A Robotic Therapy for Children with TBI

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***Abstract*—This paper presents the introduction of a study to compare different treatments within a program of counseling and education directed to parents with a cognitive rehabilitation program aimed at children through robotics. The Essentials of this program are described in detail. The aim is neuropsychological rehabilitation, addressing cognitive, emotional, behavioral and psychosocial deficits caused by brain damage.**

***Index Terms*—Children, Health, LEGO, Recovery, Robotics, TBI, Treatment**

I. INTRODUCTION

Increased survival in Traumatic Brain Injury (TBI) has led to an increase in child patients with cognitive sequel. Children are particularly vulnerable to persistent deficits, according to [1], usually the child with TBI maintains the consolidated cognitive functions until that moment, but may present problems in the functions being developed at the time of TBI and those that will be acquired in the future. Problems can arise even years after suffering brain damage when academic and social demands are more challenging. It is important to monitor these children over time to avert future financial cost to the state due to the high rate of unemployment in this group.

At the international level, there is one class A study (prospective, randomized) that has shown good results with direct clinician-delivered and indirect family-supported rehabilitation with children under 12 years old. The indirect family-supported group reached better results than the direct clinician-delivered. This study was conducted in [2].

In recent years there is an emergence of innovative technologies for cognitive rehabilitation like computerized rehabilitation programs, virtual reality, remote rehabilitation and robotics [3]. The lack of generalization of learning process is one of the criticisms to computer based cognitive rehabilitation. The neuropsychologist should monitor the activities and help the child to develop compensatory strategies and generalize learning sessions to daily life situations [4]. As an alternative technological tool to Virtual reality or remote rehabilitation, Robotics is a multidisciplinary scientific tool which motivates and stimulates learning in children [5,6]. A key point of robotics is the adaptation to any kind of activity, and furthermore, is the perfect Device for remote monitoring. The Robot, as therapist extension, can realize therapeutic and companion functions simultaneously [3].

There is a lack of randomized studies evaluating the effectiveness of rehabilitation treatment in children with TBI, so the main aim of this study is to compare a program of counseling and education aimed at parents with a program of cognitive rehabilitation directed to the child through robotics and determine which treatment is more effective in this population compared to the control group.

II. METHODOLOGY

We have three groups of children with a total sample size of 90 subjects. Given the low number of similar studies, the sample size calculation was based on the mean differences pointed out as a relevant variation by the research team, for the main scales assessed in this study. With a statistical power of 80% and a confidence of 95%, this sample size allows to capture significantly a pre-post mean difference equal or upper to 10 points between treatment and control group for Working Memory, Wechsler Intelligence Scale 4th edition (WISC-IV) and Vineland scale and a mean difference equal or upper to 8 points in Achenbach's general index scales. This sample size calculation includes a 10% of losses for possible dropouts.

Inclusion criteria: 1) age 6 to 18 years, 2) history of moderate or severe TBI, and 3) TBI 6 months prior to the beginning of the study.

Exclusion criteria: 1) previous diagnosis of severe psychiatric disorder, 2) Intelligence Quotient (IQ) below 70, and 3) significant vision, motor or hearing loss.

Patients were assigned to a treatment group with a random assignment method. The randomization was done in two phases, first girls and then boys, to ensure that there is equitable distribution. The groups consisted of:

- Group A: Parents Intervention (PI) 2h/week (group+ 5 individual sessions).
- Group B: Child Intervention (ChI) 10h/week (group).
- Group C: Control group.

A neuropsychological assessment prior to beginning the rehabilitation treatment has been done to all patients, complemented with scales of functionality to families and schools. Thereafter we are going to do a follow-up study at 3 months of treatment, a control assessment after the end of the treatment and another after one year. The objective of administering functional scales to parents and teachers is to determine the generalization of learning acquired (ecological validity) when the treatment is finished.

The subjects of group B, Child Intervention, were divided in three groups, according to their age. We delivered the robot in three phases of 2 weeks long. During this period the patients

went to the hospital 2 hours every day to get trained in the use of the robot and general problem solving. After these two weeks the children took the robot home, and they returned once every week to upload the information of the robot and set up the new activities, except those ones who live far away from Barcelona, that sent the information through Internet. This procedure took 6 months with a frequency of 2 hours per day, 5 days a week, which makes a total of 240h of treatment.

III. DESCRIPTION OF THE ROBOT

The robot is composed of a LEGO Mindstorm NXT attached to an iPod plus extra hardware that enhances the connectivity of the robot. The robot is presented in Fig.1

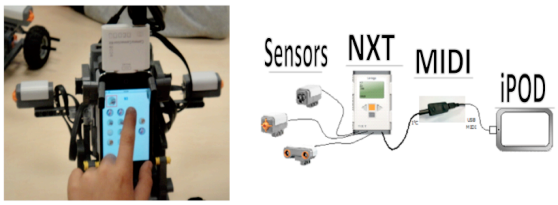

Fig. 1. On the left we can see how the robot looks like. On the right we present the schematic of the robot.

This robot has 3 main functions: 1) it is running the set of activities introduced by the therapist, 2) it is monitoring when, how often, how long and how good the child is performing the activities, and 3) it has a pet robot behavior implemented, so the results obtained from the activities, the batteries level, and the overall usability of it affects to its state, making it happy, sad, angry, sick, etc. In addition, to rehearse habits, the children need to take care of it depending on daily situations like the forecast of the day or do a feed simulation with a balanced diet.

The programming is based on a bidirectional communication between the iPod Touch and the LEGO NXT through a Teensy 2.0 microcontroller board, programmed in the Arduino IDE using the MIDI protocol between Teensy and iPOD and I^2C protocol between Teensy and NXT.

The NXT is responsible for reading the sensors (touch sensors, color sensor and ultrasound sensor) and for reading from the iPod to execute actions such a movement of joy when an activity is done properly. Using the iPad USB Camera Connector Kit, we can plug our MIDI Cable of the Teensy 2.0 microcontroller board directly into the iPod.

IV. DESCRIPTION OF THE ACTIVITIES

These activities are composed of exercises focused in learning skills and classified in three levels and themes in order to be appropriate to the children profile in terms of realization time, difficulty, and engagement. All the activities are designed as real life situation, the so-called ecological activities.

The activities are classified according to its cognitive functions as: Selective attention, inhibition, alternant attention, split attention, working memory, abstract reasoning, fluency, planning, categorization, verbal memory, and visual memory.

There are activities that are played using the iPod interface (touching, talking or showing images), some of them are played using the LEGO sensors (touch sensors, color sensors, etc.), some of them, as abstract reasoning, is required to program the robot, and others like Planning, Selective attention or Categorization is required to built an add-on to the robot.

V. STATISTICAL ANALYSIS

At the end of the experiment, a summary of study's data will be presented, showing different measures of central trend (mean, median and mode) and dispersion (standard deviation, quartiles, rank). The homogeneity of the main variables in the study between groups at the baseline moment will be tested with the Student T test in case of normally distributed variables. Mixed models of random and fixed effects will be used to carry out analyses of repeated measures collected along the different assessment moments in the study period and collected in the database designed. Results will be considered significant for p values less than 0.05. Analyses will be conducted with R 2.13 and SPSS 19.

VI. CONCLUSIONS & EXPECTED RESULTS

The versatility and worldwide diffusion of LEGO robot materials have permitted to adapt and correct those elements that didn't work properly after the preliminary tests.

Better outcomes will be expected for both treatment groups, comparing to control group. More specifically, a better adaptation to the activities of daily living and an improvement of behavior management in children under 12 after the PI is expected. In children older than 12 years, a better performance on cognitive functions, especially in tasks related to attention and executive functions, after ChI is expected.

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