Visuo-Spatial Attention And Reading Abilities:

An Action Game Prototype For Dyslexic Children

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AbstractIn modern society about 10% of children experience difficulty in learning to read. They suffer from a neuro-developmental disorder called dyslexia. According to recent research, playing action videogames - not directly related to phonological or orthographic training - seems to be a teaching tool able to specifically intervene on spatial attention and to drastically improve the reading skills of dyslexic children. This research aims at designing and implementing an educational action game oriented to promote, through forms of engaging and motivating interaction, phonological training and visuo-spatial attention training in dyslexic subjects aged between 7 and 9.

Keywords: dyslexia; adaptive education, visuo-spatial attention; phonological processing; action videogames

Introduction

Studies conducted over the years in relation to dyslexia and developmental dyslexia (DE) argue that the difficulties in learning reading and writing skills have not a pathological nature but represent an individual variant in development that determines conditions that hinder the acquisition and improvement of some skills (Stella, 2003).

Among difficulties in reading we find those related to the visual and visuo-spatial level (Pavlidis, 1985). The enhancement of reading skills (Strong, Torgerson, Torgerson, & Hulme, 2011) requires the student to take part in activities that stimulate the acquisition of a long chain of skills, including the management of attention. In particular, the visuo-spatial attention plays a key role in the acquisition of reading skills.

Attention can be nurtured by exercises that present the selection of a letter from a collection of other graphemes (Bouma, 1970), requiring a quick orientation of visual attention (Yeshurun & Rashal, 2010) before the application of the correct integration phoneme-grapheme (Vidyasagar & Pammer, 2010). The cognitive processes underlying the improvement of reading skills through visuo-spatial attention are not fully transparent to scientific inquiry yet (Dehaene et al., 2010), and 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, to locate and to delete them with a pencil. Both visual attention and language skills had been tested in children prior to the acquisition of reading. Surprisingly, the deficit in visual attention predicted subsequent reading skills much better in comparison to the 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 (Franceschini et al., 2013).

The skills called into question by this visual search task belong to two distinct classes. On the one hand there is the so-called "serial scan", which reproduces the mechanism of reading, symbol after symbol, and on the other there is the "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 and to drastically improve the reading skills of dyslexic children (Franceschini et al., 2013). However, even if there are many scientific papers that highlight the benefits of phonological training in the field of language acquisition, an effective modeling of how the sound experience can be integrated with 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 training and attention training in order to adapt educational game strategies for special needs (Wang, 1992) by supporting *teaching adaptively* (Mangione, 2013).

Training of Visuo-spatial Attention in Recent Scientific Research

The characteristics that define an action videogame are:

- High game speed;
- High degree of perceptual, cognitive and motor load (need to track the movement of items, need to plan different strategies, actions to put into practice quickly, etc.);
- Temporal and spatial unpredictability;
- High importance of the events that take place away from the center of the screen (Green, Li &Bavelier, 2009a; Dye, Green & Bavelier, 2009b).

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, action and non-action, for 9 daily meetings of 80 minutes. Children who used action videogames were able to read faster without losing accuracy and also showed progress in other attention tests. In particular, the group who used action videogames 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 with traditional treatments (Franceschini et al., 2012).

The attentional abilities are increased by action videogames, too. Hitting a moving target implies an ability of environmental perception and therefore a prompt attention to details that helps dyslexic children much more than a reading exercise. Thanks to videogames, 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 (Franceschini et al., 2013).

The individual variations detected in visuo-spatial and cross-modal attention functions explain about 50% of the variance relative to the improvements in reading, even after controlling for age, IQ and changes in phonological skills.

Another recent study (Harrar et al., 2014) 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 individuals affected by dyslexia to better integrate multi-sensory impulses.

Let us imagine the following scenario: during a conversation with an interlocutor, someone calls the speaker from behind. The focus will move from the person he is watching at and talking with to the back sound. This is a clear example of moving cross-sensory attention. Authors have discovered that shifting the focus from watching to hearing is particularly difficult for people with dyslexia (Harrar et al.,2014). This research involved participants with dyslexia and not in a video game that required players to press a few buttons in response to different 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, thus demonstrating a greater difficulty in shifting attention from one sensory channel to another, particularly when moving from an image to a sound.

According to researchers, such a phenomenon could be at the root of the problems that dyslexics encounter in reading and, if confirmed, the findings could lead the way to new strategies to improve how to learn the written language.

Traditional approaches require that the letters of the alphabet are first presented visually and then phonologically. This discovery reveals that people with dyslexia may learn associations between letters and sounds faster than listening to the sound and then observing the corresponding word. Traditional approaches to reading act exactly in the opposite way. Research results demonstrate that action videogames involving the training of many sensory abilities at the same time could be an effective exercise for patients with dyslexia.

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, as it happens during game experience, may help their ability to read and write.

The possible use of video games to increase the attentional abilities would be undoubtedly functional for populations of children and adolescents with developmental dyslexia. This is the most difficult form to treat with traditional methodologies to improve reading skills, which are repetitive and very costly for the child and therefore more likely to be subject to drop-out (Franceschini et al., 2013).

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. This seems to suggest the transferability of the proposed approach to special educational courses.

Pedagogical Design Elements

For the game play, we gave particular importance to the design of some specific aspects.

The first item is related to the use of a specific font that facilitates the process of reading in dyslexics. For this purpose we chose *DFONT 2.0*, standing for Dyslexic Font. DFONT has been specifically designed to facilitate the process of reading in dyslexics, since it has graphical properties which have been designed to facilitate the recognition of letters and words. Figure 1 shows the set of uppercase and lowercase letters of the DFONT.

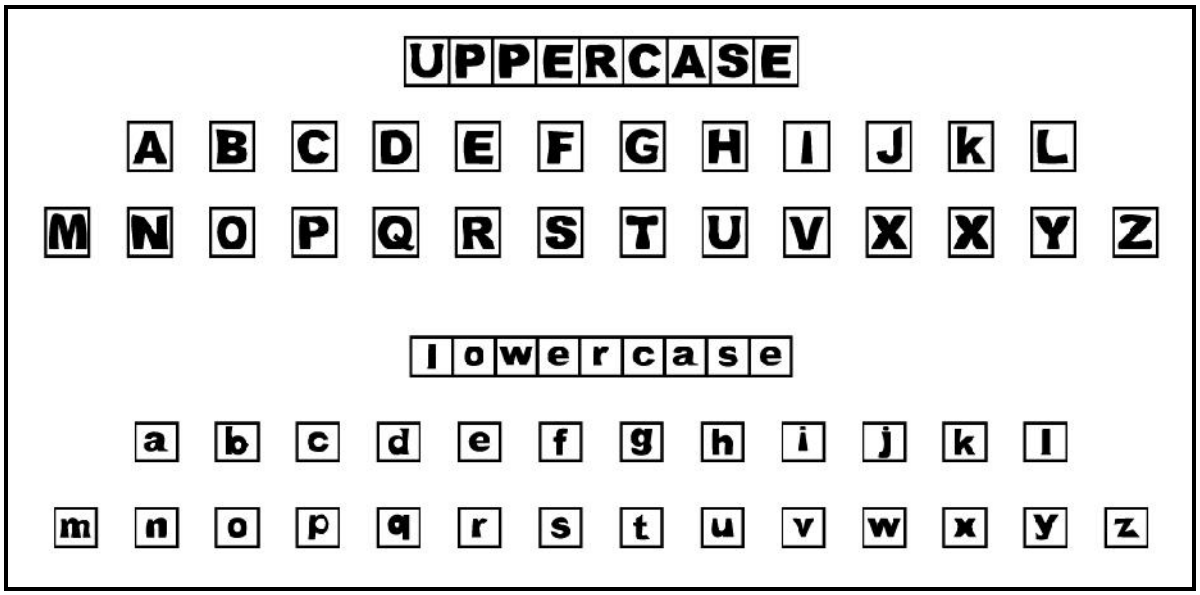

Figure 1: The character map of DFONT.

DFONT is a variant of the Arial font, which seems to be one of the most easily readable for people with dyslexia (Chung, 2002; Reid, 2004; Rello, 2008). Each letter of DFONT has been inserted in a "cage" (i.e. a square box) in order to facilitate the recognition of the individual characters. In DFONT the width of the blank character is about 3 times greater than its equivalent in Arial. This change is intended to facilitate the recognition of single words (Perea, 2012, Reid, 2004). Moreover, in DFONT kerning is absent and each letter is centered with respect to its own cage. This modification has been introduced to allow an easier identification of the position of individual characters (see Figure 2).

Another modification of DFONT is related to the shape of those letters that are more easily mistaken by the dyslexic subjects: < b , d >, < q , p >, < n , u > (Fischer, 1978; Lachmann, 2003; Reid, 2004). In many fonts, the coupled letters differ only in their orientation. In order to make them easily recognizable, their shape has been further characterized, as shown in Figure 3.

DFONT is currently being tested at the University of Salerno (Sibilio, 2014).

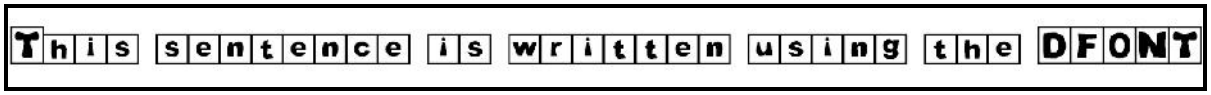

Figure 2: Sentence written using DFONT.

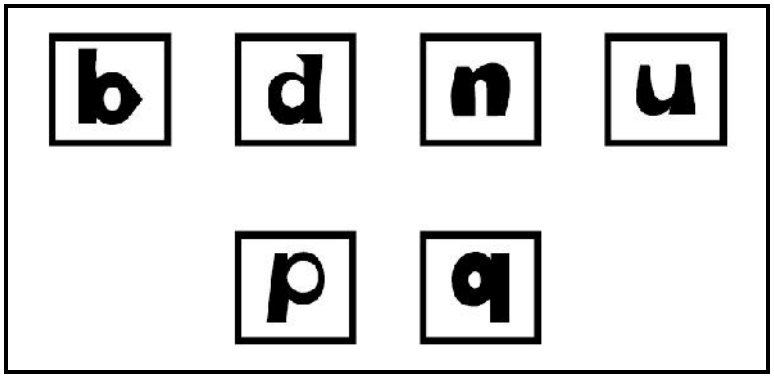

Figure 3: Letters of DFONT.

The second item refers to skill levels and specific difficulties to insert in the game. The idea is finding a balance in order to improve both users' involvement and self-esteem.

Finally, also reinforcement techniques have been designed and implemented in the game. Reinforcement refers to those devices adopted to improve performance and motivation.

Now let us describe the key aspects of the game play.

The basic goal of the game is reconstructing the right sequence of letters for the words proposed by the system. Each round is made of two distinct phases: in the first one, the system draws a word and highlights its letters on a board while pronouncing them; during the second phase, the user has to select the sequence of letters in the right order and as fast as possible. 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 or given section of the game.

As regards the identification of difficulty-related axes, we considered 5 specific dimensions:

1. *Number of letters on the board* – When letters are few, the game is easier for a number of reasons, e.g. because the player can better identify the spatial position of symbols, symbols are bigger and more clearly distinguishable, etc.
2. *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. Some letters are clearly different in their graphical aspect, whereas others may be perceived as similar;
3. *Word length* – Since the game play requires to recreate a sequence of symbols, the longer the sequence the harder the player's task);
4. *Symbol layout inside words* – For a dyslexic child, some configurations, e.g. spelling words with double consonants, are harder to be recognized;
5. *Symbol layout on the board* – The way symbols are located in the interface may influence the perceived difficulty, above all for children who are affected by concentration problems.

In Figure 4 we graphically show the differences between Level 1 and Level 4.

Figure 4. Different levels of difficulty as regards: Dimension 1 - Number of letters on the board and Dimension 3 - Word length.

Another pedagogical aspect refers to *feedback* and *reinforcement techniques*. The feedback in education is called "formative" and aims at changing the way of thinking and behaving of the students in order to enhance their learning process and their results in terms of performance. The feedback used in educational contexts is generally indicated as a crucial element for the improvement of knowledge (Azevedo & Bernard, 1995; Bangert-Drowns et al., 1991; Sales, 1993; Shute, 2008) and the acquisition of skills (Narciss, 2007). In addition to its influence on achievement, feedback is seen as a *reinforcement factor* that acts on motivation to learn (Hattie & Gan, 2011; Narciss & Huth, 2004).

As the final goal is providing a game environment to bind phonemes and graphemes, the occurrence of user errors cannot merely lead to the end of the game session. Rather, a number of reinforcements is incrementally provided to players, so that they can improve their performances. Specifically:

1. *Colors*. Any letter can be further distinguished through the use of colored boxes and high-contrast color combinations;
2. *Intonation.* Any letter can be associated to a different pitch, so that the spoken word is in a certain sense sung letter by letter.

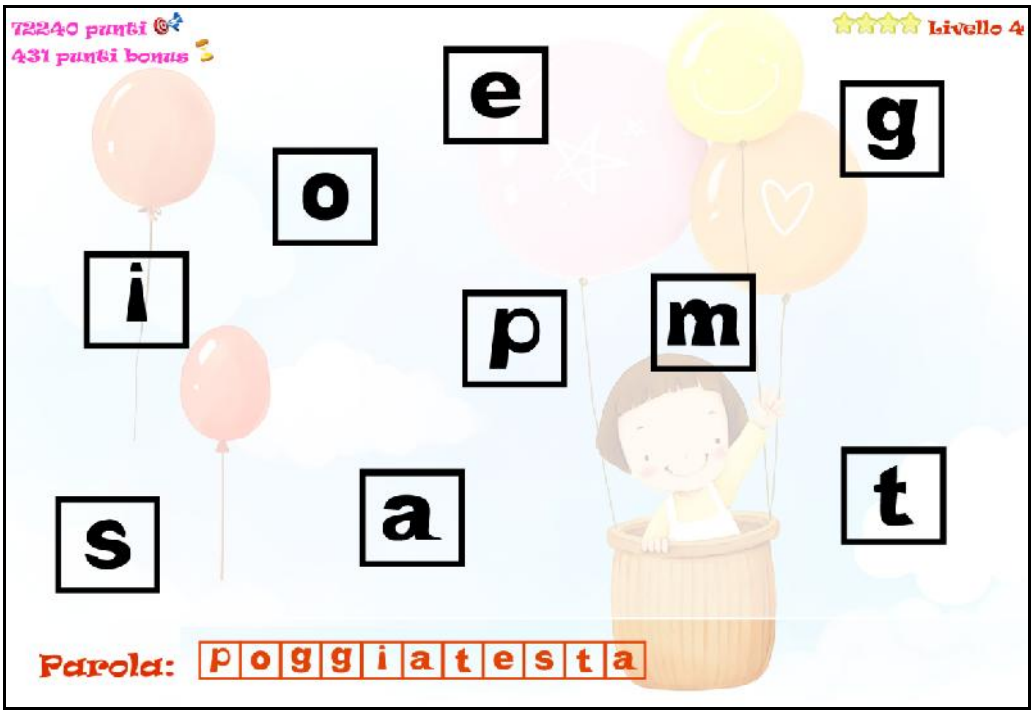

Figure 5. Reinforcement of the screenshot shown in Figure 1b as regards Dimension 1 - Colors.

Conclusion

A prototype of educational action game for dyslexics has been developed, and it is currently undergoing an alpha testing phase (i.e. software performance verification).

The beta testing will take place in schools, particularly in primary schools, involving subjects presenting DSA certification, in order to get feedback useful for corrections and improvements before releasing the stable version. The purpose of beta testing is to verify software functionality. This phase coincides, in fact, with the software verification stage that is part of the normal software development cycle.

This stage ensures that the product has been built according to the requirements and design specifications ("you built it right"). The validation stage, which ensures that the product actually meets the user's needs, and that the specifications were correct in the first place ("you built the right thing"), in the case of educational software, coincides with the stage of assessment of the effectiveness of developed teaching tools, and is historically considered controversial (Hinostroza & Mellar, 2001; Johnson, Cox, & Watson, 1994). This phase will take place at a later stage of the project, to be implemented, once the software is finally released, with, on the one hand, methods and tools of software design and, on the other hand, methods and tools of educational research.

The benchmarking tool selected will consist of MT reading tests

The MT reading tests are without doubt the most widely used objective tests to evaluate the level of learning to read at different stages of schooling. Developed in order to provide school staff a tool for objective assessment of reading skills, the MT reading tests allow to measure separately the process by which the child grasps the meaning of written message (comprehension) and the 'instrumental skills of decoding, in the parameters of fairness and quickness (Cottini, 2008).

Size and stratification of the sample group are currently being finalized, in order to establish future agreements with Italian Territorial Centers for School Inclusion (CTI), Territorial Support Centers (CTS) and the National Institute of Documentation, Innovation and Educational Research (INDIRE).

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