismiss their entire class for the day. Short-term substitute teachers are not used to fill in. Table 3 shows the number of days each school was open for business during the 2019 school year. Most classrooms in the study are losing between 10% and 20% of school days to school closings and teacher absences.

Student Absenteeism

Student absenteeism was higher than anticipated. The typical student loses more school days due to absences than to school closings, as shown in Table 4. Figure 1 shows the number of actual days in school per student in each classroom, taking into account both school closures and absenteeism. Importantly, by t-test for clustered data, days-in-school does not differ across the two groups.

Table 3: Number of school days for each classroom.

classroom_id	n_school_days	%_lost_days	school_pop
Treatment Group			
sf4	133	22.22	231
sf36	139	18.71	266
t37	141	17.54	473
t18	152	11.11	917
sf2	154	9.94	248
sf21	159	7.02	504
Control Group			
jp2	144	15.79	687
p7	149	12.87	663
l49	152	11.11	287
q1	156	8.77	632
q81	159	7.02	532
si12	164	4.09	454

Table 4: Mean Student Attendance by Classroom.

classroom_id	NStudents	DaysAbsentMean	DaysAbsentSD	DaysInSchoolMean	DaysInSchoolSD
Treatment Group					
sf2	26	39.81	23.77	114.19	23.77
sf21	23	40.26	21.57	118.74	21.57
sf36	22	40.64	31.13	98.36	31.13
sf4	24	53.67	25.34	79.33	25.34
t18	33	41.33	14.91	110.67	14.91
t37	22	33.32	16.41	107.68	16.41
Control Group					
jp2	28	51.18	18.22	92.82	18.22
l49	32	40.41	17.93	111.59	17.93
p7	34	30.68	24.45	118.32	24.45
q1	34	44.79	19.96	111.21	19.96
q81	31	41.39	19.32	117.61	19.32
si12	19	38.89	25.45	125.11	25.45

Treatment Dosage

Student attendance is but modestly correlated with Treatment dosage (number of master teacher lessons sat) for each student ($r = 0.52$). Further, dosage varies considerably within and across classrooms, as shown in Figure 2.

Testing Schedule

In the fall of the 2019 school year, before beginning delivery of the *Aprendo Leyendo* program, students in all schools (treatment and control) were tested with the measures listed in Student Assessment Instruments. Fall testing spanned the period of April 11 to May 17, 2019. Testing in this period took longer than planned. This was largely due to the unexpectedly high rate of

Figure 1: Days in school per child, by classroom. *Max* values indicate number of days each class met, taking into account school closings and teacher absences.

absenteeism, which required one or more return visits to each school in order to assess a sufficient number of students.

Testing in the winter and spring periods went more quickly as the assessment teams were prepared for the need to visit each school more than once. Winter testing went from August 26 to September 04, while spring testing ran from November 20 to December 05.

Figure 2: MSL lessons per child, by classroom. ‘Max’ values indicate number of AL lessons delivered by a Master teacher at each school.

Results

Data for the fall measurement point are read from the file *assessment_data_2019_1_fall-20200221.xlsx*, provided by Intelexia. The file contains entries for 261 students, collected between April 11 and May 17, 2019. All tasks described above, except for the word and sentence reading comprehension measures, were administered in the fall measurement period.

Data for the winter measurement point included only IDEL and RAN measures, not TVIP, HTKS, or the two reading comprehension measures. These data are read from the file *assessment_data_2019_1_winter-20200221.xlsx*, provided by Intelexia. The file contains entries for 261 students, collected between August 26 and September 04, 2019. Only IDEL and RAN tasks were collected in the winter assessment period. Note that, by coincidence, exactly the same number of students were evaluated at the fall and winter time points, 261 in the fall, and 261 in the winter. However, only 214 students were tested at both time points.

Data for the spring included the full set of conventional measures collected in the fall, as well as two novel measures of word and sentence reading comprehension. Spring data are read from the file *assessment_data_2019_1_spring-20200221.xlsx*, provided by Intelexia. The file contains entries for 281 students, collected between November 20 and December 05, 2019. The 281 students tested in spring included 221 tested in fall. There were 193 seen in all three test periods.

All summaries and analyses were carried out using the R statistical environment, version 3.6.1 (R Core Team 2019). Regression models employed the lme4 package, version 1.1.23 (Bates et al. 2015). See Appendix I for a complete list of R packages used in this report.

Fall Data

Data for the fall measurement point (*assessment_data_2019_1_fall-20200221.xlsx*), includes entries for 261 students, collected between April 11 and May 17, 2019. All tasks described in Student Assessment Instruments, except for the word and sentence reading comprehension measures, were administered in the fall measurement period.

All Students

Table 5 gives summary statistics for the variables of interest for all students. This aggregation is sensible because fall data was collected before onset of intervention in the treatment group. Therefore, we do not expect to see differences between the Treatment and Control groups at this time point. All tasks are missing a few data points, but complete data is available for 206 students. Of note is the large proportion of zero scores for all IDEL measures (**ZeroCnt**). Even for the letter naming fluency measure more than 1/3 of students could not perform the task at all. The HTKS, TVIP, and RAN tasks are clearly more sensitive at the bottom end of their range.

Column names in summary Tables 5 and 6 have these meanings:

- **Measure**: label for the particular task/scoring rubric.
- **Missing**: number of students with missing score for the task.
- **Complete**: number of students with a score for the task.
- **ZeroCnt**: number of students receiving a score of zero.
- **Mean**: arithmetic mean (average) score.
- **StDev**: standard deviation of scores.
- **Min**: lowest score obtained by any student.
- **25%ile**: 25th percentile.
- **50%ile**: 50th percentile.
- **75%ile**: 75th percentile.
- **Max**: highest score obtained by any student.

A more detailed view of data summarized in Tables 5 and 6 can be found in Appendix A.

Table 5: Descriptive statistics for n=261 grade 1 students (n=206 complete cases), in the fall measurement period.

Measure	Missing	Complete	ZeroCnt	Mean	StDev	Min	25%ile	50%ile	75%ile	Max
htks_total	8	253	36	24.55	17.74	0	6	28	40	59
idel_fnl	2	259	91	5.44	9.10	0	0	3	7	70
idel_fps_npc	4	257	242	0.51	3.22	0	0	0	0	28
idel_fps_tsl	4	257	195	3.49	12.70	0	0	0	0	103
idel_fsf_sil	2	259	155	3.13	5.91	0	0	0	4	33
idel_fsf_tlp	2	259	147	4.58	8.55	0	0	0	6	60
ran_colors_seconds	45	216	0	81.50	29.20	41	63	73	92	214
ran_objects_seconds	23	238	0	75.12	18.33	44	64	72	83	180
tvip_raw	7	254	1	56.36	16.87	0	46	58	67	125

Given the high proportions of zeros in IDEL tasks, correlations involving them will be uninformative. Looking at simple correlations among HTKS, TVIP, and RAN tasks, only two are noteworthy: the RAN tasks correlate with each other at $r = 0.66$, and HTKS and TVIP correlate at $r = 0.46$.

Summary by Group

The next step is to look at students from the two groups of schools separately (treatment vs. control). The ideal is that there should be no more than chance differences between the two groups, since these measures were collected *before* intervention had begun.

School level data is retrieved from the file *classroom_data_2019-20200309.xlsx* and merged into the assessment data. Table 6 is a summary of students by intervention group. Inspection of reveals minimal mean differences between groups. This suggests that our Mahalanobis distance approach for matching schools across groups was effective.

Table 6: Descriptive statistics for n=126 grade 1 students in the treatment group, and n=135 grade 1 students in the control group, in the fall measurement period.

Measure	Missing	Complete	ZeroCnt	Mean	StDev	Min	25%ile	50%ile	75%ile	Max
Treatment Group										
htks_total	3	123	22	24.40	18.45	0	4	28	41	55
idel_fnl	0	126	43	5.28	9.68	0	0	2	6	70
idel_fps_npc	1	125	120	0.57	3.61	0	0	0	0	27
idel_fps_tsl	1	125	100	2.98	13.62	0	0	0	0	103
idel_fsf_sil	0	126	74	3.71	6.57	0	0	0	4	27
idel_fsf_tlp	0	126	70	5.51	9.63	0	0	0	8	60
ran_colors_seconds	20	106	0	83.99	34.10	41	63	74	95	214
ran_objects_seconds	12	114	0	76.10	17.95	44	64	72	87	150
tvip_raw	3	123	1	55.88	17.40	0	45	58	68	107
Control Group										
htks_total	5	130	14	24.68	17.10	0	8	28	38	59
idel_fnl	2	133	48	5.59	8.55	0	0	3	7	48
idel_fps_npc	3	132	122	0.46	2.82	0	0	0	0	28
idel_fps_tsl	3	132	95	3.98	11.79	0	0	0	1	94
idel_fsf_sil	2	133	81	2.58	5.17	0	0	0	3	33
idel_fsf_tlp	2	133	77	3.70	7.31	0	0	0	4	43
ran_colors_seconds	25	110	0	79.09	23.44	46	63	73	89	199
ran_objects_seconds	11	124	0	74.22	18.70	46	62	72	82	180
tvip_raw	4	131	0	56.81	16.41	12	46	58	67	125

Winter Data

Only IDEL and RAN tasks were collected in the winter assessment period. The data file (*assessment_data_2019_1_winter-20200221.xlsx*) includes entries for 261 students, collected between August 26 and September 04, 2019. Note that, by coincidence, exactly the same number of students were evaluated at the fall and winter time points, 261 in the fall, and 261 in the winter. However, only 214 students were tested at both time points.

Summary by Group

Table 7 summarizes data from the two groups of schools separately (treatment vs. control). At this second measurement point, we might expect to see some differences emerging between the two groups. However, the amount of intervention time (dosage) needed to generate a positive effect is one of the key questions for this project, and it is not clear that students in intervention have got sufficient dosage to show clear benefits. In fact, there are no apparent differences between the groups on IDEL or RAN at the midpoint of the planned intervention period. A more detailed view of data summarized in Table 7 can be found in Appendix B.

Table 7: Descriptive statistics for n=121 grade 1 students in the treatment group, and n=139 grade 1 students in the control group, for data collected at the winter time point.

Measure	Missing	Complete	ZeroCnt	Mean	StDev	Min	25%ile	50%ile	75%ile	Max
Treatment Group										
idel_fnl	0	121	19	15.92	15.66	0	4	9	25	62
idel_fps_npc	0	121	82	2.89	7.19	0	0	0	2	42
idel_fps_tsl	0	121	58	16.88	28.34	0	0	2	23	172
idel_fsf_sil	0	121	32	8.00	8.76	0	0	5	11	32
idel_fsf_tlp	0	121	32	12.86	12.58	0	0	10	21	59
ran_colors_seconds	12	109	0	75.57	22.31	45	60	71	85	154
ran_objects_seconds	6	115	0	70.94	19.89	41	58	66	81	171
Control Group										
idel_fnl	0	139	14	16.12	16.05	0	4	10	23	70
idel_fps_npc	3	136	97	3.88	9.61	0	0	0	2	44
idel_fps_tsl	3	136	83	17.72	35.74	0	0	0	14	150
idel_fsf_sil	1	138	46	7.75	9.24	0	0	4	12	37
idel_fsf_tlp	1	138	44	10.86	12.76	0	0	6	18	66
ran_colors_seconds	12	127	0	76.38	26.00	40	59	70	89	193
ran_objects_seconds	6	133	0	71.83	19.58	45	59	68	81	156

Spring Data

Data for the spring (*assessment_data_2019_1_spring-20200221.xlsx*) included the full set of conventional measures described in Student Assessment Instruments, as well as the two novel measures of word and sentence reading comprehension. The file contains entries for 281 students, collected between November 20 and December 05, 2019. The 281 students tested in spring included 221 tested in fall and 193 tested in both previous test periods.

Summary by Group

Table 8 summarizes data from the two groups of schools separately (treatment vs. control). As noted, two new measures are introduced at this time-point, indicators of word and sentence reading ability. Column names have the same meanings as in previous summary tables. A more detailed view of data summarized in Table 8 can be found in Appendix C.

Table 9 shows group difference estimates for each task in the spring data using t-tests for clustered data (Donner and Klar 1996). On this appraisal, only two measures merit further scrutiny for their ability to distinguish treatment groups: word reading comprehension and sentence reading comprehension.

Table 8: Descriptive statistics for n=126 grade 1 students in the treatment group, and n=155 grade 1 students in the control group, for data collected at the spring time point.

Measure	Missing	Complete	ZeroCnt	Mean	StDev	Min	25%ile	50%ile	75%ile	Max
Treatment Group										
htks_total	2	124	7	35.07	15.94	0	26	38	48	57
idel_fnl	2	124	11	24.31	19.90	0	7	21	40	70
idel_fps_npc	2	124	60	8.56	13.22	0	0	1	14	52
idel_fps_tsl	2	124	43	35.73	45.54	0	0	13	64	176
idel_fsf_sil	2	124	25	8.31	9.37	0	2	5	12	37
idel_fsf_tlp	2	124	25	16.03	14.20	0	3	14	26	50
ran_colors_seconds	10	116	0	74.24	31.47	40	57	66	82	300
ran_objects_seconds	6	120	0	68.93	19.02	38	56	65	79	165
read_sentences	1	125	45	6.18	5.11	0	0	7	11	12
read_words_total	1	125	4	11.96	4.88	0	8	12	17	18
tvip_raw	2	124	0	64.48	15.55	2	56	66	74	102
Control Group										
htks_total	0	155	12	32.98	17.63	0	18	37	48	60
idel_fnl	0	155	13	21.96	18.48	0	7	17	35	72
idel_fps_npc	0	155	92	6.88	13.24	0	0	0	6	58
idel_fps_tsl	0	155	74	28.59	45.70	0	0	2	40	200
idel_fsf_sil	1	154	41	10.02	10.78	0	0	6	16	45
idel_fsf_tlp	1	154	39	14.03	13.53	0	0	11	24	53
ran_colors_seconds	10	145	0	72.93	23.93	40	57	68	85	205
ran_objects_seconds	5	150	0	67.70	15.68	43	58	65	76	132
read_sentences	0	155	92	3.80	4.89	0	0	0	9	12
read_words_total	0	155	4	10.15	4.81	0	7	9	14	18
tvip_raw	2	153	0	65.98	14.94	14	58	68	73	107

We used multi-level models with random intercepts for classroom and included individual attendance scores to further evaluate group differences in sentence and word reading comprehensions scores (Snijders and Bosker 2012); degrees of freedom (df) listed in each table correspond to Welch-Satterthwaite estimates of effective degrees of freedom (Luke 2016). Table 10 shows an advantage in sentence reading comprehension for students in treatment classrooms. Table 12 does not show a clear advantage of word reading comprehension for the treatment group. However, these models clearly demonstrate the importance of regular attendance for word and sentence reading comprehension outcomes.

Interpretation of estimates in models 10 and 12 is as follows. The Intercept estimate corresponds to Treatment group mean, holding age at 74 months and attendance at its overall mean. The interv_groupControl estimate is the difference between treatment and control groups. The days_in_school_mn_cent estimate reflects the estimated benefit that accrues to each additional day in school (e.g., 17 days in school would result in an additional point on the outcome measure). The age_months74c estimate is the difference in outcome attributable to each month of age more or less than 74 at the start of the school year. Children 80 months old at beginning of the school year would be expected to score about a point higher, while those 68 months old would be expected to score nearly a point lower on either test.

We also considered 4 exploratory models for the models as supplements to each of the models in Tables 10 and 12. Those supplementary models each added a single indicator of baseline status, all collected in fall of first grade: letter naming fluency (fnl); vocabulary (tvip); RAN Objects (rano); and executive function (htks). For the exploratory models targeting sentence comprehension, each of the baseline covariates accounted for reliable variance, but their additions caused no marked

change to any other parameter estimate in the model. See Table 11. The situation is the same in exploratory models targeting word reading comprehension. Again, each baseline covariate picks up variance in the model, without notable changes in other parameter estimates. See Table 13. We do note that, in two of the exploratory models (with baseline indicators of Letter Naming Fluency and Executive Function), the p value for the effect of treatment group drops below .05, but the “significance” of this should not be overdrawn (Gelman and Stern 2006).

Table 9: Difference Score Estimates for spring data (Treatment - Control).

measure	Mean Diff.	95% Conf. L.B.	95% Conf. U.B.	Statistic	p.value
idel_fnl	-2.35	-9.52	4.82	-0.643	0.5200
idel_fsf_tlp	-2.00	-5.92	1.92	-1.001	0.3170
idel_fsf_sil	1.71	-1.00	4.43	1.235	0.2167
idel_fps_tsl	-7.14	-23.89	9.61	-0.835	0.4035
idel_fps_npc	-1.68	-5.96	2.61	-0.768	0.4425
ran_objects_seconds	-1.23	-6.20	3.73	-0.487	0.6265
ran_colors_seconds	-1.31	-8.22	5.59	-0.372	0.7099
tvip_raw	1.50	-3.93	6.94	0.543	0.5875
htks_total	-2.09	-6.10	1.92	-1.022	0.3067
read_words_total	-1.81	-3.69	0.07	-1.889	0.0589
read_sentences	-2.38	-4.19	-0.58	-2.593	0.0095

Table 10: Fixed effects for group differences in sentence reading comprehension from MLM with random intercepts for room. Individual attendance (mean centered) and age at study onset (centered at 74 months) are included as covariates.

term	estimate	std.error	statistic	df	p.value
(Intercept)	6.58	0.73	9.053	9.9	0.000
interv_groupControl	-3.00	1.01	-2.979	9.2	0.015
days_in_school_mn_cent	0.06	0.01	4.352	235.0	0.000
age_months74c	0.13	0.08	1.617	253.3	0.107

Change over Time

Time Lagged Correlations

First-order time-lagged correlations can help us to understand which measures collected at an early time point may be predictive of reading achievement at a later point in time. Further the correlation of a measure with itself at different points in time gives an indication of the (test-retest) reliability of that measure.

Fall to Spring Correlations: Correlations among measures collected at both the fall and spring measurement periods (at a lag of about 27 weeks) are modest, as shown in Table 14. With the exception of letter naming fluency, IDEL correlations from fall to spring are quite low. This

Table 11: Exploratory covariate models targeting sentence comprehension.

term	estimate	std.error	statistic	df	p.value
Letter Naming Fluency (fnl)					
(Intercept)	6.64	0.70	9.433	9.9	0.000
interv_groupControl	-3.08	0.98	-3.150	9.3	0.011
days_in_school_mn_cent	0.06	0.01	4.285	236.8	0.000
age_months74c	0.08	0.08	1.109	252.1	0.268
fnl_baseline_c	0.18	0.03	5.507	256.4	0.000
Vocabulary (tvip)					
(Intercept)	6.64	0.77	8.623	10.3	0.000
interv_groupControl	-3.05	1.07	-2.842	9.7	0.018
days_in_school_mn_cent	0.05	0.01	3.817	243.8	0.000
age_months74c	0.10	0.08	1.268	251.5	0.206
tvip_baseline_c	0.09	0.02	5.183	254.2	0.000
RAN Objects (rano)					
(Intercept)	6.56	0.73	8.934	9.7	0.000
interv_groupControl	-3.09	1.02	-3.032	9.0	0.014
days_in_school_mn_cent	0.06	0.01	4.204	239.3	0.000
age_months74c	0.13	0.08	1.620	252.0	0.106
rano_baseline_c	-0.05	0.02	-3.098	253.4	0.002
Executive Function (htks)					
(Intercept)	6.59	0.69	9.574	9.7	0.000
interv_groupControl	-3.05	0.95	-3.202	8.9	0.011
days_in_school_mn_cent	0.06	0.01	4.479	228.4	0.000
age_months74c	0.10	0.08	1.258	252.5	0.210
htks_baseline_c	0.06	0.02	3.303	251.8	0.001

Table 12: Fixed effects for group differences in word reading comprehension from MLM with random intercepts for room. Individual attendance (mean centered) and age at study onset (centered at 74 months) are included as covariates.

term	estimate	std.error	statistic	df	p.value
(Intercept)	12.43	0.78	15.924	9.9	0.000
interv_groupControl	-2.42	1.09	-2.223	9.3	0.052
days_in_school_mn_cent	0.06	0.01	4.327	248.2	0.000
age_months74c	0.15	0.08	1.993	252.2	0.047

is at least partially due to the high proportions of zeros on most IDEL subtests at the earliest measurement point.

Auto-correlations for those measures collected in both fall and spring are shown along the diagonal of Table 14. Of note, auto-correlations for all IDEL measures except letter naming fluency are very low. The high proportions of zeros in the fall data for those tests, and the relatively long lag between tests both contribute to the low test-retest correlations. In fact, both TVIP and HTKS, measured in fall, are better predictors of spring IDEL scores, than are the fall IDEL scores.

Table 13: Exploratory covariate models targeting word comprehension.

term	estimate	std.error	statistic	df	p.value
Letter Naming Fluency (fnl)					
(Intercept)	12.50	0.76	16.552	9.9	0.000
interv_groupControl	-2.50	1.05	-2.377	9.3	0.041
days_in_school_mn_cent	0.05	0.01	4.284	249.7	0.000
age_months74c	0.10	0.07	1.465	250.9	0.144
fnl_baseline_c	0.20	0.03	6.255	255.0	0.000
Vocabulary (tvip)					
(Intercept)	12.51	0.82	15.284	10.2	0.000
interv_groupControl	-2.47	1.14	-2.156	9.8	0.057
days_in_school_mn_cent	0.05	0.01	3.683	253.3	0.000
age_months74c	0.11	0.07	1.613	250.5	0.108
tvip_baseline_c	0.11	0.02	6.830	252.6	0.000
RAN Objects (rano)					
(Intercept)	12.41	0.80	15.536	9.8	0.000
interv_groupControl	-2.50	1.11	-2.242	9.3	0.051
days_in_school_mn_cent	0.06	0.01	4.204	250.7	0.000
age_months74c	0.15	0.08	2.006	250.9	0.046
rano_baseline_c	-0.05	0.02	-2.833	252.2	0.005
Executive Function (htks)					
(Intercept)	12.44	0.74	16.818	9.7	0.000
interv_groupControl	-2.48	1.03	-2.409	9.1	0.039
days_in_school_mn_cent	0.06	0.01	4.561	246.0	0.000
age_months74c	0.11	0.07	1.531	251.1	0.127
htks_baseline_c	0.07	0.02	4.668	250.6	0.000

Table 14: Spearman rank-order correlations among measures from fall (rows) to spring (columns). Test-retest correlations are on the diagonal.

measure	idel_fnl	idel_fsf_tlp	idel_fsf_sil	idel_fps_tsl	idel_fps_npc	ran_objects	ran_colors	tvip	htks	read_words	read_sentences
idel_fnl	0.59	0.25	0.11	0.47	0.48	-0.22	-0.16	0.37	0.29	0.42	0.35
idel_fsf_tlp	0.30	0.25	0.13	0.20	0.21	-0.18	-0.13	0.28	0.22	0.30	0.27
idel_fsf_sil	0.28	0.24	0.14	0.18	0.18	-0.17	-0.12	0.25	0.20	0.25	0.24
idel_fps_tsl	0.28	0.25	0.06	0.26	0.25	-0.09	-0.09	0.22	0.16	0.28	0.27
idel_fps_npc	0.20	0.20	0.07	0.23	0.21	-0.11	-0.04	0.24	0.10	0.19	0.20
ran_objects	-0.39	-0.26	-0.20	-0.29	-0.25	0.70	0.59	-0.17	-0.24	-0.28	-0.27
ran_colors	-0.40	-0.09	-0.04	-0.29	-0.29	0.53	0.76	-0.17	-0.16	-0.32	-0.29
tvip	0.50	0.44	0.32	0.40	0.40	-0.13	-0.06	0.62	0.41	0.45	0.39
htks	0.37	0.34	0.17	0.34	0.35	-0.23	-0.04	0.37	0.53	0.37	0.31

Winter to Spring Correlations: Winter to spring correlations (at a lag of about 11 weeks) are notably higher, as shown in Table 15. With the exception of `idel_fsf`, IDEL correlations from winter to spring are relatively higher than those from fall to spring. This is likely due to there being fewer zeros in the winter scores than the fall, and a shorter lag. Test-retest correlations for IDEL measures are also improved, while RAN tasks show only slightly higher test-retest correlations (diagonal of Table 15). In general, the test-retest correlations for IDEL FNL, IDEL FPS (decoding), and the two RAN tasks are quite reasonable across the 11 week span. Test-retest correlations for IDEL FPS (phonological awareness) are low, but that is the measure with the highest proportion of zero scores across all three measurement periods.

Table 15: Spearman rank-order correlations among measures from winter (rows) to spring (columns). Test-retest correlations are on the diagonal.

measure	idel_fnl	idel_fsf_tlp	idel_fsf_sil	idel_fps_tsl	idel_fps_npc	ran_objects	ran_colors	tvip	htks	read_words	read_sentences
idel_fnl	0.90	0.36	0.14	0.71	0.72	-0.39	-0.30	0.42	0.35	0.66	0.64
idel_fsf_tlp	0.34	0.52	0.37	0.37	0.31	-0.17	-0.05	0.40	0.32	0.40	0.35
idel_fsf_sil	0.23	0.40	0.41	0.23	0.16	-0.11	-0.03	0.32	0.26	0.28	0.21
idel_fps_tsl	0.69	0.38	0.09	0.75	0.76	-0.32	-0.24	0.45	0.30	0.71	0.74
idel_fps_npc	0.69	0.34	0.04	0.75	0.78	-0.34	-0.29	0.36	0.28	0.68	0.71
ran_objects	-0.44	-0.20	-0.12	-0.29	-0.30	0.73	0.60	-0.23	-0.19	-0.29	-0.30
ran_colors	-0.39	-0.05	0.01	-0.29	-0.29	0.62	0.79	-0.22	-0.15	-0.25	-0.29

Change over Time

We use growth curve models to assess change over time (Singer and Willett 2003). Not all measures collected in this project are ideal for looking at individual change over time. The psychometric properties of IDEL FSF and FPS, in particular, are not well-suited to that purpose. Still, several tasks in the battery have the potential to reflect real individual growth. Vocabulary (TVIP) is of particular interest in that it is important that the MSL treatment not have a negative effect on vocabulary growth, relative to business-as-usual reading instruction. We also examine growth in growth in HTKS, IDEL FNL, RAN Colors, and RAN Objects.

All models in this section include random intercepts for students within classrooms. Time (time0) is coded as 0 for initial status (fall assessment) and 1 for year end status (spring assessment). In models that include an intermediate measurement point (winter assessment; IDEL FNL, RAN Objects, RAN Colors), the intermediate time-point is coded as 0.5. Treatment group status and its interaction with time are also of central interest in these models. Further, age at initial status (in months, centered at 74 months) is included as a covariate.

So, interpretation of estimates in models 16 to 20 is as follows. The Intercept estimate corresponds to Treatment group mean at pre-test, holding age at 74 months. The time0 estimate is treatment group change from pre-test to post-test. The interv_groupControl estimate is the difference between treatment and control groups at pre-test. The age_months74c estimate is the difference in initial status attributable to each month of age more or less than 74. Finally, the interaction term indicates the difference in growth of the control group relative to the treatment group.

A summary of the statistical models of change in TVIP, HTKS, IDEL FNL, RAN Colors, and RAN Objects, presented in Tables 16 to 20, is as follows. Students show improvement from fall to spring in all of these measures; time0 estimates are all statistically significant. Note that improvement in RAN corresponds to decreasing scores, while in the other measures improvement corresponds to increasing scores. Initial status on all measures is not different for the two groups; interv_groupControl estimates are not statistically significant. Fall to spring improvement on all measures does not differ between groups; time0:interv_groupControl estimates are all non-significant.

Table 16 shows that TVIP scores increase, on average, more than 9 points between fall and spring assessment periods, with no substantive difference between intervention groups. We also note that Age is a significant predictor of vocabulary scores at initial test. Each additional month of age corresponds to about an additional 6/10 of a point on the TVIP score.

Table 17 shows that IDEL FNL scores increase, on average, about 20 points between fall and spring assessment periods, with no difference between intervention groups. Age is not a significant predictor of letter naming fluency initial status.

Table 16: Change model for TVIP (fixed effects) tests change in vocabulary score from fall to spring. Age at study onset (mean centered) is included as covariate.

term	estimate	std.error	statistic	df	p.value
(Intercept)	55.17	1.82	30.383	14.6	0.000
time0	9.34	1.35	6.935	220.9	0.000
interv_groupControl	1.11	2.53	0.438	13.8	0.668
age_months74c	0.58	0.23	2.477	293.4	0.014
time0:interv_groupControl	0.25	1.87	0.133	227.5	0.894

Table 17: Change model for IDEL FNL (fixed effects) tests change in letter naming score from fall to spring. Age at study onset (mean centered) is included as covariate.

term	estimate	std.error	statistic	df	p.value
(Intercept)	4.83	1.79	2.693	16.7	0.016
time0	20.19	1.55	13.050	241.8	0.000
interv_groupControl	0.05	2.51	0.021	16.1	0.984
age_months74c	0.26	0.21	1.248	300.5	0.213
time0:interv_groupControl	-2.34	2.13	-1.096	252.3	0.274

Table 18 shows that RAN Colors naming times *decrease*, on average, about 9 seconds between fall and spring assessment periods, with no difference between intervention groups. Note that decreasing naming times correspond to improved performance. Age is not a significant predictor of RAN Colors initial status.

Table 18: Change model for RAN Colors (fixed effects) tests change in RAN Colors score from fall to spring. Age at study onset (mean centered) is included as covariate.

term	estimate	std.error	statistic	df	p.value
(Intercept)	85.19	3.22	26.445	12.6	0.000
time0	-9.30	1.98	-4.700	397.2	0.000
interv_groupControl	-4.70	4.44	-1.059	11.5	0.311
age_months74c	-0.36	0.45	-0.802	266.0	0.423
time0:interv_groupControl	2.18	2.72	0.801	398.6	0.424

Table 19 shows that RAN Objects naming times *decrease*, on average, about 7 seconds between fall and spring assessment periods, with no difference between intervention groups. Again, faster naming times correspond to better performance. Age *is* a significant predictor of RAN Objects initial status, with each additional month of age subtracting about 3/4 second from naming times.

Table 20 shows that HTKS scores increase, on average, about 11 points between fall and spring assessment periods, with no difference between intervention groups. Age *is* a significant predictor of HTKS initial status, with each additional month of age adding about 3/4 point to initial scores.

Table 19: Change model for RAN Objects (fixed effects) tests change in RAN Objects score from fall to spring. Age at study onset (mean centered) is included as covariate.

term	estimate	std.error	statistic	df	p.value
(Intercept)	76.40	2.08	36.785	13.6	0.000
time0	-7.46	1.40	-5.341	443.5	0.000
interv_groupControl	-1.78	2.87	-0.619	12.5	0.547
age_months74c	-0.74	0.27	-2.769	297.4	0.006
time0:interv_groupControl	0.59	1.92	0.306	447.5	0.760

Table 20: Change model for HTKS (fixed effects) tests change in HTKS score from fall to spring with individual. Age at study onset (mean centered) is included as covariate.

term	estimate	std.error	statistic	df	p.value
(Intercept)	24.36	1.54	15.769	430.1	0.000
time0	10.65	1.58	6.727	225.3	0.000
interv_groupControl	-1.15	2.14	-0.538	448.6	0.591
age_months74c	0.82	0.25	3.305	295.7	0.001
time0:interv_groupControl	0.03	2.19	0.013	233.2	0.990

Findings, Limitations, & Future Directions

Key Findings

An important result of the project is the finding of improved reading comprehension in treatment classrooms relative to controls. Students receiving MSL-based instruction implemented in treatment classrooms achieved better comprehension for connected text (sentences), than did students in business-as-usual whole language classrooms. Another relevant result is that we do not find a difference in vocabulary growth for treatment and control classrooms. This suggests that MSL-based reading instruction, with its strong systematic phonics component, does *not* lead to a reduction in word learning relative to business-as-usual whole language instruction.

Two additional results of the study, apart from those emerging from the planned outcome measures, speak to conditions on the ground in these public school classrooms. Baseline test scores, especially those from the *Indicadores Dinámicos del Éxito en la Lectura*, suggest that students' preparedness to learn to read at the beginning of 1st grade is rather poor. Moreover, high rates of absenteeism were observed across all twelve schools in the study. We believe this is a systemic problem, not unique to the schools in our project. Studies have shown that disadvantaged children in early grades who have good attendance rates show significant gains in literacy skills, but the same is not true for those with poor attendance (Ready 2010). The importance of working toward improved attendance for all students cannot be overstated.

Limitations

The study design was limited in a number of regards. First, the sample size was modest, with only 6 treatment classrooms and 6 control rooms, which limits accuracy of outcome estimates. Second,

implementation of treatment dosage fell short of what was planned due to unexpectedly high rates of student absenteeism, frequent school closings, and lack of uptake by classroom teachers. This treatment heterogeneity somewhat limits ability of the project to properly differentiate between endpoints for the treatment and control rooms.

Third, treatment and control classrooms were selected from schools within the Province of Buenos Aires that were participating in the *Red*. Standard cautions about generalization beyond the sample are in order. Fourth, assignment of classrooms to treatment condition (treatment vs. control) was determined by whether or not a school was among the subset of *Red* schools that had previously been selected for MSL based professional development, while initial status of treatment and control schools was established using a Mahalanobis distance approach. This entails that the design cannot fully account for the influence of unobserved variables on outcomes, which may result in biased estimates of program effectiveness.

Limited uptake of MSL practices by regular classroom teachers was a major challenge for the project. The team’s conversations with teachers and observations of their classroom practice suggest that the whole language philosophy is very firmly entrenched. Teachers simply don’t believe that it is necessary to teach reading skills in any systematic way. The teachers of record in the treatment classrooms, even while “buying in” to the science of reading and the MSL approach adopted here, seem to feel that the limited amount of instruction provided by the visiting master teachers is already so much more reading instruction than is provided in conventional classrooms that it must be more than enough. Any shift toward acceptance of the new pedagogical approach, with a focus on explicit and intensive instruction in foundational reading skills, will require further professional development and acculturation to new ways of thinking.

Future Directions

This study was made possible by a 2017 initiative of the Ministry of Education in the Province of Buenos Aires – Dirección General de Cultura y Educación – called the *Red de Escuelas de Aprendizaje*. The four goals of the Red are (1) to strengthen leadership qualities and pedagogical knowledge in school principals; (2) to improve the climate for learning within participating schools; (3) to improve student learning outcomes in language arts and math; and (4) to improve graduation rates and reduce grade repetition. The third goal of the Red allowed for implementation of several experimental pedagogical models in participating schools. The project reported here represents one of those models.

Business-as-usual reading instruction in Argentina can be broadly characterized as “whole language” in nature, as a matter of policy. It is based on the idea that learning to read and write will come as naturally to young children as learning to speak and understand speech. That approach stands in opposition to systematic teaching of component skills that is broadly supported by modern reading research, and is a key aspect of multi-sensory structured language approaches to early literacy instruction, as adopted in this project. Beginning in 2018, changes were introduced to the curriculum in Buenos Aires schools to allow for explicit, systematic instruction in decoding with the goal of improving the balance of pedagogical approaches to reading. Importantly, these changes enabled school leaders and teachers to explore modern methods of teaching reading without the risk of defying established policy, but even with support of policy, attendant changes to culture and practice are still difficult and slow to come.

The small scale efficacy study outlined in this report provides evidence supporting the utility of multi-sensory structured reading instruction for early grades students in Buenos Aires schools.

However, design limitations of the project, as noted above, somewhat limit the force of the conclusions drawn. Building on this project, it would be beneficial to incorporate a larger sample size (more classrooms), with random assignment to treatment condition. Further, steps should be taken to maximize treatment fidelity and treatment dosage in light of what is now known about conditions on the ground in typical public schools in the Province of Buenos Aires. One way to achieve that is to pursue a rigorous training program in reading pedagogy for teachers and principals, with emphasis on providing support for the application of these methods in the classroom. Such strategies would likely provide improved outcomes, and outcome estimates.

This project, as enabled by the Red and ancillary changes to the curriculum of Buenos Aires schools, lays a foundation for advances in early reading education in Argentina. There is a clear need for professional development in modern reading pedagogy that is well-aligned with the science of reading. But in order for these changes to occur, it is important to have continuity in policy that will enable more reluctant changes to culture and practice to follow. One avenue of future work would be to implement a program of professional development in reading pedagogy for teachers and principals that trains teachers and other support personnel in use of multi-sensory, systematic, and structured practices as part of regular (core) reading instruction. It will be important to install capacity in the system for self-sustaining professional development that cultivates and maintains strong professional relationships, and facilitates trust and open communication between teachers, administrators, and support staff, within and between schools.

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Appendix A: Fall Data by Room

The plots in this appendix illustrate the distributions of scores within each classroom for measures collected at the fall measurement point, 2019. These plots provide a more detailed view of data summarized in Tables 1 and 2 in the main text.

Colored points represent individual student scores, with different colors indicating Treatment and Control classrooms. The bottom and top of each box correspond to the first and third quartiles (the 25th and 75th percentiles) of scores for the given classroom, respectively. These are comparable to the 25th and 75th %ile values given in summary tables in the main text. The line across the box indicates the median (50th percentile) score for the room, comparable to 50th %ile values in main text summary tables.

Points that lay beyond the whiskers of each box can be considered somewhat unusual relative to the rest of the scores *in that room*. In more technical terms, the upper whisker extends from the 75th percentile up to the largest observed value that is no more than 1.5 times the interquartile range (IQR) above the 75th percentile. The lower whisker extends from the 25th percentile down to the smallest value that is at most 1.5 times the IQR below the 25th percentile.

Figure 3: HTKS score (fall).

Figure 4: RAN Colors (fall).

Figure 5: RAN Objects (fall).

Figure 6: IDEL FNL (fall).

Figure 7: IDEL FSF TLP (fall).

Figure 8: IDEL FSF SIL (fall).

Figure 9: IDEL FPS TSL (fall).

Figure 10: IDEL FPS NPC (fall).

Figure 11: TVIP raw score (fall).

Appendix B: Winter Data by Room

The plots in this appendix illustrate the distributions of scores within each classroom for measures collected at the winter measurement point, 2019. These plots provide a more detailed view of data summarized in Tables 3 and 4 in the main text. See intro to Appendix A for guidance on interpreting these plots.

Figure 12: RAN Colors (winter).

Figure 13: RAN Objects (winter).

Figure 14: IDEL FNL (winter).

Figure 15: IDEL FSF TLP (winter).

Figure 16: IDEL FSF SIL (winter).

Figure 17: IDEL FPS TSL (winter).

Figure 18: IDEL FPS NPC (winter).

Appendix C: Spring Data by Room

The plots in this appendix illustrate the distributions of scores within each classroom for measures collected at the spring measurement point, 2019. These plots provide a more detailed view of data summarized in Tables 5 and 6 in the main text. See intro to Appendix A for guidance on interpreting these plots.

Figure 19: HTKS score (spring).

Figure 20: RAN Colors (spring).

Figure 21: RAN Objects (spring).

Figure 22: IDEL FNL (spring).

Figure 23: IDEL FSF TLP (spring).

Figure 24: IDEL FSF SIL (spring).

Figure 25: IDEL FPS TSL (spring).

Figure 26: IDEL FPS NPC (spring).

Figure 27: TVIP raw score (spring).

Figure 28: Word Reading Comprehension (spring).

Figure 29: Sentence Reading Comprehension (spring).

Appendix D: Multi-sensory Structured Language PD

All teachers implementing Multi-sensory Structured Language reading instruction in their classrooms were invited to attend four Intalexia-run training sessions for a total of 16 hours during the 2019 school year. Four hundred thirty-two first and second grade teachers, resource room teachers, and principals attended at least part of the training program. These were drawn from 68 schools in 10 districts participating in the *Red*. Training was delivered to groups of about 25 each, who received their training in separate classrooms. The program was designed to provide teachers with ongoing implementation support and opportunities to share their experiences with peers. Attendees were also afforded access to the *Aprendo Leyendo* online platform which includes videos modeling MSL/AL reading instruction. Of the 432 attendees, 141 (32.6%) attended all 4 professional development sessions.

Content of the four training sessions is summarized below.

- **First Session: basic principles**

(April 8-12, 363 attendees)

Session 1 surveys basic principles of the *Aprendo Leyendo* multi-sensory structured literacy (MSL) program and the research underlying them.

Skills are taught *explicitly* via *direct instruction* and in a *systematic sequence*. Teaching is *multi-sensory* and integrates reading, spelling and handwriting. *Monitored oral reading* provides the teacher critical information about student achievement and progress. *Controlled texts* in the form of decodable chapter books ensure that students are working with age-appropriate materials within their skill level that still serve to challenge their developing reading skills. Skills taught include: phoneme awareness, orthography, morphology, syntax, and semantics.

These practices are put in the context of *Aprendo Leyendo daily lessons* in which the teacher will (a) review previously taught phonograms and skills with their class; (b) pre-teach a new phonogram or skill; (c) work through a spelling dictation exercise; (d) introduce the reading material for the day, including word and phrase lists, and a story from the decodable chapter book.

Trainees were also introduced to AL Teacher Resources: the online platform and the teacher handbook.

- **Second Session: phonograms, morphemes, decodable texts**

(June 3-6, 253 attendees)

The second training session reviews research-based practices that are the basis of *Aprendo Leyendo*, and covers the principles of MSL instruction in greater depth. These include:

- phonological awareness
- Explicit instruction, including phonics
- Systematic sequence of skills
- Integration of reading, spelling & handwriting
- Monitored oral reading
- Use of Controlled texts (decodable texts)

This training session provides a deep dive into the structure of an AL daily lesson, with explicit examples of how to approach introduction of morphemes & phonograms, working with decodable texts, teaching reading comprehension strategies, building reading fluency.

- **Third Session: fluency, comprehension, group work**

(Sept. 9-16, 250 attendees)

The deep dive continues with explicit examples of how to build reading fluency, training teachers to model reading comprehension strategies and different text structures, teaching syllabification as an aid to decoding. Training teachers in how to plan lessons.

- **Fourth Session: review**

(Nov. 12-15, 222 attendees)

In this session, Jean Chall's stages of reading development were taught. In addition, trainees learned how to administer proficiency tests at the end of each AL level (approximately every 17 AL units). They also viewed videos of *Aprendo Leyendo* classroom routines, and reviewed what they had learned in previous sessions. Trainees also completed a "Teacher Satisfaction Survey" providing feedback to the Intalexia team about the training program. The survey itself can be viewed [here](#). A summary of survey responses is available on request to info@intalexia.com. Finally, trainees were given advice on how to continue with the AL program in the next school year.

Appendix E: Master Teachers

- **Inés Guyot** joined Intelexia in 2016. She contributes to the development of the content of the program and to the research. She trains teachers in the *Aprendo Leyendo* program and she is one of the first teachers to work with the program in schools. She was trained extensively by Phyllis Bertin in the PAF Reading Program and *Aprendo Leyendo*. Guyot served as visiting master teacher at the following treatment schools: SF21, SF2, T37.

Before joining Intelexia, Guyot trained as a special education teacher for deaf children at the Universidad del Salvador. She worked for 15 years teaching deaf children to speak. She has extensive experience in primary grades, where she specialized in teaching early reading and writing. She has also served as a teacher adviser in language skills and early reading. Guyot worked in developing phonological awareness in kindergarten children. She worked in Instituto Oral Model, Wellspring School, and Colegio Las Lomas Oral.

- **Marina Campos** joined the Intelexia team in 2019 to help with the project at Red the Escuelas de Aprendizaje and was extensively trained by Inés Guyot and Florencia Aguilar. She served as visiting master teacher at the following treatment schools: SF21, T37.

Campos is a graduate of St. Catherine's School in Belgrano CABA, Argentina. She has more than 25 years of experience in elementary schools in Argentina. She worked 10 years as an English teacher at Carmen Arriola de Marin and 16 years as a Spanish teacher at Colegio Cardenal Newman.

- **Florencia Aguilar** joined the Intelexia team in 2015. She has extensive training in multi-sensory reading instruction including the PAF Program and *Aprendo Leyendo*. She has attended training seminars in these methods at the Windward Teacher Training Institute in New York and has benefited greatly from the mentoring of Phyllis Bertin, one of the primary developers of PAF and AL. Aguilar contributes to the development of content for AL, and serves as a teacher trainer, delivering professional development seminars in MSL reading instruction and the AL program. She was one of the first teachers to work with *Aprendo Leyendo* in schools. In 2016 she was responsible for piloting the full sequence of the program in first grade both in a private and public school. During 2018 and 2019, she has trained teachers in more than 20 schools across different provinces of Argentina. Aguilar served as visiting master teacher at the following treatment schools: T18, SF36, SF4.

Aguilar is a binlingual primary teacher that graduated from St Catherine's School in Belgrano CABA, Argentina. She has more than 25 years of experience teaching both English and Spanish in elementary schools. She worked at Southern Cross School for 20 years, teaching Spanish and English first and second form. She was a Deputy Primary Head at Estela Ebbeke Memorial College for 3 years. Shen then worked at Colegio Cardenal Newman for 10 years as a Spanish teacher for 1st, 2nd, and 3rd grades. She also worked for 3 years with children with learning difficulties.

Appendix F: Participating Schools

SCHOOL NAMES ARE OMITTED FROM THIS REPORT TO PRESERVE THEIR ANONYMITY.

Appendix G: TVIP Modifications

A few items in the *Test de Vocabulario En Imágenes Peabody-Adaptación Hispanoamericana* (Dunn, Dunn, and Arribas 2006) do not align well with the *Rioplatense* dialect of Spanish spoken by study participants. Therefore, the words in these items were replaced with more locally appropriate terms, as shown.

Table 21: TVIP item substitutions.

Item	Original	Replacement
36	serrar	serruchar
52	animar	bailar
76	repostar	cargar
96	acoger	recibir
129	berlina	sedán
155	zarpa	garra
170	cizalla	tijera
179	yantar	engullir
185	mielgo	mellizo

Appendix H: Team Structure

Intelexia LLC, developer and publisher of *Aprendo Leyendo*, was responsible for overall management of the project. They also provided the professional development seminars for classroom teachers. Intelexia provided the master teachers who visited treatment classrooms.

The Universidad Favaloro team was responsible for student assessment, including provision of 35 hours of training to 18 assessors, and tabulation of data.

Haskins Laboratories provided advice on study design, measurement instruments, and data handling. Haskins also provided independent evaluation of data provided by Intelexia.

Appendix I: Analysis Software

All summaries and analyses in this report were carried out using the R statistical environment, version 3.6.1 (R Core Team 2019). The report itself was produced using an Rmarkdown workflow. The following table lists the non-base R packages used in building the report.

Table 22: R packages used in this report.

package	version	date
bookdown	0.18	2020-03-05
broom	0.5.5	2020-02-29
broom.mixed	0.2.4	2019-02-21
cowplot	1.0.0	2019-07-11
dplyr	0.8.3	2019-07-04
forcats	0.5.0	2020-03-01
ggplot2	3.3.0	2020-03-05
here	0.1	2017-05-28
kableExtra	1.1.0	2019-03-16
knitr	1.28	2020-02-06
lme4	1.1.23	2020-04-07
lubridate	1.7.4	2018-04-11
magrittr	1.5	2014-11-22
Matrix	1.2.18	2019-11-27
purrr	0.3.3	2019-10-18
readr	1.3.1	2018-12-21
readxl	1.3.1	2019-03-13
stringr	1.4.0	2019-02-10
tibble	2.1.3	2019-06-06
tidyr	1.0.2	2020-01-24
tidyverse	1.3.0	2019-11-21