

The Story behind DyTECTIVE: How we Brought Research Results on Dyslexia and Accessibility to Spanish Public Schools

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Figure 1: Child playing DyTECTIVE, screenshots of the tool and billboard. Photos included with the parents' permission.

ABSTRACT

This paper presents the research and the entrepreneurial journey behind DyTECTIVE. DyTECTIVE is a tool that combines machine learning and computer games to detect risk of dyslexia and ameliorate the symptoms of dyslexia through personalized exercises. It has been used over 325,000 times, becoming the most used dyslexia online screener for Spanish. Recently, this platform has been adopted by over 800 Spanish public schools in collaboration with Regional Governments.

CCS CONCEPTS

• **Computers and Society** → **Social Issues**—**Assistive technologies for people with disabilities.**

KEYWORDS

dyslexia, screening, serious games, machine learning, social entrepreneurship

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1 DYSLEXIA BARRIERS

Achieving reading fluency is considered a critical component of empowering individuals to participate meaningfully in society and is a major contributor to improved livelihoods. However, globally up to 250 million children are unable to acquire basic literacy skills [12]. While there are many factors which contribute to poor learning outcomes, one widespread challenge is developmental dyslexia, a reading-specific disability, which by some estimates may affect up to 10 % of the global population [1]. Despite being one of the most common learning disabilities, developmental dyslexia is still under-diagnosed and often goes untreated, leading to school failure. Currently, there are three barriers of dyslexia:

- (i) It is unknown and **under-diagnosed**, especially in languages with transparent orthographies such as Spanish [13]. In fact, it is called a “hidden disability” in literature [13].
- (ii) It creates difficulties in reading and writing, related to **school failure**. These are broadly studied [1, 13].
- (iii) Current diagnosis and treatments are expensive, creating **socio-economic barriers**.

2 SOLUTIONS FOR DYSLEXIA BARRIERS

To overcome these barriers we integrated the research conducted during the last decade in a platform called DyTECTIVE. Then, to bring this platform to society, we founded the social venture Change Dyslexia¹ offering:

- (i) a **free online screener** so everyone can have access to a test and dyslexia is not “hidden” anymore;
- (ii) a set of linguistic **support exercises** that significantly improves reading and writing; and
- (iii) **scholarships** for under-privileged families so no child fails due to dyslexia.

¹<https://www.changedyslexia.org/>

The **screeener** is composed of a Machine Learning (ML) model (Random Forests) trained with human-computer interaction data extracted from a gamified test. It was evaluated with 5,059 participants divided into two training sets, 3,644 for computer and 1,395 for tablet. The model is able to classify people as having dyslexia or not with high sensitivity or recall, around 80% depending on the age group [7]. The test takes 15 minutes and it is available for children and young people from 7 to 17 years old. It is currently available in Spanish although we have preliminary results for English [10].

To support dyslexia treatment we created **training exercises** in two different moments. First, we designed 5,000 exercises based on the linguistic patterns found in the errors of people with dyslexia because they were found to improve the writing skills of children with dyslexia after playing for 20 minutes, four times per week during four weeks (n=48) [8]. Second, we advanced this approach by creating 42,000 exercises that are personalized based on 24 indicators (cognitive abilities), in order to strengthen the weakest cognitive skills and challenge the strongest cognitive skills with more difficult exercises [9]. We evaluated this approach finding significant higher rates of improvement in reading tasks (n=61) [5].

3 LESSONS LEARNT

During the last years, Dyetective was used almost 350.000 times in 50 different countries and Change Dyslexia became an example of social entrepreneurship winning awards such as the *UNESCO King Hamad Bin Isa Al-Khalifa Prize for the Use of ICT in Education*. However, this journey was far from being exempt from difficulties. The following are some of the factors that helped us to reach this point.

Descriptive Statistics Can Help a Lot: Before running a large scale user study with thousands of participants to build a ML model to predict dyslexia [7], we ran different small user studies with 40 to 60 participants only for different languages [6, 11]. This allowed us to examine the screener items by running simple descriptive statistical tests between populations. This way, we learnt about the most discriminative games and linguistic patterns before jumping to gathering the large training data to build a ML model. Humble but iterative user studies together with descriptive statistics can help know more about the problem and save a lot of resources in advance.

Cross-functional Team: Since the first experiments we started collaborating with multidisciplinary teams aiming to include the fields of knowledge that encompass dyslexia. We collaborated with (i) researchers (linguistics, data mining, machine learning, psychology and pediatrics); (ii) practitioners (speech therapists, teachers and pediatricians); and (iii) people with dyslexia (foundations and civil associations of dyslexia). In the end, these teams turned out to be extremely valuable not only from a research point of view but also because they allowed us to know the different stakeholders' views in advance of launching a disruptive tool. Hence, we were able to anticipate issues and adapt the tool before its launch.

The Need of Explainable Machine Learning Algorithms: To respond to user criticism, we needed to be able to understand the errors of our ML model and present the results in an understandable way. Consequently, we substituted the deep learning algorithms

from the first approach to Random Forests due to their good level of interpretability in the current version of the tool [7].

Do not only Think on Social Impact, but also Sustainability We learnt the hard way that sometimes leaving software for free is not sustainable in niche markets. From 2012 to 2017 we offered the research based tool *Dyseggia* (or *Piruletras* in Spanish) with exercises to support dyslexia [8]. The tool was freely available in Spanish, English -later in German [4]- and reached 32.000 users in 72 countries. However, it was not viable economically and after many efforts of volunteering our time, we had to remove it from the marketplaces. After this experience, we focused on the design of a business model that could integrate its viability with a strong social mission, giving as a result the foundation of Change Dyslexia.

Build a Community, Involve your Users: Great time of this project was devoted to the care of the community of people with dyslexia and they responded accordingly. For instance, to raise seed capital to develop the commercial tool, we launched a crowdfunding campaign with Kickstarter with a pre-sale of Dyetective's licenses that was acquired by almost 500 backers.² During the development of the product, we involved the backers in the decisions using questionnaires, focus groups and by organizing a workshop that served as a proof of concept. This turned out very useful because it allowed us to learn about our future customers (teachers, therapists and families) and adapt the tool to their needs before it was released.

Having a Strong Social Mission Can Attract Big Corporations. For instance, during 2017 we collaborated with Samsung Spain and Samsung Argentina. For one year, Dyetective was distributed under the name 'Dyetective for Samsung' in exchange for a communication campaign carried out by Samsung. This campaign reached all media (add on radio, TV, printed press, billboards (Figure 1). The Dyetective's advertising spot was watched over 2.3 million times only on YouTube,³ winning a Bronze Lion at Cannes Festival. This could not have been possible without having a strong social mission, in combination with its scientific approach.

Policy Makers and Public Institutions can Magnify Social Impact: Collaborating with public Institutions and policy makers is slow and time consuming. However, we learnt that the greater social impact came from these collaborations. Today, Dyetective is used in over 800 Spanish public schools in collaboration with different regional governments. To the extent of our knowledge, this is the first time that dyslexia is being screened and supported at large scale in the Hispanic world.

4 FUTURE GOALS

This experience shows that sometimes a research project —whose first paper was actually published in the Web for All Conference eleven years ago [2]— can have the potential to impact hundreds of thousands of people worldwide. However, there are still challenges regarding dyslexia, such as the adaptation of this approach to languages with non-phonetic alphabets (i.e. Chinese) or the use of non-linguistic items (i.e. musical or visual elements [3]) that could lead us to dyslexia assessment in pre-readers, that is, to very young children. This last perspective could bring us to the development of a language independent -or even universal- approach to dyslexia.

²<https://www.kickstarter.com/projects/1509026717/change-dyslexia>

³<https://www.youtube.com/watch?v=5K6lwF5pEOY>

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