Rob'Autism: how to change autistic social skills in 20 weeks

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Abstract. Rob'Autism proposes an approach to improve social skills of people with autistic spectrum disorders. The program focuses on linking voice to gestures, and checks the emotional effects of this linkage. Rob'Autism is divided into 20 sessions of 1 hour each, alternating preparatory sessions and robotics sessions. During the preparatory sessions, the subjects register their voices reading a story. During the robotics sessions, the subjects program the robot gestures according to the registered voices. In this program, the robots are used as an extension, and not as a companion as traditionally performed in other research programs. Consequently, the subjects immediately use it for their communication with others, showing consequent improvements of their communication skills, inside and outside the sessions, in a very short time. The program has also proven to length in time, as 6 months after its end, its effects on the subjects can still be observed. This article review the preliminary results of Rob'Autism, validated with 6 young test subjects with autism, aged 11-15.

Key words: Rob'Autism, Autistic Spectrum Disorder, voice, gesture, robot, programming.

1 Introduction

The use of robots to improve skills for subjects with autistic spectrum disorder started in the late 90's with Dautenhahn's work [4, 14]. Since then, the AURORA European project led by Dautenhahn [5] and grouping worldwide researchers (Robins [10], Billard [2], Dickerson [6], Werry [15], etc.) allowed many developments and various protocols on different robotic platforms (human like or not). Many other projects appeared since 2010 thanks to the appearance of the affordable platform NAO (Aldebaran Robotics).

Dautenhahn suggested the use of a robot as a companion for autistic young subjects, introducing the concept of *Robots as social actors*: the robot should be equipped with a specific software that makes it look as an autonomous person, in the sense that the robot comes with its own personality, and could exchange with the subjects on topics proposed by the therapist approach. For example, the robot would show the child different images, and ask him/her to point out an apple, or a boat, and so on. Then the child must show the selected image to the robot, which validates the selection or ask to choose again. In this framework, solicitations come from the robot and are performed as would a non-autistic adult do. The concept is based on the fact that autistic subject have a natural attraction to robots. Immediate search for interaction can be observed, curiosity and desired communication with the machine that was difficult to perform with human persons.

All other worldwide researchers tracked the same approach using the robot as a companion. Then the approaches explored different situations and exercises, aiming at improving one specific skill at each contact such as social interaction or communication, imagination, spontaneousness, free talking, proximity acceptance, focus and concentration, care for objects, imitation. More and more researchers are working with robots for autism, especially since the appearance of the robot NAO on the market (2009) for an available cost [12, 13, 1, 3].

The appearance of the robot was particularly studied by Feil-Safer [7] and Robins [9]. All authors showed that a humanoid shape was more efficient on children progresses than other (animals or mascots) shapes. It was mentioned that robots do not replace human beings, but may increase their capabilities [8, 11]. Still, the social companion approach has not been questioned yet, even though this approach is equivalent to replacing human being with a robot.

The Rob'Autism project proposes another approach using the humanoid robot NAO (Aldebaran Robotics): it is not used as a robot companion, but as a machine that does not do anything without the programing of the subjects. As a consequence, the robot is directly approached as an extension that allows safe communication. This paper will describe the context of the project, its sequences and the observations made in its preliminary stage.

2 Context of Rob'Autism Project

2.1 The project

Rob'Autism is a multidisciplinary project linking medical, arts and sciences fields. It was born in 2014, and can continue thanks to the collaboration of four partners: 2 academic institutions: CHU-Nantes (CPGEA Samothrace: day hospital for autistic young ones) and *Ecole Centrale de Nantes* (school of engineering), and 2 non-profit organizations: Stereolux (science and culture) and *Robots!* (Robotics and arts). Rob'Autism consists in a therapeutic support for autistic people, which lasts 20 weeks and is based on interactions between subjects and robots. Rob'Autism is organized in 20 sessions of 1 hour each, once in a week. The sessions alternate 10 non-robotics and 10 robotics work groups.

2.2 Subjects and Material

Six young teenagers aged from 11 to 15 years old participated in this experiment, 5 boys and 1 girl. These test subjects suffer from autistic spectrum disorders. The 6 subjects have some ability to read and write, and they are familiar with the use of a computer. They have known each other and the medical staff members for four years, and had participated to another work group using a software dedicated to voice exercises. The location of the work group for the robotics sessions was chosen the same as their previous working sessions, so the working environment was also familiar to the subjects.

The program uses 3 humanoid robots NAO from Aldebaran Robotics. The robots are programmed by the subjects using the software interface *Choregraphe*, which is the classical programming interface sold with the robots (i.e., no specific software was used for the programming).

2.3 Organization

The robotics sessions make the subjects program the robots and are organized as follows: two children per robot, using the same computer (See Fig. 1). The three groups face each other: the working tables are in the center of the room in such disposition that each group can see the two other ones. Each group is assisted by one nurse trained in robot programming, and a robotics specialist is also present in the room to help with specific programming requests (see below for the sessions content). When the children enter the room, they find the robots and computers always at the same place. The computers are switched on, but not the robots (except for the first session).

Fig. 1 Two out of three working groups during Rob'Autism working session. Each group contains two subjects and one nurse.

For the non-robotics sessions, a sound specialist leads the working progress of the 6 children, assisted by three nurses and a speech therapist. The room is located at the CPGEA center, with no tables but cushions on the floor.

3 Sequences

We present in this section the sequences of the project, describing the sessions and their context, the program preliminary- and post-work.

3.1 Before the 20 weeks Rob'Autism program

The medical staff was trained to program the robots during 12 hours (one and a half day) before the start of the program to get the ability to share the robot experience with the subjects and help them with simple programming questions. This knowledge is absolutely necessary as the medical staff can keep the children focused on the session objectives by helping them when necessary. Still, as the medical staff is not specialized in robot programming, the presence of a robot specialist is required during the 10 robotics sessions.

3.2 Non-robotics sessions

The non-robotics sessions aim at preparing the robotics sessions. The project focuses on linking voice to gestures. So the program was set to make the robot tell a story, using the voices of the subjects. The chosen story is *Voices in the park*, by Anthony Brown: four characters share a story in a park, and the four tell the story with their own interpretation. During the non-robotics session, the children were asked to read the story, and their voices were saved to be replayed by the robots. The global organization was the following one:

- Session 1 : Draw a Robot
- Session 3 : First reading of the story / Discuss security (fragility) of the robot / talk about first contact made in session 2
- Session 5 : Registering voice 1 / acting voice 1 (with gestures)
- Session 7 : Registering voice 2 / acting voice 2 (with gestures)
- Session 9 : Registering voice 3/ acting voice 3 (with gestures)
- Session 11 : Registering voice 4/ acting voice 4 (with gestures)
- Session 13 : listening to voices 1 and 2 / discussing tone, gestures and emotions. Modifying some passages (registering)
- Session 15 : listening to voices 3 and 4 / discussing tone, gestures and emotions. Modifying some passages (registering)

- Session 17 : Associating emotions to eyes colors / prepare decor for the show (1)
- Session 19 : Draw a robot / prepare decor for the show (2)

Once the voices are saved in mp3 files, they are divided into several shorter sound files in preparation to the robotics sessions. Each short sound file will be treated by a group to program the corresponding gestures and emotions of the robots.

The first and last non-robotics sessions are dedicated to subjects interpretation of how they imagine a robot. They were asked to draw a robot, explaining the content of their drawings. These drawings are used to link imagination to experience and feelings. The drawings of two subjects are illustrated in Fig. 3, they will be discussed in the results section.

3.3 Robotics sessions

The robotics sessions consisted in programming the motion of the robot according to the registered voices telling the story. As the subjects had acted the story in the non-robotics sessions, they already had an idea of desired movements. The sessions were organized as follows.

- Session 2 : First contact: short explanations (security) and make the robot talk (program ready, subjects only have to tape the text to be pronounced by the robot)
- Session 4 : Make the robot talk (use the behavior library to get the *say* box)
- Session 6 : Make the robot talk then move (use the library for pre-registered motions: *sit*, *get up*, *wave*, aso.), move then talk, move and talk at the same time
- Session 8 : Switch on robot / Make motions using *timeline*. Explain configurations vs. motions.
- Session 10 : Play the recorded sounds, program desired motions (voice 1) / Switch off robot
- Session 12 : Play the recorded sounds, program desired motions (voice 1)
- Session 14 : Play the recorded sounds, program desired motions (voice 2)
- Session 16 : Play the recorded sounds, program desired motions (voice 3)
- Session 18 : Play the recorded sounds, program desired motions (voice 4), change eyes LEDs colors
- Session 20 : Program emotions using eyes LEDs colors

Even though the children could concentrate the complete hour from session 14, they were limited to 45mn of work. The remaining 15mn were used to play with the voice synthesizer and make the robots talk. Robot programming using Choregraphe consists in choosing a desired function in a library on the left of the window. The user must drag and drop the chosen function in the robot interface, which is a white initially empty area in the center of the window. The function appears as a box in the window, with its name on it. The box must be connected to the robot input, then clicking on the send button, sent to robot control. The difficult part is the choice of the desired function in the library, which is in English (the subjects

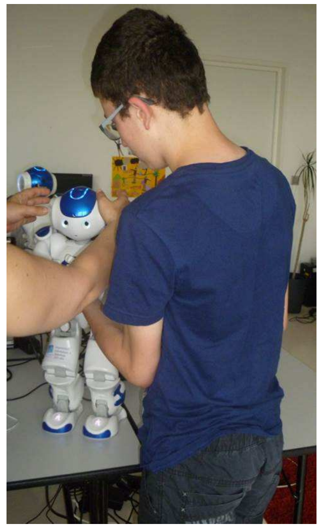


Fig. 2 Assuring security of the robot while his colleague programs motion.

only speak French, and show difficulties to read even if they can approximately manage). So the first time they had to use a given function, they would arrive at the session with the function already in the robot interface, connected and ready to use. The following session, they would be asked (with verbal help) to find it in the library, drag and drop it in the robot interface, connect it and send it to robot control.

The robot was switched on for the first three robotics session, during which the subjects were learning how to take care of the robot and insure its security. For all the robotics sessions, one subject was programming, then asked for security assistance, the second subject would stand next to the robot during the whole robot motion (Fig. 2). Once the motion is finished, could the security assistance stop.

3.4 After the 20 weeks Rob'Autisme program

A public representation of the robotic show programmed by the children was organized, grouping 12 strangers as spectators. The spectators were officials supports of the project. The sessions organizers (robotics and sound specialists, the medical staff) were also present in the room. The show took place in the same room as the robotic sessions, at STEREOLUX. The room was re-organized as follows: the working tables were removed from the center of the room, a scene was set along one of the wall and chairs were placed in the center of the room, facing the scene. This setting was performed before the arrival of the subjects. A lunch grouping the work group (subjects, medical staff, robot and sound specialists, Stereolux organizer) was organized, then all went to the room to welcome the spectators. The children sat in front of the scene, directly on the ground. The spectators were sitting in their back, on the chairs. The program was explained to the public, then the show was performed. Once finished, questions and remarks of the public were answered during a 20 minutes discussion. Finally, strangers could get up and go out of the room.

4 Results

Consistent improvements in focus, communication and social skills were observed. We will summarize here the most important ones. Three general observations should be pointed, concerning 1) the impressive velocity of the changes in subjects behaviors and attention; 2) the memory of the subjects from robotics session to robotics session: they remembered everything learned at the last robotics session even if it was two weeks back (sometimes more because of holidays) and 3) the changes outside the sessions, that could be observed from the third robotics session.

The first programming contact with the robot consisted in making it talk. The subject had to enter the text from the keyboard. The global following points could be observed.

- *Concentration time*: The nurses had great difficulties to make the subjects focus continuously during more than 12 minutes when the program started. Breaks were organized to make them relax (explanations, interactions). At robotics session 14, the subjects were able to work the complete session on programming the robot movements. But it was observed that they were getting tired, and started to go away from the robot. To avoid tiredness and keep them close to the robot, the working time was limited to 45 minutes. The 15 minutes left were dedicated to playing with the voice synthesizer, making the robot talk in funny ways or in forbidden ways.
- *Sharing with others*: The first talks of the robots were trials. The subjects made the robot talk for themselves, following nurses "instructions". Each time a subject finished taping a sentence, silence and attention of the others were required, and everybody would listen to the robot talk. With this approach, the subjects very quickly switched to programming to show to the others, and a kind of contest started, which aim was to find the more silly thing to make the robot say. The same organization was performed when programming the robot movements: once a movement is finished by one subject, everybody stops and looks at the robot performance. Doing so, the subject could enjoy the pride to share their respective work with others, to work with the objective of showing / sharing.
- *Acquiring robot programming abilities*: Choregraphe software is very simple to understand. Still, some great difficulties occur for the studied population: the software is in English (subjects are French), the function library contains a lot of functions, so finding a specific function (in English) is a difficult task. Moreover, saving the work was far from a programming reflex when the subjects started

the sessions. At each robotics session, the programmer's how-to was re-said, re-explained until the knowledge was acquired by the subjects. Programming a desired movement was the most difficult part of the training, as the notion of body configuration (static) and body trajectory (dynamic) is particularly difficult to integrate. Added to this, the necessity to remember to save the configurations: the robot will understand what to do, not once it is shown how to do it, but once what to do is saved in its file. Most basics robot programming knowledge was acquired by the 6 subjects at the end of the program. The subjects also remembered this knowledge 6 months after the end of the program.

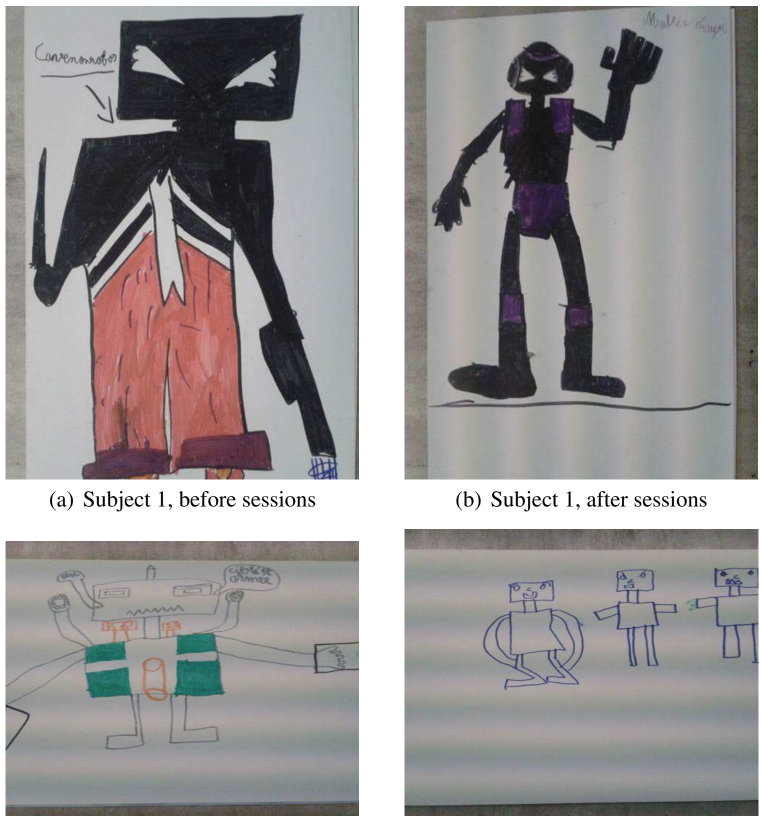
- *Voluntary communication*: The changes in voluntary communication started at the end of the first robotics session. They were the most spectacular changes, that came from two facts: the understanding that the robot is theirs and can talk for them and the showing to (sharing with) the other groups. The puppet master effect (see below) led to spectacular results: first the subjects used the robot to talk for them, using forbidden vocabulary. The sentences are short and mainly limited to series of slang words. Then the robots say complete sentences borrowed to movies or personal life scenes, or they say slang with different intonations (playing with the level and speed of the voice synthesizer). Then, the robot expresses things directly connected to the subject state of mind. Finally the subjects directly express themselves, as typing becomes to slow to say things. The puppet master effect is described in more details in section 4.3.
- *Verbal communication*: The subjects using the robots build a strong relation with the object, allowing the robots to say things the subjects would have never express. Once again, they benefit the puppet master effect, as when the robot talks, people look at it and accept anything said by it. It gives the subjects an example of positive reaction to what is said by the robot, then they feel safer saying it themselves. Verbal communication was very low at the program start. One of the subjects even did not talk at all. Focusing on the robot programming, the subjects' desire to use the robot was the strongest: verbal communication started with shy, short and rare questions about the programming. Then it became more and more often, up to the level of discussion (any subject). It took five robotics sessions before voluntary verbal communication with eye contact. The subject who was suffering the most with language skills took longer, but volunteered for the voices to be given to the robot.
- *Taking care of objects*: Security of the robot was explained from the very first session (non robotics). The robot NAO is a fragile platform, and during the sessions one subject was programming while the other one would insure robot security: standing next to it, ready to catch it if the robot falls. An interesting fact was observed at the sixteenth session: one of the robots fell down because of a motor breakdown: the motor generated a sudden motion of the knee, which had a consequence of robot jumping then falling from the table. A spare robot was immediately given to replace the damaged one, so the session could continue. The six subjects showed very concerned by the fall, but instead of caring for the objects, turned naturally to the robotics specialist and expressed their being sorry for the fall of the robot. This clearly illustrates their understanding of the ma-

chine the robot is, and what the robot helps them with. They have accepted the machine as a helping tool for communication. They have accepted to care for the machine, but doing so they have shown respect, not to the machine, but to the machine specialist (human being). This also has illustrated how important it is *not to lie* about the robot nature (funny machine vs. companion), as using the robot as a machine enhance the link to the human beings behind the robot. At the end of the program, the subjects would very carefully put back the robot in its box. They were very proud of this responsibility (the subjects asked to do it). Once the robot is in the box, they look back up to the robot specialist, hoping they have done well.

- *Writing and reading* (foreign language): the subjects writing abilities were slow at the beginning of the program, with many orthographic and grammatical errors. They quickly got autonomous self-correction, thanks to the voice synthesizer, as it would say whatever was taped without any interpretation of the meaning. They would tape, listen to the result, modify (sometimes ask the nurse for help), listen again. Only when the saying was correct, would they accept to make the other listen to their performance. The three first robotics sessions needed a lot of concentration for correctness of the writing, then the focus eased as the orthographic and grammar abilities increased. Once they became comfortable with this point, the subject started playing with the voice synthesizer, experimenting nonexistent words and generating sounds. Choregraphe software uses a functions library, the functions are described with an English word and a representative drawing. The English language was completely unknown to most subjects. The fact that the functions were described with English words did not seem to annoy their use, as the subjects easily recognized the drawings associated to the functions.
- *Organization, focus and efficiency*: To program the movements of the robot using the function *timeline*, it was needed to first imagine which movements are desired, then decompose the motion into fixed configurations that have to be saved in the software. Then the software generates trajectories from one registered configuration to the next one. There are two possibilities to register a configuration: 1) from the software interface, act on the motors of the virtual robot and put them one by one at the desired values; 2) release the tension in the motors of the real robot, put it in the desired configuration and put the tension back. This second situation is much easier to use, and was the one chosen for the application. Still, imagining the needed configurations and registering them required a strong focus from the subjects, even for simple motions. The first time they used the function (session 8), they managed 15 minutes of focus (time to make a gesture with the arms). The next time (session 10) they managed a 35 minutes of focus, as they were using the registered voice 1 and were building the motion with it.

4.1 Robot image

The subjects' resulting drawings before (left) and after (right) Rob'Autism program are illustrated in Fig 3. Most had first represented a robot as a threat, equipped with heavy weapons, before the program starts. The first contact with the robots was disappointing for them, as it looked not scary at all, even looked fragile and did not move as in their imagination (like a super hero). At the end of session 2, their



(a) Subject 1, before sessions

(b) Subject 1, after sessions

(c) Subject 6, before sessions

(d) Subject 6, after sessions

Fig. 3 Robot representation for two subjects, before and after Rob'Autism program

disappointment had disappeared, replaced with amusement and interest. After the program has finished, the robot emotions are drawn first. Some are still equipped with weapons, but they have become protective robots and emotionally capable. These could be interpreted as the robot as social companion, as enhanced by so many authors. But a discussion with one of the children should be mentioned here:

- The robot is smiling because he is happy?

- No, the robot is smiling because *I* am happy.
- So this is you smiling?
- Yes.
- Why are you happy?
- (direct eye contact, with smile) Maybe the robot will tell you later.

This discussion had summarized most of the concept that was developed in Rob'Autism project: the use of a robot as a tool for communication, and not as a companion. There is no ambiguity for the subjects about the mechanical nature of the robot, which remains an object, such as a toy. But the subjects have used it to express emotions and say things.

4.2 The public show

The public show was organized with a limited number of strangers (12), sitting in the back of the children. The children were present in the room to welcome the arrival of the strangers. The show (introduction, performance, discussion) lasted around 90 minutes, during which the children sat quietly, listening to the introduction, watching the show and listening to the discussions afterward, answering questions when asked. They were solicited to interfere in the discussion, with the following questions: *Who was the first voice of the robot?*. The children did not move, and after a short time two of them pointed their colleague, who smiled looking down at his feet. The second question asked who was the second voice. After a few seconds, 5 children pointed "the second voice" saying his name and laughing. The pointed one said nothing but smiled, watching the ground. It was obvious that he was waiting to be pointed. Same scenario for the third and fourth voices. During the whole moment, the children never looked back at the public, remained sit.

When the public went out of the room, the children were at the door shaking hands and saying goodbye. Some people who attended the show asked afterward if the children really were autistic, which illustrates the amazing change in their behaviors with this program, as there was no doubt on this point when they first entered the room at the beginning of Rob'Autism.

There was no guaranty on the children behaviors with this public show. A few months before, it would have been impossible to perform it. The change concerns the desire of the children to share with the society what they had created. They were proud of their work, and proud to show it. The proud feeling was stronger that day than the stress of meeting strangers, the stress was naturally forgotten. After the departure of the strangers, all stayed in the room and enjoyed a drink with the team (medical staff, robotic and sound specialists). The children could follow organized discussion even among themselves, with normal tone of voices. Then they cheered a goodbye to the robot and sound specialists, taking them in their arm and wishing good holiday time with happiness smiles.

To conclude with this public robotic show: A program started in this year with the same children (Rob'Autism level 2), 6 months after the 2015 robotic show. At the second robotics session, one of the children stood up and asked in the name of his friends (watching him but remaining seated) to organize another show at the end of the program. Even though the children were surprised with the 2015 show, they clearly enjoyed it whole. The request, and the way they made it, illustrate the progress in communication skills they have made, and their will for improvement. The children have become actors of their project, not just attendees of the sessions.

4.3 Puppet masters

Rob'Autism puts the robots as screens protecting the programmers from a direct interference with other human beings. The programmer is like a puppet master, acting in the shadow while doing great things. The use of robots for autistic children is classically made differently: the robot arrives with its own abilities, as a companion, and requires from the subjects like an adult could be requiring. Oppositely, in Rob'Autism, the robot is presented as an extension. The puppet master technique amplifies the robot abilities to make the autistic subject communicate. As the subject remains hidden, he/she is free of saying and doing anything. The public will look at the robot, and the responsibility of what was said or done is left to the robot: the programmer is not involved. This is a very comfortable way to start interfering with the world when ones do not have natural abilities for interaction. This point, actually, is the post important one in this project, and its effects should be evaluated and compared to the classical approach.

5 Conclusion

This paper explains the 20 weeks Rob'Autism protocol aimed at improving autistic people communication capabilities. The 20 sessions were described, as well as preparation and conclusion of the program. Several key points were addressed to perform the program, which uses three robots for six subjects: 1) the necessity to train the medical staff to program the robot, and the obligations to have a robot specialist in the room; 2) The importance for the programming subjects to see the other programmers' contributions and show their own; 3) The importance to alternate robotics and non-robotics sessions; 4) The importance to organize a final *public* show. This work was a preliminary study, questioning the efficiency of robot companion approach and proposing an extension approach based on the puppet master technique. Observed results showed fast changes in communication behavior, to the point that even though the autistic characteristic was obvious for all the subjects with a quick look at them when they started the program, but not so obvious at the end of the program, after only 20 hours of training (only 10 hours with the robots). The effects were observed during the sessions, but also very quickly outside the sessions. Finally, the progresses were still effective 6 months after the end of the program.

The next step should answer other questions on the program effects: are the changes permanent, or is it necessary to restart regularly a robot training session? Do the subject continue to improve with the same velocity their communication skills if using the robot longer, or do their skill stabilize? Also a larger population should be studied to check the generalizations of the results and the limits of this approach.

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