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Promoting interaction amongst autistic adolescents using robots

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***Abstract*— Most autistic people present some difficulties in developing social behavior, living in their own world. The intent of this study is to improve the social life of adolescents with both autism and mental impairment, with a main focus on promoting their social interaction and communication. An experiment designed to call for the adolescents' attention and enforce their collaboration is described; in it a LEGO MindStorm robot behaves as a mediator/promotor of this interaction. Further, sensory motor coordination and accuracy skills of the adolescents are also slightly explored. Four scenarios were envisaged. Results are described showing the outcomes of the experiment.**

I. Introduction

AUTISM is a global development disorder which typically manifests itself during the first three years of life [1]-[3]. The symptoms that characterize autism manifest themselves through a continuum of severity, ranging in degree, from light to severe and may be associated with a set of other types of disorders. On the basis of the diagnosis of this disorder we consider three nuclear behavioral changes, as follows: a) Qualitative changes in social interactions. b) Qualitative changes in verbal and non-verbal communication skills. c) A reduced, repetitive and stereotypical repertoire of activities and interests [4]. This leads to the need for immutability in daily routines, the absorbing interest for one or more stereotypical patterns that are restrictive of theirs interests and the presence of motor mannerisms [5-7].

Intensive research [8-10] has focused on the introduction of robots in the classroom of children with autism, with the main goal of supporting professionals and families in the promotion of the children's cognitive capabilities, social interaction and communication skills. Robots seem to act as a key tool able to call for attention of autistic children, and promote their cognitive and social development [11].

This work is part of a larger collaborative project [12] between the University of Minho and APPACDM (an association for mentally disabled people) of Braga. The project's main aim is to develop a robotic tool able to improve the social life of adolescents with both autism and intellectual deficit, with a main focus on promoting their social interaction and communication. A particular interest will be on the promotion of sensory motor coordination and movement accuracy capabilities of these adolescents. The robot should be used to elicit tasks that somehow will force the execution of some of the daily duties that adolescents are used to practice with the therapists and carers. The idea is that the robot may be used both as a complement to this daily therapy and a substitute for the therapist for the most trivial tasks.

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II. Related Work

Therapists of emotional, cognitive and physical impairments use different props to support therapeutic processes. For example, a wide range of toys to foster externalization can be found in children´s therapists' working rooms. More recently, the use of robotic toys have been explored to facilitate the therapeutic process of children with ASD (Autism Spectrum Disorder), with the robot acting as a mediator between the child and the therapist. In fact, many children with ASD are interested to play with mechanical toys or computers. Research [8-10, 13-15] has found that interacting with the robots draws these children into a range of new social behaviors.

There are a few projects investigating the use of robotic platforms for therapy with children suffering from ASD.

Herein, the main goals and outcomes of some of these projects are briefly described, but many others are also important and are not described due to space limitations.

The project AURORA has been investigating, since 1997, the use of a robotic platform as a tool for therapy with autistic children [8]. The main issue is to study if and how robots can become a toy that might serve an educational or therapeutic role for children with autism, focusing on helping to increase their communication and social skills [8,14].

In this context, another research [15] refers to the effects of repeated exposure of autistic children to a humanoid, concluding that, in some cases, the children started to use the robot as a mediator, an object of shared attention, for their interaction with their teachers [9,18].

Kaspar, a small minimally expressive humanoid robot, also part of the Aurora project, continues the researchers' investigation on the potential use of robots as therapeutic or educational "toys", specifically used by children with ASD.

The research focuses on ways through which robotic systems can engage autistic children in simple interactive activities, such as turn-taking or imitative interactions [18].

The ROBOTA project is part of a current trend of robotics research that develops educational robot toys. ROBOTA stands for the name of a series of doll-shaped mini-humanoid robots, whose physical features resemble those of a human baby. These studies investigate the potential of using an imitator robot to assess children's imitation ability and to teach children simple coordinated behaviors [9,15]. They can engage in complex interaction with humans, involving speech, vision and body imitation.

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Keepon is a small creature-like robot designed for simple, natural, nonverbal interaction with children. The minimal design of Keepon‘s appearance and behavior is meant to intuitively and comfortably convey the robot‘s expressions of attention and emotion [16, 17]. For the past few years, they have been observing 2-4 year-old children with autism interacting with Keepon, that is only capable of expressing its attention and emotions [17].

Despite this research there are many open questions which remain unsolved and other related questions to address: What is the effect of repeated exposure to these toys? What should be the feature of these robots? What outcomes can be further expected from this interaction?

This work intends to show research as an answer to these previous questions. It describes an ongoing work aimed at improving the social life of adolescents with both autism and intellectual deficit, with a main focus on the promotion of their social interaction and communication where the robot acts as a tool to improve these adolescents' motor control.

Therefore, experiments were delineated in order to: a) make the robot's and objects' features appealing to the adolescents; b) enforce sensory motor coordination and motor control skills; c) enforce their color knowledge; d) encourage an active participation of the target group; and e) promote interaction amongst two individuals.

III. Methodology

The different experiments took place in the facilities of the APPACDM in Gualtar (figure 1).

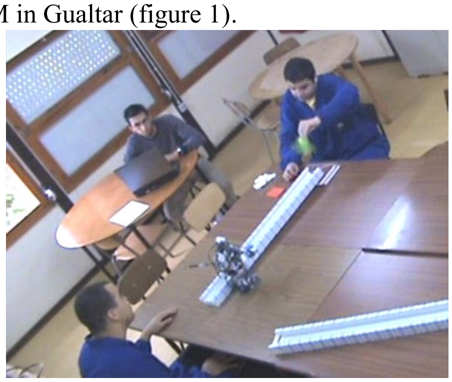

Fig. 1- Classroom setup for the experiments.

The addressed target group is very sensitive to changes in their daily routine/life, namely to changes in their usual surrounding environment. In order to reduce the stress related to these changes, experiments were performed in the classroom where the adolescents usually work. Each adolescent has an educational program that has been specifically delineated for him. However, no therapy or methodology specifically addresses their daily routine and the educational program is more delineated towards basic social behaviours, such as hygiene.

A. The robot

The robot used in the experiments is a LEGO MindStorms NTX, with a human-like shape. It is important to note that at this point the robot was being controlled using Bluetooth technology by one of the researchers, in order to assure robustness and feasibility.

B. The adolescents

Two autistic adolescents with mental disorders were chosen as the target group. These adolescents have behavioral characteristics somewhat different from each other. Adolescent 1 does not like the changes in his daily routine and these changes can cause an aggressive behavior. On the other hand, adolescent 2 presents a less aggressive behavior and does not require so many cares. Both have some difficulties in communicating, especially in speaking.

C. Experiment

The experiment was carefully designed by carers, therapists and researchers. The idea was to explore the use of color cards to elicit sensory motor coordination. These are features that we wanted to promote in the adolescents. Further, we wanted to call for their attention and encourage their active participation in the experiment and also their contribution towards a common goal. We have envisaged four different scenarios, as depicted in figure 2. At one end of the path, stood the adolescent and at the other end there was the robot. A ball travelled along the path, from the robot to the adolescent and vice-versa.

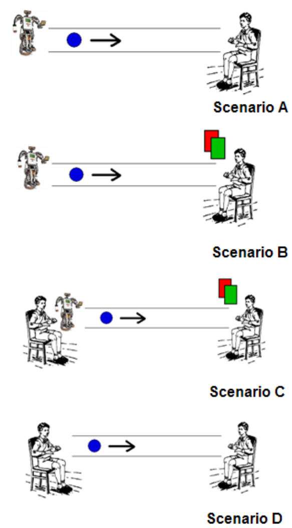

Fig. 2 – Four possible scenarios. The ball circulates along a path that connects the two users involved in the experiment

Scenario A was the simplest and the first one that the adolescent was faced with. Initially, the ball was located near the adolescent. Once he threw the ball towards the robot through the path, the robot kicked the ball back to him. The adolescent was expected to correctly control the required strength to send the ball.

Scenario B introduced two new elements to the setup. Two coloured cards, green and red, were placed over the table nearby the adolescent. Several times the cards were mixed, such that their position over the table changes. The adolescent was expected to show the green card with one hand and throw the ball with the other.

In Scenario C, the two adolescents participated in the experiment, each at one side of the path. An adolescent sat next to the robot, and his role is to eventually adjust the robot such that it could kick the ball when required.

In Scenario D, the robot was removed and only the two adolescents, the path, cards and ball remained. The idea was to verify if they started playing together, reproducing or not the same rules that had been applied in Scenario B and C.

The ball was blue, a different color from the card's color, so that no influence occurred in the cards' choice.

E. The sessions

In a previous work [12], it has been described that the robot was introduced to the students through three basic stages: exploration, demonstration and interaction phases. Results have been presented [12] reporting the exploratory and demonstration phases, in which the robot was gradually introduced by the carer to the adolescents, allowing them to observe and accept it as an object in their routine, avoiding strange behaviors from the adolescent. Herein, the interaction phase is described. The robot, adolescent and carers are all together, but the carer has a more secondary role with no interference in the experiment.

Each experiment is first demonstrated by the researcher. Both Scenarios A(C) and B(D) are performed on the same session, firstly Scenario A(C) and then Scenario B(D). Each individual experiment (scenarios A and B) was repeated several times with adolescent 1, and later on the scenarios (C and D) involving both adolescents were also repeated in order to find a kind of pattern behavior in the adolescents.

IV. Results

Four individual sessions and two joint sessions with both adolescents were performed. These sessions were planned in such a way that all of them had the same duration time and the same operation modes, allowing to compare results and to verify the evolution in the robot-adolescent interaction. Each session lasted for 20 minutes, 10 minutes for each scenario. Sessions are performed weekly for 4 weeks. Whenever the adolescents seemed to lose interest there was some positive reinforcement from the researcher. Individual experiments, comprising scenario A and B, were performed only with Adolescent 1. In Scenario A and despite some initial resistance, adolescent 1 managed to play the proposed game with the robot. Initially, he was only interested in the robot's components, but after two sessions, he was able to push the ball towards the robot, which kicked the ball back to him. Frequently, some stereotypical patterns, like motor manifestations, were performed. However, when he was concentrated in the experiment, these patterns seemed to calm down. Sometimes, he was not able to control his strength, but with positive reinforcement from the researchers, he was able to complete the task successfully.

In Scenario B, the researchers introduced the use of colored cards to activate the movement of the robot's arm to throw the ball. Adolescent 1 is not capable to distinguish the green from the red card, so he initially activated the robot movement, picking the card by trial and error. He became capable of differentiating the two cards, and correctly choose the card that elicited the robot to behave as he wanted it to. Despite the fact that he could not associate a name to the color of the card, the need to differentiate the two cards forced him to pay special attention to this property. This enforces basic cognitive knowledge, which is one of the goals of his daily educational programs. By the second session, when the researchers mixed the cards, he was able to choose the right one. It is important to stress the fact that this adolescent could not still say the colors of the cards, even when asked to do it. But this experiment taught him that they were different and they elicited different actions.

Figure 3 presents results from the video analysis of the scenario B experiments, and data was collected according to the choice of the cards. During the first session the adolescent did not succeed in activating the robot's motion, because he mainly kept throwing the ball as in scenario A. The research tried to encourage and even demonstrate the experiment a few times more, but without results. However, in the following sessions, the adolescent was able to activate the robot using the green card, and to understand the goal of each card in the game. There was a growing interest in using the green card relatively to the red one.

Figure 4 presents results from the video analysis of the experiments, regarding scenario A and B. Four behaviors were considered: Ignores Robot; Motor Manifestations; Looks for Help and Stares at the Robot. The tendency to produce no movement and just to look at the robot, the behavior *Stares at the Robot*, decreased over time as the adolescent gets used to the robot and it is no longer new but rather something he accepted. Note that the behavior *Ignores Robot* decreased throughout the sessions. In fact, the adolescent became so engaged with the robot that it ignored completely. The motor manifestations presented no specific pattern, and overall showed some tendency to decrease with the session' number. On the other hand, we believe that a social interaction was in fact achieved since the adolescent tried to progressively include the researcher more and more in the experiment.

Two weeks later, we started to perform joint sessions, involving both scenarios C and D, involving two adolescents. Adolescent 2 is capable of differentiating several colors and can even say their names, he knew the cards' roles, and when performing alone in scenario B, he had no doubt which card to pick, even when the researchers changed the cards' places.

In scenario C, one of the adolescents was responsible for showing a card and the other to adjust the robot position, if necessary, so that the robot could kick it. After 5 trials, their roles were exchanged. When the robot was completely removed (scenario D), there was some disappointment. But then the researcher suggested that both adolescents could play with each other, and made a demonstration together with adolescent 2. When interacting together, the adolescents showed a tendency to throw the ball to each other, without including the cards and the rules that existed before.

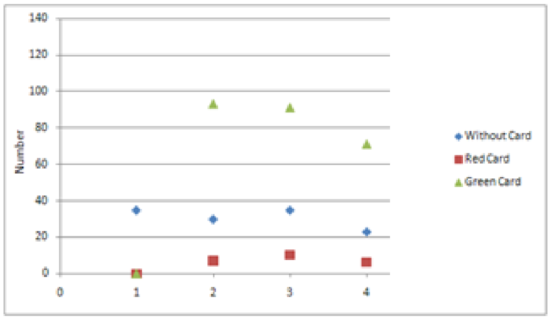

Fig. 3 – Occurrences in scenario B by adolescent 1

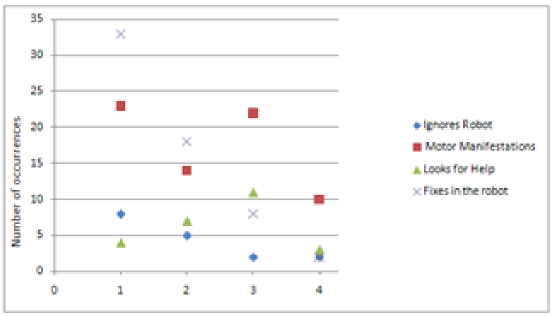

Fig. 4 –Interaction of adolescent 1 (scenarios A and B)

However, after being reminded by the researcher, they started to play like before the robot's removal. Adolescent 2 is more interactive and also presents a more developed cognitive level. He showed some preference for being the one that has to show the cards, while adolescent 1 was more interested in performing the robot's role. They continued to play together and had to be forced to stop. These were considered excellent results from both the therapists and the carers, and later on, the parents were very excited about it.

V. Conclusions

In this paper, we described results of an experiment, which aimed to call for the attention of two autistic and mentally impaired adolescents, and enforce their collaboration. We were particularly interested in answering some questions, namely: "what kind of robots, and what robot features, are better suited to help to capture autistic children's attention and, as such, improve their learning capabilities and development?". We applied a mobile modular robotic platform as a means to encourage the participation of these adolescents, and promote the interaction between the two of them who previously did not showed no interest in cooperating. It is well described in literature [8-11] that strong colors and cyclic and repetitive movements seem to attract autistic adolescents. Furthermore, these people seem very pleased to play with mechanical toys or computers. We have explored these issues to promote the final interaction between the two adolescents. In addition to this, we have tried to teach some fundamental cognitive knowledge and also the capability to undergo coordinated behaviors. The work presented is part of a research project concerning the use of robotic platforms to reach autistic people. In further studies, attention will be devoted to the temporal analysis, performing a statistical analysis, in order to better understand the evolution of interaction with time. Other experiments will be carried out, trying to involve more strongly the goals of traditional therapies in these robotic experiments.

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