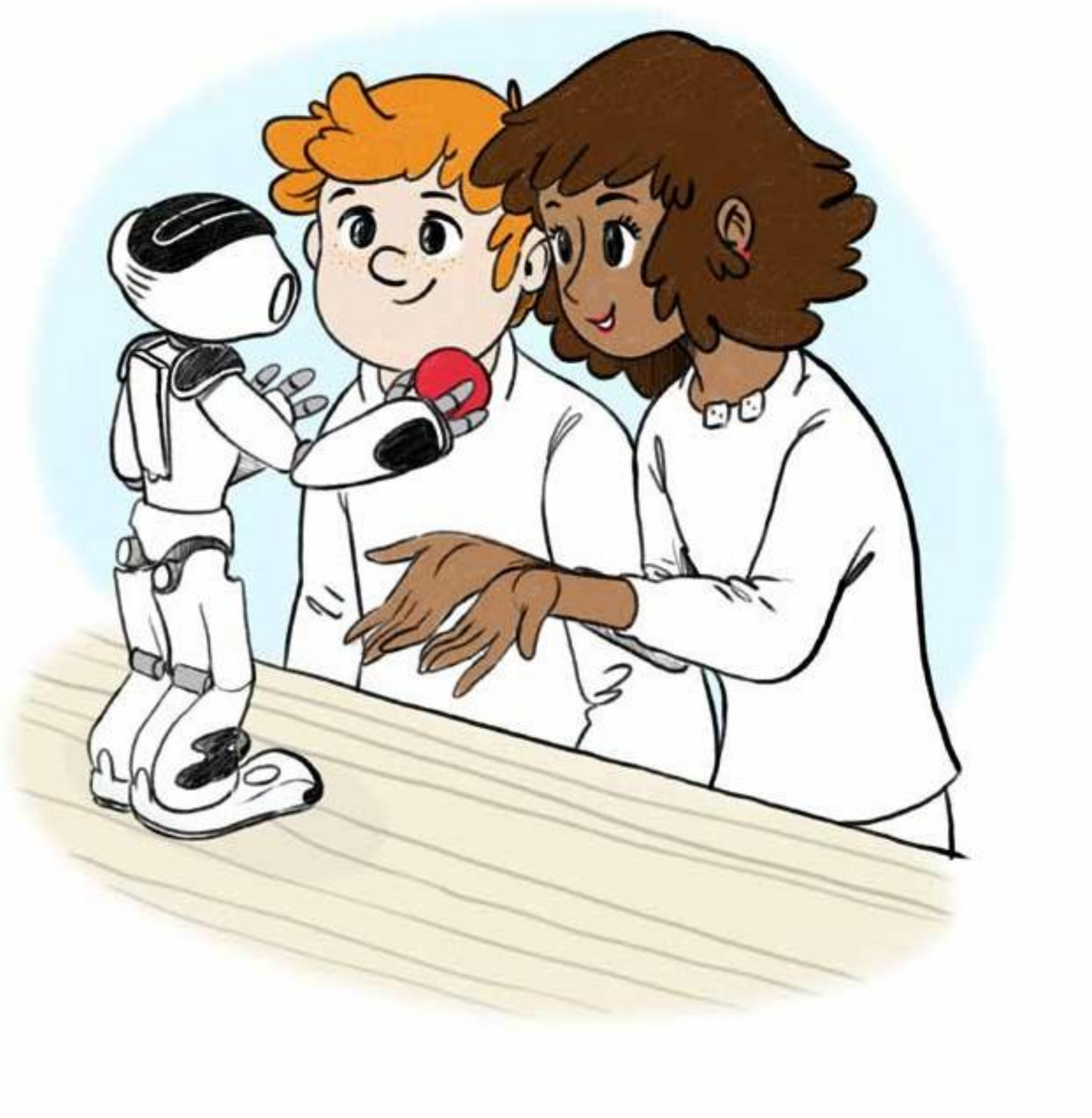
NAO, a humanoid robot as ***a therapeutic mediator*** for young people with autism



NAO, a humanoid robot as ***a therapeutic mediator***
for young people with autism

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a Aldebaran & ERM book

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Foreword

In recent decades, robotics has established itself as a specific field of research within the world of healthcare and education. This is also the case with children with neurodevelopmental disorders. Driving the expansion of social robotics is the fact that it has the potential to surpass the limits of classic therapeutic activities, by overcoming their lack of intensity for example, and that it can be provided in a natural context despite its artificial nature, which could help with the generalisation of the progress made. Many studies have been taking place regarding robotics and neurodevelopmental disorders for almost a decade, creating an emerging area of study which shows no sign of slowing down.

Currently, there are a number of robots on the market that promise to help children with autism spectrum disorder and other neurodevelopmental disorders to develop their social skills and learning and to support them in their education; a prospect that could fundamentally change treatment. As a professor at Sorbonne University, Head of the Child and Adolescent Psychiatry Department at the Pitié-Salpêtrière Hospital within the AP-HP (Greater Paris University Hospitals), and a member of the Social Robotics, Interactions and Perception (PIRoS) team at the Institute of Intelligent Systems and Robotics (ISIR) of the CNRS (French National Centre for Scientific Research), I have myself contributed to this emerging field alongside the pioneers of the field with my engineer colleagues Mohamed Chetouani (1), Sofiane Boucenna (2) and Salvatore Anzalone (3). Technological progress has enabled innovation in a multitude of treatments for children with autism spectrum disorder and other neurodevelopmental disorders. One specific area is social robotics, which centres around evaluating relationships between humans and robots.

In the field of neurodevelopmental disorders, robots have been used both in clinical and educational environments. Educational robotics refers to robots specifically designed to interact with children during their educational activities. In the field of education, children with neurodevelopmental disorders are considered as children with special educational needs. Traditionally, approaches within educational robotics have been divided into learning about robots on the one hand and learning with robots on the other.
In other words, robotics education versus robotics for education. The first approach relates to technical teaching focused on robotics while the second involves teaching different subjects (technical and other) using robotics. The use of educational robotics can be part of the school curriculum or an extracurricular activity (4).

Despite the many studies carried out, there is no clear evidence in the literature that robots can be used effectively to treat children with autism spectrum disorder and to support their learning process as children with special educational needs (5). With that in mind, it is fundamentally important to make the distinction between robots used for children with special educational needs and robots used by students with special educational needs.
For example, by robots used for children with special educational needs, we mean robots used to improve the level of attention of children with neurodevelopmental disorders during diagnosis and/or treatment.
In this case, the robots are just auxiliary tools to be used during this clinical time in the same way as any other technological device. In the case of robots used by children with special educational needs, however, the robots are considered as tools used to teach subjects on the school curriculum through activities focused on computational thinking to promote active learning.

When Alexandre Mazel from Aldebaran asked me to write the preface for the white paper on NAO and autism spectrum disorder, I hesitated at first.
For one thing, Aldebaran is a business I do not have any particular links with. For another, the white paper on the use of NAO with autistic children is not strictly speaking a review article or even an exhaustive overview of the topic. It is more of a collection of feedback from users who have used NAO with patients with autism spectrum disorder. The users are teachers, psychologists and special educators (including healthcare professionals) or engineers and researchers in computational science. Some use NAO practically as it is delivered by Aldebaran, while others add new features.

At the same time, I have to recognise that NAO remains one of the most widely-used robotic platforms.
In a recent study of the scientific literature conducted by one of my colleagues, Charline Grossard, we collated almost 14 scientific studies using NAO for therapeutic purposes and 4 using Kaspar, while all of the other robotic platforms covered (Charlie, THEO4, QT robot, Ribit, Caro, etc.) had only occasionally been used in studies (5). As it happens, I have used NAO myself in several projects, including very recently in work on handwriting correction (6) (a video is available at the following link: https://youtu.be/0iLScP0Pjz). In addition, as a child and adolescent psychiatrist, I was interested in the idea of giving a platform for feedback from real-life users, some of whom lay outside the mould of scientific research teams.
So, dear reader, what will you find in this white paper? I would like to do something different and introduce the paper from the perspective of the different ways NAO has been used.

I'll start first of all with how it is used by specialist teachers. The first account is from Thierry Le Buhé, a specialist teacher working in a day clinic, who gives us an ethnographic description of the children's engagement with NAO, who are receiving treatment. The teacher controlled NAO himself and offered four types of activities; dictation, reading, imitation and risk-taking in terms of balance. On the whole, he observed good engagement from the children, often seeing better levels of attention, and found that NAO was a good supplement to existing teaching tools. The second experiment is more valuable in some ways since it was carried out at the scale of a whole school district, namely the Dijon school district. It targeted children at nursery school, with the teachers having been trained in the use of NAO with a view to using it for group activities, like saying hello, or singing nursery rhymes, but also individual activities - recognising words and yoga-type motor skills activities. Something extremely interesting is that the team had incorporated some information on the education of children with neurodevelopmental disorders for the teachers, which meant they were able to ask NAO questions and receive answers. Two researchers from INSHEA (higher national institute of training and research for the education of disabled young people and adapted teaching) have observed the different trials in the classes and are yet to do a qualitative and quantitative analysis of all these experiments. Nonetheless, the quantity of activities offered and the scale of this trial already show how easy NAO is to use and how well children engage with it.

The last educational robotics project was a collaboration between a team of support engineers (Movia) and West Hartford Public Schools. In this project, the Wizard of Oz technique was used, meaning that NAO was controlled by an operator. A dozen children were involved in the experiment for six to eight weeks with two sessions per week, the robot being controlled by an engineer and the specialist teacher being present at the session. The programme of activities was tailored according to the children's specific abilities, but we do not have detail on the activities carried out, or even the scores used. Regardless, the authors do describe four individuals who demonstrated quantifiable improvements, but in the qualitative description they also indicated that one pupil disengaged from the robot.

The second type of use described in this white paper is use in a clinical environment. We essentially have two of these, the first being the use of NAO by clinical psychologist Olivier Duris, working in a day clinic. He put together two groups of six children, who attended 50 group storytelling sessions at the day clinic, with or without NAO. On a qualitative level, it shows that NAO's presence improved the children's understanding and participation in the storytelling groups NAO was involved in. The quantitative aspects are not really described but have been measured and will probably be the subject of future publications. The second clinical use described in the white paper was a collaboration between the university hospital in Nantes and an engineering support team led by Sophie Sakka. This time, use of NAO was offered as a group activity where one or more robots were programmed in preparation for a drama activity involving a robot. Here again, the team describe the qualitative progress of individual children but also the group dynamic when children with neurodevelopmental disorders were put into groups with one or more robots.
The last three contributions to the white paper are all from engineering teams, with or without clinicians, offering a number of adaptable solutions enabling different activities. The HERO team, which I was delighted to find includes Giuseppe Palestra, a former member of ISIR, offers 18 different exercises thanks to the development of an interface enabling different activities to be run with NAO. Dr Fady Al Najjar's team offer dialogues, motor skills activities and role play games thanks to a solution combining NAO and a mobile phone with pictograms showing emotions. And finally the DREAM project team offers imitation, joint attention and turn-taking activities. In most cases, these teams are also working on producing metrics from sensors, recording audio and also video which gives them quantitative variables concerning eye contract, joint attention, facial expression, taking turns to speak, etc. All these solutions must be clinically validated, however, to show the accuracy of the metrics and also their relevance, which is not necessarily available as things are. However, the DREAM project has announced a large randomised controlled trial including 69 children over eight sessions, the results of which could be an important step.

All in all, I believe that this white paper will give readers a good demonstration of the vitality of the social robotics field in relation to autism spectrum disorder and how NAO has played a part in this vitality for many years now, through its ease of use by clinicians or teachers who are not necessarily specialists in robotics, but also through the simplicity of integrating new algorithms and solutions created by engineers wishing to increase the interactive capabilities of the NAO robotic platform. It is probably this design and ease of use that are behind the success reported in these many accounts from real-life users.

David Cohen MD, PhD

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* https://youtu.be/0iLScP0Pjz

AU TI SM –

INTRODUCTION.

Autism spectrum disorder refers to a group of neuro-developmental disorders characterised by difficulties with social interaction and communication and restrictive and repetitive behaviours and/or interests. The most striking difficulties are problems with imitating others, an inability to read others' emotions, and limited initiation of and response to joint attention behaviours. These symptoms can vary in severity, resulting in different levels of disability.

For the moment, there is no treatment able to improve the quality of life of people with autism very significantly. Treatment is purely symptomatic and involves personalised educational therapy. This therapy is most effective when undertaken at an early stage of development.

In children and adolescents, all of these autistic traits will have varying levels of impact, depending on the support received, on their ability to learn, their socialisation and, later, on their level of independence as an adult.

MECHANICS AND TECHNOLOGY

We are seeing rapid growth in the use of new technologies in daily life, such as connected objects, humanoid robots, software and artificial intelligence, applications for tablets, augmented reality, virtual reality, etc. Applications (web or tablets) are still by far the most accessible solutions.

The existing studies in the scientific and medical literature since the 1990s show that children with ASD (autism spectrum disorder) have a great affinity for mechanical components, computers and robots. Robots do not judge, enable the child to hold their gaze and lead to an improvement in attention.

Today, the use of new technologies in autism treatment is built around four complementary approaches aimed at developing:

- Expressive and communicational skills
- Cognitive and emotional skills
- Social and interactional skills
- Acquisition of knowledge

Therapy based on computers, tablets and personified robots is therefore offered more and more often for autistic children and adolescents. With the increasing sophistication of humanoid robotics, robotshave been proven to have great potential as a therapeutic mediation tool in the field of cognitivedisorders.

HUMANOID ROBOTS AS THERAPEUTIC MEDIATION TOOLS FOR AUTISTIC YOUNG PEOPLE

A number of researchers have shown that autistic children prefer interactive robots to static toys, that a machine appearance is less anxiety-inducing for them than human traits, and that they are more reactive to instructions introduced by a robotic movement than by a human movement.

More specifically, humanoid robots, which are anthropomorphic machines, allow the amount of information received by an autistic young person in their interactions to be 'stripped down', thanks to factors such as predictable and identical movements, a synthetic voice with no expression of personality and limited intonation, etc. Moreover, the robots are linked to a software component that makes it possible to simulate basic 'social and affective' abilities. This combination of characteristics generally facilitates a decrease in anxiety and better sensory receptivity in young people with ASD.

In a number of countries and for a number of years, based on this consensus on the value of humanoid robots in work with autistic young people, we have been seeing an explosion of specific research projects, empirical applications and software developments with or without AI, as well as the creation of pedagogical content.

Humanoid robots are gradually taking their place as genuine therapeutic mediation tools for young people with autism spectrum disorder; hundreds of robots are active as assistants in medical centres for autistic children.

A CAREFULLY-SELECTED OVERVIEW OF APPLICATIONS

Amidst this growing mass of research and applications, we wanted to provide you with an overview, one that is not intended to be exhaustive, as it is mainly focused on the use of the NAO robot designed by Aldebaran. Nevertheless, the selection of examples that follow will give you an idea of the existing, sometimes surprising, applications, with proven results achieved in France and internationally.

This eBook is intended to be useful to as many people as possible, whether researchers, therapists, specialised educators or teachers. Its aim is to enable a better understanding of the use of NAO as a therapeutic mediation tool for young people with ASD and to perhaps spark a desire to implement certain applications or to take them further within readers' own organisations.

The contributors can be contacted using the contact details at the start of the articles and a bibliography is provided as well as hypertext links to help you find out more.

HERO

HERO TEAM AND ITS SCIENTIFIC BACKGROUND

HERO (https://www.herovision.it/) is *an innovative start-up* focused on the development of solutions of high technological and social value, based on robotics, Artificial Intelligence (AI) and human-machine interaction, with Healthcare as first field of application. HERO technical team is composed of experts in the field of AI, from the academic world, with several scientific papers on the use of technologies for a better life.

Giuseppe Palestra, Co-Founder and Researcher of HERO, is a PhD in computer science and his research* is focused on AI, Pattern Recognition and Computer Vision.

Berardina De Carolis, Co-founder and Head of R&D Department, is a PhD in computer science and Assistant Professor and Researcher at the Department of Computer Science, University of Bari. Her research interests** are in human-computer interaction, natural language generation, user modeling and agent-based systems.

Founded in 2016 HERO has received important awards, as the Seal of Excellence of the European Commission, in 2017 and 2019, for its integrated robot-software solution named Robots Friends of Children. It is based on a *therapeutic behavioral treatment protocol individualized to help autistic children and to collect a great amount of data* in order to personalize cares and foster research in this field. HERO solutions have been validated thanks to collaborations and clinical studies conducted at:

- Department of Engineering - Cognition – Handicap of University of Paris 8, Paris, France;
- Department of Medicine and Surgery of the University of Parma;
- Department of History, Society and Human Studies of the University of Salento;
- Department of Computer Science of the University of Bari.

HERO SOLUTION FOR AUTISM: ROBOTS FRIENDS OF CHILDREN

HERO solution has been developed starting from the perception of the *serious problems encountered by the parents of autistic children.* By its innovative software - based on internally developed AI, computer vision and Human-Robot Interaction (HRI) algorithms - HERO has developed a therapeutic behavioral *treatment protocol applied to different Socially Assistive Robots* to promote a gradual improvement in the overall levels of development of the autistic children, as verbal, social and adaptive skills.

The robots allow the patient to perform exercises belonging to standard protocol families, *ABA* and *ESDM*, defined by the clinical staff and thanks to the computer vision algorithms, the software stores metrics and objective KPI, creating a continuous triadic interaction model Therapist - Robot – Child. HERO solution is applicable:

- *in health facilities* (or other facilities where autistic children may receive care, for example schools, association, professional studies), where children are supported by clinicians and therapists during their interaction with robots (as NAO);
- *at home* to store data about their interaction with robots in a more familiar context (in continuity with the activities carried out at the health facilities), using a different robot.

With several treatments (18 for NAO) HERO solution allows therapists to define a personalized approach based on:

- *age* of the children, preferably between 4 and 13 years;
- *level* of *functioning* (high, medium or low);
- their *specific* needs in terms of stereotypical behaviour, communication and social interaction;
- their *gaps* in the following *learning areas*: imitation, communication, cause-effect and social learning.

GENESIS OF THE HERO PROJECT

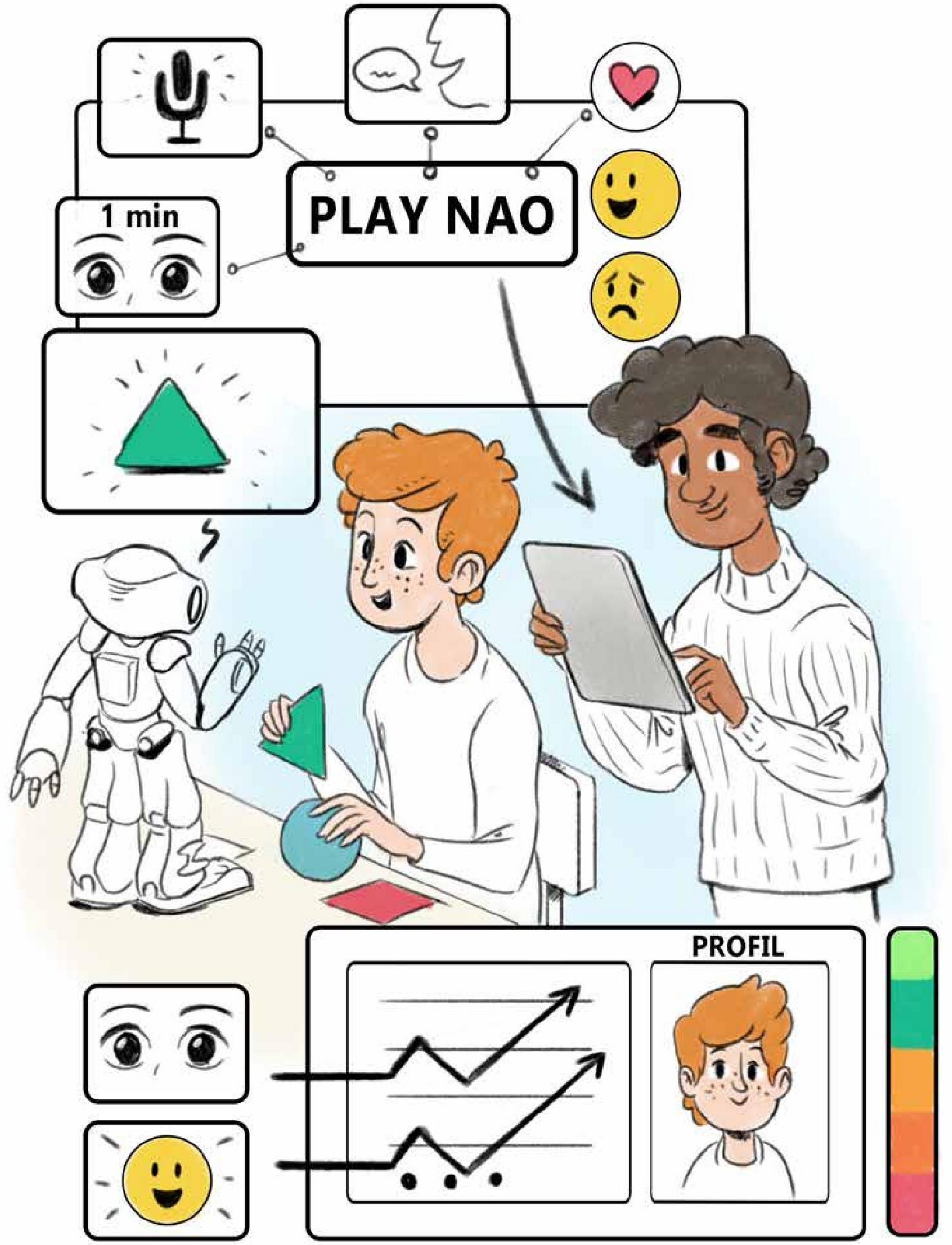
Over the past 15 years, the use of ICT has increased in regard to the autism treatment, because *ICT are particularly attractive for autistic people,* especially for children. Progress in robotics has led to analyze the impact deriving from the use of social robots in this field and serious games and robotics applied to autistic individuals shows relevant achievements and results. *More than 750 clinical studies report relevant benefits at behavioral level:*

- *repetitive* and *stereotyped behaviors* of autistic children are decreased in interaction with the robot,
- interacting with the robots autistic children improve *communication* and *language development;*
- autistic children have numerous *social behaviors towards robots* with characteristics similar to those that typically develop children towards humans.

HERO experts had launched studies and technological developments to support the experimental diffusion of solutions for autistic children and, in *November 2016*, they founded *HERO*, to develop an *innovative integrated (Robot + Software) solution. NAO* was one of the first robots used (already in 2013 before HERO foundation) thanks to its distinctive features:

- useful aspect and dimensions for interacting with children;
- high mobility thanks to its conformation;
- widespread presence of visual, sound and tactile sensors;
- power of its information system and its basic functions.

First HERO release was in 2017, validated and tested by clinical studies in Italy and France with very interesting results. In 2019 HERO launched *PlayNAO*, an integrated solution composed by NAO and our software, *with 18 different treatments and advanced features*, based on the computer vision to collect significant data for therapists and parents of the children.



HERO INTERVENTION MODEL A CHALLENGE FOR THE ROBOTS : PERFORM SEVERAL FUNCTIONS TO MEET THE NEEDS OF THE THERAPEUTICAL PATH

HERO solution aimed to *optimize the entire therapeutic path:*

- attracting *children's* interest by robots and fostering proactive participation in treatments (in health facilities and at home);
- providing *therapists* with a relevant set of objective and homogenous data (automatically - currently it is their responsibility to transcribe manually data), in order to customize treatments and monitor each progress and progress;
- allowing *health facilities* to better organize spaces and activities, expanding the range of assistance services;
- informing *parents* about children's progress and emotional state;
- aggregating the information collected for the benefit of *research* in the field of autism.

To achieve these results, it is essential to make the most of the information content of each interaction, through *advanced mechanisms for detecting, processing and reporting data* and this is possible thanks to the *dashboard* developed by HERO.

In our intervention model, robots (NAO and other robots provide) perform several functions:

- *stimulation* of the child's interest, who recognizes in them a playmate with whom to interact (according to a more predictable interaction pattern than what happens with other children
- *treatment mediation,* according to the therapist - robot - child triadic model;
- *learning support* in areas such as imitation, cause and effect, communication and social learning;
- *collection of objective data, automatically and continuously,* even outside the treatment sessions at health facilities.

OPERATIONAL ASPECTS A ONE TO ONE INTERACTION

Each robot has specific methods of use and PlayNAO is particularly suitable for *one-to-one interaction* (One Child – One Robot) *sessions in health facilities*, at the presence of qualified and trained personnel. After a careful examination of the child's needs, a treatment path is defined and the most suitable treatments for the child are identified, among the treatments available (actually 18).

Each *exercise* is *repeated several times* until it is correctly carried out 5 times (a standard session lasts about an hour) in order to allow the child to better learn how it works and to develop knowledge, skills and abilities necessary to perform it at its best. During the treatment *PlayNAO*, thanks to its sensors, *collects all useful data to evaluate the interaction of the child and his emotional state* (as eye contact, joint attention, imitation, and basic emotion recognition).

Qualified personnel must, therefore, be trained in the use of the robot, through an iPad with which they give the robot the indications regarding the treatment to be performed and can view the information detected during the interaction.

METHODOLOGICAL PROTOCOL

HERO solution is based on the traditional *ABA treatment*, with a protocol in 3 main steps: *stimulus presentation, behavioral response, and reinforcement.* It provides exercises with an increasing level of difficulty (on a scale of 3 levels), regarding:

- *eye contact:* this is an ability indispensable to communicate and to get the attention of an interlocutor but also they need to acquire complex communication skills (verbal and gestural);
- *joint attention:* several studies highlighted that autistic children show a limited joint attention with respect to the typically developing children and it is associated with language and imitation abilities lacks;
- *body imitation:* one of the major features of autism is a reduced ability to imitate body movements and it determines a relevant risk of lack in social communication;
- *facial expression imitation:* social competence development in childhood is closely connected to emotion recognition skill. The lack of the emotion recognition ability is a typical sign of autism (autistic children exhibit non-typical facial activity in response to facial expression stimuli) and autistic children are less reactive to basic facial expressions (happiness, disgust, fear, sadness) in comparison with typically developing children.

nEC: Number of Eye Contact
nPE: Number of Positive Expressions
nNE: Number of Negative Expressions
nFE: Total number of Facial Expressions
nREACT: Number of Reactions
PASS: Achievements

A *low functioning child*, showing difficulties with eye contact, will need to follow a protocol starting from the basic level and only after completing it correctly the child will gradually explore the next levels.

A medium functioning child could be already able to handle eye contact, but not still able to perform tasks related to joint attention. So the therapist could start from one of the joint attention exercise levels.

An high functioning child that doesn't need to practice eye contact, joy attention, or body imitation could directly start from the facial expression imitation exercise to learn to recognize and imitate facial expression.

Results *& perspectives*

Clinical studies show very promising results in each need (eye contact, joint attention, body imitation and facial expression) and learning area (imitation, cause effect, communication and social learning). Talking with qualified personnel involved we also collected encouraging feedback about the usability of the solution, the accuracy, usefulness and usability of the data collection functions.

WE ESTIMATE SIGNIFICANT GROWTH PROSPECTS IN TERMS OF:

- development of new treatments by interacting more and more with qualified professionals inclined to technological innovation, to respond to the needs of the community;

- use of new features of NAO (and other robots we use), released by Aldebaran developers team, to enhance and increase services offered to therapists and children through our solution;

- smart environments where robots can interact with additional sensors and collect more information;
- testing our solutions in the school environment to offer new learning opportunities for autistic children (creating learning paths that involve intermediation by robots, to support the activities of teachers and support staff);

- customization and promotion of our integrated solutions (robot + software) to help people with other mental diseases (for example elderly people with neurodegenerative diseases) or those with other types of health needs.

* https://scholar.google.com/citations?user=mYOH7BIAAAAJ&hl=fr
** https://scholar.google.com/citations?user=tzLPfD4AAAAJ&hl=fr

Rob'Autisme

ROB'AUTISME: THE ROBOT AS A PROSTHETIC FOR COMMUNICATION; AN EXTENSION OF ONESELF

As of 2021, 42 adolescents between the ages of 11 and 16 have taken part in the Rob'Autism programme, at a rate of six new participants each year. Participants with varying profiles and at different places on the autism spectrum were accepted, the only selection criterion being their ability to use letters, that is to be able to identify the letters of the alphabet and associate them with the corresponding sound. Enrolment was on a voluntary basis, and people with different profiles came forward; some attended school, others were not socialised, the symptoms were different from one case to the next (mutism, echolalia, self-harm, etc.), all received medical care but at differing levels, some were independent (in terms of getting around, etc.), and all lived in their family home.

SOPHIE SAKKA

Senior Lecturer

Sophie Sakka is a teacher-researcher at Centrale Nantes. Her research focuses on humanoid robotics and human movement, particularly the modeling of the dynamic equilibrium of bipedal systems with the aim of creating autonomous prostheses and exoskeletons (disability).

At the same time, she is the president and founder of the association Robots! whose objective is the diffusion of knowledge and skills on robots and their use to the general public. Sophie Sakka is also a lecturer on topics related to robotics.

BACKGROUND

The Rob'Autism experiment began in September 2014 with a group of six adolescents, who took partin the programme for two years. In 2015, a new group started in parallel with the first. Since 2014, the association Robots ! has been taking on six new participants each year, who follow the programme for two years.

This endeavour started when four institutions came together: the association Robots !, the digital sciences research unit (LS2N) at the Ecole Centrale de Nantes, the cultural centre Stereolux and the centre for older children and teenagers at the University Hospital of Nantes. Workshops were set up based on the hypothesis that the participants, despite their cognitive disability, would be able to succeed in getting to grips with a form of technology and programming a robot. The objective of the workshops was to put together a short play, with robots as the actors; just one actor the first year and several actors the second year.

The spectacular side of the results surprised all of the partners. Therefore, after two years of workshops, the Ecole Centrale de Nantes and the association Robots ! decided to continue their collaboration and to carry out research on the mechanisms of this specific therapeutic programme. A research project was carried out to this end from 2017 to 2020, and research continues to this day, undertaken by the LS2N research group and supported by a number of institutional and private partners.

STRUCTURE OF THE PROGRAMME

The proposed therapeutic programme consisted of 20 weekly sessions lasting one hour, alternating between 10 sessions to programme the robots (the actors) and 10 sessions to prepare the show (voices, music, set, etc.). The content was focused on improving social skills such as behaviour, communication and interaction. Exercises were prepared for each session in line with the characteristics and the progress of the participants, and milestones reached in the process of creating the show.

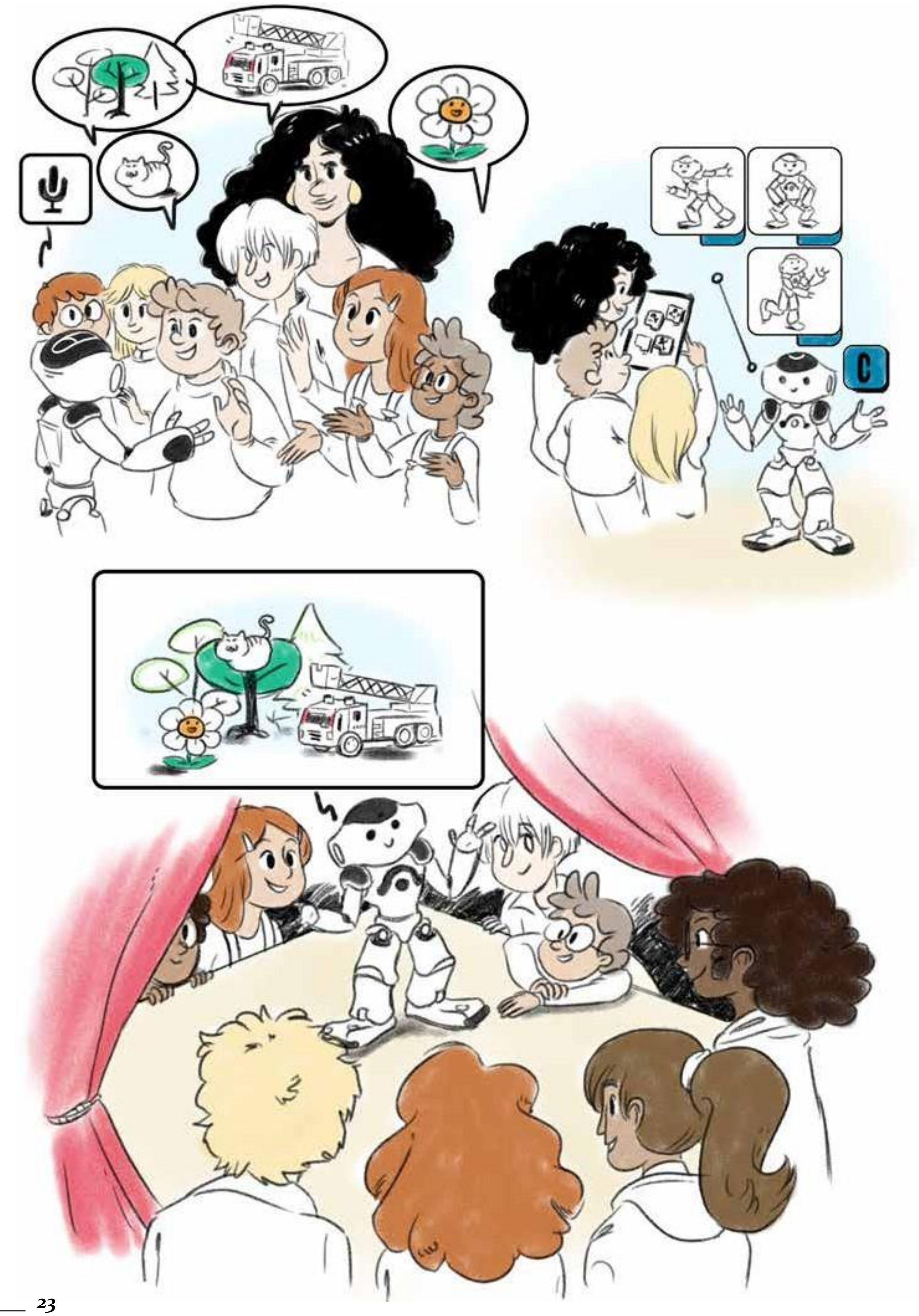
In the first year, the story only involved one actor, and was provided to the six participants. The idea was to put the robot in the role of a storyteller using the voices of the participants; these were recorded telling the story during the non-robot sessions, the recordings were segmented into sentences and replayed on the robots during the robot sessions, where the participants had to programme the appropriate movements using the Choregraphe interface provided by Aldebaran.

During the second year, the participants were supported in writing their own story, involving several characters. The concept of compromise was defined and applied within the group, so that all of the participants could come to a consensus on a story that they were all happy with. This time, the robots used voice synthesis for the dialogue, but the participants' voices were used for voice-overs, for example to set the context. The music, sound and sets were prepared as part of the staging of the show.

The short play was performed at the end of the programme, for each year. A venue was arranged, and the robots were able to run through their programming on stage before an audience of a limited number of unknown people, around forty people maximum: the participants' families, the partners, journalists, the team who led the workshops and the participants.

RESULTS OBSERVED

Spectacular progress has been observed in all 420 of the participants in the Rob'Autism programme since 2014, confirmed quantitatively one year by an ADI-R (Autism Diagnostic Interview-Revised) test in nine participants (in the first and second years of the programme). The progress made in terms of social skills on the three ADI-R criteria were observed to remain stable over time. The assessments were carried out in collaboration with the parents, who combined their own observations (behaviour in the home) with those of the staff in the participant's everyday environment (depending on the case, this could be a school, healthcare setting, classes with a tutor or another environment regularly attended by the participant). Accounts of radical life changes were received, both concerning the participant (ability to form friendships, to integrate into a group, to develop independently, to achieve voluntary and coherent communication, care for people and objects, increased calm, concentration, attention) and their environment



(decreased need for daily support or individual attention, increased calm, a lighter load on the organisation). During the workshops, cohesion was observed between the participants; they went from acting individually at the beginning to looking to contribute to the group and to adopt joint decisions. Their concentration improved dramatically, enabling voluntary communication, the search for compromise and learning.

THE ROBOT AND THE THERAPY

The research set out to define *the exact role of the robot in the progress that was observed in the participants*. A number of experiments were conducted to better understand it; the Rob'Autism participants are all adolescents with autism spectrum disorder, but the method was used with the 20 sessions + performance for care home residents suffering from Alzheimer's disease, and with individual sessions for other groups with other pathologies (adults with ASD, and children and adolescents with various cognitive disorders such as Rett syndrome and multiple disabilities).

The main observation was that *the robot is in no way a replacement for a therapist*. It will not lead to any cognitive improvement on its own, even if programmed. However, *its organised and simplified nature appeals to and engages the participants in a therapeutic programme, enabling a cognitive connection to be made*. The robot acts as a catalyst, a sort of therapeutic accelerator, and has no value without the therapy.

In this case, what kind of therapy was used in the Rob'Autism programme? A micro-society was constructed, simplified and always involved the same places (a room for the robot workshops, a room for the non-robot workshops, a room for the performance), the same people (organiser, supervisors, technical specialists and participants), the same routines for arriving, entering the sessions, the sessions themselves and leaving. Everyone's roles were defined and stayed the same throughout the programme. In this context, the participants had a social space in which they could (re-)define their identity.

The work done in the workshops was structured around three different levels of communication;

- *two-way communication,* that is one-to-one, requiring continuous concentration, was induced through work in pairs, requiring for example taking turns to use the robots, or to interact with the supervisors;
- *group communication* consisted of showing the group what they had done and seeing what others had done. Attention was maintained using applause at the end of the demonstrations, amplifying their sense of existence through contribution to the group and their pride in sharing their work.
- The third level of communication was *social communication,* achieved through the performance to an audience. At the end of the show, the audience applauded, expressing recognition of the participants for their contribution.

Managing contradictions was also taught in this structured environment. To this end, the robot is an optimised mediation tool; at once lifeless and animated, it allows the person operating it to work within a semi -place where they can be both a participant in and a spectator of a scene. The elements are known (the framework) and unknown (the implementation within the framework). For example, the participants knew that they were going to work in pairs (the framework), but they did not know who with (the elements of the framework). In exactly the same way, the show performed was known because they had created every component of it, and unknown at the same time as they had never seen it all put together.

—

Perspectives

Whether to use a robot as a companion or as an extension is a therapeutic choice; a robot companion draws out a participant and stops them from shutting themselves off, while a robot extension requires intervention from the participant to act and encourages them to open up, making them an active contributor to social interaction. A robot companion has the advantage of not requiring any skills, while a robot extension requires intervention from the participant, and therefore the ability to further their skills.

The participants in the Rob'Autism project were selected for their knowledge of some letters of the alphabet as a minimum (shapes and the associated sounds), showing their ability to learn and therefore to further their skills.

The project, in its current form, could be reproduced by teams outside of the Robots ! association. It will thus be rolled out for adolescents with autism spectrum disorder. In addition, the characteristics of the robot mediator used as an extension of self and its effect on the human cognitive system will enable this therapeutic approach to be used in the treatment of other conditions causing cognitive disabilities.

Thierry Le Buhé

Hôpital F. Truffaut


Fig.5 : Taking Risks

A ROBOT ARRIVES AT THE HOSPITAL...

I am a teacher who specialises in neurodevelopmental disorders and I work in a day clinic for children aged four to twelve with Autism Spectrum Disorder (ASD).

Thanks to financial support from a charitable organisation, the day clinic obtained a NAO robot. The initial plan was to use NAO in my class only, for educational purposes. This decision demonstrates the head of the centre's desire for a more relaxed use of NAO, in a clearly defined place, while also giving the healthcare team the chance to get used to its presence, or even go further if everything goes well...

NAO isn't a technological object like a tablet or a smartphone. It stands out from any existing frame of reference. It's like a UFO in a way! Its android appearance and sophisticated range of movements and gestures - particularly when it rotates and tilts its head to follow the person's interacting with - can be disconcerting for many adults and make them feel uneasy. It seems likely that there is a conflict between what the brain is perceiving - a 'human' appearance - and the unnatural movements and voice. But who is this stranger who's come straight out of the future to disrupt our quiet and peaceful life at the day clinic?

THE IMPORTANCE OF INTEGRATING NAO: A 'NEW MEMBER OF THE TEAM'?

It wasn't easy with NAO at the beginning. NAO divided the team, and not everyone was won over. One member of staff said to me: "New things are always a bit scary." NAO, this 'worrying strangeness', to use Freud's words, became the focus of fantasies.

For some of the healthcare staff, NAO threatened familiar, well-established practices and it was therefore, beyond what they were actually saying, a feeling of loss of control that was being expressed. Some professionals can't stand this feeling. Again, the robot deeply unsettles people because of its innovative, never-before-seen quality. NAO users are, still to this day, pioneers.
The sometimes fiercely-argued objections seem like knee-jerk reactions. But this stage is crucial. It needs time, the chance for the team to rationalise the unknown. Little by little, NAO will find its place. But we need to go through several phases first: perceiving NAO as a danger; observing the robot from a distance; realising that there is no danger; first contact with this animated object; taking part in activities; acceptance; integration, etc.
Is NAO an emotional robot?

When I presented NAO to the whole team for the first time, I clumsily used the words 'emotional robot'; some of the healthcare team had a very strong reaction. They immediately highlighted the contradiction between how they perceived the robot and the children's disorders that have been studied at length. This contradiction was unacceptable to them because reconciling such contradictory notions seemed inconceivable.

The word 'robot' brings to mind the idea of a machine, an inanimate or non-living object, and at the same time, here it has the particularity of a child-like appearance.
On the other hand, the word 'emotional' brings to mind what is human or living, and feels emotions.
In view of these two terms, it is right to reflect on how the children are going to be able to comprehend this object. Won't this humanoid robot create confusion when it comes to differentiating between the non-living and the living? Also, many autistic children experience difficulty decoding simple emotions. Doesn't that mean that NAO will cause further anxietyfor these children and therefore hinder the therapeutic process? And what would it have been like if NAO had facial expressions? It's a good thing that it doesn't have any facial muscles, since there would have been even more confusion. These are all questions that, especially working with a vulnerable group of people, I should have known the answers to.

Today, after intensive experience and substantial training, I would have been able to reply that robots don't feel anything themselves, but they can simulate 'emotional gestures.' The robot is not alive, but it simulates through computer programming.

During this presentation, I made NAO fall forward onto the table. The team gasped. Already, adults were projecting attributes specific to humans onto this robot. The purpose of this fall was to show that NAO could get back up on its own (quite a remarkable feature). But through the reaction of the healthcare team, I sensed that there was something more going on. Because after all, if an object falls over and a mechanical part breaks... you fix it. It's just an object! But some saw NAO fall and potentially hurt itself...
That shows that this object triggers empathy, which contradicts the reactions of rejection. Therein lies the ambivalence of the healthcare team in their reactions to NAO.

Countering the initial worries and confusion seen in the adults, we see spontaneity from the autistic children.

Fig.1 : robot compagnon

NAO AND THE CHILDREN

First contact

The children's first interactions with NAO were left to happen naturally. There is a wealth of learning to be had from their reactions.

Here are some examples of interactions.

EXEMPLE 1: ROBOT COMPAGNON

When this boy saw NAO for the first time, he lay down on the floor and took a long look at the back of the robot (Fig.1). What intrigued him was the lack of a cable connecting it to a socket, a computer or the like. For this non-verbal child, NAO raised questions. It was so different to his toys. The child understood at first glance that NAO wasn't a living thing. However, it took several sessions before he was satisfied that there was no cable. A cable would have been proof for the child that NAO was indeed an object. And so, a compromise formed in the child's mind: NAO is an object, but not like other objects; it's a robot. Over the course of further sessions, NAO became a companion. In this photo, you can see the child lining up figurines, as many autistic children do. By lying down on the floor, the child is putting himself at the robot's level, which also supports the idea that the child is taking part in a shared game. It's the start of an interaction. NAO moves and turns its head towards the figurines, sensing the sound and movement.

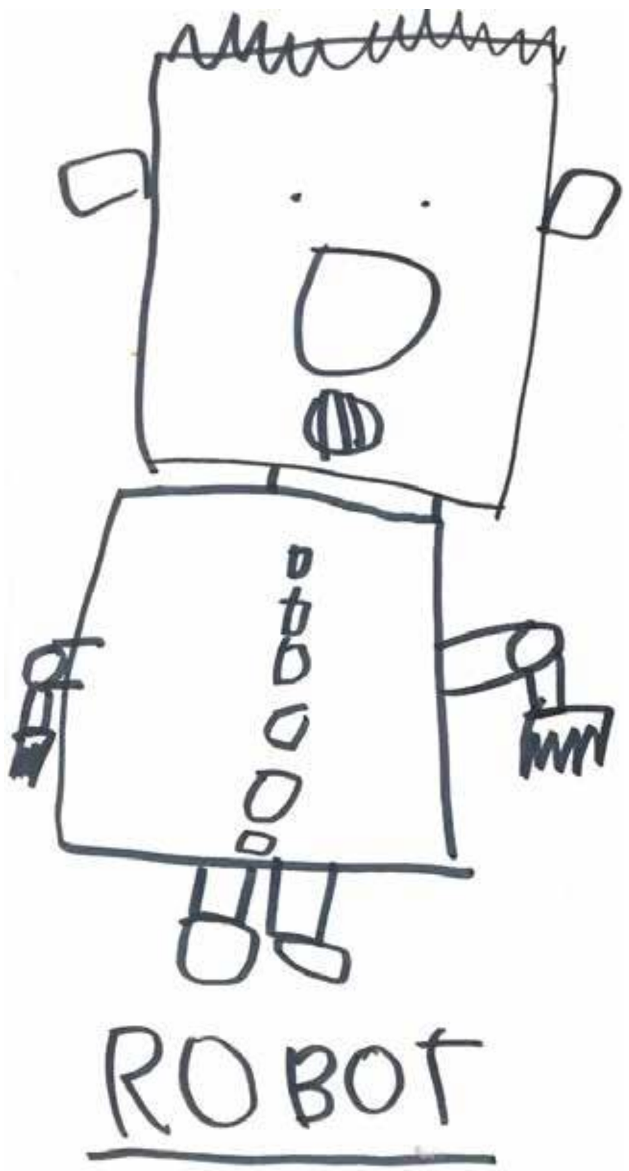


Fig.2 : dessin du robot

EXEMPLE 2 : LE ROBOT APAISANT

Anxiety is a major symptom in autistic children. This can range from mild anxiety to severe distress which overwhelms the child, stopping them from carrying out a task. I had noticed a little girl becoming increasingly stressed on Thursdays. She tensed up and became bad-tempered to the point of hysterical outbursts (shouting, hitting out, crying), which required intervention from three adults to stop her from hurting herself with her uncontrolled movements.
This child attended a primary school part-time, and every Friday morning, the teacher gave her a dictation task (of five or six words). This task caused the pupil a lot of worry and explained her reaction the previous day.

THE ROBOT EMBODYING THE ADULT

Adults are figures of authority, and despite their kindness, they evaluate the quality of the child's work. Often children don't carry out a task for their own satisfaction of learning, but to please an adult, whether it's a teacher, educator, healthcare worker or parent. Compliments are important for children. They seek them out. That's why they are scared of making mistakes and exposing themselves to criticism from the adult. This is particularly acute in autistic children.

THE DICTATION

To tackle this situation, I set up a system in which NAO served as a third party. It 'helped' the teacher, enabling a triangular relationship with the child and therefore making new types of interactions possible. Every Thursday, we practised the dictation task. The little girl was sitting down opposite NAO, with her picture book and workbook. I controlled NAO with my computer from a distance, at my desk. The fact that the adult was no longer in a one-to-one relationship with the child led to a significant decrease in manifestations of anxiety.

NAO greeted the child and suggested doing the dictation. The child always agreed. I established this as a routine, reassuring the child. Every dictation session invariably took place in this way, with no surprises. Then, NAO spoke the first word.
The pupil wrote it in her workbook. And so on. With each word written, NAO praised the child. At the end of the session, NAO thanked the child for completing the task and gave her a little nursery rhyme in English. The outbursts on Thursdays quickly stopped.

Fig.3: au dessus

Fig.4: à gauche

READING

One of the other areas where NAO can be used is in teaching children to read. In photos 3 and 4, you can see NAO reading to a child. She was very attentive, listening to NAO and following the words in her picture book, sometimes using her finger to help her. She often repeated the words spoken by NAO.

NAO can be a valuable addition to the teaching materials traditionally used in the classroom (blackboards, whiteboards, workbooks, textbooks, picture books, other books, etc.) It brings additional possibilities in back-and-forth scenarios. The child writes down what NAO dictates in their workbook; they silently read the story being spoken out loud by NAO in their picture book, etc. NAO can even enhance applications on tablets, adding a spatial dimension and movement.

EXEMPLE 3 : TAKING RISK

Learning means taking a risk. The risk of making a mistake, but more than that, the worry that they won't be able to overcome or move past this mistake. For many autistic children, the consequence of a mistake is a huge loss of self-esteem. The child thinks that they're no good at it, they're useless, that they'll never manage it and there's no point in trying again. This genuine and intense feeling, exacerbated by growing anxiety, is heightened by the presence of the adult/evaluator.

In Fig.5, you can see a boy copying the balance pose that NAO is doing. Until then, this child didn't dare to lift his foot from the ground, for fear of falling over and, subconsciously, of endlessly repeating this fall. For the first time, following NAO's example, he dared to put himself off-balance and risk falling, and ended up successfully finding his balance. NAO helped to restore this boy's sense of self-worth and self-assurance. The child gained in confidence. He was prepared to try other, progressively difficult, poses.

Several months later, doing dance poses, he said to me:

- Look, I've got more flexible!
- Do you remember when you were doing balance poses with NAO?
- Yes, actually I need to practice again with NAO....

IMITATION

We all learn through imitation and NAO can be used to help with this. Here, children are copying NAO's movements in a yoga session; in this case (photo 6), the downward dog pose. The fun aspect of this psychomotor session was relaxing, motivating and enjoyable for these children.
In this small number of examples, the reassuring observations drawn from the interactions between children and NAO have made it possible to demonstrate, in response to the various concerns raised by the healthcare team, that:

- The children can differentiate NAO the robot from a human.
- *NAO can help to reduce anxiety and therefore enable the child to take risks, and to be in a better state for learning.*
- Its humanoid but simplified appearance sets off an initial form of interaction.

NAO therefore has an important place in the hospital as a therapeutic mediator. I hope that, in the near future, the healthcare team will appropriate this tool and themselves develop workshops using NAO, or that it will spark a wave of creativity, change things up, etc.

Fig. 6

A FEW RECOMMENDATIONS FOR THE BEST WAY TO INTEGRATE NAO:

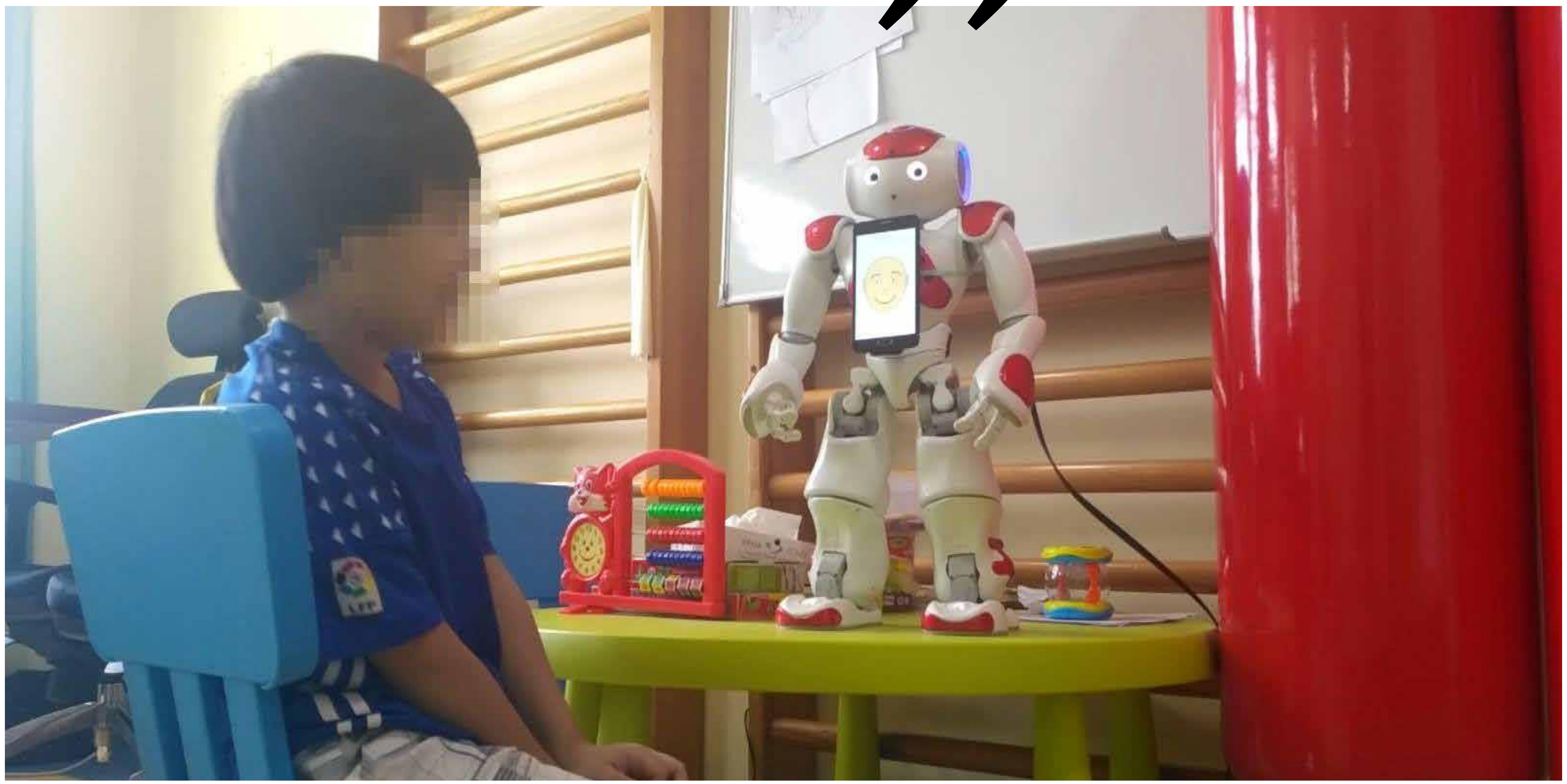
To sum up, here are some tips for future users on how best to integrate a NAO into a team:

- give it time
- invite questions and concerns about the robot
- inform the team about the real abilities of the robot, but also its limits (repeated bugs for example), using scientific data, to break down fantasies.
- let members of the team handle the robot themselves to get a better idea of what it is like

// UNITED ARAB EMIRATES

Dr.Fady Al Najjar

PERSONALIZED ROBOT INTERVENTIONS FOR AUTISTIC CHILDREN: AN AUTOMATED METHODOLOGY FOR ATTENTION ASSESSMENT



INTRODUCTION

Could robots also be used to improve the social abilities of humans, training their capacity for attention and interaction? Is it possible for an individual to learn from robots to establish richer relationships with other humans, fulfilling their inherent empathic potential? These questions are particularly pressing for the individuals who are prevented by clinical factors from establishing typical social relations with others - for example autistic subjects who experience social attention as effortful and potentially upsetting.

In the present study, a simple autonomous assessment system based on attention cues was created and deployed, combined with an enhanced adaptive semi-autonomous interaction system based on patient interests. Both systems were implemented in an interactive autonomous humanoid robot. The function of the robot was to increase the attention and engagement levels of the patients during interactive sessions. Increasing the attentional and interactive capabilities of ASD patients has the potential to enhance their academic functioning by gradually habituating them to socially interactive sessions of increasing length. The proposed approach utilizes simplified hardware with some upgrades to the onboard hardware of the robot to target multiple interaction and attention cues simultaneously. This technique can serve as a useful form of ASD intervention to facilitate adaptive interactions with patients based on their status while involving minimal subjective biases. In this study, we empirically tested the proposed system on a group of ASD children. The study empirically proves that the proposed assessment system represents the attention state of the patient with 82.4% accuracy.

The paper proposes a robot-mediated therapy and assessment system for children with autism spectrum disorder (ASD) of mild to moderate severity and minimal verbal capabilities. The objectives of the robot interaction sessions is to improve the academic capabilities of ASD patients by increasing the length and the quality of their attention. The system uses a NAO robot and an added mobile display to present emotional cues and solicit appropriate emotional responses. The interaction is semi-autonomous with minimal human intervention. Interaction occurs within an adaptive dynamic scenario composed of 13 sections. The scenario allows adaptive customization based on the attention score history of each patient.
The attention score is autonomously generated by the system and depends on face attention and joint attention cues and sound responses. The scoring system allows to prove that the customized interaction system increases the engagement and attention capabilities of ASD patients. After performing a pilot study, involving 6 ASD children, out of a total of 11 considered in the clinical setup, a long-term study was conducted.

BEHAVIOURAL ASPECTS FOR CHILDREN WITH ASD

- Children with ASD are prevented from developing social interaction and communication skills which significantly impact human development, learning, and well-being, and the ability to respond to them.

- Neurological accounts often highlight that parts of the social brain systems of ASD children are hyporesponsive to social stimuli and gaze cues. This hyposensitivity is the cause of their unresponsiveness to the social signals of other individuals and the related difficulties in perceiving the eyes of other people as socially salient, which is why ASD children rarely establish eye contact. Avoiding eye contact leads to impaired social attention and, hence, difficulties in communication and interaction with others, which may result in severe academic and social problems.

- Owing to the continuous increase in the number of children diagnosed with ASD worldwide, the growing related social costs, and the absence of universally established diagnostic and therapeutic protocols, effective treatment of ASD is considered a public health emergency and an open research question.

STIMULATING INTERACTIONS WITH ASD CHILDREN THROUGH HUMANOID ROBOTICS

The developments in artificial intelligence and robotic technologies have proven promising for stimulating interactions with ASD children and performing more frequent assessments.

- Robots fill the gap between conventional human therapy and child toys and can perform endless repetitions without boredom, eliminating the concerns of training intensification.

- Anthropomorphic robots are designed to reproduce human features, behaviors, and emotions while simplifying their informational complexity, thereby reducing the cognitive and emotional burden and decreasing the possible stress for the patient.

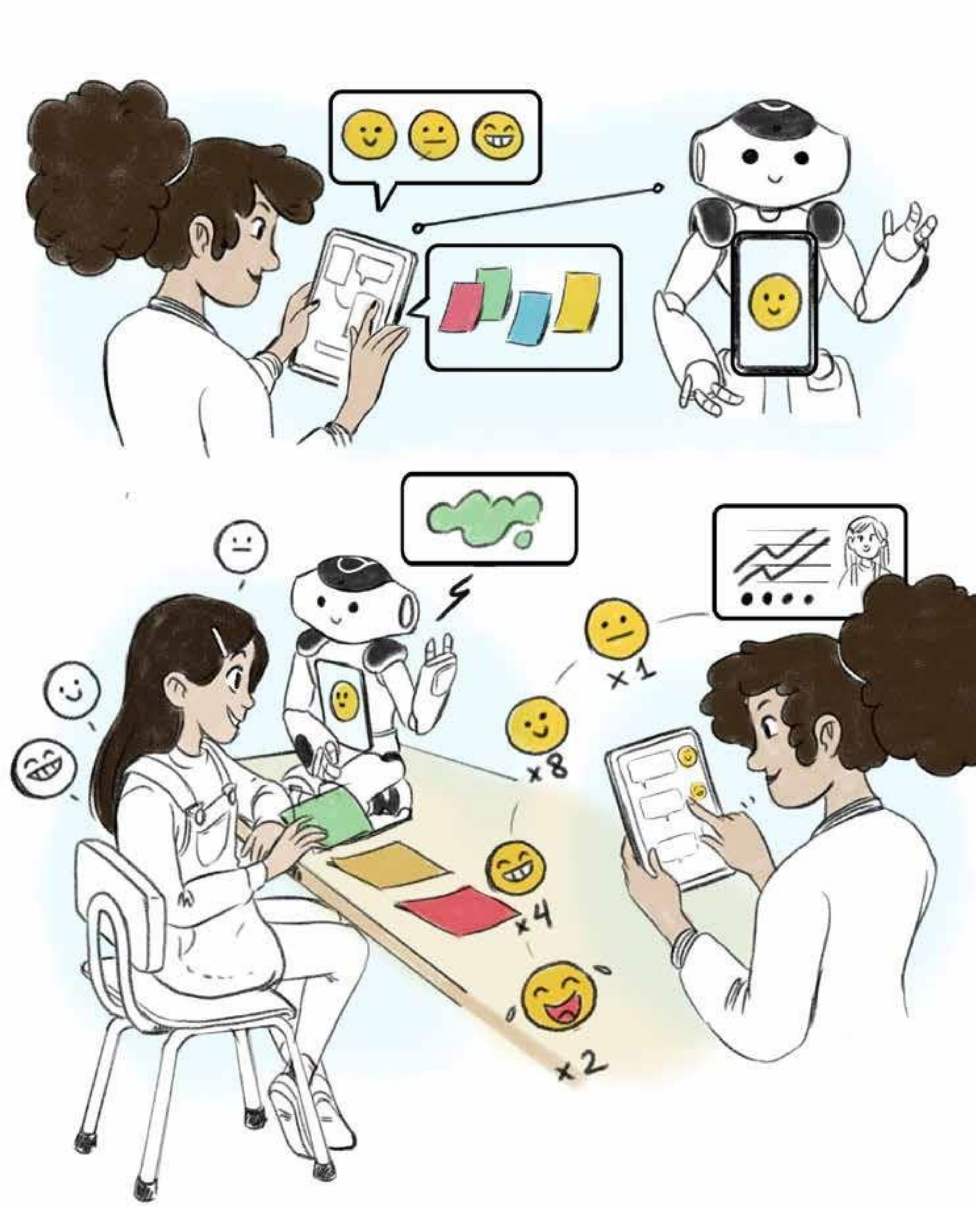
- Consequently, it is believed that robots can improve the quality and length of engagement during social interaction and increase the possibility of stimulating the patients' social and cognitive abilities.

- Crucially, robots can also automatically conduct score-like assessments.

- Robots continuously collect information that is relevant to diagnosis, which is useful for building retrievable databases of patient assessments and interaction histories. Such databases can be used to guide therapists in the personalization of their interactions and assessments.

- Compared with traditional assessments, the assessment methods augmented through robotic means allow for more comprehensive and articulate tracking of greater numbers of patients with more heterogenous individual situations and needs.

- Such personalization can be applied locally, within the same team or clinic, or globally as integrated clinical dataset sharable by professionals in different places through interoperable systems.



Current robotics techniques, however, still suffer from various limitations. Most pre-programed systems have fixed behavior (i.e., they are unable to autonomously perform adaptable closed-loop interactions), are not tailored to the individual needs of patients, and cannot keep track of their recovery progress.

- For these reasons, semi-autonomous and adaptive robots are greatly needed to recognize the behavioral cues of children and respond accordingly.

- On the other hand, semi-autonomous adaptive systems, especially complex systems, need high-performance hardware, such as GPUs chips, to process real-time data and update interactions.

- Moreover, such fully autonomous and complex robots and systems are not yet reliable outside controlled research setups.

The paper is organized as follows:
sections 2 and 3 provide thorough descriptions of the proposed assessment and therapy system, including the experimental setup and procedures. Sections 4 and 5 analytically present the study results and discuss their implications in the context of the research objectives. Section 6 concisely restates the study methods and main findings and addresses the scope for future research.

METHODOLOGY

Participants

The participants in the study were 11 male patients diagnosed with ASD of mild to moderate severity (Childhood Autism Rating Scale [24] - which is essentially a diagnostic scale; CARS2 of 30–36.5) who were under the age of 16 years, with a mean age of 9.03 (±2.56) years. Only patients with verbal response capabilities were considered, as the participants were preliminarily asked to understand verbal communication and respond with yes or no at least.

System Design

1. NAO Robot with a Chest-Mounted Mobile Phone - The proposed approach to robot intervention in autism therapy and diagnosis uses a specifically designed NAO humanoid robot (Aldebaran NAO robot) with an additional display on its chest to show facial features.

Fig. 1. NAO robot with a mobile phone attached to a chest holder to show the Emotions Selector mobile application.

Fig. 2. (a) Custom-designed NAO chest holder side view, showing the attached standard mobile holder. (b) NAO chest holder rear view, showing the added Velcro strap for fastening.

2. Attention Assessment System - This paper presents a novel simple numerical diagnostic assessment method that does not require any external camera or monitoring equipment. It utilizes the naoqi image processing capabilities of the NAO robot and the capabilities of the mobile phone to detect patient attention cues and generate numerical measures. All attention cues are detected and updated in every iteration of the system algorithm, running at average speed of 1Hz, and each score is updated based on certain parameters as below.

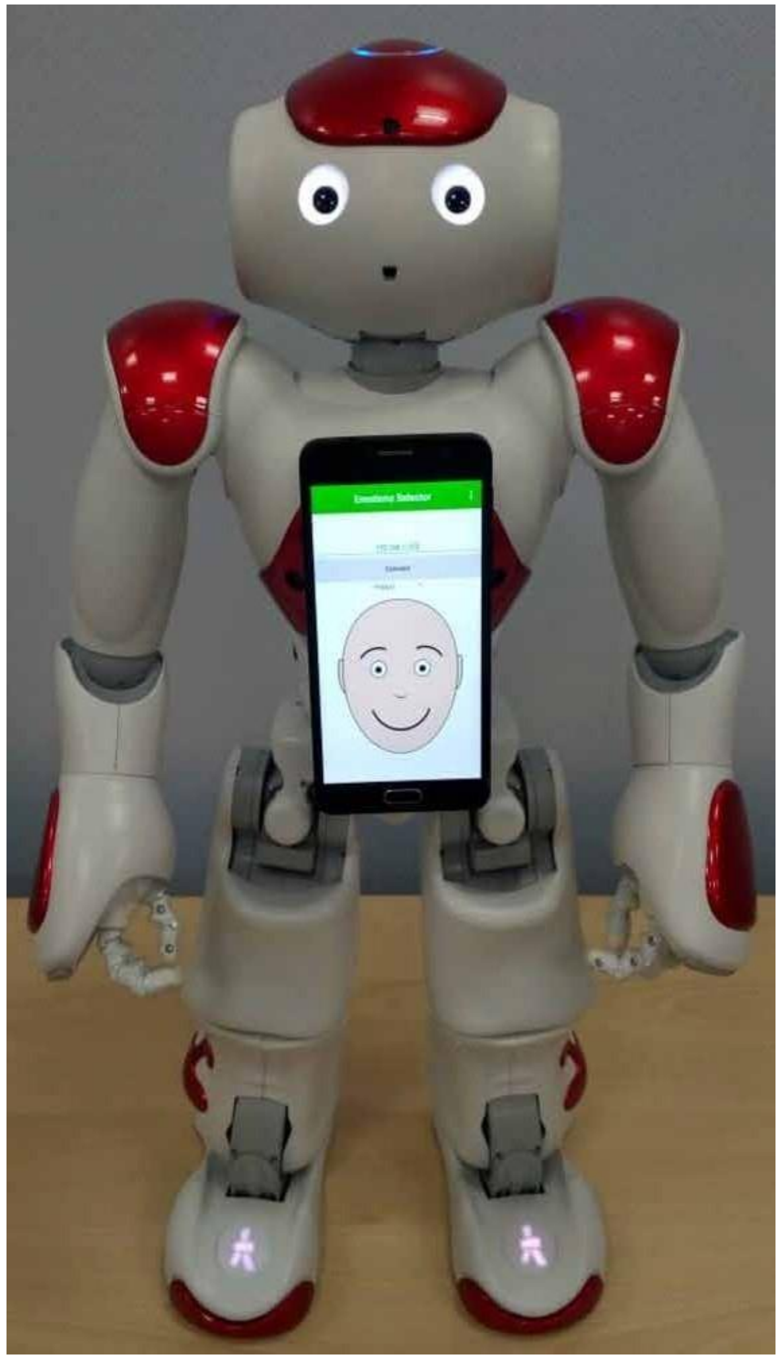


Figure 1.

Attention Score – The camera of the mobile phone was configured as an IP camera using the IP camera mobile application utilized for face detection to produce and accumulate an attention score.

- *Attention Score* – The camera of the mobile phone was configured as an IP camera using the IP camera mobile application utilized for face detection to produce and accumulate an attention score.

Figure 2.

- *Joint Attention Score* – The joint attention score measures the extent to which the patient's responses are synchronized with the robot's motoric actions and requests.

- *Sound Response* – A mobile application called WO Mic turns the mobile phone microphone into an IP microphone, and client software on the computer connects the WO Mic as a sound input for a sound response module algorithm.

- *Emotion Detection* – The assessment system estimates the emotional state of the patient by detecting facial features.

3. Adaptive Dynamic Scenario and Weights - A dynamic interaction scenario is employed, which depends on the real-time scores of the assessment system to tune the interactions based on the previous interaction results. This method helps maintain interaction and assessment sessions by reducing human intervention in the scenario flow. Moreover, it allows the operator to have control, although limited, by interfering with operator-defined robot responses added to the interaction in real time to ensure the meaningfulness and interactivity of the scenario. The scenario is divided into sections, where each section contains interaction dialogues, motions, and plays for a certain topic, such as greetings and getting to know each other, entertainment games and songs, and conversational questions and requests.

4. Control Interface - We reduced the need for human intervention to make robot-aided sessions more easily replicable in clinical and domestic environments, as reproducibility is essential to make the system usable by therapists and parents without technical supervision.

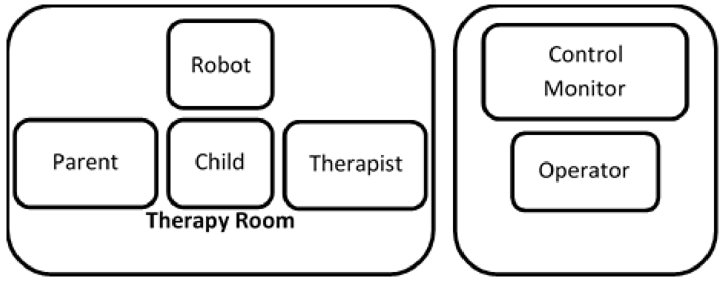
Figure 6.(a).

EXPERIMENTAL SETUP

Experiments were conducted in Al Ain Hospital rehabilitation center in collaboration with autism therapists. The operator, who is not a therapist, sat in a separate control room monitoring the robot–child interaction setup remotely and controlling the assessment system. The robot was placed in the therapy and interaction room standing on a table so that it was at the same level as the patient sitting on a chair, as shown in Fig. 6(a). The setup was composed of the robot, patient, therapist to intervene in potentially harmful situations, and parent (if available), as shown in Fig. 6(b). A camera recorded the interaction sessions, so that the parents could watch the sessions if they were not available at the session time.

Fig. 6. (a) Therapy and interaction room setup. (b) Schematic diagram of experimental setup.

Figure 6.(b).



1. Experimental Protocols - The robot was introduced to the child as a new friend. The experiment started by asking the child to sit on a chair facing the NAO robot and talk with it. The therapist was asked to fill out the therapist assessment sheet during the experiment if possible, or later at the time of watching the video. At the end of the session, the parent was asked to fill the parent feedback form.

2. Real-Time Score Visualization - The accumulated attention, joint attention, and sound response scores were presented in real time in a separate single compact plot, to convey the level of interaction between the patient and the robot to the operator.

DISCUSSIONS

- The long-term interaction progress results show that robot intervention in autism therapy is highly beneficial for autistic patients. They enjoy the treatment sessions and give enough attention to learn or enhance a skill in every session. Noticeable changes in patient behaviors and skills took a few weeks, until the patients became familiar with the robot voice and moves. Breaking the ice took one or two sessions on average, until the patients interacted with the robot freely and excitement reached a steady level.

- The autistic patients built strong bonds with the robot as a friend who encouraged them to withstand the therapy time. One of the patients once brought some friends to meet the robot as a new friend. We observed that the therapists at the hospital went further by encouraging their patients to do energy-draining physical therapy exercises by offering a session with the robot as a reward. The therapists reported that the patients asked about the robot every day and looked forward to the day of the robot session.

- Moreover, most parents reported that their children mimicked and repeated many of the robot responses at home, and some of the children asked their parents at home the same questions that the robot had asked them during the session. Five out of six parents believed that their children performed as well as at home.

- The therapist assessment shows an increasing trend, with all patients demonstrating an increased attention level over time.

- Emotion predictions are of great assistance in understanding the emotional states of children in different scenario sections. Mapping the predicted emotions using the attention score and associated scenario section enables understanding of the facial responses of patients to specific topics and could facilitate the detection of difficulties in emotional responsiveness and other similar autism characteristics.

The objective of this study was to develop a simple robot-mediated assessment and interaction technique to prepare such systems for long-term presence in autism rehabilitation centers. This system can be used by therapists and parents after short training.
The proposed system is easily replicable due to its simplicity and ease of use, and can cope with a large number of patients simultaneously. In addition, it may play a complementary and coadjutant role in the therapy of the patients who cannot continue traditional treatment sessions or need sessions with a frequency higher than rehabilitation centers can offer due to a lack of therapists.

Because of the heterogeneity of ASD disorders, one predefined intervention scenario cannot possibly address the needs of all patients. The proposed adaptive dynamic scenario and weighting technique allows customized interactions for each child. Such adaptive techniques have proven effective in sustaining social engagement during long-term children–robot interactions [28]. The employed techniques maximize engagement, which is one of the strongest predictors of successful learning [29], using a ludic mobile robot to stimulate social skills in ASD children. Moreover, the proposed system reduces the therapist's subjectivity in assessment and allows for early intervention.

The current study has several limitations that need to be highlighted with a view to address them through future developments and integrations. First, only one-on-one interaction is possible, to allow the child to focus on the robot only and to allow the system to capture the child's attention cues. Moreover, the study included a relatively small number of patients, and more results may be revealed when it is applied to more patients. Also, the proposed interaction system is only applicable to patients with moderate severity and who have at least minimal verbal response capabilities. Some children may become distracted by the mobile phone display on the robot, since they are used to playing games with such devices, which may lead to drops in attention score. This issue occurred only at the beginning of the early sessions where the children were exploring the robot features and it has been partly addressed by fixating the display in a way that it cannot be moved by the children.

CONCLUSIONS

An adaptive robot intervention system for ASD assessment and therapy was designed for clinical use and tested empirically on six ASD patients in an autism rehabilitation center. The results demonstrate that the proposed assessment system can accurately represent the attention levels of patients with mild to moderate ASD and simple verbal communication skills, matching over 80% of therapist assessments. The proposed adaptive, dynamic interaction system yielded remarkable improvements in the attention levels of most of the patients in long-term therapy.

Based on these outcomes, our hypothesis is that a properly designed robot intervention system can increase the attention levels of ASD children insofar as it enhances their engagement and, in so doing, helps them improve their communicative and social skills. Moreover, the same system can facilitate the assessments of autism symptoms providing therapists with a useful set of reliable and objective quantitative methods. The proposed system is so flexible, robust, user-friendly, and easily customizable that we infer it could be utilized without effort by parents in domestic environments. Not only does not the system require any previous technical experience, but – thanks to the scalability of robotic intervention - it enables the efficient treatment of a large number of patients, increasing the frequency of the sessions that can be administered to the children while implementing exactly replicable protocols.

Some authors maintain that exposure to digital technology can aggravate the social symptoms of autism in children, worsening their deficits and possibly increasing the chances of developing obsessive compulsive behaviors. The outcomes of our research mitigate these worries. Our research provides robust anecdotal evidence that proper design and supervised application of robots in autism therapy has the potential to make ASD subjects feel spontaneously engaged in basic forms of social interaction and, at least apparently, significantly less anxious than during the typical interactions with other humans. We speculate that one of the contributing factors in achieving this positive result is the fact that robots allow effective forms of pseudo-social interactive engagement while decreasing the complexity of the social context and hence reducing the excessive emotional and cognitive burden that autistic children typically have to process. Our hypothesis is that this technology offers ASD children an opportunity to familiarize with social interaction in a context that they find conducive and reassuring with a pace that they can comfortably control by means of tasks that they can repeat at will without hurry. That is why we believe our robot-based interventions have the potential to support the development of social skills in autistic subjects and can teach them new ones, consolidating their ability to interact with other humans.

Perspectives

Future developments of the proposed system would have to aim to increase the assessment accuracy and further enhance the patient's engagement with the robots, broadening the set of available types of interaction and increasing the degrees of freedom that define such interactions. Multiple cameras could be employed where a fixed observation setup is possible (considering the specificities of the clinical setting) to preserve the robot's mobility while broadening their interactive capabilities. Furthermore, a large set of patients would be desirable to test more extensively all the functionalities of the system and tune them for performance improvement. Finally, it would be useful to test whether a virtual avatar displayed on a tablet could reduce the costs involved in the use of embodied mobile robots, simplifying the use of the interactive system in the home setting: however, we anticipate that the quality of the interaction with a virtual avatar might be inferior in terms of both quality and length to the interaction established by the children with a physically embodied robot.

NAOtismIA

HOW HUMANOID ROBOTS STIMULATE THE EMERGENCE OF BEHAVIOURS NECESSARY FOR COMMUNICATION AND INTERACTION

The NAOtismIA project is part of the French national strategy on autism, commitment no. 2 of which is to provide early intervention for children under 7 years old. The purpose of this project is to help children aged between 3 and 5 years old with autism spectrum disorder to communicate better during interactions with children of the same age and adults. The idea is to work with them from a very young age, taking advantage of brain plasticity to make lasting progress in interactions and communication with others.

This project is being carried out by the Rectorat (local education authority) for the Dijon school district and the DRNE (Regional Delegation for Digital Technology in Education) of the wider Bourgogne-Franche-Comté school region.

THE PARTNERS INVOLVED IN THIS TRIAL INCLUDE:

Institutional partners:
The ARS (Regional Health Agency) for Bourgogne -Franche-Comté
The INSHEA (higher national institute of training and research for the education of disabled young people and adapted teaching) in Suresnes

Partners in the health and social care sector :
ACODEGE (the association for the management of the pre-primary autism teaching unit at the Fontaine aux Jardins école maternelle [compulsory nursery school for children aged 3-6] in Quétigny, Côte d'Or)

Partner companies:
ERM Robotique: developed the applications
Aldebaran: developed the NAO hardware
Microsoft: provided a collaboration and storage space

The team :

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PURPOSE :

The purpose is twofold; to use NAO as an aid both for learning and for social interactions in order to create possible exchanges between the children with ASD and the other children at the nursery school and between the children with autism and the adults (working at the pre-primary autism teaching unit and at the school). The team responsible for implementing the project examine the results for observable effects such as:

- *Verbal and motor imitation:* the children copy simple movements at NAO's request as well as phrases with a communicational purpose
- *Gaze:* the children look towards NAO's eyes following verbal instructions from the robot
- *Understanding:* responses and cooperation from the children following NAO's requests and/or instructions.

SCHEDULE FOR THE TRIAL:

The trial was conducted over three years from 2017 to 2020 and began at the UEMA (pre-primary autism teaching unit) in Quétigny (Côte-d'Or). For a year, the team trained and became familiar with NAO. Interactions between the different partners helped them all to become aware of the issues involved and all contributed to developing and adapting the applications on shapes, colours and yoga.
Next, during the 2 nd year, NAO was deployed in the UEMA (pre-primary autism teaching unit) with the pupils. This marked the start of the testing phase for the applications with children as beta testers.
They were in their last year at the UEMA unit and this stage was not counted towards the results of the trial.
Finally, in the 3 rd year, the trial was expanded in the first unit while an awareness campaign began in a second UEMA within the school district and also in an ordinary nursery school class. Two researchers from INSHEA contributed to the trial evaluation by securing the protocol and documenting the added value gained through using the robot by analysing short videos sent regularly via a secure process.
The factual information passed on to theresearchers is in the process of being analysed.

METHODOLOGY AND TRIAL OF NAO AT THE SCHOOL

Three applications were developed specifically for this trial, making it possible to guide the children's days with NAO. In the morning, the class comes together for a daily activity
- *'Dire bonjour' (Say Hello):* For this, NAO is an assistant to the teacher who asks it about the date and the children and adults present. *Say Hello*
This session is finished off with a nursery rhyme. It is greatly appreciated by the pupils who imitate movements more while watching NAO.
Nursery rhyme.
Next, there are individual teaching sessions on vocabulary around objects with the application dedicated to recognition of colours and/or objects.
These sessions last 5 minutes and take place in a space divided into separate booths to help keep the pupils calm. The child sits at a table with coloured objects on it and the specialist educator sits behind them. NAO is placed standing on a table facing the pupil.

NAO is the instructor and gives the pupil instructions as well as feedback on their answers. The educator controls NAO via the tablet. NAO is also acting as a physical instructor to prompt or guide the pupil since the errorless learning strategy is used.
NAO is involved in an acquisition phase but also in the consolidation and evaluation phases depending on the instruction.

Example for colours:
Each sequence is different: the activity consists of matching the colour with an object, a card or the name of the colour said out loud. The lesson starts with two colours (yellow/red).
There are nine acquisition stages because only one variable is changed each time. Each stage is worked on several times. To proceed to the next stage, the pupil has to have completed the activity correctly on their own on the first attempt during three successive sessions on different days. These different acquisition stages can be modified according to the children's needs. The teachers and/or specialist educators adapt by restarting or advancing in the learning process, depending on the child's response.

SEQUENCE SHEET

UEMA Fontaine aux jardins — Année scolaire 2018 / 2019

Etapes de mise en place de l'activité

Etapes	Déroulement	Avec l'adulte	Avec NAO
	Couleurs travaillées : jaune / rouge		
1	L'élève dispose de 2 objets identiques devant lui (1 jaune, 1 rouge).	L'adulte nomme la couleur demandée et montre une carte de la même couleur.	Nao nomme la couleur demandée et ses yeux indiquent la couleur.
2	L'élève dispose de 2 objets différents devant lui (1 jaune, 1 rouge).	L'adulte nomme la couleur demandée et montre une carte de la même couleur.	Nao nomme la couleur demandée et ses yeux indiquent la couleur.
3	L'élève dispose de 2 objets différents devant lui (1 jaune, 1 rouge).	L'adulte nomme la couleur demandée. La carte sera utilisée en deuxième intention si l'élève se trompe.	Nao nomme la couleur demandée et ses yeux restent neutres. Les yeux de NAO pourront être une aide si l'élève se trompe la première fois.
4	L'élève dispose de 3 objets différents devant lui : 1 jaune, 1 rouge + 1 d'une autre couleur (objet distracteur).	L'adulte nomme la couleur demandée. La carte sera utilisée en deuxième intention si l'élève se trompe.	Nao nomme la couleur demandée et ses yeux restent neutres. Les yeux de NAO pourront être une aide si l'élève se trompe la première fois.
5	L'élève dispose de 2 cartes (1 jaune, 1 rouge) devant lui. (début de la phase de généralisation).	L'adulte nomme la couleur demandée.	Nao nomme la couleur demandée et ses yeux restent neutres.
6	L'élève dispose de 3 cartes devant lui : 1 jaune, 1 rouge + 1 d'une autre couleur (distracteur).	L'adulte nomme la couleur demandée.	Nao nomme la couleur demandée et ses yeux restent neutres.
7	L'élève dispose de 4 objets devant lui (2 jaunes, 2 rouges).	L'adulte nomme la couleur demandée.	Nao nomme la couleur demandée et ses yeux restent neutres.
8	L'élève dispose de 5 objets devant lui : 2 jaunes, 2 rouges, 1 d'une autre couleur (distracteur).	L'adulte nomme la couleur demandée.	Nao nomme la couleur demandée et ses yeux restent neutres.
9	L'élève dispose de 10 objets devant lui : 4 jaunes, 4 rouges, 2 distracteurs.	L'adulte nomme la couleur demandée.	Nao nomme la couleur demandée et ses yeux restent neutres.

ANALYSIS :

For each individual sequence, two cameras film. There are 28 videos each week (7 children, twice a week) enabling the pupils' progress to be evaluated.

There are three levels of understanding of verbal language :
- Level 1: One-word instructions: 'Red', 'yellow'
- Level 2: Instructions with a verb: 'pick up', 'show', 'give' + requested colour
- Level 3: Whole-sentence instructions: 'pick up the yellow object', 'show me the yellow card'.

Evaluation during the session is done using a rating grid on what has been learnt (grid put together in close collaboration with Karine Martel and Philippe Garnier, teaching and research staff at INSHEA) to validate the acquisition stages.

ANALYSIS :

OBSERVATIONS
Séquence : les couleurs

Prénom de l'élève		Séance n°	

Situation de travail	Date		Heure		Présence NAO	
	Contrat de travail		Renforçateur utilisé		Durée de la séance	/ 5 min
Mode de jeu	Verbal + visuel		Verbal + visuel si erreur		Verbal	
Mode de difficulté	Niveau 1 (Mots)		Niveau 2 (Verbes)		Niveau 3 (Phrases)	

Observations

Fig.1 Show the color
Fig.2 Show the shape

Observation has shown that children like having NAO as a communication partner during these learning sessions. NAO is an additional tool which gives good results, with the children showing more interest in the proposed activities.
The children attend the pre-primary autism teaching unit for a period of three years, after which the support of NAO will not necessarily be continued in their education. It is therefore important to work on generalising what has been learnt and for that purpose, sessions are done with a specialist educator without NAO, following the same protocol and mirroring the sessions with NAO. The teacher or specialist educator uses the same words and the same movements the robot requested. Considering the significant differences observed in favour of NAO, the teachers and/or specialist educators make sure to be as 'neutral' as possible and are very careful with their facial expressions and clothing in order to help the pupils to concentrate. It is through repetition and work getting the students used to this that the teachers and specialist educators succeed in achieving the same skills that the children demonstrated spontaneously with NAO. This repetition enables them to reproduce what they have learnt outside of the specific context.

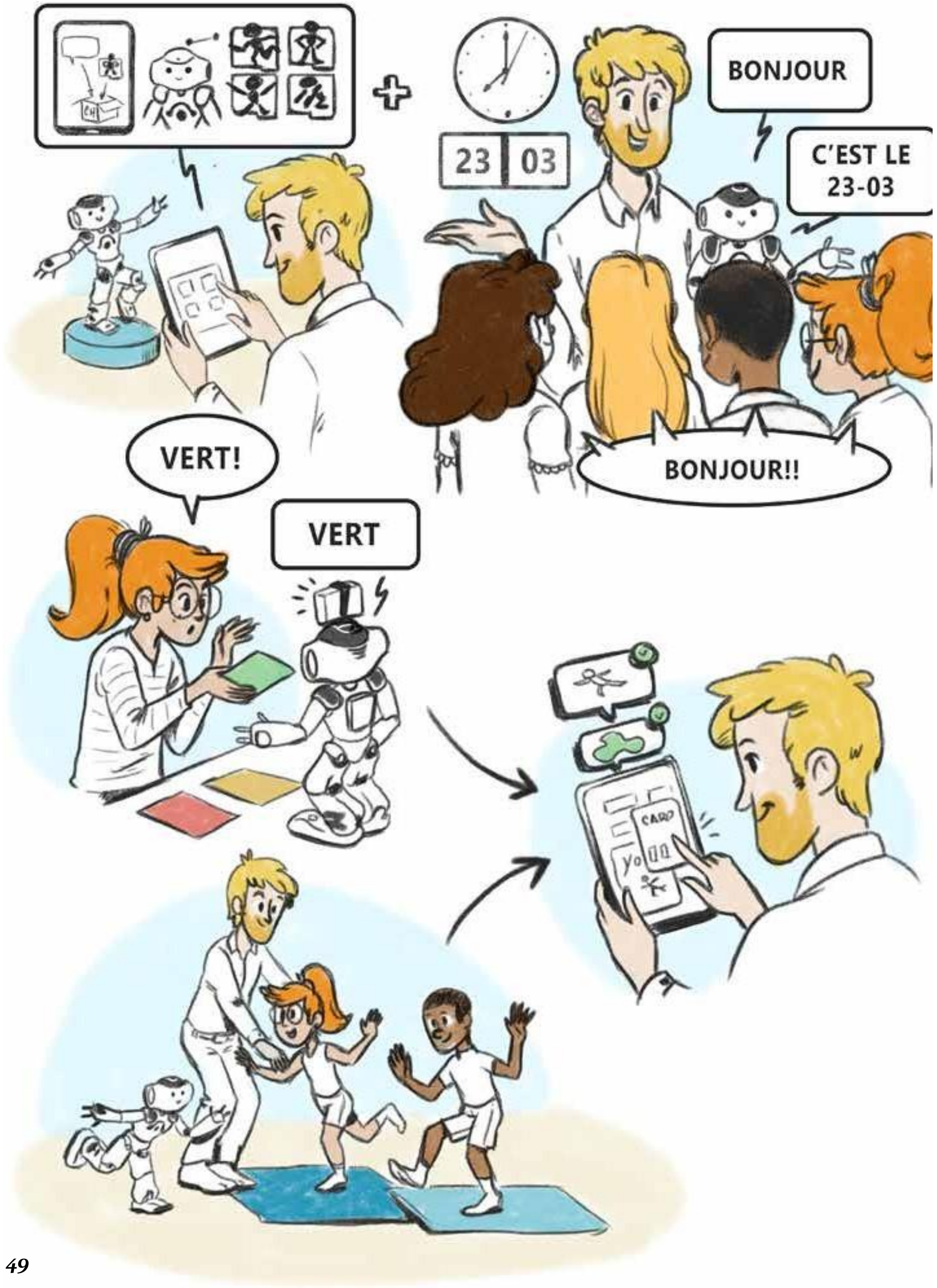
MOTOR SKILLS ACTIVITIES WITH THE YOGA APPLICATION

The aim is to teach the children to imitate movements and increase their repertoire of motor skills. The application has been specially reworked to adapt the movements to children aged between 3 and 5 years old who experience motor difficulties due to their disorder. It is movements such as raising an arm or taking a step to the side, for example, that NAO asks of the children.
This session takes place with one child or a pair for 10 minutes. Here again, NAO is the instructor and gives the pupils the instructions for the activity as well as feedback. An adult provides the physical prompts for errorless learning. They are on hand to guide the pupil and are controlling the robot via the tablet.
NAO is the only motivator and reinforcer, and is involved in an acquisition phase but also consolidation and evaluation phases.

There are three levels of understanding:

- *Level 1:* Initial instruction - 'Copy me' - then non-verbal action
- *Level 2:* Initial instruction - 'Copy me' - then verbal instruction (action + body part).
- *Level 3:* Initial instruction - 'Copy me' - then instruction with the use of sentences.

Observation has shown that the children's gaze is very much directed at the robot and its movements.



The children are highly stimulated by noise at school, the presence of others and smells and they feel lost when they arrive. What we have noticed is that NAO's help seems to have a not

insignificant effect in terms of the pupils' concentration as well as the concept of sparking their interest in the task.

AskNAO Tablet for autism is a complete solution aiming to help teachers and specialist educators in supporting children with autism spectrum disorder. The solution includes the NAO robot along with a set of educational and fun applications specially designed to meet the needs of children with autism. INSHEA got involved in this work to carry out an in-depth analysis of what happens during the sessions in order to confirm (or disprove) the added value provided by the NAO robot in terms of progress in the children's interactions and communication. It involves analysing whether NAO's contribution is significant for the children and to document how all of the qualities that can be attributed to the robot help the children. It is also about developing solutions for transferring skills, if there is an improvement in communication ability or social behaviour.

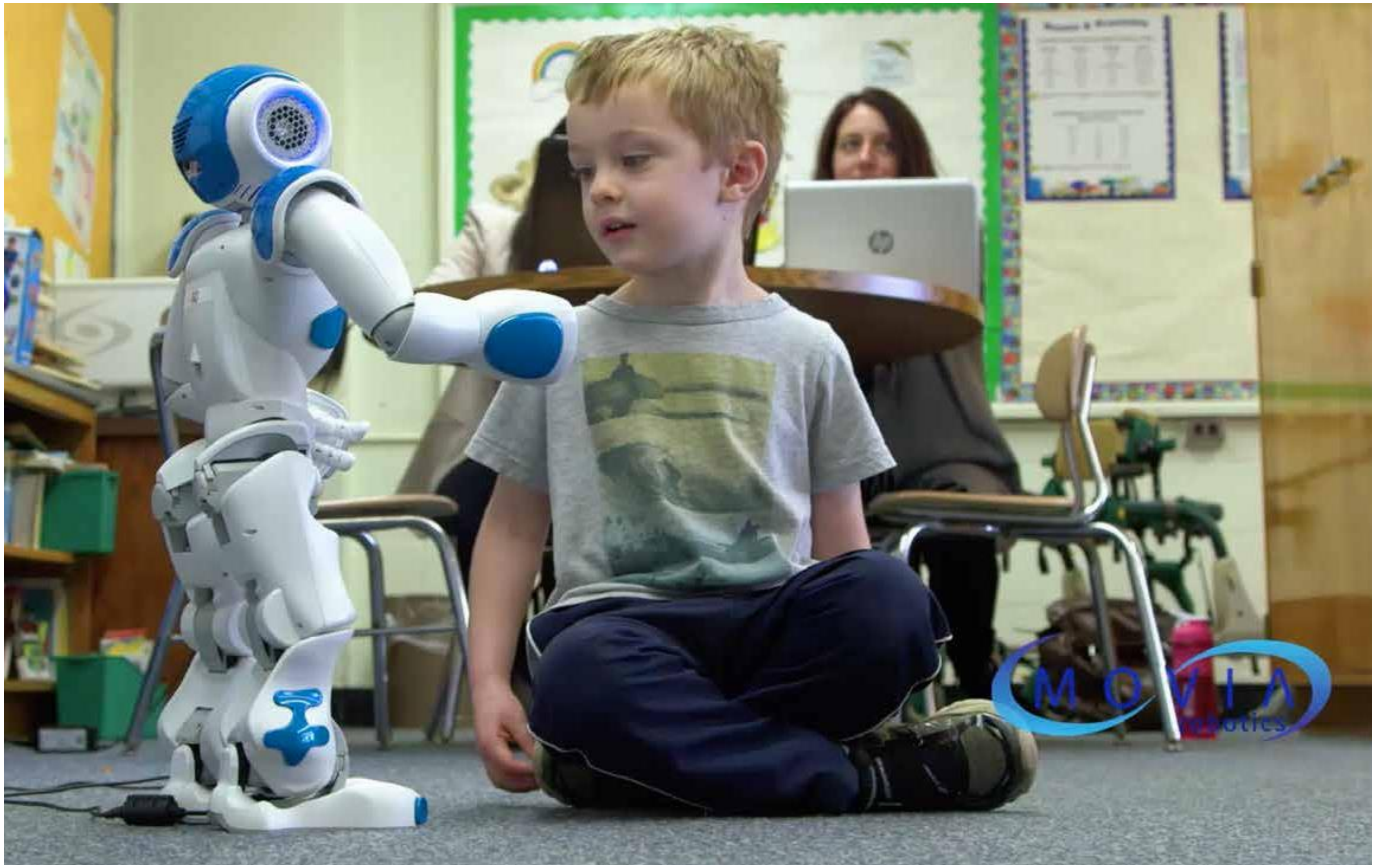
CONCLUSION

The trial in the UEMA and grande section de maternelle class (last year of nursery school) is still ongoing, the pandemic having interrupted the work. It is clear that there is a desire to extend this type of programme into the long term, making it possible to measure the impact of this technology on children who have difficulties with communication and interactions and to integrate the trial into teaching along with all the possible improvements and findings.
The results are still being studied and it will be useful to examine them in the light of the data collated across all sites. However, the initial results seem to show great benefit both for the teachers and special educators involved in the trial and for the pupils, who seemed to change their behaviour during contact time with the NAO robot. The status of the robot has not strictly speaking been defined for these same pupils, who consider it as a peer at times and as an assistant to the adult running the activity at other times. This should be explored in more detail in order to determine in which circumstances the robot takes one status or the other.

Besides these initial observations, the trial should continue with the analysis of any progress made in terms of interactions and communication, which is the basis of the study.

Perspectives

MOVIA



INTRODUCTION

Humanoid Robotics have shown a new ray of hope for students having Autism Spectrum Disorders (ASD) characterized by difficulties with social interaction and communication, and by restricted and repetitive behavior. To study the same, a pilot program was initiated by West Hartford Public Schools district (WHPS), West Hartford, Connecticut in collaboration with Movia Robotics conducted over a period of 3 years in the PreK-5 program for children with Autism Spectrum Disorders (ASD) to assess the efficacy of the NAO robot (manufactured by Aldebaran) as an instructio- nal and therapeutic tool to support student academic learning and social development on their Individualized Education Plan (IEP).

The findings of the pilot study indicated a positive interaction between the students and the robot, with improved motivation, engagement, and skill attainment. Robot-Assisted Instruction (RAI) provided staff with an effective instructional technology tool to support the unique abilities and needs of students with ASD.

RAI resulted in educational and therapeutic benefits for students with ASD, including demonstrated motivation and focused engagement skill attainment on targeted skills. Students demonstrated generalization of skills to other environments. Based on this outcome the district implemented RAI in its regular program of delivery to the special needs students.

BEHAVIOURAL ASPECTS FOR CHILDREN WITH ASD

Children with ASD show various behavioral aspects as per various studies carried out in this arena.

- Children with ASD who have imitation impairments at a young age also present with language delays in the preschool years.
- Imitation deficits in young and older children with ASD correlate with their other social skills such as joint attention (i.e., ability to coordinate attention between people and objects) and their understanding of others' intentions.
- Studies suggest that Imitation training, such as reciprocal imitation and visually cued imitation, improves the social communication skills of children with ASD.
- Another study suggests that children with high functioning ASD showed fewer correct responses during gestures following imitation, gestures to command, and gestures during tool use.
- Findings indicate that enhancing the motor performance of children with ASD may facilitate their poor social communication skills.
- Young and older children with low and high functioning ASD have impaired fine and gross motor coordination including basic motor skills such as locomotion and upper limb tasks as well as static and dynamic balance tasks.
- Children with ASD have deficits in appropriately responding to Joint Attention (JA)(the ability to focus one's attention to that of a social partner). Studies suggest that spontaneously initiating JA is significantly impaired in children with ASD. Four-year old children with ASD improved their response and initiation of joint attention behaviors following joint attention training.
- Another study found that young children with ASD make significant gains in language development following JA based intervention as compared to an untrained control group.

CHALLENGES FOR EDUCATORS

An educator can have a very difficult time with the engagement in a typical classroom setting. These difficulties can be both academic and behavioral in nature. These difficulties are further exacerbated by the anxiety a child with ASD can have being in a classroom due to inability to handle the various situations. In order to ensure that students with ASD are accessing their education appropriately, educators need to have a very specific and individualized way to reach these students. Typically, a student with ASD will need a highly structured and predictable schedule with very little changes in order to maintain him or herself in a classroom. In addition, other school-based interventions usually are needed to help adapt the school setting to the needs of students with ASD. With a classroom, being itself a somewhat unstructured place at times, educators have found that students with ASD are falling behind in their development as compared to typically developing students, especially in the area of having the learning readiness skills needed to participate in instructional lessons.

BENEFITS OF ROBOT ASSISTED INSTRUCTION (RAI) SYSTEM

Research has shown that children with ASD have a unique affinity towards robots. This is evidenced by their willingness to engage and interact with the robots socially. Several researchers have shown that children with ASD may demonstrate more engagement with robots than with humans. RAI provides staff with an effective instructional technology tool to support the unique abilities and needs of students with ASD. Beyond engagement, there are many beneficial effects for the child when interacting with a robot.

- Multiple studies have shown an increase in compliance within participants after working with robots
- Research has also shown an increase in cognitive learning gains
- Research has also shown an increase in compliance within participants after working with robots
- Children with ASD produce higher rates of JA that are comparable to typically developing children when interacting with robots
- Children demonstrated generalization of social skills with people, including eye contact in the presents of robots
- Research demonstrates that children with ASD produce more vocalizations when engaging with robots than with other humans or a computer screen. This was shown in a study where students exhibited increased verbalization and socialization with an embodied robot versus a screen-based app and were more socially comfortable than with humans
- It was also observed that Robot-based intervention can target JA behaviors during triadic interactions between the child, the tester or teacher, and the robot with the robot as the object of JA.
- Various studies show that Robot based interventions can also be used to facilitate complex motor coordination and postural control of children through imitation.
- Robots can be used to facilitate action imitation and interpersonal coordination.
- Research in embodied cognition shows that joint coordination activities improve interpersonal coordination.
- Research using robots with children in joint movement activities shows gains in interpersonal coordination as well as spontaneous appropriate verbalizations.
- Robot-Assisted Instruction (RAI) systems provide the basis for a deployable assistive technology system for working with students with ASD in the school environment.
- The ability of the robot to lead the child through training interventions, leaving the specialist free to direct and observe the interactions, is beneficial to both the child and the specialist.
- The child finds the interactions more enjoyable and accessible with the potential for more time on task.
- Having the robot lead the activities gives the therapist a better opportunity to collect data and dynamically assess the progress of the child.
- The objective nature of the robot interaction also removes some variability of delivery due to unrelated issues..

METHODOLOGY ADAPTED FOR THE PROGRAM

Team - A multidisciplinary team was established to provide oversight of the planning and integration of RAI and to provide a forum and process to support the collaborative and collective practice between the Whiting Lane staff and MOVIA consultants.

Participants - Twelve elementary aged children from WHPS participated in the 6 to 8 week pilot study. Students selected for participation in the study included students with a diagnosis of ASD on defined criteria and students who had a clear preference for the robot.

Materials - The physical system included a NAO robot from Aldebaran (formely Softbank Robotics). The robot was semi-autonomous with the Robot-Assisted Instruction Specialist (RAIS) providing commands through a laptop connected through Wi-Fi.

Robot-Assisted Instructional Intervention Delivery - Robot led sessions were created that incorporated multiple activities designed to involve the work with different aspects of the child's behavior and so that the goals and objectives were specific, measurable, attainable, relevant, and timely (SMART goals).
The content and the scheduling of each RAI session was based on the individual and unique needs of the students and the number of students involved in the sessions.

Procedures - Sessions were conducted twice a week. Students were seen for 20 minutes during a standard pull out from their classroom. This was part of their regular schedule for being seen by the psychologist, PT/OT, or speech pathologist. The WHPS specialist led the session and the MOVIA RAIS operated the robot. Data was collected by the Specialist in her normal way and by the MOVIA RAIS specialist.

Assessment - The participants in the pilot study were assessed after each session by the RAIS. The RAIS created a report for the school indicating the students' performance during that session. This data was based on observation. The student was also assessed by the school staff in the same way that all of the special needs students are assessed. The following results were reported by the school staff utilizing the typical tools for each student. The district assessment and analysis of each student's performance and progress was based on that student's IEP goals/objectives.

OBSERVATIONS DURING THE PROGRAM

Both the Whiting Lane staff and the RAIS reported high engagement throughout the pilot study. Student performance data allowed staff to scaffold the level of difficulty and provide modifications to the lessons/activities and sessions. Analytical results based upon data collected is shown below for four of the participating students:

- One student's engagement fell off halfway through the semester. This decline was credited to the student's attaining mastery of the material and, because no new material was available at that time that was tailored to the student's specific needs, the studentbe came bored with the interactions.

- Students demonstrated skill attainment on targeted skills (attention, literary skills, reading comprehension, social skills, coping, articulation, reciprocal communication).

- The WHPS staff reported students demonstrating generalization and carry over of skills acquired in the RAI sessions to other environments (i.e., classroom, home, playground).

- Students demonstrated positive response to the robot's feedback & positive reinforcement.

- Students personified the robot and established a positive social relationship with the robots. As an example, a student wrote a card to the robot following the end of the sessions stating that he would remember the robot and he hoped the robot would remember him.

- The positive relationship and response to the robot was also reflected in parental feedback on their child's progress in social interactions. One of the parents requested a play date with the robot and her child.

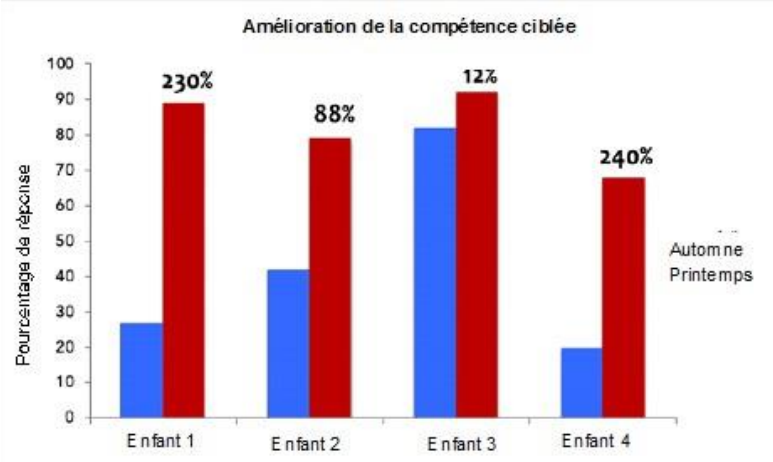
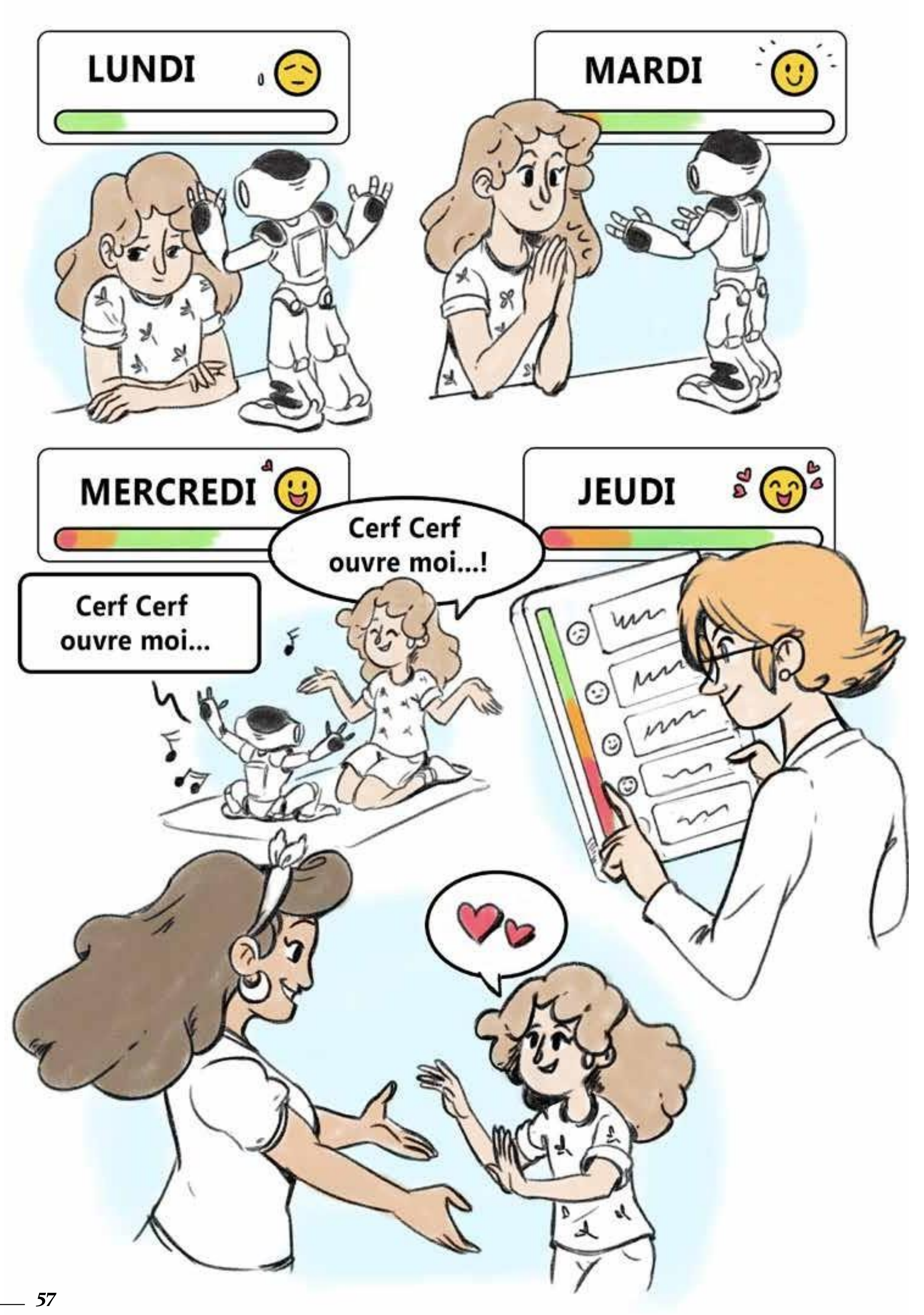


Fig.1

REVIEW AND ASSESSMENT

The review and assessment of these measures and data indicated that RAI resulted in educational and therapeutic benefit for students with ASD. The WHPS utilization of RAI provided staff with an effective instructional technology tool to support the unique abilities, characters, and needs of students with autism (ASD). The relationship between the student, robot, and teacher reflected a high degree of motivation and engagement in the lessons.



BEST PRACTICES FOR IMPLEMENTING RAI

The use of the system led to a set of best practices for implementing RAI in the elementary school setting, as follows:

1. Establish a multidisciplinary team to provide oversight and support the collaborative practice of the RAI specialist.
2. Provide for functional training and technical support prior to implementation.
3. Identify and select students to participate in the RAI sessions based on their unique abilities, characteristics, and needs.
4. Determine the Core Curriculum goals and targeted skills for instruction and intervention.
5. Develop smart IEP goals and objectives and align/correlate them to the RAI activities.
6. Develop a schedule for RAI sessions and lesson preparation, identifying potential barriers to the instructional activities and impart them with fidelity.
7. Determine the process and measures for formative assessment and progress monitoring, as well as data collection/analysis, to evaluate student progress and determine appropriate modifications to the RAI lessons/sessions
8. Integrate RAI as an integral part of a school's assistive technology and instructional framework and practice.
9. Provide communication/information to parents and the school community on RAI to support continued work and efforts to improve assistive technology and specially designed instruction.

RAI was shown to be a viable and successful tool for interventions with the school's ASD population. The RAIS operated system provided very good success for outcomes. Lessons learned from this pilot led to the successful development of a system that is easier to use and can be operated by the teacher or therapist themselves without the need for additional personnel.

Perspectives

The use of NAO robots to help withinterpersonal skills and group dynamics in work with young people with autism *spectrum disorder*

CONTEXT

Olivier Duris - Can the use of robotic mediation in a group situation improve the narrative skills of subjects with ASD and thereby impact on children's interpersonal skills (socialisation)? Or how introducing a robot in a child-robot-therapist relationship, as well as in a group of children with ASD, could change the children's relationships with each other and with the therapist.

A research project which has been carried out on the NAO robot's impact on the narrative skills of autistic children, but also on the narrativity of the therapist included in the child-robot-therapist triangle. Children with ASD demonstrate significant difficulties in ordering a story or recounting memories except in the form of snippets or muddled combinations of affects and depictions. Helping children to identify with the therapist's pleasure in sharing a story can enable them to take this on themselves and find their own pleasure in telling a story, then their own story, in which events follow on from each other coherently, forming a story with a beginning, a middle and an end.

Thesis defended publicly on 3 March 2021 by Olivier Duris for the degree of Doctor of Psychopathology and Psychoanalysis Supervised by Serge Tisseron

PURPOSE

Robots seem to promote an increase in the ability of children with ASD to integrate in social situations, and also seem to have a beneficial impact on children's empathetic abilities, more specifically on their awareness of affects, emotions or feelings.

The goal of this experiment was to see if a story told by a humanoid robot like NAO in a 'storytelling' workshop could be more easily understood by children with ASD, thus supporting the therapeutic functions of storytelling mediation and enabling children to better recognise the emotions of characters in stories, as well as their own, thereby improving their empathetic abilities and relations with others. To find this out, Olivier Duris and the team at the André Boulloche day clinic (CEREP-Phymentin association) used *the storytelling workshop methodology developed by Pierre Lafforgue,* with the difference that a programmed Nao robot was used to tell the different stories.

'Storytelling mediation workshops' were held with a NAO robot storyteller. NAO is characterised by both a relatively fixed "face" and a synthetic voice. Autistic children find it less difficult to interact with robots, whose movements are predictable and repetitive, than with human beings. Similarly, a robot's voice is treated as a different sound to a human voice because it carries no social emotion and cannot be perceived as a marker of identity.

METHODOLOGY

An experiment was carried out in a day clinic with children aged between 4 and 14 years old. Each session started with the same introductory rhyme spoken by the psychologist ("Cric-Crac, c'est l'heure du conte. Cric-Crac, alors raconte.") [Cric-Crac, it's time for the story. Cric-Crac, so tell the story.] Next, the children were told the story, then the psychologist brought the story to a close with another routine line ("Cric-crac, le conte est dans le sac") [Cric-Crac, the story is in the bag].

Then came a period of time dedicated to a drama activity, where the children re-enacted the story they had been told, and finally some time for drawing.

These last two activities encouraged group association based on the story that had been told. It is important to note that the drama activity could not take place until the children in the group had assimilated the story well enough to be able to re-enact it together.

Each story was therefore told in the same way for several weeks, without moving on to another story until every child had been able to take part in the drama activity several times. Over two years, four stories were explored, in the following order: 'The Three Little Pigs', 'The Wolf, the Goat and the Kid', 'Little Red Riding Hood', 'Hansel and Gretel'.

PARTICIPANTS

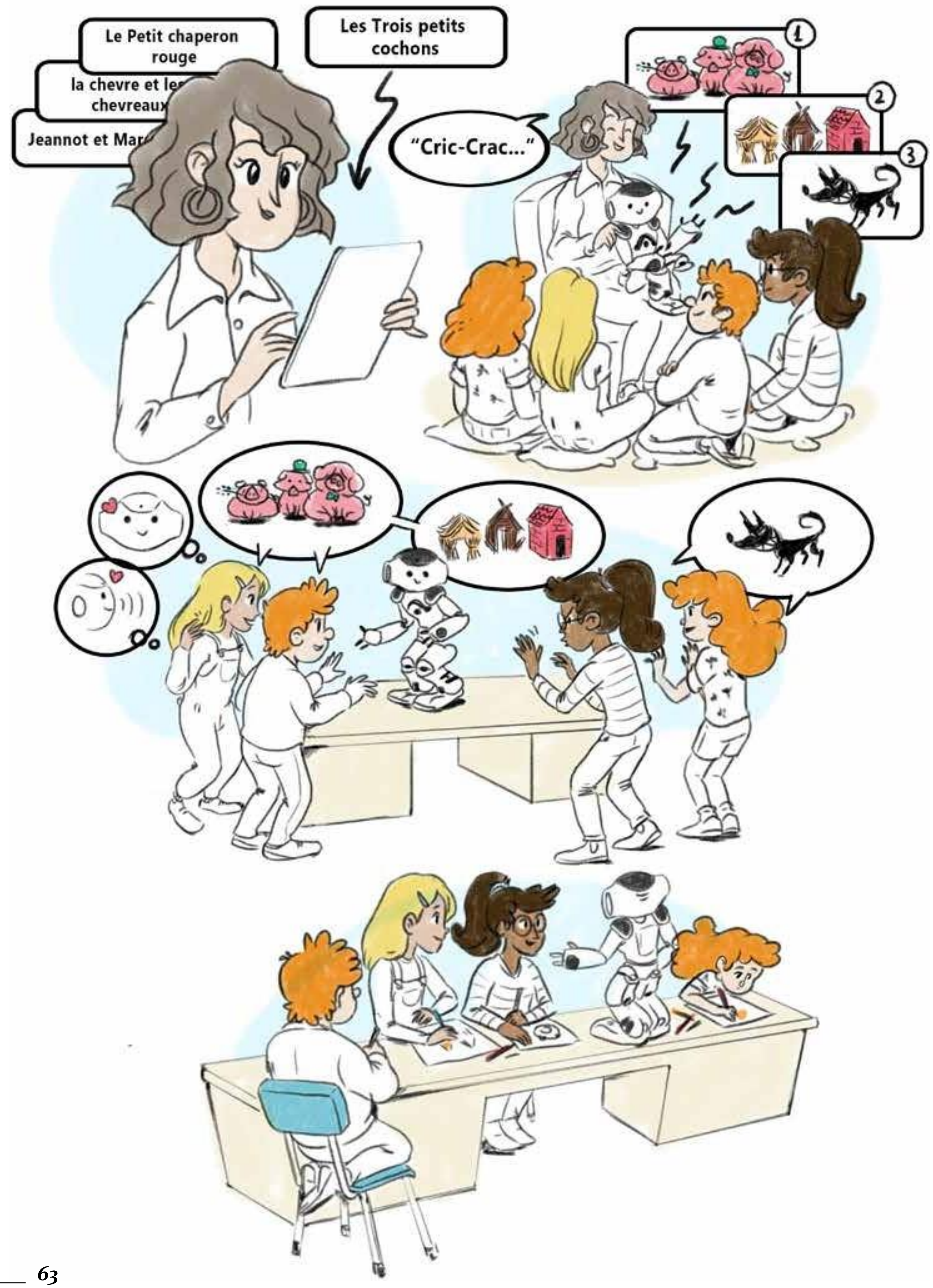
The experiment was carried out for two years (2016-2018) with two groups of 6 children, aged between 4 and 14 years old, who had been attending the clinic for at least 6 months. The process consisted of 50 sessions held at the day clinic on a weekly basis, each session lasting 45 minutes.
Direct non-participant observation was used within the group, and each child underwent different tests, at t=0 and t+2years (TSEA (Socialisation Test for Children and Adolescents)/WISC-IV and WISC-V446/Rey-Osterrieth complex figure test/CARS/Vineland Scale), in order to measure the robot's impact on the patients' development more closely. For a truly comparative experiment, the second group was a 'control' group, in which the stories were told by a psychologist, following Lafforgue's methodology. The rest of the process followed was exactly the same for the two groups, only the 'storyteller' differed.

Perspectives

RESULTS OBSERVED

The qualitative observation of the two groups throughout the experiment showed greater containment in the group with the robot, as well as a better understanding of the story and simplified and more active participation in the therapy session. The group dynamic and the narrative and empathetic abilities of the children in the experimental group were therefore impacted more positively than those of the group where no robot was used to tell the children the stories.

In summary, Olivier Duris was able to observe through his research that *the use of humanoid and non-humanoid robots in therapeutic workshops for young people with ASD enabled greater containment within the therapeutic setting and improved narrative and emotional skills* (understanding stories, recognising emotions and expressing emotions), *as well as interpersonal and social skills* (communication, interaction, imitation and joint attention). This research has also shown to what extent the use of such a tool can enable *a reduction in autistic defence mechanisms* (echolalia, sound envelope, stereotypies, agitation and withdrawal). Finally, throughout his work, the idea has emerged that the robot is only a tool and in no way replaces the human. It represents a mediation tool requiring the presence of a health professional when used' in the field of therapy. Olivier Duris'; objective is therefore not to ensure that the machine will one day replace the human in the care of patients, but to show the interest of this tool as a medium. Her research work has highlighted the benefits of using robots to initiate social behaviors and improve emotional skills in young ASD patients, but a wide variety of methods using a robot as a therapeutic tool can be considered, and a large number of additional therapeutic benefits are yet to be discovered. It seems essential to question and anticipate the use of these robotic tools in the psychologist's practice, and particularly with the ASD children's clinic, in order to work best with patients while embedding the practice in a constant questioning of emerging technologies.



projet DREAM

An evidence-based approach to robot-enhanced therapy for children on the autism spectrum:

lessons from the DREAM project

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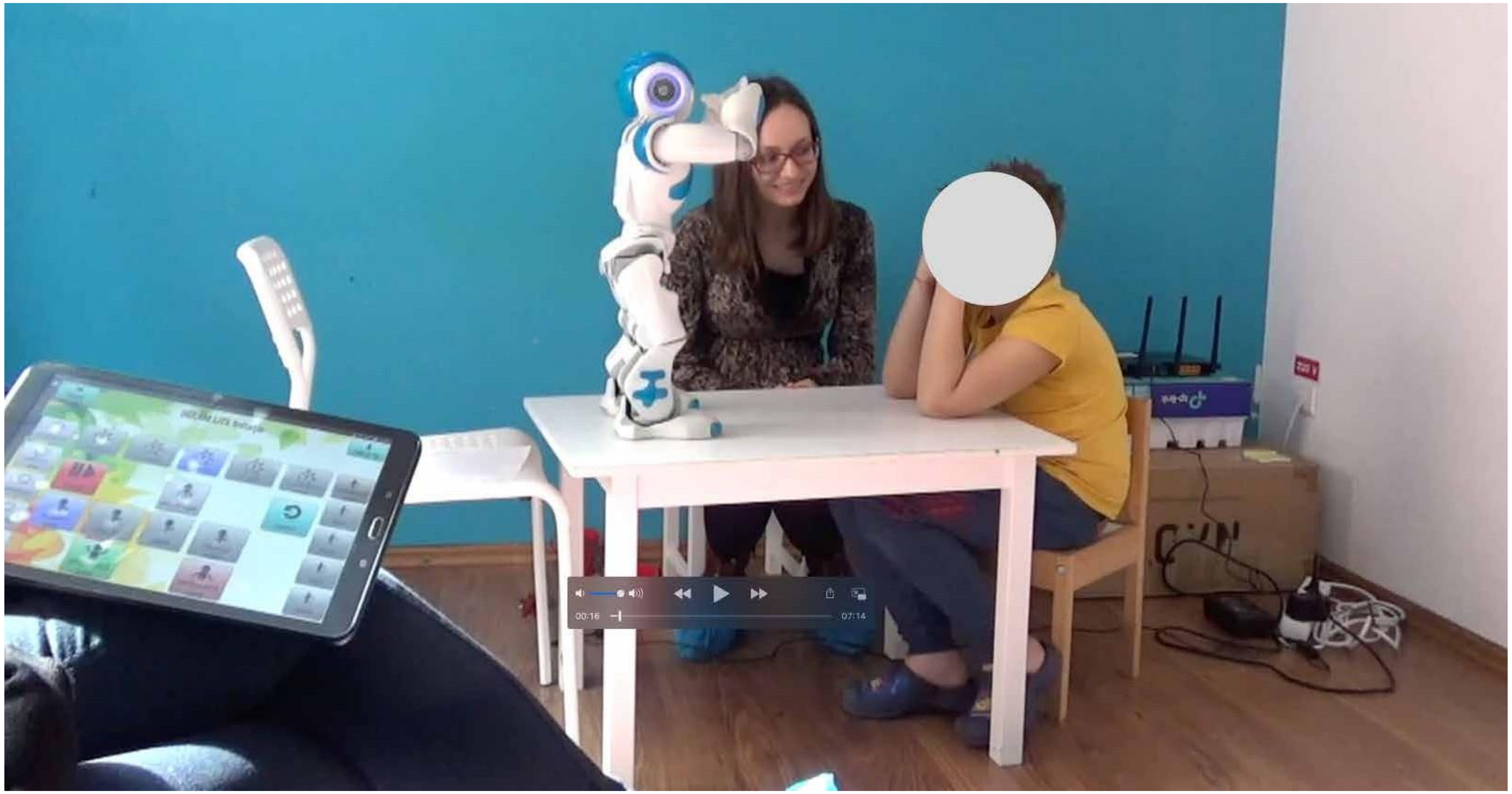


EVIDENCE-BASED PRACTICE AND ROBOT -ENHANCED THERAPY

Evidence-based practice is a widely accepted framework for decision making across multiple disciplines, which states that the practitioners in the field should be using the interventions and procedures that are supported by the best available evidence. Decisions should also take into account the characteristics and the preferences of the clients, as well as the clinical expertise of the service provider [5]. We already stated that the children are interested in interventions that involve a robotic partner, but what about the evidence for robot-based interventions? Is it good enough to start adopting them as a routine practice?

Over the years, huge progress has been made to prove that robot-based intervention could have a say in the treatment of children on the autism spectrum. Researchers have moved gradually their focus from showcasing how children react to the presence of the robot, that they attend to it, to more therapeutically informed studies which ask if the children learn useful skills form these interactions and transfer them to other life contexts (e.g., interaction with their siblings or parents). Some studies have taken rigorous measurements of relevant behaviours and skills, and have compared robot-enhanced interventions to other forms of interactions (e.g., a toy or a computer) or even a standard behavioural treatment. However, there are several points that much of the previous research has missed in order to establish robot-enhanced therapy as an evidence-based intervention that could solve the real-life challenges that the families of these children and the institutions working with them are confronted with: (1) studies were generally small (just few children were included) and many did not provide long term interventions; (2) studies did not assess overall clinical improvement, but rather changes in very specific skills; (3) most of studies did not prove that robots could rise to the promise and become at least partially autonomous, being able to change how the treatment is provided. This is where the DREAM project that we will present in the following lines showed his strong points.

THE DREAM PROJECT

The project "Development of Robot-Enhanced therapy for children with AutisM spectrum disorders" (DREAM; https://dream2020.github.io/DREAM/) was an EU funded research project that took place between 2014 and 2019 and promoted several major objectives for the field of robot-based therapy for children with autism [6; 7]:

1. Develop a sensory system capable of capturing and interpreting relevant child behaviour.

2. Develop a semi-autonomous decision making system based on which the robot could respond to the behaviours of the child and provide contingent feedback;

3. Test the efficacy of robot-enhanced therapy in a large and rigorous study (a randomised clinical trial) comparing it to standard treatment;

4. Assess the efficacy for specific skill and overall changes in symptoms;

5. Assess the effectiveness of the intervention in a real life context (e.g., schools, special education institutions) based on a scaled down and cost-effective version of the system.

These goals cover some of the main points needed to move robot-based interventions in the focus of the evidence-based practice approach. The studies conducted in the project targeted the development of some key social skills that many children on the spectrum have difficulties with, namely imitation, joint-attention and turn-taking (as a key ability for collaborative play and interaction). In every instance, the robot guided the interaction with the child, indicating what task will be performed, giving the instructions and providing feedback. The therapist supervised and intervened to ensure that the child understood the instructions, provided prompt when needed, and corrected disruptive behaviours (e.g., running from the table where the tasks were performed) when such behaviours occurred. All intervention sessions were carried as play-like activities and followed the discrete trial training structure, in which the robot offered a discriminative stimulus (a short and clear instruction), waited for the response of the child, and offered a contingent feedback on the behaviour of the child, either as positive social feedback or as a correction and encouragement to try again. The child had three opportunities to express each expected behaviour. If he or she did not succeed after these trials, then the therapist would provide a prompt.

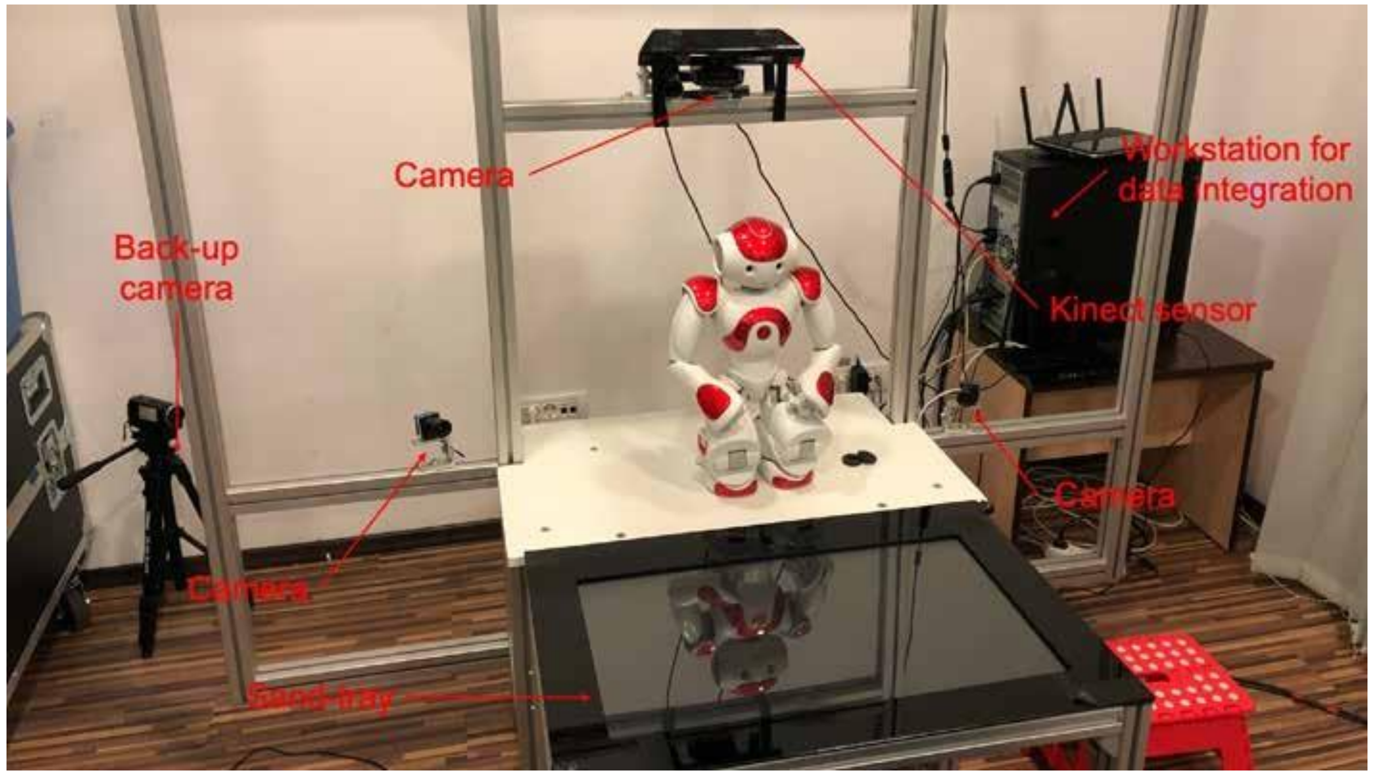


Fig 1. Experimental set-up for semi-autonomous system.

Several tasks were developed to train each type of skill. For example, imitation was trained using objects (e.g., imitating a plane), meaningful movements (e.g., wave hand and say goodbye), and movements that do not have a common meaning. For joint-attention training, we varied the amount of cues that were offered by the partner, starting with pointing and looking at an object of interest while doubled by vocal indication, to tasks in which only the gaze was used as a cue. Finally, for turn-taking, the child and the partner played several games, with different levels of complexity, like sharing information about favourite foods or activities, categorising objects and continuing a pattern of images based on some visual characteristics. For joint-attention and turn-taking, we used the "sand-tray", a large touch-screen computer placed in front of the child and the partner, allowing them to play interactively by indicating and moving images representing different objects.

The experimental set-up developed as part of the DREAM project is presented in Figure 1.

The interaction between the child and the robot in an intervention session is depicted in Figure 2.

THE RESEARCH DESIGN

The main study of the project was a randomised clinical trial that included children diagnosed with autism spectrum-disorder, with ages between 3 and 6 years old. The diagnosis was based on patient records and was confirmed by an assessment using the Autism Diagnostic.

Observation Schedule (ADOS). Children were excluded if they had any other neuro-developmental disorder. The final sample included 69 children, recruited from several centres dedicated to the treatment of children on the autism spectrum from Romania. All children were also following some form of treatment in the center where they were recruited.

Participants took part in 12 sessions: two for conducting the ADOS and social skills assessments at the beginning of the study, two for conducting a similar assessments at the end of the study, and 8 interventions sessions in which all three targeted skills were trained in interaction with another human partner (the control group) or with a NAO (the robot-enhanced therapy group), following identical protocols. The intervention was personalised for each child, depending on the level of skills that he has shown in the initial assessment, so that children with better skills were introduced to more difficult tasks, while children with lower skills started with easier tasks and the level of difficulty was later adjusted, depending on their progress.

Fig 2. Interaction between the child and the robot under the supervision of the therapist.

The NAO robot was directly controlled via a software system developed in the project which allowed it to move between different phases of the intervention sessions following a certain script, but also to evaluate the behaviour of the child and provide feedback depending on the correspondence between his or her behaviour and the expected one. The automatic judgements made by the robot were supervised by another psychologist that was in the room, placed in front of a computer from which he or she could override the decision made by the robot, before it was implemented in the intervention. This is what we called supervised autonomy.

The sensorial component of the system extracted in real-time information about the eye contact between the child and the interaction partner, the level of positive emotions expressed by the child, ass well as other information about his or her position related to the interaction partner (e.g., being seated at the table or moving away and exiting from the task). Moreover, the system allowed us to record the entire interaction, with multiple views synchronised across cameras, while also collecting information about the performance and the level of engagement expressed by the child. This practically allowed us to look at the data without the need to review every individual video in order to code and extract the information related to the performance and reactions of the children in the study.

THE RESULTS

We are in the final stages of data analysis and what we can tell at this moment is that the intervention meditated by the NAO robot was as effective in increasing imitation and turn taking as the standard intervention. For joint-attention, both interventions had similar effects, although there was no clear improvement over time. Both groups also had a significant effect on overall symptoms of autism spectrum disorders, as assessed with standardised instruments. The results also pointed out that the children who received the intervention mediated by NAO expressed more positive emotions and made more eye-contact with the interaction partner, than children in the control group. This is an important result, given that behavioural interventions for children on the spectrum have to be delivered over long periods of time. It is possible that they might be more engaged in the long run if the robot is used as a mediator. Overall, these results point that when compared in a rigorous study, similar to those in which medical treatments are being tested, the robot-enhanced intervention is as effective as standard intervention.

THE EFFECTIVENESS STUDY

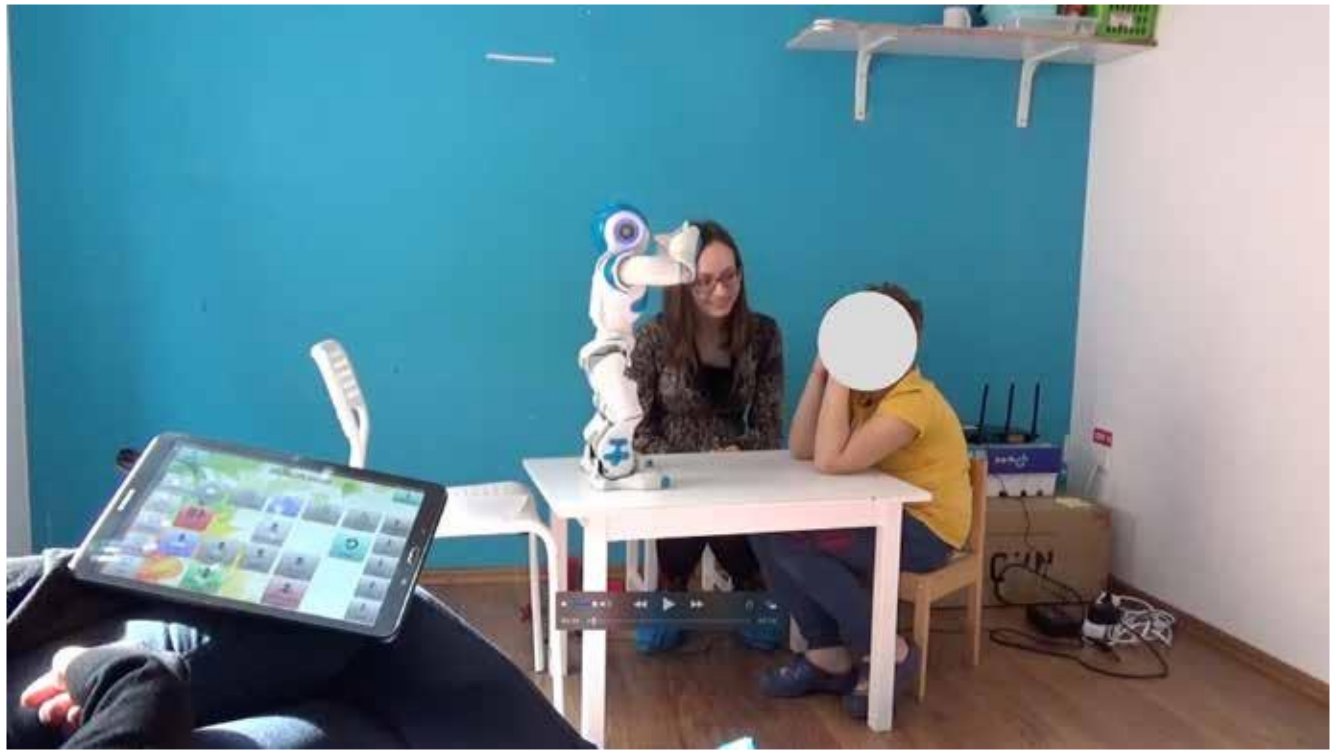
Beside this well controlled study in which children were carefully selected and the set-up allowed us to have a comprehensive, automatically coded set of data, and a semi-autonomous robot, we intended to test a more ecological version of the intervention protocol. We thought of a solution which would allow us to deliver a similar intervention without the complex set-up required by the previous study and to see if we could reach positive results in special education institutions working with children that have autistic symptoms as well as other psychological and developmental problems, as it is likely to happen in most real-life scenarios. The delivery system we proposed, called "NAO DREAM Lite" integrated the NAO robot with the AskNAO tablet and a modified interface for delivering the intervention developed in the DREAM project. We compared the intervention mediated by the NAO with a wait-list condition, over a short-time intervention: 1 initial assessment, 1 final assessment, and 3 intervention sessions. Children were included if their record indicated a formal diagnostic of an autism spectrum disorder or some clinical indication that such symptoms are present. All children that met the above criteria and were able to follow the instructions were considered eligible.

The final sample included 79 children, with ages between 3 and 10 years old.

In this study, a therapist supervised the intervention by introducing the robot, correcting disruptive behaviours and by offering prompt, while another psychologist controlled the robot from the tablet interface, as presented in Figure 3.

The results indicated significant improvements of the children in the condition mediated by the robot, as compared to the control condition, in imitation skills, but not in joint-attention or turn-taking. Moreover, the parents of the children in the group that received the intervention mediated by the robot indicated significant improvements in the overall social abilities of their children, compared to the reports from parents of the children in the control group. These results are very encouraging, given the short length of the intervention and the relative easiness in providing it to these children.

Fig 3. Experimental set-up for DREAM Lite used in the ecological study.



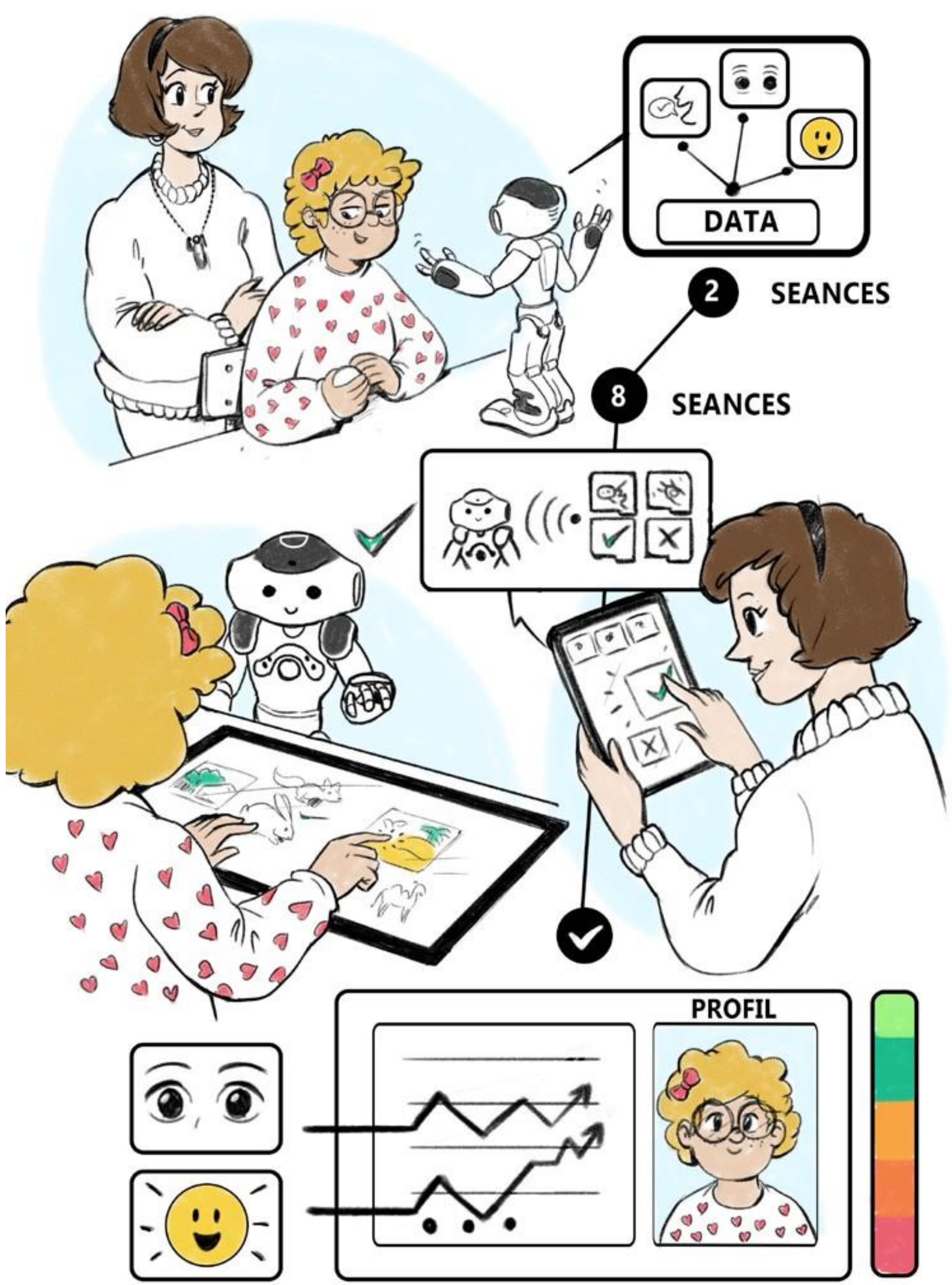
Résultats
& Perspectives

CONCLUSION

Robot-based interventions for children on the spectrum have made great progress since this innovative idea has been brought up by case studies and small experiments reported in the literature. The DREAM project has brought the use for robots closer to the evidence-based approach, proving that the effects are consistent and visible across specific skills and overall symptoms, even when compared to a standard intervention. Moreover, the project also pointed that interacting with the robot has consistent effects on the engagement of the children during the intervention, potentially keeping them involved in the task over longer periods of time. Finally, the project also proved that the intervention could be easily transferred to real-life context, where it could be offered as an extension of classical interventions, in order to develop the social skills of children with autism symptoms.

NEW PERSPECTIVES

The positive results that we obtained in the DREAM project are likely to stimulate other researchers in developing and testing intelligent and autonomous robots. The next generation of social-robots working with children on the autistic spectrum will be more capable of interpreting the behaviors of the children and respond in a therapeutically consistent manner.
It is likely that the DREAM trial was just the beginning of a series of randomised controlled trials that will investigate very rigorously the effects of robot-enhanced therapy, in order to establish it as an evidence-based treatment. Moreover, the interventions that will be offered to children on the spectrum will probably become more and more personalized, varying in difficulty or in the skills that are trained, depending on the developmental needs of the children interacting with the robot, connecting this field to the major trend in medical and rehabilitation research called personalised evidence-based therapy. The robot developers and the market are also likely to respond by offering new solutions in the form of more intelligent robots that make it easier for therapists to provide assistance to the children.
If using a robot and customizing the intervention becomes easy enough for a therapist with little technical expertise, then robots will likely become a common presence in school and educational institutions for children with autism.



NAO, a humanoid robot as ***a therapeutic mediator*** for young people with autism

Conclusion

by Pierre-Henri BERNEX - Société iUS (iUpSales)

–

So, dear readers, this e-book is drawing to a close and we hope that you have enjoyed discovering or rediscovering examples of the use of the NAO robot for or by children with autism spectrum disorder.

We have purposefully given this document a fun feel, both through the formatting and the illustrations, to highlight this humanoid robot technology marked out by compassion and social benefits, in this case primarily for children with special needs. The various accounts in this white paper paint a picture of a strong momentum or, as Professor David Cohen described it, a vitality within the field of social robotics.A level of enthusiasm that seems to be ever-growing for the complex world of social robotics in ASD can be observed amongst three categories of 'explorers': specialised teachers, engineers (researchers) and clinical psychologists.

We can also be glad that associations and companies have taken on the subject, including the association Robots! (Nantes, France), MOVIA (USA) and our partner ERM Robotique (Carpentras, France), which has refined the AskNAO user interface by integrating applications, amongst many others.

These innovators have a shared agenda, which is to confirm the advantages of this new tool for the children and the adults working with them, to develop the most efficient approaches possible depending on whether the goal is to treat the disorders or facilitate learning, and finally to simplify the use of the robot as far as possible despite the fears and misconceptions it engenders.

We see that the NAO robot, when used in a therapeutic and/or educational context, not only does not replace the teacher or therapist, but also makes it possible to bring together up to four areas of expertise: teachers, engineers, psychologists and even artists (multimedia approach).

We are no doubt only at the beginning, considering the rapid advances in this technology and its use to help other groups. For example, in older people to improve their communication abilities and strengthen the quality of their individual and collective social interactions. This is aimed more specifically at people suffering from Alzheimer's disease and related disorders (ADRD), the idea being an attempt at reconstructing the participants' identities or, if nothing else, slowing down the development of the disease.

We would be delighted if this document about the NAO robot could go on to help spark and create a large community bridging the gap between users and researchers, whatever their areas of expertise or nationalities, in order to open up new fields of possibility in practices related to teaching and mental health for children and for older people.

"If youth but knew, if age but could." *Henri Estienne*

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NAO, a humanoid robot as ***a therapeutic mediator*** for young people with autism

Preface by David Cohen MD, PhD

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