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Engagement is the key: a new journey for ADHD treatment

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Abstract. Attention deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders diagnosed in children, for which Cognitive Behavioral Therapy (CBT) represents the main standard treatment used worldwide, despite its pedantic approach negatively affects both patients' engagement and improvement. In this work we aim to renovate ADHD treatment with a new approach for cognitive, behavioral, and emotional patient rehabilitation. Iamhero is a first prototype of hi-tech multisensorial therapeutic environment, that bases its strength on patients physical and emotional engagement, leading therefore to cognitive and behavioral skills improvement. The first results show encouraging improvement in learning skills in patients that have steadily used the system for six months. In this paper we explain Iamhero main features, and the first experimental results obtained.

Keywords: Digital therapeutics, ADHD, engagement.

1 Digital therapeutics and ADHD treatment

Social and demographic changes that modern society is facing make ever more timely and urgent healthcare sector enhancement, with smarter solutions allowing a better therapy delivery and management, but most of all a full end-user engagement, in order to improve its empowerment and therapeutic compliance. Among the solutions that embrace both technology and medicine Digital Therapeutics (DTx) are emerging, namely as a “deliver evidence-based therapeutic interventions that are driven by high quality software programs to prevent, manage, or treat a medical disorder or disease”. [1] DTx can be applied on a wide range of pathologies, especially those whose cure or treatment have a psychological basis or are enhanced by a proper patient behavior, such as neurodevelopmental disorders, anxiety, depressive disorder, substance abuse, obesity, diabetes, etc. Within the framework of DTx, we present in this article a hi-tech multisensorial therapeutic environment called Iamhero, that aims to help young ADHD patients to improve their cognitive and behavioral skills. According to the main guidelines [2], Attention Deficit Hyperactivity Disorder (ADHD), is a neurodevelopmental disorder characterized by a persistent pattern of inattention and/or hyperactivity/impulsivity that are often associated with other

psychiatric comorbidities. The main treatments can be divided in pharmacological (stimulant or not stimulant) treatments or non-pharmacological treatments, such as Cognitive Behavioral Therapy (CBT); such options are often combined with personalized educational plan at school and parental training. Although CBT represents a gold standard, it still has clear limits, as the scholastic and repetitive approach of some of the activities realized with the young patients may lead to frustration and refusal of the treatment, or more generally to a low level of engagement, with consequent negative influence on the treatment efficacy [3]. At the same time, such approach presents limits also for the therapist, as it does not allow a real-time evaluation of patients progresses. Iamhero system set itself as a key to resolve these challenges, aiming at improving patient's engagement and therapist's therapy management.

2 Iamhero: a new boost for ADHD treatment

Iamhero is a game-based therapeutic environment that bases its strength on patients physical and emotional engagement, leading therefore to cognitive and behavioral skills improvement. The system has been developed in collaboration with a pool of ADHD experts and end-users that - in a user-centred design approach – not only have highlighted the therapeutic goals to pursue but have also provided feedback throughout the development and test phase. Another key factor for Iamhero development is represented by Emotional Design. According to Norman [4], emotions are a crucial component that affects cognitive process. Each component of Iamhero games – such as the use of challenges, self-consistent tasks, use of positive or negative feedbacks, a consistent narrative, an age-tuned graphic design - has been designed to work on patient's engagement and trigger emotions.

Iamhero is composed by three macroelements:

Applied games: *Topological categories*, *Infinite runner* and *Space adventure* are three games used in clinical environments under therapist supervision. “*Topological categories*” (Fig. 1) is a 6-levels VR-based game that allows to incrementally train one or several topological categories and simultaneously work on attention, planning, focus, memory, and the ability to wait and stand still. “*Infinite runner*” is an 11-levels exergame in which the player will simulate the game character movement by running on the spot and shifting laterally, to avoid obstacles and capture specific items. Through the game is possible to



Figure 1. Game session of *Topological Categories* game

work on semantic categories, motor coordination, attention, ability to wait and respect of the rules. “*Space adventure*” is a 7-levels game (with 3 difficulty modes) that can be played by means of a motion-sensing device or mouse. The game allows to work on the ability to work on the patient's attention, memory, ability to solve complex problems and to reflect on the cause-effect relationship resulting from actions. **Gamification**

app: contains four minigames that aim to enhance the same skills acquired by the patients during the clinical sessions. The app can be used both on iOS and Android tablets or smartphone under parent supervision, therefore continuing the therapy beyond the clinical sessions. **Dashboard:** platform that allow the therapist to administer the applied game in clinic, assign tasks to be executed at home on the gamification app, monitor patients' performances, evaluate goals achievement and accordingly personalize the therapy.

The advantages of Iamhero are multiple: 1) the system allows a holistic training, as the presence of increasing degrees of complexity in the different game levels enables to train little by little more skills simultaneously. 2) the system constantly provides reinforcement or warning. 3) Whenever a task is completed, the game analyzes it on the basis of specific parameters (e.g., comprehension of topological or semantic categories, attention, planning, environmental stress, etc), based on which a score is elaborated. 4) Each score, as well as the progress trend are available in real-time within the dashboard, allowing the therapist to personalize both the session and the treatment in the short-to-medium term.

First results

The games here presented have been experimented for six months in a private clinic in the framework of a national research project (Progetto BRAVO)[5]. An experimental sample of 60-patients group has been selected, ranging from 5 to 12 years old and with a diagnosis of ADD or ADHD in comorbidity with language and learning disabilities. Patients have been sorted in Control Group (CG) that attended only standard therapy session in clinic, and an Experimental Group (EG), in which standard treatment were interspersed with session with applied games (plus the use of the gamification app at home in time between the clinic appointments).

In order to evaluate the system usability and to conduct the first efficacy assessments, standardized tests have been administered at the beginning (T0) and end (T1) of the experimental period. The efficacy resulting from combining traditional therapy with applied games has been verified through a repeated-measurement Analysis of Variance (ANOVA-MR) of standardized tests scores, evaluating from statistical perspective not only the differences between the two administration timings (pre and post experimental period) but also to analyze possible differences between the control and experimental group. The analysis has been conducted specifically form the tests mostly administered among the experimental sample for the purpose of ensuring compliance with the statistic assumptions at the basis of the theoretical framework. Results highlight an overall average improvement of cognitive performance of patients and underline the statistical significance ($p < .05$) of the differences between T0 and T1 as regards the following cognitive skills: ability to select in the mental lexicon target words belonging to specific semantic categories, lexical, concentration, inhibition, and selection abilities, Visual Motor Integration ability, Performance-related age in relation to child IQ and improvement measures. These results (Table 1) confirm that both groups have experienced an improvement of the abovementioned abilities, but in some cases the improvement is stronger in the experimental group, suggesting a positive effect of Iamhero system, the satisfaction, engagement, and positive emotions felt during the game.

Table 1. Standardized tests ANOVA-MR results

| Test | CG | EG | CG | | EG | | Time | F (p value) | |
|------------------------------------|----|----|-----------|-----------|-----------|-----------|----------------------------------|----------------------|----------------|
| | | | pre | post | pre | post | | P Interaction | p Group |
| BVL – Grammar comprehension | 17 | 25 | 21. 32 | 20. 79 | 21. 62 | 25. 90 | 3.5 4 (.07) | 5.82 (.02) | 0.5 3 (.47) |
| BVL Phonological fluency | 17 | 26 | 5.2 8 | 6.5 8 | 4.4 1 | 7.1 4 | 10. 21 (.01) | 1.30 (.26) | 0.0 1 (.93) |
| BVL Semantic fluency | 17 | 25 | 13. 33 | 15. 92 | 13. 98 | 17. 34 | 12. 35 (.01) | 0.21 (.65) | 0.2 1 (.65) |
| BVL Phrases rep. | 17 | 23 | 7.9 7 | 9.3 8 | 7.3 6 | 9.1 0 | 7.4 9 (.01) | 0.08 (.78) | 0.0 8 (.78) |
| BVL Non-words rep. | 16 | 25 | 8.5 8 | 9.2 0 | 7.9 0 | 10. 18 | 11. 95 (.01) | 3.88 (.06) | 0.0 1 (.93) |
| GOODENOUGH DRAW | 11 | 12 | 5.2 0 | 5.8 1 | 5.4 4 | 6.0 3 | 16. 52 (.01) | 0.01 (.95) | 0.4 3 (.52) |
| VMI | 11 | 10 | 14. 39 | 16. 39 | 13. 53 | 14. 93 | 4.6 7 (.04) | 0.14 (.71) | 0.3 7 (.55) |

Conclusions

In conclusion, Iamhero system shows promising results when applied in combination with ADHD non pharmaceutical therapies. More investigation will be carried out in the following months within a clinical trial, to confirm the first results obtained. At the same time, the system is open for new development in order to enrich the applied game set and the related trained skills, as well as exploring neurodevelopmental disorders that can benefit from the same game-based approach.

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