Tablet language stimulation and sight-reading applications to narrow toddlers' literacy gap

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Description: Policymakers and scholars alike worry over the learning gap of children: by age 3, low-income children hear 71% fewer words than high-income children (Hart and Risley, 2003). Early vocabulary knowledge predicts reading ability in later years (Berlinski and Schady, 2015). This gap arises early, is persistent, and has widespread consequences for schooling, criminality, and health (Elango et al., 2015). Scholars have tried to remedy this gap with early childhood non-reading interventions (Attanasio et al., 2015), late childhood reading interventions (Marulis and Neuman, 2010), or early childhood peripheral reading interventions, such as letter awareness or home-based shared reading, (National Early Literacy Panel, 2008). These interventions give moderate to large effect sizes (Elango et al., 2015).

However, scholars have yet to attempt an early childhood sight-reading intervention. We implement an initial pilot study of a tablet-based early literacy method (digital flashcards with picture associations and recordings) for 4 months in Mozambique, with a small trial of treatment/control groups. The main outcomes are the ability to recognise new words (decoding) and the ability to read an age-appropriate book (comprehension). These measures correlate to adult labor market outcomes (Carneiro, Crawford and Goodman, 2007). We expect positive results: anecdotal evidence suggests that the method leads to increased vocabulary and to a passion for reading. After the pilot phase, we intend to run a Randomised Control Trial with 768 children over 2017-2018. We will use the lessons learned from the pilot and the preliminary results for a grant application to the Nuffield Foundation, the Education Endowment Foundation, and/or the ESRC.

This project has several advantages: the method is standardised and does not rely on teacher quality. It is cheap and scalable. If it proves effective, it may become a useful tool towards achieving one of the UN millennium goals of universal primary education.

Literature review

We position our research at the intersection of two strands of the literature. The literature on reading interventions has found important gains and effect sizes around 0.88 (Marulis and Neuman, 2010). These studies focus on children over 6 years old—for younger children, interventions focus on hearing or playing with letters, or home-based shared reading, but not sight-reading (National Early Literacy Panel, 2008). Nearly all reading interventions use phonological awareness (Wanzek et al., 2015), i.e. a child first recognises letters, then syllables, then the word sound, and finally the connection to auditory memory. As for early interventions, the literature reached a consensus that they are cost-effective for low-income children with benefit-cost ratios between 4 and 7 (Elango et al., 2015). For example, Outhwaite (2014) conducted an intervention with 37 children aged 4-5 in Britain using a math stimulation application in iPads and reported effect sizes up to 1.24.

This research project fills a gap in this literature with a sight-reading intervention using a tablet during early childhood. We expect positive results from an early childhood literacy intervention because building larger cognitive capacity in early childhood increases learning capacity in late childhood ("self-productivity") and targeting a school-specific, cognitive skill may be more effective in preventing the cognitive learning gap.

Sight-reading application

We will implement and upgrade the method of Doman and Doman (2005), where parents used paper flashcards to teach children to read *visually* (whole words) rather than phonologically (letters). Children may be more engaged with whole words that they can relate to, for example the whole word "mum" is the name of "the most important person in the world," but separate letters are less meaningful (Hughes, 1971). We will use a photograph of the child's mother to teach the word "mum" and a photograph of the child to teach the child's name. This approach could strengthen the child's emotional connection to the learning program and facilitate learning. The enduring popularity of the book over 40 years and anecdotal evidence from mothers suggest that children enjoy this method and become passionate readers by school age. It also suggests strong externalities with other cognitive skills (Harvey, 1994).

We emphasise that the application will not teach children to read but to learn some words by sight. Children trained in recognising these words will likely show an improvement simply from practice effects. Therefore, we are interested in the children's ability to decode words outside of those presented in the program. It is possible that the training will not generalise to other words and that children will be unable to read new words. However, Hughes (1971) reports that a child learning with this method for 6 months with 15 minutes per day reached phonological awareness on her own and could translate "unfamiliar written words into sounds at a single glance," possibly because visual reading released cognitive resources to discover and understand the phonology of the language (Therrien, 2004). Furthermore, this method may be more appropriate for a language with a deep orthography such as Portuguese, which is the language spoken in Mozambique and which has slower reading times (Seymour, Aro and Erskine, 2003).

To the best of our knowledge, no computer application implements this paper-based method nor teaches children under 6 to read alone. For example, ABCMouse and FastForWord are two

products based on the phonological method and aimed at older children. This may explain why scholars have yet to undertake an economic evaluation of the early literacy method.

We undertake the implementation of this method using Dr. Morin's background in computer science. The application itself is a valuable by-product of our research project. The program consists of digital flashcards that teach association between pictures, word spellings, and recordings. In addition, it will also implement (1) scaffolding (Heckman and Mosso, 2014), with minimal new information and a selection of words appropriate for the child's age and cultural context; (2) a multi-sensory experience with the tactile interaction with the tablet, a recording of each word in the native language, a visual image, and possibly an emotional connection to selected images (such as a picture of the child's mother to illustrate the word "mum" and a picture of the child to illustrate the child's name); and (3) successive relearning, a combination of active recall and distributed practice, which are the "highest promising techniques" from cognitive science (Dunlosky et al., 2013). Furthermore, the intervention is dynamic and can continue indefinitely with new words to learn every day. The application will be simple and child-proof, similar in spirit to the educational TV show "Sesame Street," which increased school readiness in the 1970s and 1980s (Kearney and Levine, 2015).

This method has a low cost and scalable with cheap tablets and a server such as the Raspberry Pi and without additional staff training. If it succeeds in narrowing the literacy gap, it could become an economical and cost-effective intervention, especially in developing countries.

First phase: pilot

We undertake this project with two phases, first with a pilot with up to 45 children, then with a randomised control trial with 768 children.

The pilot study will occur in the Nhapúpwè kindergarten in Inhambane, Mozambique (http://nhapupwe.org/). They have agreed to collaborate with this research and take responsibility for its implementation. They have 45 children aged 3-6 from all socioeconomic backgrounds. The pilot will run either during the last term of 2016 or during the first term of 2017. We have been assured by the kindergarten that all children in the school are fluent in Portuguese, the mother tongue of one of the Principal Investigators. We ask for parental consent and child assent according to the ethics guidelines in Economics (ESRC), Psychology (British Psychological Association), and Education (British Educational Research Association). With a non-response rate to consent between 18 and 40 percent (Araujo et al., 2016), we expect an enrolment between 27 and 32 children, or about 2 children in each cell.

The developing world is an ideal location to trial this method: the poor quality of teachers (Banerjee et al., 2007) and the limited vocabulary of parents (Berlinski and Schady, 2015) give an upper bound on the contribution of this method.

We will randomly allocate children into one of two groups:

- a treatment group that uses a tablet to learn to read with the whole word approach of Doman and Doman (2005);
- a control group that does not use a tablet.

The main outcomes of the program are the Peabody Picture Vocabulary Test (PPVT) for words not taught in the application (decoding) and the ability to read an age-appropriate book (comprehension). Since children may differ initially on their vocabulary knowledge, we test them at baseline as well. We will also test spill-overs into other cognitive skills, such as IQ measured with simple pattern tests (Psychometrics Centre at Cambridge), and non-cognitive skills, such as parenting stress (Huebner, 2000). We can then extrapolate to long-term benefit-cost ratios and adult earnings with from long-term studies such as the Jamaica intervention (Berlinski and Schady, 2015) or from human capital production functions (Attanasio et al., 2015).

The randomisation will be stratified with respect to age and socioeconomic background. We do not have enough children to randomise with respect to other variables, e.g. the language spoken at home, and we will use this pilot to gain experience for the larger Randomised Control Trial. We have applied for ethics approval with the Faculty of Economics for this phase of the project.

Second phase: Randomised Control Trial

The second phase of the study will expand the procedures from the pilot. The main difference is the sample size: in the second phase, we will recruit more kindergartens. We will undertake this effort while Dr. Morin is in the field during the pilot phase.

We will randomly allocate children into one of four groups—the two groups from the pilot phase and the following two additional groups:

- a treatment group that uses a tablet with a more standard method to improve phonological awareness with one of the applications available on the market;
- another control group that uses a tablet to play games (this is an active control group, as opposed to the passive control group in the pilot phase).

Our sample size is a minimum of 768 children. As we have 4 cells per grade (one for each group) and 3 grades, this sample size ensures 64 children in each cell and gives statistical power to detect an effect size of 0.5 (at the conventional levels of Type I error $\alpha = 0.05$ and Type II error $\beta = 0.2$, see List, Sadoff and Wagner, 2011). We will ensure that the randomisation is balanced with respect to initial vocabulary knowledge, tested at baseline. We will also apply the lessons learned from the pilot to the Randomised Control Trial. We expect it to run between January 2017 and June 2018. The treatment occurs at the classroom-level to capture learning externalities between children.

This phase has a wider research focus and we will adjust the parents' questionnaires and we will submit a separate request for ethics approval for this study after we have secured funding for it. We will change the "Participation and Information Sheet" to include additional possibilities for research. The parents of program participants will be asked to complete a follow-up questionnaire every 6 months to inform on the persistence of the intervention effects. In addition, we will ask participants for their national identifiers to secure the option of a longer-term program evaluation with the impact on educational scores throughout school, on economic outcomes during adulthood, and to calculate cost-benefit ratios for public policy.

Timeline:

- July-August 2016: we request ethics approval and develop a first prototype of the sight-reading application, with vocabulary testing, ready for children to use in a classroom connected to a server;
- August-December 2016: Dr. Morin visits Mozambique to implement the application, test the hardware, incorporate feedback from the classroom experiment, and talk to more kindergartens to increase the sample size.
- September-December 2016 or January-April 2017: the intervention runs during one school term, with baseline and endline tests;
- October 2016 - February 2017: we submit funding applications to the Nuffield Foundation, the ESRC, and/or the Education Endowment Foundation to run a randomised Control Trial with 768 children.

Qualifications of the research team members:

Dr. Miguel Morin has obtained competitive funding from Cambridge-INET, the Russell Sage Foundation, the Economic History Association, the Keynes Fund, and the Foundation for Science and Technology (Portugal). His research papers focus on the effects of technology adoption and on economics education. He has experience with children with several volunteering roles. Dr. Sriya Iyer is an experienced researcher with an established publication record in development economics. For her previous research, she has been funded by Cambridge-INET, John Templeton Foundation, the Population Council, the Isaac Newton Trust and The British Academy.

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