Dytective: Toward a Game to Detect Dyslexia

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ABSTRACT

Detecting dyslexia is crucial so that people who have dyslexia can receive training to avoid associated high rates of academic failure. In this paper we present *Dytective*, a game designed to detect dyslexia. The results of a within-subjects experiment with 40 children (20 with dyslexia) show significant differences between groups who played *Dytective*. These differences suggest that *Dytective* could be used to help identify those likely to have dyslexia.

Keywords

Dyslexia; Serious Games; Detection; Screening

Categories and Subject Descriptors

K.3 [**Computers in Education**]: Computer Uses in Education—*Computer-assisted instruction*.

1. INTRODUCTION

Dyslexia is the most common neurological learning disability. Even though 10% of the worldwide population are dyslexic, few are diagnosed. Diagnosing dyslexia is non-trivial; it is expensive and generally requires an expert. In the UK, only 5% of people with dyslexia are diagnosed, and the cost of this is low literacy (over 85% of illiterate adults have dyslexia) [1]. In fact, dyslexia is called a *hidden* disability due to the difficulty of its diagnosis. A tool to screen *undiagnosed* children with dyslexia without requiring a specialist could have a crucial impact in the education system preventing school failure, which is associated with dyslexia, even if dyslexia is not related to overall intelligence [3].

To meet this need we developed *Dytective*, which, to the best of our knowledge, is the first game to screen dyslexia in Spanish.[1]

[1]This work is protected by a provisional patent application titled "Method to Detect Individuals with or at Risk of Neurodevelopmental Specific Learning Disorders using Human Computer Interaction" filed on March 20, 2015.

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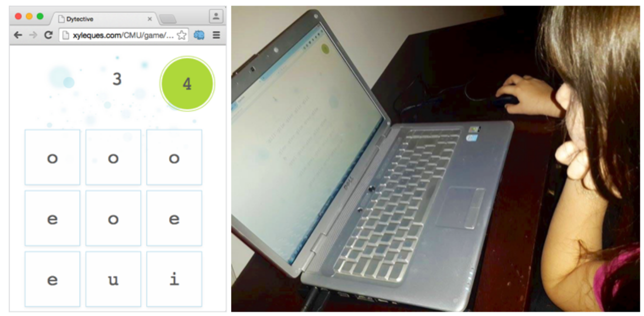

Figure 1: The first level of *Dytective*. Players hear the character that they should click and then click it quickly within the time limit (shown in the green circle).

2. RELATED WORK

Lyytinen *et al.* [4] created the computer game *Literate*,to identify children at risk of having dyslexia before school age in Finland. Its exercises are aimed towards the connection of graphemes (letters) and phonemes (sounds). They conducted two user studies with 12 and 41 children between 6 and 7 years old with very promising results. Later, Gaggi *et al.* [2] developed and evaluated a game with 24 pre-schoolers in Italy, that aimed at eye-hand coordination, visual spatial attention, rapid speech-sound identification and discrimination as well as visual-to-speechsound. Van den Audenaeren *et al.* [7] performed a user study with 20 pre-schoolers in Flanders and are currently developing the game *DYSL-X* for early risk detection of dyslexia, which includes letter and end-phoneme recognition as well as psycho-acoustical tests.

To the best of our knowledge *Dytective* is the first game that aim at screening dyslexia in Spanish using human computer interaction measures.

3. DYTECTIVE GAME

Running Dytective. The player's goal is to accumulate points by hitting the target letter/syllable as many times as possible in a 15 second window. The player hears the target letter/syllable and then a board is shown containing also distractors; counters with the score and with the remaining seconds were place at the top (Figure 1). After each game iteration the player go up a level.

Content Design. The game aims at three skills children with dyslexia have difficulties with: (i) letter recognition, (ii) syllable recognition, and (iii) phoneme to grapheme (sound to letter) mapping, that is, phonological awareness.

Dependent Variable	*Children with Dyslexia*			*Children without Dyslexia*			Significance	%
	M	SD	Mdn	M	SD	Mdn		
Clicks	4.63	3.10	4	6.08	2.66	6	$W = 6121.5,\ p < 0.001$	131.32
Hits	3.81	2.67	4	5.84	2.72	6	$W = 5344,\ p < 0.001$	153.28
Score	17.84	10.35	17	28.74	14.75	27	$W = 5502,\ p < 0.001$	161.10
Accuracy	0.80	0.30	1	0.95	0.14	1	$W = 7181.5,\ p < 0.001$	118.75
Speed	0.25	0.18	0.27	0.39	0.18	0.4	$W = 0.9447,\ p < 0.001$	156.00

Table 1: Results for the comparisons between groups: Means, medians, standard deviations, significance and relative percentage difference with respect to the smallest average value.

We established seven levels based on the number of cells in the grid starting with a 3x3 grid up to 7x7. To gradually increase their difficulty we defined a set of linguistic criteria based on how language is acquired and the specific difficulties of dyslexia, extracted from the analyses of the errors that people with dyslexia make [5].

- **Level 1** targets vowels; distractors (vowels only) are randomly selected.
- **Level 2** targets consonants, distractors are randomly selected among all consonants.
- **Level 3** targets similar looking letters. These are letters that have mirror *i.e. 'u' and 'n'* and rotation features *i.e. 'p' and 'd'*. For this level distractors are randomly selected among a group that shares the features of the target letter(s)/syllable(s) [5].
- **Level 4** targets consonants that share phonetic and visual rotation features (*'b','d','p','q'*) [5].
- **Level 5** targets syllables with the following structures CV *i.e. 'ca'* and VC *i.e. 'on'*.[2]
- **Level 6** is for checked syllables with CCV structure, *i.e. 'pla'*.
- **Level 7** aims at checked syllables with CCVC structure, *i.e. 'glis'*.

4. USER STUDY

We recruited 40 **participants**, 20 of them with dyslexia[3] ($M = 8.60, SD = 0.82$ years old) and 20 without dyslexia serving as a control group ($M = 8.60, SD = 0.94$). They were all were native speakers of Spanish, their ages ranged from 7 to 10 years and they were all attending school (second to fifth grade). We used a within-subjects design to compared the performance of both groups. Each participant had to play on-line to one game of each level (seven games in total),[4] being supervised by a parent or psychologist.

As **dependent variables** we measured the (i) the total number of *Clicks* per game (each participant played 7 games, one per level); (ii) total number of *Hits*, *i.e.* number correct answers per game; (iii) the final *Score i.e.* sum of correct answers or all game; (iv) *Accuracy* defined as the number of *Clicks* divided by the number of *Hits* per game; and (v) the *Speed*, calculated as the number of *Clicks* divided by the time spend (15 seconds), *i.e.* number correct answers per second.

[2]C refers to consonant and V refers to vowel.

[3]They all had diagnoses except of 3 participants which were under observation by professionals, the previous step before having an official diagnosis.

[4]`http://xyleques.com/CMU/game/`

5. RESULTS

A Shapiro-Wilk test showed that none of the data sets were normally distributed hence we used dependent 2-group Wilcoxon Signed Rank test for non-parametric data to test differences between groups. In Table 1, we show the results for the comparisons between groups. Significant differences among groups were found for all the dependent measures.

6. CONCLUSIONS AND FUTURE WORK

We have presented the first prototype of a screener for dyslexia in Spanish, *Dytective*. An experiment with 40 participants has shown very promising results suggesting that this tool could be used to screen dyslexia. Currently, we are carrying out a large scale study with *Dytective* to be able apply machine learning techniques [6] that were already found to be useful to predict dyslexia. Since estimations of dyslexia are much higher than the actual diagnosed population we believe this has a great potential impact.

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