Measuring the Reading Abilities of Dyslexic Children through a Visual Game

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***Abstract*—In modern society about 10% of children suffer from a neuro-developmental disorder called dyslexia, which implies difficulties in learning to read. According to recent research, playing action videogames can be a valid teaching tool to improve the reading skills of dyslexic children through forms of engagement and interaction. This paper describes the design, implementation, validation and experimentation of an educational action game oriented to promote phonological and visuo-spatial attention training in dyslexic subjects aged between 7 and 9.**

***Index Terms*—dyslexia, adaptive education, visuo-spatial attention, phonological processing, action videogames.**

I. INTRODUCTION

Studies conducted over the years in relation to dyslexia, and specifically developmental dyslexia, argue that the difficulties in acquiring reading and writing skills have not a pathological nature. Rather, these effects represent an individual development variant which determines conditions that hinder the acquisition and improvement of some specific skills [1].

The enhancement of reading skills requires the student to take part in activities that stimulate the acquisition of a long chain of skills, including the management of attention [2]. In particular, a key role is played by the visuo-spatial attention [3].

Attention can be nurtured through exercises that present the selection of a letter from a collection of other graphemes [4], requiring a quick orientation of visual attention [5] before the application of the correct phoneme-grapheme integration [6]. The cognitive processes underlying the improvement of reading skills through visuo-spatial attention are not fully transparent to scientific inquiry yet [7], thus they are the subject of innovative and experimental studies.

Researchers from the General Psychology Department of the University of Padua studied visual attention in dyslexic children of primary school, investigating the brain's ability to isolate individual symbols on paper. Each of the 96 children involved in the research had a sheet with a few lines of doodles or non-alphabetic bullet markers and they had to look for the corresponding targets by sliding the rows from left to right, and – after locating them – to delete such symbols with a pencil. Both visual attention and language skills had been tested in children before the acquisition of reading ability. Surprisingly, the measurement of their deficit in visual attention was able to predict subsequent reading skills much better than their language skills. Since recent studies have shown that specific rehabilitation programs can improve reading skills, children at risk of dyslexia could be treated with prevention programs based on visuo-spatial attention even before the acquisition of reading [8]. The skills called into question by this visual search task belong to two distinct classes. On the one hand there is so-called *serial scan*, which reproduces the mechanism of reading symbol after symbol, and on the other there is *spatial attention*, that takes into account the position of each symbol in context.

The ability to play action videogames – not directly related to phonological or orthographic training – seems to be a teaching tool able to intervene specifically on spatial attention in order to drastically improve the reading skills of dyslexic children [8]. The mentioned scientific literature suggests that an effective way to encourage the development of reading literacy consists in practicing the skills that are the preconditions of the reading process. The teacher is required to foster – if possible – reading skills whose development has been affected by the disorder to obtain an "indirect" improvement of the reading activity itself.

As regards phonological aspects, even if many papers highlight the benefits of phonological training in the field of language acquisition, an effective modeling of how the sound experience can be integrated into language recovery programs does not emerge with equal force and clarity.

Based on this theoretical framework, this project aims at the design and development of an action game, simultaneously involving both phonological and attention training in order to adapt educational game strategies for special needs [9] by supporting teaching adaptively [10].

II. TRAINING VISUO-SPATIAL ATTENTION

The characteristics that define an action videogame are:

- High game speed;
- High degree of perceptual, cognitive and motor load (fast tracking of item movements, planning of different strategies, prompt performance of actions, etc.);
- Temporal and spatial unpredictability;
- High importance of the events that take place away from the center of the screen [11, 12, 13].

Researchers tested the attentional, phonological and reading skills in two groups of dyslexic children, matched

for age and for disorder severity, before and after the use of two types of game, respectively action and non-action video games, for 9 daily meetings of 80 minutes. Children who used action video games were able to read faster without losing accuracy and showed progress also in other attention tests. In particular, the group who used action video games increased reading skills more than they did in 8760 hours of spontaneous development, and achieving a final degree greater than or equivalent to the one obtained through traditional treatments [14].

Experience demonstrates that attentional abilities are increased by action video games, too. Hitting a moving target implies an ability of environmental perception and therefore a prompt attention to details that may help dyslexic children more than a reading exercise. Thanks to video games, dyslexic children have learned to steer and focus their attention. Consequently, they are able to extract the relevant information from a written word in a more efficient way, thus reducing the excessive side interference due to their disability [8]. The individual variations detected in visuo-spatial and cross-modal attention functions justify about 50% of the variance related to the improvements in reading, even after controlling for age, IQ and changes in phonological skills.

A recent study contained in [15] confirms that action games can help people who suffer from dyslexia to improve their ability to read and write. Such games – according to scholars – are able to stimulate those individuals to better integrate multi-sensory impulses.

Let us consider the following scenario: during a conversation with an interlocutor, someone calls the speaker from behind. Immediately the focus will move from the latter person to the back sound. This is a clear example of shifting cross-sensory attention. Researchers discovered that moving the focus from watching to hearing is particularly difficult for people with dyslexia [15]. This research involved participants affected as well as not affected by dyslexia in a video game that required players to press a few buttons in response to heterogeneous inputs, namely audio and visual stimuli. The dyslexics were less responsive in pressing the button when switching from one visual stimulus to an aural one (and vice-versa), thus demonstrating a greater difficulty in shifting attention from one sensory channel to another, particularly when moving from an image to a sound. If confirmed, such a phenomenon could be at the root of the problems that dyslexics encounter in reading, and research results could suggest new strategies to improve their skills in learning the written language.

Traditional approaches require that alphabetical signs are first presented visually and then phonologically. Research results demonstrate that action video games involving the simultaneous training of a number of sensory abilities could be a more effective exercise. In addition, through a suitable training dyslexics may enhance their ability to integrate multisensory stimuli and to understand written words as well. Training dyslexics to quickly move the focus from visual to auditory stimuli through an ad hoc game experience may help their ability to read and write.

The use of video games to increase attentional abilities would be particularly functional for populations of children and adolescents with developmental dyslexia. This is the most difficult form to treat, since traditional methodologies to improve reading skills are repetitive and very costly for the child and therefore more likely to be subject to drop-out [8].

The analysis of empirical evidence confirms the importance of the strategies used to reveal the actual improvements in reading and writing skills, in the praxis and the space-time integration of the mentioned subjects.

The design of a new action video game specifically aimed at improving reading skills allows us to combine in a single tool the indications coming from the training of preconditions, those from visuo-lexical domain (i.e. the recognition of graphemes) and the phonology-related ones. The goal of the proposed game is acting on the indirect mechanisms that strengthen activities (action games), superimposing a layer referring to the mechanisms related to decoding and phonological skills.

III. ELEMENTS OF PEDAGOGICAL DESIGN

In the awareness that "the effectiveness of game based-training is thoroughly dependent on the processing demands inherent to the exact game experience" [16], we have to itemize some functional considerations that guided the choice and design of the game tasks described in Section IV.

A. Phonological Training

With regard to phonological training, the reading process is different for different orthographies. Katz has synthetically described the relationship between morphology and phonology as follows: "The attempt to make an efficient match between the written form, on the one hand, and morphology and phonology, on the other, typically determines whether the orthography chosen is a syllabary, a syllabary-cum-logography, or an alphabet. Further, within the group of alphabetic orthographies itself, there are varying degrees of dependence on the strict alphabetic principle: the range of correspondence between grapheme and phoneme varies both in consistency and completeness. The degree of this dependence is to some extent a function of a language's characteristic phonology and morphology, just as was the choice of the kind of orthography itself" [17].

Currently the game has been designed and tested in Italian language. According to [16], the Italian writing system is *shallow*: "It has highly consistent spelling–sound correspondences". The shallowness causes that naming latencies are linearly related to length in letters [18]. "Latencies decrease as children gain skill in computing pronunciations over larger groups of letters. Italian dyslexics have not made this shift; like younger normal readers, they read aloud slowly but relatively accurately" [17]. In other words, the shallowness implies that an insufficient phonological word analysis does not automatically translate, in the dyslexic subjects, into a higher number of errors, but rather in an increase of slowness at the expense of text comprehension. "In languages with *loose* relationships between graphemes and phonemes (e.g., English), when the phonological analysis of words is insufficient, a variety of errors is produced. In languages with considerably more regular grapheme–phoneme correspondence (e.g., Italian), the number of errors may be small since phonological reading is generally correct, and the most conspicuous symptom is slowness in reading" [18]. Bavelier and colleagues summarize effectively: "Performance in read-

ing aloud is only weakly related to comprehension in shallow orthographies, for which it is possible to read aloud quickly and accurately with little or no comprehension" [16]. The implementation proposed below starts from these concepts.

B. *Visuo-spatial Attention Training*

Scientific research has confirmed that deficits related to visuo-spatial attention are among the main expressions of dyslexia [6, 14, 19]. Attentional dysfunction is an important core deficit in dyslexic individuals. Letters must be selected from among other cluttering graphemes by rapid orientation of visual attention before the correct letter-to-speech sound integration applies.

In this regard, "the cognitive processes involved in reading a written text may differ in reference to structures of different complexity, starting from the design characteristics of a letter (lines, angles, etc.)" [20]. As a consequence, it is possible to improve the process of reading in dyslexic individuals – in terms of accuracy and speed – by acting on specific parameters such as letter spacing, size and shape [21, 22, 23].

The action game described in Section IV uses a font that facilitates the process of reading in dyslexics, called DFONT and developed at the Department of Human, Philosophical and Educational Sciences of the University of Salerno. Such a font, shown in Fig. 1, is made of 102 glyphs, including uppercase and lowercase letters, numbers, accents, punctuation, and other symbols.

The key graphical feature of DFONT is related to letter shaping. A particular attention has been paid to differentiate the shape of the letters *b*, *d*, *q*, *p*, *n*, and *u*, namely those letters that, in most fonts, have a similar form and differ as regards their spatial orientation, being often confused by dyslexics [24, 25, 26].

Each letter of DFONT is also surrounded by (and centered in) a squared "cage". This particular change has been made to stem the phenomenon of crowding [27, 28]. This should help dyslexics to distinguish both the individual characters and the extent of each word more easily. Another customized parameter concerns word spacing: the size of the blank character in DFONT is equal to about 3 times its equivalent in Arial. In fact scientific literature suggests that a greater spacing between words increases the readability of the text for dyslexics [29].

The effectiveness of DFONT was tested through a pilot study, using reading speed and accuracy tests of the MT battery [20].[1]

DFONT has been released both in TTF (True Type Font) and OpenType format, consequently it is usable under any operating system.

IV. GAME DESIGN

In accordance with the educational and pedagogical principles explained above, we have designed, implemented, tested and released a Web-based action game for children affected by dyslexia.

The goal is engaging young dyslexic users, aged 7-9 approximatively, through an approach that recalls hidden object games. A *hidden object game* is a genre of puzzle video game in which the player must find items that are hidden within a picture.

a b c d e f g h i
j k l m n o p q r
s t u v w x y z
A B C D E F G H I
J K L M N O P Q R
S T U V W X Y Z

Figure 1. Lowercase and uppercase letters of DFONT.

Figure 2. Screenshot of the beginning of a match.

In our implementation we adopt the metaphor of a torn canvas to be repaired by solving a puzzle. The way to reach this goal is reconstructing the right sequence of syllables for the words proposed to the player, words that correspond to hidden objects. At the beginning some areas of the background are masked (see Fig. 2), and only guessing the right sequence of syllables allows to uncover them.

A game session consists of a variable number of rounds, ranging from 10 to 20 words to reconstruct, depending on the level. Each round is made of two distinct phases: in the first one, the system selects a word and spells it as a whole. During the second phase, the user has to select the sequence of syllables that form that word, in the right order and as fast as possible. Over the game board right syllables are mixed with a number of wrong syllables.

As shown in Fig. 3, words and syllables to guess are written using DFONT, the special font described in Section III. From tests conducted on a number of dyslexic users, this font has proved to be effective, allowing a better and easier recognition of letters.

If the player guesses all the syllables of a word, the corresponding image area is uncovered. Background images are conceived not only to enrich the graphical interface and to improve the game experience, but above all to test the player's ability to focus on graphemes. In fact, as

[1] MT tests have been created by the *MT group* at the Università degli Studi of Padua. MT originally stood for *Memory Training*.

mentioned earlier one of the aspects to improve in dyslexics is the ability to focus attention on specific spots.

Like in most games, score is influenced by player's performances. Guessing the right syllable guarantees a number of points which depends on the difficulty level and on the number of letters forming that syllable. Besides, a time bonus is assigned when the player's response is particularly prompt.

Like in many edutainment initiatives, the game play somehow hides its real aims. In fact, from the player's perspective the goal is uncovering all the objects and gaining as many points as possible by quickly choosing syllables; but in the meantime the child affected by dyslexia is improving his own ability to relate graphemes to phonemes.

After an overview about the game play, let us discuss two key concepts. The first issue is related to skill levels. Similarly to most games, in our proposal the player has to face increasing difficulties in order to get involved in the game play. According to in-use terminology of video gaming field, we define the concept of *level*, or *stage*, as a difficulty phase of a given section of the game. As regards this peculiar aspect, we have identified the following axes (see Fig. 4):

- *Number of syllables on the board* – When syllables are few, the game is easier for a number of reasons, e.g. the player can better identify the spatial position of symbols, symbols are bigger and more distinguishable, and so on;
- *Type of letters on the board* – A key problem for a dyslexic child is being able to focus on a graphical symbol and to recognize it against others. In this sense, some letters are clearly different either from a graphical (e.g. I against W) or from a phonetic point of view (e.g. A against T), whereas other can be perceived as similar (e.g. K against R or T against D respectively).
- *Word and syllable length* – Since the game play requires to recreate a sequence of symbols, the longer the sequence the harder the player's task;
- *Syllable complexity* – For a dyslexic child, some configurations - e.g. spelling words with double consonants - are harder to be recognized;
- *Symbol layout on the board* – The way symbols are presented in the interface influences the difficulty in reconstructing sequences, above all for children who are affected by concentration problems;
- *Semantics* – For a child it is easier to associate an image to objects of a common scenario (such as the word "dog") than to abstract concepts (such as the word "complexity"). In this sense, uncovering the graphical counterpart of guessed words is a form of reinforcement, as explained below.

The second key aspect refers to audio-visual aids and reinforcement techniques. Since the goal is providing a game environment to bind phonemes to graphemes, there is no fatal error that leads to the end of the game session. Rather, a number of reinforcements is provided to players, so that they can improve their performances. In particular:

- *Finding hidden objects* – Young players should be mainly encouraged by the goal of completing a level by discarding all masked areas. In this sense, we tried to couple the approach of educational games to the one of puzzle games. In order to provide a further form of reinforcement, the uncovered objects correspond to the words to reconstruct.
- *Score* – Points are assigned to the player depending on his/her performances. Obtaining the highest score is a good way to motivate a game player. Scores are parametric, taking into account difficulty levels, syllable lengths and user promptness;
- *Word respelling* – If the player needs a help, he/she can ask for a repetition of the word and of the current syllable. This implies a decrease in the score;
- *Symbol visibility and color contrast* – Any letter group can be better distinguished through bounding boxes and high-contrast color layouts. This visual aid is an evolution of the adoption of DFONT, a monospaced font where letters are surrounded by colored squares. In the case of a graphically rich background, this effect can be amplified, as shown in Fig. 5.

This application is an evolution of the one described in [30] and shown in Fig. 6. With respect to the first release, many improvements suggested by an early experimentation phase have been introduced in order to make the game play more effective.

Figure 3. Screenshot of the beginning of a match.

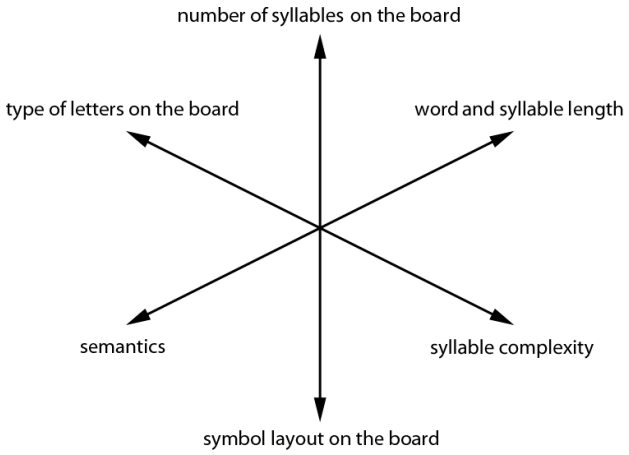


Figure 4. Levels of difficulty for the game.

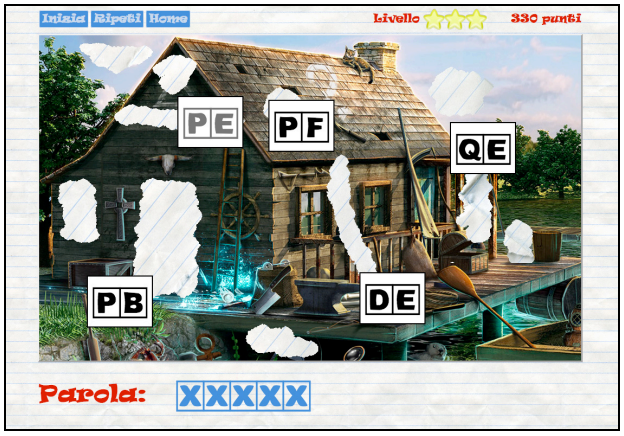


Figure 5. Reinforcement type: symbol visibility and color contrast.

Figure 6. The early interface of the game.

First, the didactic target has been adjusted by supporting syllables instead of single letters to be spelled. This implies a closer adherence to phonemes rather than to basic graphemes. Besides, in its first version the game layout proposed simultaneously all the letters to form the current word, plus a little number of wrong letters. On the contrary, now the player has to choose the right syllable among different versions of that syllable, and the selection changes syllable by syllable. As a consequence, in the setup phase it is possible to identify specific variants to test the player's ability.

The game experience has been improved by introducing 3 difficulty levels that can be selected either by teachers – thus allowing a user-tailored setup able to challenge and engage the player without causing frustration – or by players – thus adding longevity to the game play.

Moreover, from the latter point of view a multiplicity of scenarios have been introduced. Preparing a new level requires a relatively small work amount, since the underlying code has been conceived to easily parse new contributions. The multi-level game play allows to build a complete learning path, going from easy spellings (short words, basic letter groups, clear graphical backgrounds, etc.) to more challenging levels (long terms, letter combinations hard to remember and discover, rich graphical environments intentionally conceived to stress concentration, etc.).

The game is freely available in Italian language, and it is hosted on a server of the Università degli Studi di Milano. The address is: http://www.lim.di.unimi.it/madrigale.

V. EXPERIMENTATION

A. Research Questions and Pilot Study

To validate the prototype a pilot study was carried out in order to verify if the tasks of the game could match the reading skills we wanted to encourage and support, namely speed and accuracy in reading.

Effectiveness testing focused on the identification of possible relationships between reading skills in general (as measured by the standard parameters of speed and accuracy) and the activities proposed by the software. In order to assess the degree of development of reading competence, we employed the tests of "fairness and speed" of the so-called MT battery [20].

MT tests are one of the most popular tools in Italy for this kind of evaluation, providing reference classes based on research conducted for more than three decades. In Italy they are widely used as objective tests to assess the level of reading skills in the eight school degrees from primary to secondary school.

MT tests can separately measure the process of meaning comprehension of the written message (*understanding*) and the ability to decode the written message itself, in terms of *speed* (syllables read per second) and *accuracy* (number and type of errors committed).

The evidence of "fairness and speed" is based on a series of texts to be read aloud. MT tests differ in level of difficulty depending of the reference class and school period during which they are administered.

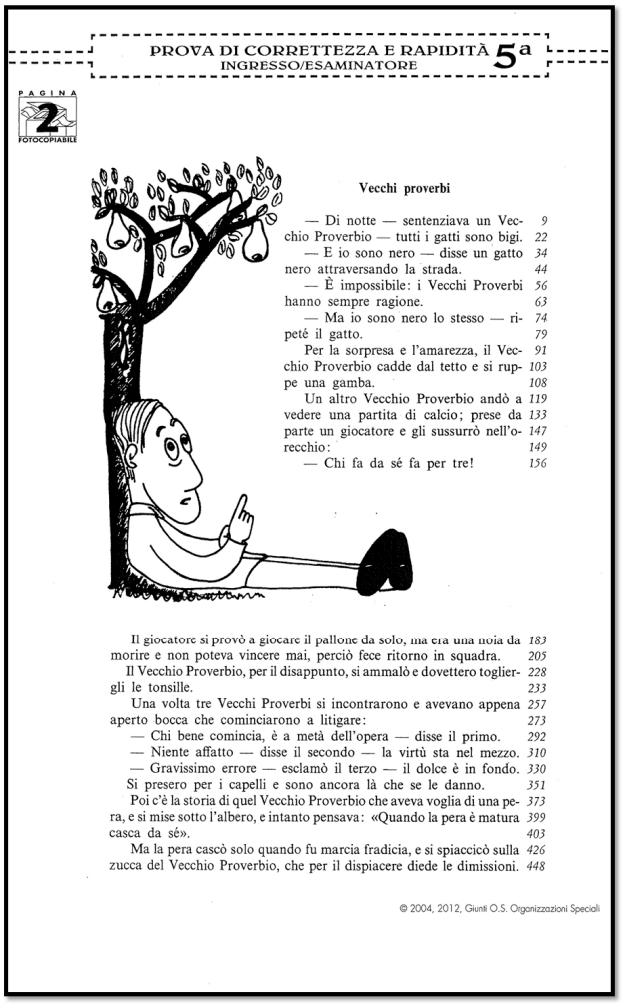
The pilot study was conducted on a sample of 12 students attending the fifth grade of primary school. First they had to complete MT tests of "fairness and speed" and later they were required to play the mentioned video game. It is worth noting that such students had no certification of dyslexia, so the purpose of the testing phase was not only identifying possible relationships between reading skills in general and game activities, but also discovering high-risk cases of dyslexia in players.

The administered text, shown in Fig. 7, was composed of 448 syllables and provided classes and reference standards for the interpretation of results. The test was administered individually by an experienced operator who recorded the reading time and the number and type of errors, as suggested by the MT manual. The collected data have been translated into scores of speed and accuracy.

The criteria for the interpretation of students' performances are shown in Table 1, where accuracy is measured in terms of *m* (number of mistakes) and speed in terms of *s* (number of syllables read per second).

TABLE I.
INTERPRETATION OF MT RESULTS

Test	Good	Sufficient	Warning	Action required
Accuracy	$0 \le m \le 3$	$4 \le m \le 10$	$11 \le m \le 19$	$m > 20$
Speed	$s > 4.0$	$2.61 \le s \le 4.0$	$2.18 \le m \le 2.60$	$s < 2.18$



PROVA DI CORRETTEZZA E RAPIDITÀ 5ª
INGRESSO/ESAMINATORE

PAGINA 2 FOTOCOPIABILE

Vecchi proverbi

— Di notte — sentenziava un Vecchio Proverbio — tutti i gatti sono bigi. 9 22
— E io sono nero — disse un gatto nero attraversando la strada. 34 44
— È impossibile: i Vecchi Proverbi hanno sempre ragione. 56 63
— Ma io sono nero lo stesso — ripeté il gatto. 74 79
Per la sorpresa e l'amarezza, il Vecchio Proverbio cadde dal tetto e si ruppe una gamba. 91 103 108
Un altro Vecchio Proverbio andò a vedere una partita di calcio; prese da parte un giocatore e gli sussurrò nell'orecchio: 119 133 147 149
— Chi fa da sé fa per tre! 156

Il giocatore si provò a giocare il pallone da solo, ma era una noia da morire e non poteva vincere mai, perciò fece ritorno in squadra. 183 205
Il Vecchio Proverbio, per il disappunto, si ammalò e dovettero togliergli le tonsille. 228 233
Una volta tre Vecchi Proverbi si incontrarono e avevano appena aperto bocca che cominciarono a litigare: 257 273
— Chi bene comincia, è a metà dell'opera — disse il primo. 292
— Niente affatto — disse il secondo — la virtù sta nel mezzo. 310
— Gravissimo errore — esclamò il terzo — il dolce è in fondo. 330
Si presero per i capelli e sono ancora là che se le danno. 351
Poi c'è la storia di quel Vecchio Proverbio che aveva voglia di una pera, e si mise sotto l'albero, e intanto pensava: «Quando la pera è matura casca da sé». 373 399 403
Ma la pera cascò solo quando fu marcia fradicia, e si spiaccicò sulla zucca del Vecchio Proverbio, che per il dispiacere diede le dimissioni. 426 448

Figure 7. The text administered to students.

As regards game tests, whose results are publicly available on the Web, each student had to face two different scenarios. Inside any scenario, the player had to guess increasingly difficult words, in accordance with most parameters listed in Section IV (number of syllables on the board, word and syllable length, syllable complexity, symbol layout on the board). As regards the type of right and wrong letters on the board, students had to select the hardest difficulty level, which implies alternative syllables very similar to the right ones (e.g., "GAB" against "GVB", "GAP", "QVB" and "GUB").

B. Data analisys and evaluation

After the administration of both the MT test and a game session, scores have been compared to game performances in order to find significant relationships. Table II provides a synoptic view, showing MT test results in the first two columns, and game results in the last two columns.

As regards the latter measurements, it is worth noting that the game records the number of seconds t to select each syllable and the total amount of mistakes m. In order to make time variables comparable to test results, we have to invert measured time t (thus obtaining frequency $f = 1 / t$) and to compute the average value.

If we focus only on the performances measured by MT test, the table above shows that subject 1 and 2 are in the warning area as regards reading speed, whereas subject 3

TABLE II.
TABLE OF RESULTS

	MT test		Game		
id	***m***	***f***	***m***	***t***	***f = 1 / t***
1	7	2,5	2	3,67	0,27247956
2	9	2,22	0	2,82	0,35460993
3	11	1,96	0	3,46	0,28901734
4	2	3,42	0	2,37	0,42194093
5	2	4,53	0	2,34	0,42735043
6	2	4,62	1	2,37	0,42194093
7	2	4,07	1	2,58	0,3875969
8	4	4,27	1	2,38	0,42016807
9	1	3,01	0	2,91	0,34364261
10	8	3,56	1	3	0,33333333
11	1	4,87	1	2,61	0,38314176
12	2	5,27	0	2,36	0,42372881

requires an immediate action as regards accuracy. Other subjects obtain either average or good results for both parameters.

Now such results have to be compared to game performances. Data analysis suggests the existence of a quite strong correlation between speeds ($r = 0.79$, $r^2 = 0.63$) and a loose correlation between mistakes ($r = 0.05$, $r^2 = 0.002$). This implies that, when reading speed in MT tests decreases, the time required to identify and select syllables in the game increases (see Figure 8).

On the contrary, the number of mistakes measured in the two contexts does not show a strong correlation (see Figure 9). A possible reason is due to the amount of syllables to be read during the game, significantly smaller than the amount proposed in MT tests, which does not allow to obtain statistically relevant data. However, in the future this problem can be solved through a suitable increase in the amount of words per scenario as well as through the administration of a bigger set of scenarios to each student.

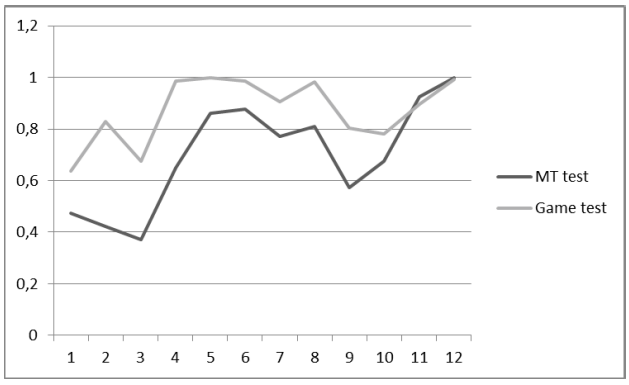


Figure 8. Correlation between normalized speeds.

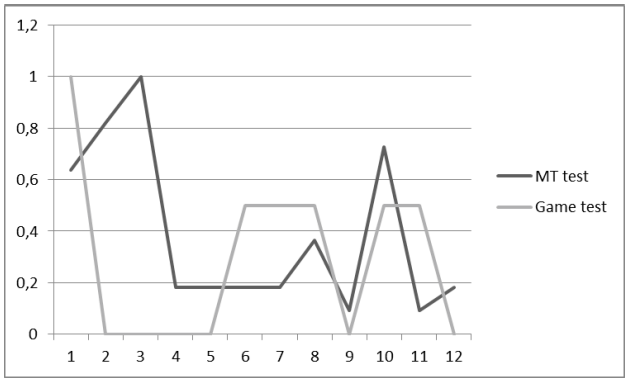


Figure 9. Correlation between normalized numbers of mistake.

VI. CONCLUSIONS

The research goal was the creation of an action game aiming to promote the development of reading skills in dyslexics through a game-based approach.

Even if in our tests we have not been able to find a correlation as regards accuracy, so the software seems unable to foster this specific kind of ability, retrieved data about the development of reading skills are encouraging. Let us recall that scientific literature gives a greater importance to speed-related parameters, since in transparent languages like Italian reading accuracy increasingly improves thanks above all to mnemonic mechanisms. On the contrary, in absence of specific training, speed does not follow such an evolution [31].

In summary, data seem to indicate that the activities proposed by our prototype mainly involve the speed of reading. However, since the educational and therapeutic programs in Italy are primarily designed to promote the development of fast reading, and not of accurate reading, the impact of our approach is positive an promising.

Consequently, the second phase of the research can start. Recalling that the pilot study was administrated to children with no certification of dyslexia, now we want to test if the developed game can specifically help dyslexic users as regards fast reading. In particular, it will ensure two groups of dyslexic subjects will be created: a control group and an experimental group respectively. The former group will perform only those educational activities provided by school syllabus. The subjects belonging to the latter group will be asked to support traditional activities through game play sessions for a period of six months (currently we are still evaluating the number and duration of sessions).

Both groups will be periodically administered the tests of accuracy and rapidity of the MT battery. Any changes in the reading speed emerging from the comparison between the control and the experimental group will be measured, in order to understand if the prototype can effectively improve dyslexics' performances.

As regards the game implementation, in a future release a scenario editor will be available too. At the moment of writing the key problem in this sense is the implementation of an effective and easy-to-use Web tool to set the mask effect on a user-defined background image.

Another software aspect to improve is related to the automatic pronunciation of syllables and words: now the game invokes Google APIs, but the result barely fits the requirements of a phoneme–based application.

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