Conference Proceedings New Friends 2015

The 1st international conference on social robots in therapy and education

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Introduction

The proceedings of the international conference New Friends 2015 reflects the multidisciplinary nature of the conference theme, addressing the demand for expertise in both practice and research with expertise from a wide range of disciplines, like psychology, nursing, occupational therapy, physiotherapy, AI, robotics and education.

The event featured keynotes by Vanessa Evers and Matthias Scheutz, oral and poster presentations (based on 48 accepted submissions), product and business demonstrations, competitions and practice oriented workshops, covering:

- *practitioners' perspective of end users' needs,*
- *good examples of trials, practice and intervention guidelines,*
- *interdisciplinary collaboration,*
- *innovations in robotics, therapy and education*
- *theoretical studies and empirical research,*
- *legal, ethical, philosophical and social issues.*

We welcomed 118 registered attendees, not including representatives from sponsoring companies and institutions, local co-organizers and student volunteers. This is quite respectable for a 1st conference and demonstrates the relevance of the conference theme and profile.

In recognition of this, we are proud to announce that this will be the first in a series: next year we hope to see you again at New Friends 2016 in Barcelona!

We thank the following people formaking this possible with their contribution to this conference: Sytse Dugour, Wytse Miedema, Adam Hagman, Cristina Abad Moya, Adri Acero Montes, Atina Hrkac, Tom Ederveen, Vanessa Evers, Miquel Aranaz

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LUDI: a Pan-European Network Addressing Technology to Support Play for Children with Disabilities

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Abstract: The right to play is enshrined in the United Nations Convention on the Rights of the Child as a consequence of its importance to overall child development. Children with disabilities are often deprived of this right due to functional limitations, the lack of supporting technologies, and social and cultural contexts in which play is frequently seen as secondary when compared to rehabilitation interventions. This paper presents the COST Action LUDI, a Pan-European network aiming at the recognition of the theme of play for children with disabilities as a multi- and trans-disciplinary research field to which the contribution of psycho-pedagogical sciences, health and rehabilitation sciences, humanities, assistive technologies and robotics, as well as the contribution of end-users' organizations, is necessary to grant the right to play for children with disabilities.

Keywords: Play, children with disabilities, assistive technology, LUDI

INTRODUCTION

Play is the most prevalent activity in childhood. Although sometimes play is regarded as a leisure only activity, there's a huge body of knowledge, starting back from the 1950's, showing that play is the motor for child development [1,2,3]. Its importance is recognized by the United Nations, establishing play as one of the rights of the child (Article 31 of the Convention on the Rights of the Child). With the current technology ubiquity, it comes as no surprise that children are today very familiar with technological toys. Technological developments have thus influenced children's occupations namely play [4].

For children with disabilities play is not less important than for typically developing children. For them, the use of technology may be challenging, if accessibility issues were not taken into consideration in the design [5,6]. On the other hand, for many children with disabilities, (assistive) technology is the mean to access to play activities, and this has been addressed by many authors. For example, Cook et al., describe how robots can be used as assistive technologies for play, learning and cognitive development [7]. Cabibihan's et al., review on social robots for children with autism spectrum disorders shows the opportunities created by robots to increase the autonomy of the child [8]. Children with disabilities have more possibilities in playing with the use of technology. Within the International Classification of Functioning, technology can expand the child's health dimensions and environmental determinants of health. For example, Miller & Reid report that competence and self-efficacy increased in children with cerebral palsy engaging in a virtual reality play intervention [9]. Technology opens the doors to more play scenarios. Playfulness can be more present. It provides adults opportunities to get in contact and to have meaningful time together [10,11].

LUDI, A NETWORK IN THE FIELD OF RESEARCH AND INTERVENTION OF PLAY FOR CHIDLREN WITH DISABILITIES

Despite the scientifically recognized importance of play and the technology available, children with disabilities are often deprived from the right to play. Physical and/or cognitive impairments may prevent them to access to play activities. Social and cultural contexts may also raise hurdles for children's play. In fact, frequently parents and caregivers place play very low in the hierarchy of activities a child with disabilities should engage, something to be done only if there's some free time after educational and rehabilitation commitments. In therapy play is seldom considered the goal per se.

Using technology to support play faces sometimes doubts, resistance and concerns from the professionals. For most of the rehabilitation professionals, technology in care or education was and still is not part of their education or continuous professional development [12]. As technological developments are going fast, it's hard to keep pace with them. Some professionals fear that this evolution might reduce their therapeutical influence or even will place their jobs at risk. Looking at technology, many tools are still at the development stage, prototypes emerging from innovative projects, and thus are not 100% reliable and user friendly.

Many disciplines, like psychology, education, (rehabilitation) medicine, or engineering, have focused on the topic of play. However, a holistic view, encompassing all the different perspectives, is necessary to effectively grant the right to play for children with disabilities. This motivated the creation in 2014 of "LUDI – Play for Children with

Disabilities", a 4-year Action supported by the European Cooperation in Science and Technology (COST) framework (www.cost.eu). LUDI is a Pan-European network of researchers, scientists, practitioners, users and their families, including members from 27 European countries and from 5 international partner countries (www.cost.eu/COST_Actions/TDP/Actions/TD1309; www.ludi-network.eu). Its main goals are:

a) *Collecting and systematizing all existing competence and skills: educational researches, clinical initiatives, know-how of resources centers and users' associations;*
b) *Developing new knowledge related to settings, tools and methodologies associated with the play of children with disabilities;*
c) *Disseminating the best practices emerging from the joint effort of researchers, practitioners and users.*

A DATABASE OF TECHNOLOGY TO SUPPORT PLAY

One of ultimate goals of LUDI is the recommendation of guidelines to the design and development of technology to support play for children with disabilities and of methodologies to evaluate usability, accessibility and effectiveness of that technology. As a first step towards this goal, a database of available technology to support play for children with disabilities, including methods for assessing usability, accessibility, and effectiveness, is being created. Clearly, given the existing number of technologies (e.g. many toys brands have new collections every six months), it is not possible to have a fully comprehensive database. Instead, the objective is to collect a vast number of examples that can inspire users and clinicians, can elicit cooperation and foster discussion. For example, a parent will be able to retrieve from the database technologies available for his child with a particular age and disability, a researcher will be able to list robots that are being used to support play, or a clinician will be able to find assessment methods for an intervention with a particular technology. The database will be available from the LUDI webpage (www.ludi-network.eu) and will be open for everyone to contribute and consult.

CONCLUSIONS

Given the importance of play for child development, the challenges children with disabilities face to have access to play activities, and the fragmentation of research initiatives, often conducted within a particular scientific field framework, the LUDI COST Action aims at creating a multi- and trans-disciplinary research area that focus on play (for play sake) for children with disabilities. LUDI, together with international organizations such as the International Play Association and the International Council for Children's Play, will promote the cooperation between rehabilitation professionals, engineers, educators, psychologists, sociologists, users and their families, and all of those that are involved in the theme of play for children with disabilities.

By collating state of art and agreements about definitions of play, models, assessments, and interventions, a body of knowledge will be created supporting everyone who wants to stimulate the play of children with disabilities at home, schools, daycare centers, or in public spaces.

Technology, as an enabler for children's play, will have a central role in LUDI.

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Modelling Social Skills and Problem Solving Strategies used by Children with ASD through Cloud Connected Social Robots as Data Loggers: First Modelling Approach

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Abstract— In this paper, we present a set up of cloud-connected social robots to measure and model the effect of LEGO Engineering and its collaborative nature on the development of social skills in children with Autism Spectrum Disorder (ASD). Here we introduce the first approach to the modelling process designed.

Keywords— Modelling, ASD, Autism, Social Robots, Cloud, Data Logger

1. INTRODUCTION

There exists a growing body of research centered around robotics and autism, using a social robot as a data logger. Previous research includes children with ASD working with humanoid robots (e.g., NAO or KASPAR), working together to build robots [1], [2], talking to the robot and mimicking a robot [3]. Also, we present a cloud-based system to speed up the analysis of how therapies based on working in groups and building LEGO change their social skills, social network, and cognitive skills.

The project consists of an 8-week study (one two-hour session per week).The sessions have a format of a workshop on building LEGO Robotics with a Robot Companion (NAO Robot, AISOY Robot, or SAMSUNG Robot) that will be on the table as a helper, social mediator, and will remind the kids of the time schedule.

During the sessions, Children sit at a table with a laptop to program the LEGO robot and a complete LEGO MINDSTORM EV3 set (The LEGO Robot). Children work in groups of 2 selected at random, and they keep the same group for all sessions. A Social Robot (NAO Robot, AISOY Robot, or SAMSUNG Robot) is on the table as a helper, social mediator, and remember the time schedule.

In each of these sessions, we collect information that allows us to create a reliable model of how these children socialise with each other and with the adults in the classroom, and how these children solve engineering problems (see Figure 1). While the children with ASD social skills model has been studied since a long time ago, the engineering thinking skills is not approached by the community. Previous studies showed that only people in the field of science and technology were trained in engineering skills. However, it has been proved that engineering skills are needed in very day life, bringing clear benefits to the quality of living for those children who can acquire and use them [4], [5]. Do children with ASD follow the same strategies that neurotypical children? How they are dealing with this problem?. The model obtained should give an answer to these two questions and see if we can redesign their educational and training system [6]. Furthermore, in [7] is claimed that there is a connection between engineering thinking and human sensitivity that makes the quality of live better.

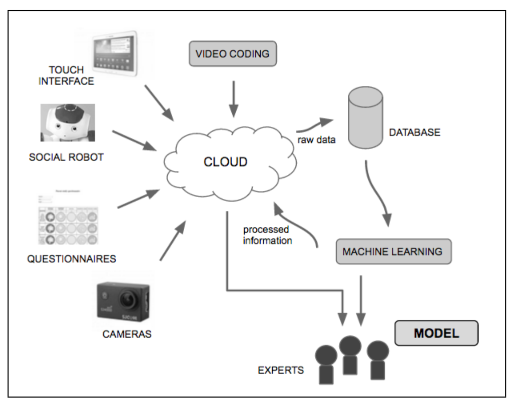

Fig. 1. Schematic of how data flow through the cloud until the model is obtained.

2. MODELLING PROCESS

The modelling process is divided into two paths according to the two outcomes mentioned in the introduction of this paper. On the one hand we model how children with ASD deal with the social situation, and, on the other hand, we are modelling how they solve engineering problems (see Figure 2).

Through the video observation, the quantitative data obtained from the interactive systems, and the descriptors obtained after processing the information through the machine learning algorithm we can identify the interactive behaviors and their quality in terms of intensity and duration.

The system is supposed to identify interactive behaviors and to measure the amount of social engagement children are experiencing.

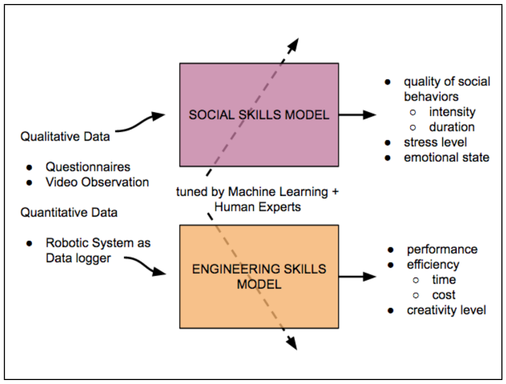

Fig. 2. Modelling description process

A. Human Experts

Through video observation (video coding) and questionnaires to the students, parents, and teacher, we are going to collect qualitative data. Through a web-based tactile interface to interact with the robot and the video recordings we are going to extract quantitative data. The qualitative data that we are going to measure is detailed in the VIDEO CODING document and the attached questionnaires. The quantitative data that we are going to analyze from the touch screens includes the number of times they are using the touch screen, what they are touching, and at what time during the session. The quantitative data we are going to obtain from the videos are:

- The number of times and how long every kid is talking during all sessions.
- The distance between kids during all sessions
- Eye tracking and facial states during all sessions

B. Machine Learning as Descriptor Mining and Rule Extractor

The main purpose of the Machine Learning algorithm is to classify all information to extract a set of rules that will define the model. In this project, we have data from two different kinds: qualitative and quantitative.

1) Modelling quantitative data: Similar to [8], we have Children Assitant Agents (CAA) placed in the cloud system and connected to its individual Social Robot. All CAAs are linked to an Information Management Agent (IMA) that receive all information from the CAAs to build the model. Because the model is scalable to different cloud sites, we can have multiples IMAs.

Because we are searching for two different models, IMA's functionality is based two strategies:

- The social skills model rules are better predictable, so we are based in [9] UCS, accuracy-based Michigan-style LCS that takes advantage of knowing the class of the training instances. UCS evolves a population of classifiers based on rules. Once the quality of the rules is proved the model can be extracted from the collection of rules and each classifier.
- For the engineering skills model we have a greater level of uncertainty, so we decided to use first use a system to classify and then a system to extract rules [10], [11]

2) Modelling qualitative data: We have used multicriteria decision-making systems, which would be the second part of modeling, as to the assessment models or from different experts [12]

3. RESULTS AND CONCLUSIONS

Can be the model used only with the data obtained from the social robot as data logger? Because we had only four children in all sessions during the first workshop, this is a hard hypothesis to answer. Results showed that the quantitative data we obtained was potentially good. However because we used different robotic platforms (AISOY, NAO, and a custom robot), and because the number of children was small the results were inconsistent. In any case, we tested the technology, and it shows us that we need to mix the qualitative data with the quantitative data in a more integrated way.

We expect to get a consistent model as long as we are using only one platform with more children.

ACKNOWLEDGMENT

Our thanks to LEGO Foundation and TTT Outreach, Think Tank Team, Samsung Research America to fund the project. Also to CASPAN Center in Panama to cover part of the research project there.

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Matching Robot KASPAR To ASD Therapy And Educational Goals

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Abstract. *Aim* of this study was to identify the potential added value of therapy robot KASPAR to the therapy or education goals for children with autism spectrum disorder (ASD).
Methods After conducting focus group sessions, an online questionnaire was adopted to elicit the expectations of 54 multidisciplinary ASD practitioners about therapy and/or educational goals that KASPAR can contribute to. *Results* indicate that practitioners expect KASPAR to bring added value to ASD objectives in domains such as communication, social / interpersonal interaction and relations, play, emotional wellbeing and preschool skills. *Conclusions* Practitioners are convinced that KASPAR can be useful in interventions for a broad range of therapy and education goals for children with an autism spectrum disorder.

Keywords: therapy, robot, children, ASD, autism, KASPAR, intervention, objectives

INTRODUCTION

Interactive technology, and robots in particular can contribute meaningfully to interventions used in both therapy and education for children with autism spectrum disorder (ASD). Robots possess a number of characteristics (e.g. simplicity, predictability, embodiment, interactivity) and can adopt various roles in therapy that can be valuable assets in therapy and/or education settings for (some) children with ASD [1,2]. Children are reported to enjoy interaction with a robot more, show more communication, initiative or proactivity, learn quicker and more pleasantly compared to with an human counterpart or other interventions. Moreover, robotic interventions might be well equipped to answer this population's multidimensional and heterogeneous individualized demands for support [2]. ASD manifests itself in many different forms and severities and there is not one best therapeutic approach for all, people need different support, what is beneficial for one person, might harm the other [3]. Robots allow for a personalized and individualized approach.

However, in order for socially interactive robots to actually make a difference to the lives of children with ASD and their carers, they have to find their way out from case studies with 'standalone' robots in robotics labs to the children's therapy and/or education environments as part of interventions. Being effective in eliciting a certain target behaviour of a particular child will not automatically ensure effective clinical implication in therapy settings [4]. Robot interventions need to be robust and easily targeted to the children at hand [4]. Children have to enjoy interacting with a robot, and practitioners need to consider the robot as a desirable intervention in their day to day care delivery work. As formulated in [3], socially assistive robots shall "balance goal-oriented treatment with a nonthreatening but engaging and productive interaction". To date, unfortunately, only limited emphasis has been devoted to how robots can be best integrated into therapeutic protocols and therapy sessions [2]. Many implementation questions still remain unanswered.

One socially interactive robot that has extensively been used in studies with children with ASD is KASPAR [5]. In the current study we focus on this semi-autonomous humanoid child-size robot (Figure 1).

To increase the likelihood of adoption by professionals in practice, the aim of this study was to identify the potential added value of therapy robot KASPAR in the therapy or education for children with autism spectrum disorder. To what therapy and educational goals can KASPAR contribute to according to professionals?

Figure 1. Therapy robot KASPAR

METHODS

Nine focus group sessions with ASD practitioners (n=53) were conducted to create an overview of therapy and educational objectives that are relevant for children with ASD. Participants saw both a video as well as a live demo of KASPAR. This overview was the basis for the items in an online questionnaire. The goal of the questionnaire was to match KASPAR to these ASD objectives. Descriptive analyses was performed on the data that was obtained from 54 respondents. All respondents are experts in the area of therapy or education for children with ASD and work for e.g. special need schools, youth care organizations, medical day care centres or centres for orthopedagogical treatment.

RESULTS

Main results indicate that a (large) majority of ASD practitioners expect a meaningful role for KASPAR in several objectives in domains related to communication, social/interpersonal interaction and relations, play, emotional wellbeing and preschool skills, but also in other areas (see figure 2). In all of these domains, a number of objectives have been formulated.

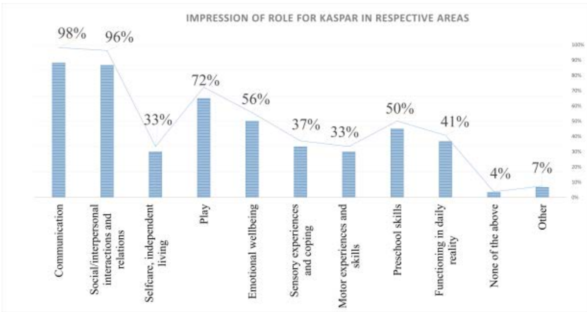

Figure 2. Impressions of role for KASPAR

Table 1 shows the top 10 ASD objectives (with International Classification of Functioning, Disability and Health for Children and Youth codes [6]) where most practitioners expect a meaningful role for KASPAR.

Table 1. Top 10 objectives expected role for KASPAR.

Therapy or Educational objectives	Percentage respondents
Imitation in play (d130)	93%
Making contact (d3)	89%
Imitation in social/interpersonal interaction and relations (d130)	85%
Orientation to listen (d115)	83%
Turn taking (behaviour) (d720)	83%
Social routines (greet, say goodbye, introduce) (d72)	81%
Attention (b140)	80%
Learn a new form of communication (d3)	76%
Talk – use verbal abilities (d330)	69%
Train or practice skills (d155)	65%
Pose a question / ask for help (d815)	65%
Follow up instructions (d3102)	65%

Table 2 shows the top 10 objectives where KASPAR is unlikely to be able to contribute.

Table 2. Top 10 objectives no KASPAR role expected.

Therapy or Educational objectives	Percentage respondents
Conflict management (d175)	44%
Balance and equilibrium (b235)	41%
Strengthening of muscles (b7306)	39%
Distinguish main from minor issues (d198)	39%
Respect / value others (or things) (d71)	37%
Potty training (d53)	35%
Domestic skills (d6)	35%
Problem solving skills (d175)	35%
Negotiate about rules (d8808)	33%
Understand what body is "saying" (b2)	33%

CONCLUSIONS

Practitioners expect that KASPAR can meaningfully contribute to a broad range of objectives for children with autism spectrum disorder. These results are in line with other research in the area of robot assisted therapy for children with ASD. Studies often focus on social communication and social skills such as turn-taking, joint attention and collaborative play [1]. Interestingly, this work shows that also for many other ASD objectives – which might be less obvious for robot developers and less explored by current robotic initiatives - are worthwhile to consider developing robotic interventions for. The next step will be to co-create KASPAR interventions (based on these findings) that will be tested and used by ASD practitioners in (daily) care and/or therapy situations with children with ASD.

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Touchscreen-Mediated Child-Robot Interactions Applied to ASD Therapy*

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Abstract. Robots are finding increasing application in the domain of ASD therapy as they provide a number of advantageous properties such as replicability and controllable expressivity. In this abstract we introduce a role for touchscreens that act as mediating devices in therapeutic robot-child interactions. Informed by extensive work with neurotypical children in educational contexts, an initial study using a touchscreen mediator in support of robot-assisted ASD therapy was conducted to examine the feasibility of this approach, in so doing demonstrating how this application provides a number of technical and potentially therapeutic advantages.

Keywords: ASD, Robot-Assisted Therapy, Sandtray

INTRODUCTION

The application of robots to aid in the therapy of children with Autistic Spectrum Disorders (ASD) has become increasingly established [1], [2], with evidence suggesting that it can provide beneficial outcomes for the children [3]. In addition to this, recent efforts have emphasised providing an increasing degree of autonomy for the robot [4].

Providing such autonomous behaviour in interaction contexts is a challenging task, with sensory and motor limitations imposing a number of constraints. In our previous work, we have developed a methodology that makes use of a touchscreen mediator between children and robots to overcome a number of these difficulties: the Sandtray [5]. In this setup, a child and a robot engage in a collaborative task that is provided on the touchscreen (e.g. sorting of images into categories). The Sandtray has been successfully applied to a range of neurotypical child-robot interaction studies in various contexts, for example behavioural alignment [6], education [7], and others. As the Sandtray was inspired by the therapeutic intervention of sandplay (with this having proposed advantages for children with ASD [8]), we now seek to apply this same methodology to robot-assisted ASD therapy.

Touchscreens (without the robot) have found previous applications to this domain [9]. For example, a touchscreen has been used to enforce collaborative activity between pairs of children with ASD, resulting in an increase in coordination and negotiation behaviours [10], a finding supported elsewhere [11]. Furthermore, there have been attempts to enable sandplay therapy-like interactions with touchscreens [12],

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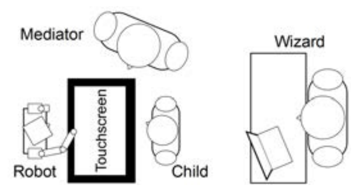

Fig. 1. Indicative setup and use of touchscreen for child-robot therapeutic interaction - robot is controlled by a wizard, and the mediator provides input to the interaction if needed (*not to scale; positions are indicative only*).

although our approach differs in both application context and involvement of the robot. These studies indicate the suitability of using touchscreens for children with ASD.

There are a number of advantages afforded by the use of such a mediating touchscreen in HRI. Firstly, it provides a shared space for collaboration that does not require complex manual dexterity for either the child or the robot; indeed it provides the same affordances for both interactants (pointing and dragging). Secondly, it reduces the sensory processing load (vision processing) on the robot since information on screen-oriented activity by the child can be obtained directly from the touchscreen. Thirdly, it provides a straightforward means of changing the task (or more broadly the interaction context) by just changing the images displayed on the screen: for instance, a sorting task can be appropriate for domains as diverse as mathematics and nutrition just by changing the pictures displayed.

The aim of this contribution is to motivate and illustrate how such touchscreen mediators can specifically serve as useful tools in the domain of robot-assisted therapy by first describing an application currently in progress, and then discussing the opportunities and challenges for the future.

APPLICATION CASE STUDY: TURN-TAKING

An initial application to ASD therapy has been implemented and evaluated. Turn-taking is an important social skill that is used as part of therapeutic interventions [13]. We have created an emotion image categorisation task (using *sad* and *happy* faces) on the Sandtray for a child and Nao robot to play, with robot verbal behaviour used to encourage turn-taking behaviours. For this study, the robot was explicitly remote controlled (*wizarded*) by a remote operator (fig. 1).

With a four year-old girl with ASD, six interaction sessions with the Robot-Sandtray turn-taking task were con-

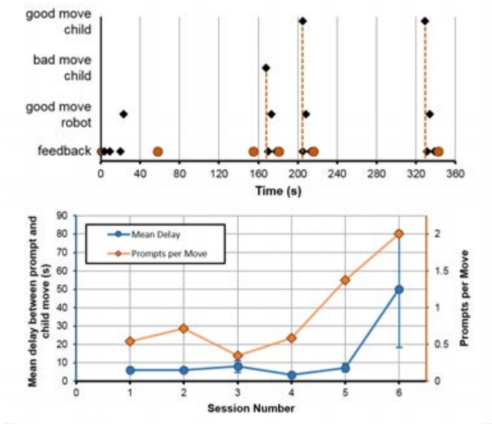

Fig. 2. (*Top*) Sample data from the sixth child-robot Sandtray turn-taking interaction session. The *feedback* was employed to encourage the child to move and to give them feedback. Orange circles indicate robot encouragements for the child to take a turn. (*Bottom*) Trends over six sessions, showing change in delay between robot prompt and the child moving, and the mean number of prompts per child move (*with 95% CI*).

ducted over a period of four weeks. Other robot-based therapy activities were conducted at a separate time. Each interaction had a mean length of 11:06 mins (*sd 5:03 mins*).

Since interaction data can be captured through the touchscreen, it is possible to retrospectively examine the events that occurred and their timing. Considering the relationship between robot encouragement and child moves in a single interaction (e.g. fig. 2, top), the data suggest that both the number of robot encouragement instances required before the child made a move, and the delay between suggestions and actual moves increases over time (fig. 2, bottom). A clinical explanation for this relationship is not proposed here, although the ideal behaviour in this context is a turn-taking interaction with the robot, without necessarily requiring explicit prompting. What can be noted though is that data such as these provide some insight into the interaction between the child and the robot over time.

DISCUSSION AND OPEN QUESTIONS

The examination and use of touchscreen-derived information has two benefits. Firstly, it may come to constitute an additional source of information for the therapist to aid in diagnosis or inform future therapy, with additional processing making aspects of emotion available for example [14]. The extent to which this is clinically useful is an open question that requires investigation. It should however be noted that we do not suggest that such data can replace traditional diagnosis information, rather that it can provide supplemental information. It should be further noted that the touchscreen-derived information alone is likely to be insufficient to provide a complete characterisation of the child's behaviour.

Secondly, since the information captured by the touchscreen is directly accessible to the robot system, it can be used by the robot to adapt its behaviour to the specific circumstances of an individual child in individual interactions, e.g. [6]. In the case of autonomous robot behaviour, such a source of information that does not require the overhead of complex visual or audio processing is a significant benefit.

Extensive previous work has been conducted with this touchscreen mediated interaction between (neurotypical) children, and robots. While this has shown that the touchscreen effectively constrains the content of the interaction (thus facilitating robot autonomous behaviour) [15], it is an open question as to whether a similar effect (such as helping to maintain focus on the interaction) is observable for children with ASD, or over what time scales such an effect may be manifested.

To conclude, we have presented data from an example set of interactions between a child with ASD and a robot in the context of the Sandtray. This provides an illustration of the type of data that is readily available through the use of the touchscreen mediation technology. While further development and data collection is required (and is ongoing), we suggest that the use of touchscreens as mediators for child-robot interactions in the context of ASD therapy provides benefits in terms of behaviour characterisation and technical feasibility that should be further taken advantage of.

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Multitouch-device-based iPod-LEGO Social Robot for Physical and Cognitive Rehabilitation in Children with Special Needs and Elderly People

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Abstract— This paper describes a robotic platform based on LEGO combined wirelessly with multitouch device in order to perform a cognitive rehabilitation, or a physical rehabilitation in either children with special needs or elderly people. Based on a previous studies we propose technical improvements on the iPod-LEGO robot. Also promising results are presented in order to see the effectiveness of these treatments using our robotic platform.

Keywords— Social robot, cognitive rehabilitation, children, elderly people

1. INTRODUCTION

This article is about a robotic platform as an enhancing tool for therapeutical purposes either in children with special needs or elderly people. Robotics is a multidisciplinary scientific tool which motivates and stimulates learning in children [1]. A key point of robotics is the ability to adapt to any kind of activity while being the perfect device for remote monitoring. Robots can perform therapeutic and companion functions simultaneously [2], becoming an extension of the therapist. In recent years there is an emergence of innovative technologies for cognitive rehabilitation like computerized rehabilitation programs, virtual reality, remote rehabilitation and robotics [2]. Other studies [3] indicate that humans prefer a real robot to a virtual version in one on one interactions precisely because their physical nature evokes a higher sense of presence in the user, making them more trustworthy and engaging. Robotics is itself something that is easy to be accepted by people, also, as a tool can contribute to collaborative work, adapting the level of the sessions according to the childrens educational performance [4]. Besides, robots can support therapists collecting data that can be useful to better evaluate and monitor the level of success acquired during therapeutical activity. In the last decennia robots have been used effectively in therapy and educational interventions with primary school children. For example, they have been used in therapy and educational interventions: with autistic children [5], with children with motor and physical impairments [6] and longterm hospitalized children [7].

This paper describes the robot used for cognitive and physical rehabilitation in children with special needs and elderly people and its technical improvements.

2. PREVIOUS WORK

Previous studies completed by the team composed by engineers from La Salle Engineering School (Ramon Llull University), University of Deusto, and University of Comillas, have proved that robot features and activities can improve physical and cognitive performances based on the interaction with the LEGO NXT robot through a multitouch device connected to sensors and actuators. During the first stage of the project carried out during 2013 the three participant universities developed the software for the multitouch device (iPod 4G) and accomplished the wired communication between the ipod and the LEGO NXT robot (see Fig. 1) through an electronic device (Teensy 2.0) [8]. Team La Salle used this robotic platform during 2013 in order to see the effectiveness of rehabilitation treatment in children with TBI in a long-term interaction. Also, team La Salle used it to show how the drop-out rate in children is lower in the group with robots than in another treatment directed to parents due to the engagement with robotics. Team Deusto used it for cognitive therapies associated with memory and mathematical problem-solving in elderly people [9] and as caregiver and social assistant robot for the elderly to perform physical and mental activities for them to maintain their healthy life habits and, as a final result, improve their quality of life [10]. In the following lines the main objectives for the second stage are explained.

3. OBJECTIVES

In this second stage the objectives are:

- To implement a technological solution based on the previous study where the communication was bidirectional between the iPod 4G and the LEGO NXT through a Teensy 2.0 microcontroller board. Using the MIDI protocol between Teensy and iPod, and I2C protocol between Teensy and NXT. The NXT was responsible for reading information from sensors (touch sensors), and from the iPod in order to execute actions such as movements of joy when an activity is done properly. By using the iPad USB Camera Connector Kit (an iPod jailbreak was required to adapt the device), we could plug the MIDI Cable of the Teensy board directly into

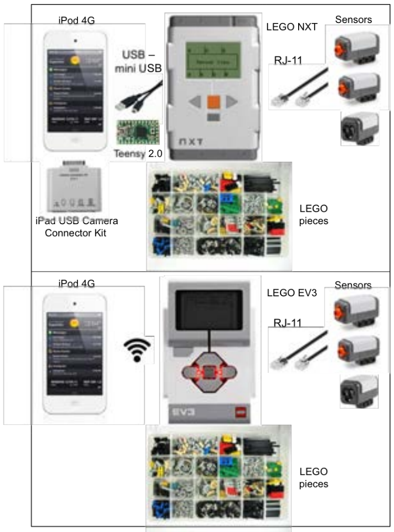

Fig. 1. First stage on the top: iPod-LEGO NXT wired connection via USB through Teensy 2.0 device. Second stage on the bottom: iPod-LEGO EV3 wireless connection via Bluetooth.

the iPod. The technological improvement has been done by Team Comillas. They worked on a bluetooth wireless communication between the new LEGO Robot called EV3 and the iPod 4G (see Fig. 1 in order to reduce the technical problems from the wired communication. Also, with this solution it is not necessary to use the MIDI protocol we were using to transfer data between the iPod and the LEGO NXT to make the programming become much easier.

- To design and develop a set of apps that contain new activities for cognitive and physical rehabilitation aimed at two groups: elderly people and children with special needs. Also, adding new features in the pet functionality where the robot behaves differently depending on the results obtained from the activities, the battery level of the iPod and its overall usability affects its state, making it happy, sad, angry, sick, etc.

4. RESULTS

Team La Salle got significative results in different cognitive measurements during pre and post time with children with a brain trauma showing how useful could be the iPod-LEGO robot for this kind of treatments. On the other hand, based on the tests, Team Deusto showed how easy was to use the robot to deliver basic coaching for physical activities as proposed by the client.

5. CONCLUSIONS

Robotics concepts have revolutionized the manufacturing processes in industries since the industry revolution, now are becoming to get introduced into everyday life environments such as vehicles, homes, offices and schools. Living with robots is already a reality, as happened with the interaction with computers. Robots are already in field of rehabilitation. Based on a previous studies we propose technical improvements on the iPod-LEGO social robot used for cognitive or physical rehabilitation in either children with special needs or elderly people. As a result an improved robotic platform has been developed avoiding different technical problems we had in the past using this new wireless communication via bluetooth. We are able to fix many of the issues we had with the wired communication, such as the continuous broken wires due to the intensive user-robot interaction and an easier programming to transfer information between devices instead of using MIDI commands through the Teensy 2.0 device.

Our expectations are also focused on a better use of the robot as an enhancing tool for a satisfactory rehabilitation for children with special needs and elderly people. So, if this target of people improve their physical ability or their cognitive functionalities, that means their quality of life improves.

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The Impact of a Robotic Cat on Dementia Caregivers' Psychosocial Work Environment – a Pilot Study

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Abstract. The aim of this pilot study is to contribute to the knowledge of professional caregivers' psychosocial work environment when they use an interactive robotic cat. Based on recurring interviews, over three months, with three individual caregivers at a dementia care center in Sweden, the findings indicate that the caregivers experience that the cat can have an positive impact on their psychosocial work environment regarding working with people (communication and interaction), as well as help reducing feelings of stress, and insecurity when working alone

Keywords: Robotic cat, Dementia care, caregivers' experiences, psychosocial work environment, qualitative method.

INTRODUCTION

Health Robotics [3,4,6,8] and welfare technology [2] is being developed in response to new societal challenges such as the aging population, and is often presented as a means to free up resources, meet the user's needs, and promote research, development and innovation. The area is new and evolving why there still are few research results, with mixed results [6]. *The aim of this pilot study is to contribute to the knowledge about professional caregivers' psychosocial work environment when they use an interactive robotic cat.*

Health care personnel is an occupational group in Sweden with high frequency of work stress and stress-related mental illnesses [1]. Causes of work related mental illness may be due to a variety of psychosocial factors [7]. In this study, the focus is primarily on such factors presumed to arise when working with the health robotic assistive device JustoCat (or the "robotic cat"): working alone, risks of threats and violence, conflicts, working with people, social contacts.

METHOD

The project has followed three individual caregivers from the dementia care center Eskilshem for three months during the autumn/winter 2014. The caregivers were given one robotic cat each which they gave to one of their patients, i.e. one cat stayed with the same patient the whole time and they had unlimited access to the cat every day. In-depth interviews – according to a semi-structured design [5] – with the three persons were conducted once a month at their workplace. The interviews took about an hour each time. A total of nine interviews were carried out, and later transcribed. The interviews began with a series of neutral opening questions about personal background, interest, etc, in order to get the conversation started and providing an atmosphere conducive to open and undistorted communication between participant and the interviewer [5]. Further into the interview, questions of more personal and potentially sensitive character, were asked. The method of repeatedly interviewing the same individuals over time proved very fruitful since it gave the interviewees time and opportunity to reflect on issues and questions, raised by the interviewer, between each interview. The interviews were audio recorded and transcribed, and the data were categorized. The analysis was mainly concerned with identifying themes on a latent or interpretative level [9]. A check was performed to ensure that the themes worked in relation to the coded extracts as well as the entire data set.

FINDINGS

The caregivers were asked questions about how they use the robotic cat in relation to the specific patients that had been given a cat. Particularly, the questions focused on the cats' potential impact on the caregivers' experiences of: working alone, risks of threats and violence, conflicts, working with people, social contacts. The main findings from the study will be presented according to two themes that have been inductively extracted from the narratives: the use of the robotic cat as an (a) Activator, and as a (b) Pacifier.

Activator

Listening to the caregivers' experiences of how they use the robotic cat in their daily care of the patient, it is obvious that they use it to promote communication, i.e. to stimulate and to activate the patient to talk and to interact with the caregiver. The interviewees explains that they use the cat as a tool to evoke memories and conversation topics, for example:

"To have something to talk about – you do not need to talk about the non-existing bus or train that never arrives. You have some kind of tool to change the monotonous conversation. You talk about the cat instead and it often recalls memories." (IP1)

In this way, the cat promoted verbal communication between the personnel and the users. As a conversation, or memory, stimuli, the cat was appreciated among the caregivers for its effect on the patient (positive impact on attitude) as well as its function for helping them to talk and communicate with their patients.

The interviewees also said that they had noticed that the cat could promote communication between the users (i.e. without the interference of the caregivers):

"Often when the cat is involved the patients starts talking about it. That makes you happy! The cat makes it easier to get a discussion going, and faster to divert. So it helps a lot, feels easier." (IP1)

This aspect of the cat, as a conversation starter, between users is experienced as beneficial for the caregivers' work environment since it promotes a good social atmosphere in group situations. In this way the cat may contribute to the psychosocial work environment regarding factors such as working with people, and social contacts.

Pacifier

If the cat was used as an "activator" regarding communication, it was used rather as a "pacifier" regarding physical interaction. In one-to-one situations (between the caregivers' and the users), the cat was used for calming purposes, for example.

"I think that it helps me do a better job, especially when she is hallucinating. It's easier for me to "reach" her when she kind of loses herself in the hallucination. She becomes stiff in her body, but when having the cat it is different, then she relaxes." (IP3)

Similarly, in group situations involving several patients, the cat was used to deflect negative behaviors that might otherwise interfere with other patients, as illustrated in the next conversation between interviewer and interviewee:

> IP3: The other patients are now less disturbed by her, now when she has the cat to care for. Before they got angry with her, because she disturbed them by her picking behavior.
>
> Interviewer: How is the situation for you and your colleagues then, when she becomes anxious and the other patients get angry?
>
> IP3: It's stressful. For example, when we had the Lucia ceremony, it was stressing that she disturbed the others. But when we gave her the cat, she was occupied with picking on it.

This aspect of the cat, as a "pacifier", or distractor, is experienced as beneficial for the caregivers' work environment due to calming and diverting effects on the patients.

Furthermore, the interviewed caregivers also spoke of the cats' potential for contributing with security in certain problematic work situations. For example, using the cat as a pacifier in stressful evenings when the caregiver work alone at the ward, taking care of eight patients and trying to get them all to bed. In those situations, the cat might function as a helping hand for the individual caregiver when s/he is especially exposed to risks of conflicts and violence.

CONCLUSIONS

The findings from the pilot study indicate that the caregivers use the robotic cat in two distinct ways with different impacts on the psychosocial work environment.

As conversation starter and memory trigger, the robotic cat is used to activate and stimulate the patient to engage in communication with others (caregivers or other patients). When used in this way, the interviewed caregivers experience that the cat is contributing to their psychosocial work environment regarding factors such as working with people and social contacts.

The robotic cat is also used as pacifier to calm patients and divert negative behaviors. When used in this way, the interviewed caregivers not only feel less stressed, but also more secure, especially when working alone and are exposed to precarious situations involving potential conflicts and violence.

The findings point to several potential benefits for individual caregivers when using a robotic cat in their daily care for patients. However, further studies are needed to evaluate the findings from this pilot study and to explore potential benefits as well as risks.

ACKNOWLEDGMENTS

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Acceptability Of A Service Robot Which Supports Independent Living Of Elderly People

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Abstract. Prolonging independent living of elderly people is preferred for many reasons. Service robots to prolong independent living of elderly people has been given increasing attention. To capture the view of elderly people concerning a re-enablement robot, focus group sessions were conducted in the Netherlands, UK and France. In these focus groups a scenario of a re-enablement robot was discussed. The results showed that elderly people find the idea of having a robot acceptable. Nevertheless, such a robot needs to have high intelligence. Additionally, elderly people preferred the robot not being able to refuse a given task, even though this may decrease the user's ability in the longer term.

Keywords: Service robots, elderly, independent living, acceptability.

INTRODUCTION

The ageing population in Western countries is increasing. This population prefers to stay at home as long as possible, nevertheless their abilities to daily activities diminishes. Activities related to mobility, self-care, and interpersonal interaction & relationships were identified in a previous study as most threatening with regard to the independent living of elderly people [1]. And when one no longer has the ability to meet one's own needs other options, such institutionalized care, are explored. However, institutionalized care is expensive which makes prolonging independent living of elderly people also desirable at a societal level.

Traditionally informal or professional caregivers offer care to those who need help to continue to live independently at home. However, social structures have changed resulting in informal carers being less inclined and/or able to provide care and additionally we also face an increasing shortage of care staff [2]. Thus, in order to maintain the quality of care at home technical solutions, and more specific robotic solutions, are being given increasing attention.

The ACCOMPANY (Acceptable robotiCs COMPanions for AgeiNG Years) project aimed to further develop the functionality of an existing service robot, the Care-O-bot [3], in order to support elderly people to prolong independent living of elderly people [4]. Re-enablement is an aspects that ACCOMPANY seeks to promote. Elderly people should execute tasks themselves as much as possible in order to maintain their existing functional abilities. A re-enablement robot should encourage the user to perform tasks by themselves when possible and should only provide support when the user cannot perform an activity. Such a robot should be capable of doing more than just executing functional tasks as it should motivate and stimulate the user to execute tasks themselves. However, this means that such a robot should be able to monitor and to interpret a situation as the user in some situations might actually need the support of the robot. This introduces the complex situation whether the robot should be allowed to make decisions depending on the situation. For example: would it acceptable for the service robot to 'decide' to refuse to execute a task, given by the user, in order to get the user to exercise abilities they might otherwise lose?

This paper explores this dilemma and presents the view and thoughts of elderly people in the Netherlands, United Kingdom and France on the acceptability of such a re-enablement robot.

METHOD

Focus group sessions were conducted with elderly people at four different sites: the Netherlands – Zuyd University of Applied Sciences (ZUYD), UK – University of Birmingham (UB) and University of Herefordshire (UH), and France – MADoPA. In these focus group sessions a scenario with a re-enablement robot was verbally explained and discussed. In this scenario a 78 year old lady, Marie, ignores the robot's advice to walk around which will help her ulcers to heal. Marie likes the robot to remind her to take her antibiotics but dislikes the reminders to elevate her leg. And finally, she does not tell her nurse the truth in the scenario about how much she is moving. Participants were asked for their thoughts concerning this scenario. All data was audio and/or video recorded.

Participants

Elderly people were contacted through care organizations, except for the participants of UB who were contacted through the Birmingham 1000 Elders [5]. Elderly people were selected based on four criteria: 1) aged 60+, 2) living at home, 3) no cognitive decline, and 4) receiving home care.

Data analysis

All data was transcribed verbatim, translated into English and coded using a combination of directed analysis and Ritchie & Spencer's Framework Analysis [6]. The final codes were worked into themes. All of the data was then combined into a single report.

RESULTS

In total 55 elderly people (19 male, 36 female) participated in focus group meetings at ZUYD (10), UH (5), UB (21) and MADoPA (19). The mean age of the participants of ZUYD and MADoPA was 78.5 years. The age of the participants of UH and UB was unknown, except that they were aged 65+.

All participants could relate to the scenario of Marie and agreed that people do not always do what is best for them. The majority of these participants thought the user should have the control of their life. They were very straightforward that when the user would want to do something others would disapprove, the robot was not allowed to interfere: the user's view on how the robot should act was seen as most important and the autonomy of the user should be honored. On the other hand, the elderly participants also believed that the user had agreed to accept the robot and that it was not forced upon the user. They therefore thought that collaboration with the robot was a reasonable obligation. This shows that the respect for autonomy of the user starts even before the robot is installed in the user's home.

Providing reminders was seen as a useful task by all participants as they were aware that people might start to forget things as they become older. Although some participants were worried that these reminders could become annoying if repeated often (at an inconvenient time) or when the reminders would be given by a mechanical voice. They therefore wished the robot would only provide reminders tailored to the situation (e.g. the robot should not provide a reminder to go for a walk when the user is watching the news).

The feelings concerning the robot stimulating health-promoting behavior (e.g. telling Marie to move around to help her ulcers to heal) were mixed. Some thought it would be useful, while others had compassion for the discomfort it could cause. Some participants also argued that people are normally not forced into cooperating with health-promoting behaviors (e.g. people are free to smoke tobacco and drink too much alcohol) and thought it was up to Marie to decide if she would move or not. Again participants wished the robot would only provide useful information depending on the situation.

Some of the participants of UB were also worried that a robot which could refuse to bring the user a drink (in order to get the user to exercise abilities they might otherwise lose) would harm the user (e.g. dehydration of the user). For this group it was more important that the robot would keep the user safe.

DISCUSSION

A re-enablement robot that would give reminders (e.g. to take medication) was seen as helpful. However, in order to be acceptable such a robot needs to be able to react on the user's behavior and provide useful reminders and/or information depending on the situation. This requires the robot to be flexible, recognize circumstances, interpret these and make decisions based on the situation.

In all focus groups it was also acknowledged that, in order for the robot to be acceptable, the autonomy of the user must be respected and no decisions of user should be overruled by the robot. The robot must be within the control of the user. However, such a robot may actually reduce the quality of life the elderly user because when the robot does too much it can de-skill, de-motivate and/or otherwise erode the abilities the user still has, decreasing one's ability in the longer term.

CONCLUSION

In this paper the acceptability of an re-enablement robot by elderly people was explored with the use of focus group sessions. It became clear that elderly people find the idea of having a robot to support them in their daily life acceptable. However, such a robot needs to have high intelligence as it needs to be able to act upon the situation (i.e. it should recognize circumstances, interpret these and make decisions based on the situation). Our data also suggest that people prefer a robot that obeys the user and does not refuse to perform a given task, even when this may decrease the user's ability in the longer term and thereby undermine the user's ability to live independently.

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Influence of Social Avoidance and Distress on People's Preferences for Robots as Daily Life Communication Partners

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Abstract. This study investigates (1) whether people prefer robots vs. humans as communication partners for different roles and situations in daily life and (2) the influence of social avoidance and distress on people's preferences for robots vs. humans. Results showed that in Japan, a certain amount of people preferred robots as communication partners for many roles and situations. Additionally, social avoidance and distress influenced these preferences. This result suggests that robots would be particularly useful for individuals with high social anxiety.

Keywords: Human-Robot Interaction, social acceptance, social avoidance and distress.

INTRODUCTION

It is likely that social robots will become a part of our daily lives in the near future. However, questions regarding (1) whether people prefer robots vs. humans as communication partners for different roles and situations in daily life and (2) the type of people who prefer to interact with robots remain unanswered. Although Takayama, Ju, and Nass [1] identified types of roles that people expect to robots, previous studies have not sufficiently addressed the answers to the above-mentioned questions.

Several psychological factors are known to influence human-robot interaction. For example, it is revealed that human-robot interaction is inhibited by people's robot anxiety and negative attitude toward robots (e.g., [2]). That is, people who experience anxiety toward robots tend to avoid communicating with a robot. Conversely, people who experience anxiety toward other people may have difficulty communicating with people and may prefer to communicate with robots rather than with peoples.

This study investigates two issues. First, we examined people's preferences for robots vs. humans as communication partners with regard to different roles and situations. Second, we examined the influence of social avoidance and distress on people's preferences of communication partners.

Therefore, we formulated the following research questions. Q1: Do people prefer robots vs. humans as communication partners for different roles and situations in daily life? Q2: How do social avoidance and distress influence the communication partner preferences?

METHOD

An online survey was conducted in March 2015. A total of 206 Japanese participants (Men: 103, Women: 103; Age range: 20–29; Mean: 25.2; *SD*: 2.91) were recruited through an online survey company.

In order to address Q1, the questionnaire included items assessing the participants' preferences for robots vs. humans as communication partners. These items were developped for this survey. In this survey, participants were not presented with a clear definition (e.g., humanoid type) of a robot for think their own image. Twenty-five roles and situations (see Table 1) were presented, and the participants were asked to select either a human or a robot as a communication partner for each role and situation.

In order to address Q2, a Japanese version of the Social Avoidance and Distress Scale (SADS; [3]), which was originally developed by Watson and Friend [4] and includes 28 true-false items, was administered to assess participants' degree of social avoidance and distress. Social avoidance and distress is an important factor related to social anxiety.

RESULTS

To answer Q1, the rate at which participants selected humans or robots as their communication partners were calculated (Table 1). Results showed that for one third of the total roles and situations presented, approximately 20% of the total participants preferred to communicate with robots, as compared to humans. Furthermore, for two roles and situations (No. 7 and No. 10), over half of participants preferred to communicate with robots as compared to humans.

To answer Q2, the SADS scores of participants who selected humans as communication partners were compared to those of participants who selected robots as communication partners. Results of *t*-test with SADS score as the dependent variable and communication partner preference as the independent variable showed that for all roles and situations, the SADS scores of participants who selected robots as communication partners were higher than those of participants who selected humans as communication partners (Table 1).

Table 1. The rate at which participants selected humans vs. robots as communication partners and differences in SADS scores between participants who preferred humans vs. robots as communication partners.

No.	Item	*n* (%) of selection of Robot	95%*CI*	*Means* (*SDs*)of SADS scores: Human	Robot	*t*	*p*
2	Talking about serious events experienced during the day at home	29 (14.1)	9.3–18.8	15.8 (7.2)	20.7 (6.0)	-3.898	.000
13	Seeking medical attention at a hospital	29 (14.1)	9.3–18.8	15.7 (7.0)	21.2 (6.8)	-3.998	.000
14	Seeking career counseling at school	32 (15.5)	10.6–20.5	15.8 (7.0)	20.3 (7.4)	-3.196	.003
23	Being nursed during hospitalization	33 (16.0)	11.0–21.0	15.5 (7.0)	21.4 (6.1)	-4.916	.000
22	Being nursed at home	34 (16.5)	11.4–21.6	15.6 (7.0)	21.0 (6.7)	-4.257	.000
17	Seeking mental health counseling at a clinic	36 (17.5)	12.3–22.7	15.5 (7.1)	21.3 (6.0)	-5.085	.000
16	Seeking mental health counseling at school or in the workplace	38 (18.4)	13.1–23.7	15.7 (7.0)	20.1 (7.0)	-3.490	.001
18	Being taught at schools or cramming schools	39 (18.9)	13.6–24.3	15.6 (7.0)	20.4 (6.9)	-3.966	.000
1	Talking about trivial events experienced during the day at home	41 (19.9)	14.5–25.4	15.8 (7.1)	19.3 (6.9)	-2.943	.005
15	Seeking outplacement counseling at an employment agency	41 (19.9)	14.5–25.4	15.6 (7.0)	20.1 (7.2)	-3.611	.001
12	Being provided with health consultations	42 (20.4)	14.9–25.9	15.7 (7.0)	19.6 (7.1)	-3.242	.002
21	Being trained for new tasks at workplace	42 (20.4)	14.9–25.9	15.2 (7.0)	21.3 (5.9)	-5.709	.000
20	Being taught new job-related skills for a part-time job at the workplace	54 (26.2)	20.2–32.2	15.4 (7.1)	19.6 (6.7)	-3.979	.000
5	Becoming a playmate at home	60 (29.1)	22.9–35.3	14.9 (6.9)	20.4 (6.5)	-5.430	.000
19	Being taught to study at home	60 (29.1)	22.9–35.3	15.5 (6.8)	18.9 (7.7)	-2.997	.003
4	Consulting about concerns at tome	63 (30.6)	24.3–36.9	15.8 (6.8)	18.0 (7.8)	-1.972	.051
24	Being cared for at home when old	67 (32.5)	26.1–38.9	15.1 (6.9)	19.4 (7.0)	-4.147	.000
25	Being cared for at a nursing home when old	69 (33.5)	27.0–39.9	14.9 (6.9)	19.7 (6.8)	-4.763	.000
8	Being guided at a tourist spot	81 (39.3)	32.6–46.0	14.9 (6.9)	19.0 (7.1)	-4.072	.000
6	Getting fortune-telling on street or store	85 (41.3)	34.5–48.0	15.0 (7.1)	18.6 (6.9)	-3.557	.000
9	Enquiring about the characteristics and features of products at stores	87 (42.2)	35.5–49.0	15.2 (6.9)	18.2 (7.3)	-3.004	.003
11	Placing orders for food and drink at restaurants	95 (46.1)	39.3–52.9	14.7 (7.2)	18.6 (6.7)	-4.082	.000
3	Complaining about an issue at home	99 (48.1)	41.2–54.9	15.4 (6.8)	17.6 (7.5)	-2.215	.028
7	Asking directions at station or on street	104 (50.5)	43.7–57.3	14.9 (7.0)	18.0 (7.2)	-3.170	.002
10	Paying for items at the checkout counter of a store	107 (51.9)	45.1–58.8	14.9 (7.5)	18.0 (6.7)	-3.147	.002

DISCUSSION

The study demonstrated that some of young Japanese prefer robots as communication partners than peoples for many roles and situations in daily life. Especially for a couple of roles and situations, direction-giving and cashier, over half of participants preferred to communicate with robots as compared to humans. It is considered that people tend to prefer a robot for structured tasks. Further, we found the differences in SADS scores of participants who selected humans and those who selected robots as communication partners. This result indicated that robots are particularly helpful for people with high social anxiety. Thus, introducing robots as communication partners in daily life situations may be helpful for individuals with high anxiety. And investigating psychological factors associated with peoples' preferences for robots may be helpful for introducing communication robots in daily life.

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Is it real? Dealing with an insecure perception of a pet robot in dementia care

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Abstract. When asked by dementia patients whether a pet robot is real, caregivers face the dilemma as to what the best answer is. We asked Dutch and Spanish caregivers what they consider the best answer and find that most would leave the choice to the patients. There appear to be fundamental differences between the answers in both countries: Dutch respondents often compared the pet robot to a real animal while this option was not chosen at all in Spain.

Keywords: robot assisted activity, social robots, multidisciplinary research, triangulation, dementia care

INTRODUCTION

In general, and gradually more commonly, pet robots in the care of people with dementia are used to increase their feeling of health and wellbeing, and to decrease anxiety. They stimulate patients to be more communicative and enable caregivers and family members to make contact with them - they calm down or indeed revitalize, are less anxious and/or confused, feel less lonely and/or depressed, are happier and laugh more, remember earlier times (reminisce)and communicate more and better with their surroundings [1, 2]

But how are these effects reached? How to use the robot? For which clients are pet robots suitable or and for which ones not? What do you have to watch out for? How to work with groups of people or an individual client? When and how do you involve relatives ? These are a few of the many questions care professionals, volunteer caregivers and family members who (want to) work with pet robots have. There is a need for information and practical guidelines when using pet robots in the care of people with dementia [3].

To meet this need the project “New friends, old emotions” was initiated at the end of 2012. This project focussed on practice oriented research into the use of various robotic animals(1) in individual patients and in groups, (2) in various stages of dementia (3) in cooperation with professional caregivers, relatives and volunteers and give as many ‘evidence based’ answers as possible to the questions listed above. The findings were to be translated into a set of guidelines and recommendations for the use of pet robots in dementia care.

IS IT REAL?

During a pilot study within this project, we observed an observation of a woman with severe dementia cuddling a robotic cat, obviously enjoying it. After while, she stopped, seemed confused, and looked up to the caregiver, asking ‘Is it real?’

This is an illustrative case of practice with a challenge: dementia caregivers usually go with a patient’s point of view. But what if this point of view is insecure? This could specifically occur when using life like robotic pets and we wanted to know what the best strategy would be.

We decided to incorporate this case as a multiple choice question in a larger questionnaire [4] on the attitude of dementia caregivers towards therapy with robotic pets. In Madrid, twenty care professionals of different age and educational level who attended a course were invited to take part in this research and answer the questionnaire. In the Netherlands, 29 care professionals from different care institutions all over the country were recruited to take part.

RESULTS AND DISCUSSION

When looking at the cumulative frequencies for the different answers we see that only a minority would answer “no, it is not real” (12%) , the single most common answer is “what do you believe?” (35%), and the majority of caregivers favor a positive answer (53%).

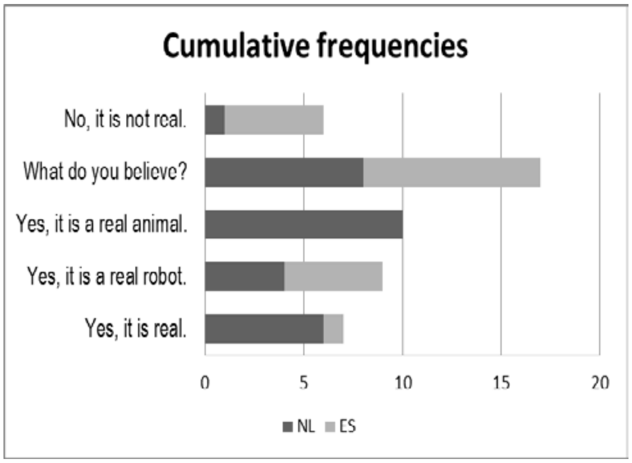
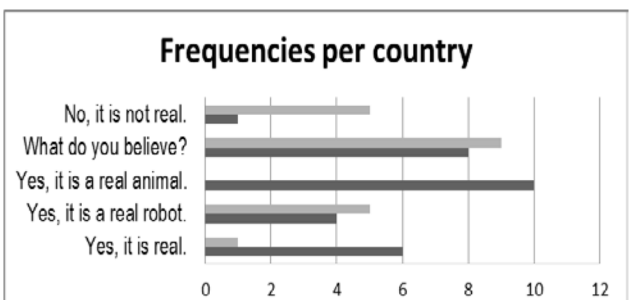


Figure 1. Cumulative frequencies of the different answers. Grey signifies the Spanish and black the Dutch caregivers

However, a closer look at the answers given in Spain and the Netherlands separately presents a slightly more complicated picture: nearly half the respondents in Spain would leave the patients to make up their own mind while the yes has only an insignificant majority over the no. In the Netherlands about a quarter of all respondents would leave the decision to the patient, but the majority (69%) would answer yes. Only one person would answer no.



	Yes, it is real.	Yes, it is a real robot.	Yes, it is a real animal.	What do you believe?	No, it is not real.
ES	1	5	0	9	5
NL	6	4	10	8	1

Figure 2. Frequencies resolved per country. Grey signifies the Spanish and black the Dutch caregivers

So in general we find a much more positive way of answering in the Netherlands. Moreover, no respondent in Spain found positive identification with a real animal an appropriate option while more than a third of Dutch caregivers chose this answer – as much as the other two positive answers combined.

CONCLUSION AND FURTHER RESEARCH

In summary, we find that a large group of caregivers prefers to leave the answer to the patient. We find two significant differences in the country-resolved data:

- In general the Dutch respondents favor more positive answers as compared to the Spanish.
- The comparison to a real animal was chosen by about a third of all Dutch respondents and not at all in Spain.

Even though the sample size is not overly large we would not like to discount this as purely coincidental.
So further investigation is needed to answer the question

- Will we see the same tendencies in a greater sample?
- A second interesting point we have not addressed here at all, would be to look into the expectations possibly reflected in the caregivers' answers. In other words: do they expect the therapeutic value of the robot to depend on its perceived reality?
- One caregiver pointed out that her answer would depend on factors like patient type and context. It would require more in depth research to establish the influence of situational factors on caregivers' reply.

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Inquiry learning with a social robot: can you explain that to me?

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Abstract. This paper presents preliminary results of a study which assesses the impact a social robot might have on the verbalization of a child's internal reasoning and knowledge while working on a learning task. In a comparative experiment we offered children the context of either a social robot or an interactive tablet for verbally explaining their thoughts, while keeping the content of the learning task identical. Results suggest the context of a social robot leads to a faster response time from the children.

Keywords: Social robot, child-robot interaction, inquiry learning, verbalization, interactive explaining

INTRODUCTION

Talking with other people can provide a context for articulating and explaining ideas. This can facilitate greater understanding of ones own ideas en knowledge. For the past 15 years, research has proved that generating explanations leads to deeper understanding when learning new things [1], [2], [3]. There are two forms of explaining: (1) explaining the subject of interest to oneself, which is called self-explaining and (2) explaining the learned subject to another person, which is called interactive explaining [9]. Several studies have provided successful examples of self-explanation activities [1], [11]. However, a social partner may implicitly create more opportunities for explanations, which are difficult to trigger in the case of self-explanation.

The role of a partner can range from being a passive one, who just listens, to an interactive one who provides support and feedback to the learner [3]. Although there are some similarities between an activity with a partner who just listens and self-explanation activities, the presence of another person can provide the benefit of an audience effect [3]. Generating explanations to another person has been associated with the construction of knowledge [8], [10]. This is because the addition of a social partner might lead to more verbalization of reasoning and explanations, which relates to the development of metacognitive skills.

This study investigates the effect of a social robot on the explanatory behavior of young children when working on an inquiry learning task. Inquiry learning is based on constructivism, which we have combined with aspects of the socio-cultural theory about collaborative learning [12]. This choice was based on the following arguments: (1) inquiry learning provides an open-ended task, (2) the collaborative aspect provides a clear role for the robot as a peer learner, (3) children can use different strategies in operating inquiry tasks and the verbalization of these strategies can provide insights in the way children approach such tasks.

Inquiry learning is often described as a cycle or spiral that involves several processes. Klahr's [5], [6] Scientific Discovery of Dual Search (SDDS) model identifies hypothesis generation, experimentation, and evidence evaluation as the core processes of scientific inquiry learning [7], [4], [13]. In the phases of hypothesis generation and evidence evaluation the child has the most opportunities for verbalization of his/her thought process.

DESIGN

The purpose of the present study is to assess the effect of a social robot on the verbalization of reasoning and knowledge during a collaborative inquiry task. The inquiry task focused on exploring the phenomenon of balance using a balance beam. The study employed a between-subjects design with two conditions. In the first condition, children performed the balance inquiry task together with an expressive *social robot*, the RoboKind Zeno R25. The robot was presented as a peer but with well-developed inquiry skills. Futhermore, the children received a tablet. Through this tablet the children could indicate they wanted to move on to the next assignment or ask for additional help. In the second condition, children performed an identical inquiry task about balance with a *tablet* only. The tablet provided the same assignments, suggestions and questions. In both conditions the robot or tablet would ask the child to verbally explain their hypothesis and conclusion at the specific stages in the inquiry task.

It was hypothesized that the presence of a social robot would trigger children to give more explanations than with the tablet. Furthermore, in the robot condition it was expected that the time between asking a question and the childs response was shorter than in the tablet condition.

Participants were 12 Dutch elementary school students (33.3% female) with an average age of 8.8 years (SD = 2.1). The students were randomly assigned to either the robot condition (n = 6), or the tablet condition (n = 6). A review of school curricula showed that students were not yet educated in the phenomena of balance. Therefore, it was expected that the students had little or no prior knowledge.

METHOD

This experiment focuses on measuring the *duration* of verbalization and the *response time* of a child's response to questions from the system. Both measures were assessed from videos recorded during the sessions, which were annotated on three levels.

This project has received funding from the European Union Seventh Framework Programme (FP7-ICT-2013-10) as part of EASEL under grant agreement n° 611971.

The first level was child speech and contained one label: *verbalization*. This label was used when children provided explanations about the assignment or balance and was used directly to assess the *duration*.

The second level was system speech and contained three labels: (1) *giving explanation*, this label was used when the system (robot or tablet) would give an explanation or a verbal response to the child or answer of the child, (2) *asking question*, this label was used when the system would state a question, and (3) *waiting for response*, this label was used when the system had stated a questions and was waiting for a response of the child, effectively measuring the *response time*.

The third level was child actions and contained two labels: (1) *interacting with balance*, this label was used when the children were working with the balance, for example placing or removing pots or removing the wooden blocks, (2) *pressing button*, this label was used when the child would press one of the button of the tablet (in both conditions).

Future work will investigate the remaining annotation levels, however this paper focuses on reporting the *duration* and *response time* as discussed above.

RESULTS

In total 149 annotations were identified for the label *verbalization* of which 77 annotations refer to the robot condition and 72 annotations to the tablet condition. The total duration for all annotations with this label was 758.11 seconds (SD = 4.20). The mean duration for the robot condition was 5.80 (SD = 4.94). The mean duration for the tablet condition was 4.32 (SD = 3.09). An independent sample t-test showed no significant difference between both conditions concerning the *duration*, t = 1.264 (df = 10), p = .118 (one-tailed).

The label *waiting for response* was annotated 146 times of which 71 annotations refer to the robot condition and 75 annotations to the tablet condition. The total duration for all annotations with this label was 217.22 seconds (SD = 2.79). The mean duration of this label in the robot condition was .94 (SD = 1.14) and 2.00 (SD = 3.67) for the tablet condition. An independent sample t-test showed a significant difference between both conditions concerning the *response time*, t = -2.54 (df = 10), p = .015 (one-tailed).

CONCLUSION

This study investigated the effect of a social robot on the duration of verbalization and the response time to questions in the context of an inquiry-learning task. To assess this effect the social robot was compared with the use of a tablet. It was hypothesized that providing the children with the context of a social robot would lead to more verbalization about the task than when the children would only use a tablet. Results indicated that children in the robot condition verbalized more than children in the tablet condition but this difference was not significant. The second hypothesis concerned the response time of children when a question was asked. The results showed a significant difference between the robot condition and the tablet condition in favor of the robot condition.

It seems that children verbalized more easily (shorter response time) when a social robot was used compared to a tablet, but not necessarily more extensively. However, the sample was very small (n = 6 per condition) and a larger sample with more participants may provide more information.

FUTURE WORK

For our future work we want to repeat this experiment with a larger sample in order to increase the external validity. Furthermore, for the repeated study we are planning to perform a qualitative analysis of the answers children give to the questions in order to gain insight in the reasoning of children. Since this experiment was done in the context of inquiry learning, the reasoning of children might give us some interesting insights in what they have learned from the experiment and whether there is a difference in learning between the participants in the tablet condition compared to the robot condition.

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A Comparison of Children Learning New Words from Robots, Tablets, & People

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Abstract. This work investigates young children's perceptions of social robots in a learning context. Because social robots are a relatively new technology, direct comparison to more familiar means of learning could give us useful insights. Here, we compared the efficacy of three sources of information (human, robot, and tablet/iPad) with respect to children's rapid learning of new words. Our results suggested that in this simple case, all three interlocutors served equally well as providers of new words. However, children strongly preferred learning with the robot, and considered it to be more like a person than like an iPad. Follow-up work will examine more complex learning tasks.

Keywords. Education; learning; children; social robots.

INTRODUCTION

The development of children's early oral language skills is critical for nearly all subsequent learning. Differences in children's early vocabulary ability can predict differences in reading ability in middle and high school [1], which could magnify over time, inhibiting later growth [2]. Given the importance of language, it would be beneficial to find new ways to supplement the education of children who may not currently be getting enough support, instruction, or practice. We suggest that emerging technologies can help fill this gap.

Computers, tablets, iPads, and even robots are being introduced in many educational settings [3]. Technology has the advantages of being easily customizable, adaptive to individual learners, as well as broadly deployable. But despite the frequent success of these technologies, we often intuitively assume that humans have some "special sauce" that makes us more suited to being teachers and learning companions than any kind of technology. This may be especially true with regards to learning language, which, as a socially situated medium that is *for* sharing meaning, still seems a uniquely "human" ability.

To this end, we are exploring the effectiveness of technology, specifically robots, as language learning companions for children. Robots occupy a unique role because their embodiment allows them to employ more of the "human" behaviors and social cues that are recognized as crucial in language learning [4]. Children seem to readily learn words from both mobile devices [5] and robots [6], [7]. However, one concern about some of these prior studies is that the learning conditions presented may not reflect children's usual language learning, which often proceeds rapidly and without feedback from a teacher. As such, in this work, we focus on one particular type of rapid, albeit approximate, word learning without feedback, known as "fast mapping" [8]. Although grasping the full meaning of a new word can take time, the initial mapping is often accomplished quickly. Accordingly, we ask whether children display a process of fast mapping with a social robot or a tablet, just as they would with a human interlocutor. We expected that children would learn equally well from the human and robot, and that the tablet would fair somewhat worse due to its lack of social embodiment. Furthermore, we probed children's perceptions of the robot in an attempt to understand how they construed it. The study is modeled closely on the procedure in [9].

METHODS

Nineteen children ages 4-6 (10 female, 9 male), from a Greater Boston area preschool serving a mainly middle-class population participated in two sessions, set about one week apart. The experiment followed a within-subjects design.

In Session 1, children were first asked questions about whether they thought a robot was more like a person or like an iPad. Then, each child looked at three series of ten pictures of unfamiliar animals, presented one image at a time on the tablet. They viewed ten pictures with just the tablet, ten with the robot (Figure 1), and ten with the second experimenter (thirty total). The order of the interlocutors was counterbalanced to handle order effects. The order in which the pictures were presented was held constant across interlocutors. A Samsung Galaxy Tablet was used to present the animal pictures. When the tablet was the interlocutor, recorded human speech was played back through the tablet's speakers. The robot was a DragonBot [10], which was teleoperated by a second experimenter.

Figure 1: Children viewed pictures of novel animals with the DragonBot as well as with a person or with the tablet.

During the picture viewing, the child's interlocutor commented positively but uninformatively on the animal shown for 8 of the 10 pictures, e.g., "Look at that!" The remaining two animals were named, e.g., "Ooh, a kinkajou! See the kinkajou?" This presented the opportunity for fast mapping to occur. After each set of pictures, we measured children's learning with a recall test. Finally, we asked the earlier questions again, and probed children's preferences for learning from the human vs. robot vs. iPad.

In Session 2, we wanted to see whether children's thoughts about robots had changed, and to test retention of the animal names they had learned. They were given the same recall tests and were asked the same sets of questions.

RESULTS

We found that, across the three conditions, children learned a mean of 4.3 of the 6 animals correctly *(*71.7%

correct, *SD*=1.84). However, there were no significant differences across conditions in how many names were learned. In Session 2, children's retention was nearly as good, naming a mean of 3.9 of 6 animals correctly (65.0% correct, *SD*=1.48), indicating that they did learn the names.

Children expressed a strong preference for learning with the robot. After Session 1, 63.2% (12 of 17) children preferred the robot, 1 child preferred the iPad, 1 preferred the person, and 5 liked all three equally (two children were not asked this question in Session 1). After Session 2, 73.7% (14 of 19) children preferred the robot; 2 preferred the iPad, and 3 liked all three equally. Thus, although learning success appeared the same, enthusiasm was higher for the robot.

Regarding children's perceptions of the robot, the most telling questions were *"When a robot answers a question, is it more like a person or more like an iPad?"* and *"When a robot teaches you something…"* Prior to interacting with the robot, children were split in their answers ("Answers…": 52.6% person, 47.4% iPad; "Teaches…": 47.4% person, 52.6% iPad). After interacting, more children thought the robot was more like a person ("Answers…": 78.9% person, 21.1% iPad; "Teaches…": 68.4% person, 31.6% iPad). However, during the follow-up Session 2, some children reverted back to their original opinion ("Answers…": 36.7% person, 63.2% iPad; "Teaches…": 68.4% person, 31.6% iPad). For the remaining questions, children generally thought the robot was more like a person.

DISCUSSION

We examined the efficacy of, as well as children's subjective attitudes toward, three different sources of information (human, robot, and tablet) with respect to word learning. Our results suggested that in this simple case, contrary to our hypotheses, all three interlocutors served equally well as providers of novel animal names. We suspect that this is due to the simple nature of the learning task. When only one picture is shown and named, children need not observe the interlocutor's social cues to understand what is being referred to by the novel name that is provided. Given that the key benefit provided by the robot and human over the tablet is their ability to offer social cues, it is understandable that, because these cues were not necessary, the tablet was equally well suited to the learning task.

However, children showed a clear preference for learning with the robot. Their enthusiasm and, therefore, likely engagement was higher with the robot. It is unclear whether this was merely a novelty effect. We suspect that given a sufficiently interesting activity with the robot, children's preference for a robot over a tablet would not simply be novelty – recent work has shown that children can remain interested and engaged with a robot during educational games for a month or more [6], [7].

Regarding children's perception of the robot, our results suggest that although children initially expect a robot to engage them just like any other technological tool, their perceptions of it rapidly change. Note that this shift was evident for the two questions in which children were invited to appraise the robot as an active, social partner, i.e., as an interlocutor that is able to teach and answer questions. They come to perceive it as being more "human," more like a *someone* than a *something*, which suggests that they will attend to its social cues when they need to learn.

Follow-up work is now in progress to probe the social dimension farther. We are looking at tasks that require social information for learning (e.g., gaze) and more closely mirror what happens in "real-life", such as when a child needs to determine which of multiple target objects is the referent. Because robots can operate in the same spaces that we do (while tablets are limited to a two-dimensional screen world), it is an interesting challenge to identify clear differences between the social capabilities of a human and a robot. Our future work will continue exploring how children learn from different agents, and which social cues are truly important for learning.

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How do diabetic children react on a social robot during multiple sessions in a hospital?

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Abstract. In the European project ALIZ-e, many aspects of social robot interaction were evaluated, mainly with healthy children. In this paper, we take the lessons learned and apply them in a field experiment with diabetic children. The observations showed that a robot requesting help added to the bonding, that the children with diabetes acquired relevant knowledge, seemed to appreciate the robot more than the healthy children in earlier experiments and showed to have different profiles between them that set requirements for personalization.

Keywords: social robot, field testing, diabetes

INTRODUCTION

The European project ALIZ-e aimed at persistent long-term interaction of a robot for diabetic children in the age of 7-11. The project works on models and methods for robot's interactive behaviors to achieve long-term interaction and support the development of self-management attitudes, knowledge, skills and behaviors (e.g. self-efficacy, education, bonding). Within this project experiments have been done with both sick and healthy children who use a robot that adapts to them on certain aspects (e.g., emotions influenced by child [1], keeping the activity challenging for each child [2]). This paper presents our lessons learned and an experiment conducted in the wild (i.e., the hospital): An evaluation of the prototype showing the envisioned interaction with children with diabetes in the course of 3 sessions.

LESSONS LEARNED AND IMPLICATIONS

The present experiment was the last experiment within the ALIZ-e project and thus incorporated the lessons learned from the previous 4 years and evaluated this with the intended users (children with diabetes). Lessons are: (a) children are able to recognize the emotions of a NAO robot [3], (b) personality is hard to take into account [4], and (c) that adapting robot state to the user [1], exhibiting thinking behavior [5] and remembering small facts [6] support positive interaction. Activities are more motivating when the activity is challenging [1] and it is possible to switch between activities [7]. Finally we saw that children are willing to disclose information about themselves [8] and most children like touching the robot [9]. Based on these results, an experiment was designed in which children performed multiple activities over various sessions from which the robot remembered some small facts in an enclosed environment (robot playground see Figure 1). Furthermore, during interaction the robot showed thinking behavior, emotions and interest in the child while also disclosing information about itself. Next to this the robot was dependent on the child to move from one point to another (walking or lifting). The general research aim was get insight into the child's knowledge gain, activity preferences and profile characteristics for personalization.

Figure 1 Robot playground

EVALUATION

17 diabetic children in the age of 6-10 (M=8.24 yrs, SD=1.25 yrs) from the MeanderMC (Amersfoort, The Netherlands) participated in the experiment. We used tests (knowledge and self-efficacy), questionnaires (fun and self-determination) and observations (game preference, video and logging data) to quantify and qualify the interaction with the robot.

Every child had three sessions of about an hour in the hospital with the robot. These sessions were at least 14 days apart. The first session started with the self-efficacy questions and a knowledge test containing 32 questions of which 8 were asked each session (24 in total and 8 as a reference). Then a short introduction about the activities was given. A trivial pursuit kind of quiz was played on a swiveling tablet that can turn towards the robot and the child, a sorting game which is played on a large horizontal placed touch screen on which the robot and child have to put pictures (pizza, broccoli) in the correct category (low/high carbohydrates) on one of the sides of the display and watching an educational video with the robot. Next to this, the robot was introduced as Charlie who is in training to become a diabetes pal. He knows a bit about diabetes, but also has to learn a lot. The children could walk with Charlie from one activity to another activity. In between the activities, Charlie asked some questions about how they deal with diabetes, but also about their hobbies. Then they started with the quiz. In the second session, the children could choose which activity they wanted to start with (quiz or sorting game), while in the last session there was only time for one. At the end of each session, questions about fun and self-determination were asked, and after the third session there was also a post knowledge test.

RESULTS

The knowledge test showed significant differences in knowledge acquired. A paired sample t-test showed a significant increase in knowledge from the pre to the post test for the first 24 questions (first session M=11.35, SE=0.77; second session M=13.7, SE=0.66; $t(16)=5.6$, $p<0.001$). The final eight questions (25-32) did not show significant improvement (first session M=5.94, SE=0.34; second session M=6.29, SE=0.44; $t(16)=1.19$, $p=0.250$).

No time-effects were observed for self-efficacy, fun and self-determination due to ceiling effects (high scores overall).

The children had the same preference for the sorting game as for the quiz. In the second session 9 of the 17 children chose the sorting game as their favorite and 8 chose quiz and they also agreed starting with this game. In the third session 8 children chose to play the sorting game and 9 the quiz.

After an analysis based on grounded theory [10] of the video and logging data 5 types of children were identified on which the robot could adapt its interaction in the future: 1) children who are confident about themselves and their illness, 2) children who feel excluded from the group, 3) children who are afraid to make errors, 4) children who feel uncomfortable with the situation and 5) children who are too young to play the activities and have meaningful robot interaction.

CONCLUSION AND DISCUSSION

With questionnaires it is hard to acquire useful data with young children, due to ceiling effects. Experiments over a longer period of time can solve part of this problem. Furthermore, observations provide useful information, but take a lot of time to analyze. However, the observations provided the insights that the children actually learn something from the robot and that their interaction is not distracting them from the subject matter. The user profiles provided a starting point to improve the user profiles and how the robot could adapt to certain user profiles. For example, Charlie could be more supportive with children who act a bit shy.

In general, we noticed that a robot that was not all-knowing and dependent on the child's help (e.g., when falling or going to another activity) really evoked valuable behaviors and was appreciated by the children. We also saw that the minimal interaction with the experimenter and the shared space of child and robot created by the playground was beneficial for the child's involvement. Furthermore, we observed that children with diabetes seem more inclined in bonding with the robot than healthy children as observed in previous studies (e.g. [1]). This could be inferred, amongst others, by the gifts the children brought. This could be because they normally feel outside the group. Finally, because the children were brought to the experiment by their parents who often waited in the same room as the experiment leader (outside the experiment room), we also got some idea about the home situation. In further research we will take the influence of the social environment on how a diabetic child deals with his/her illness more into account, i.e., the family life (home), the caretakers (hospital) and peers (diabetes camp).

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Learning A Second Language with a Socially Assistive Robot

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Abstract. We created a socially assistive robotic learning companion to support English-speaking children's acquisition of a new language (Spanish). In a two-month microgenetic study, 34 preschool children will play an interactive game with a fully autonomous robot and the robot's virtual sidekick, a Toucan shown on a tablet screen. Two aspects of the interaction were personalized to each child: (1) the content of the game (i.e., which words were presented), and (2) the robot's affective responses to the child's emotional state and performance. We will evaluate whether personalization leads to greater engagement and learning.

Keywords. Education; children; language learning; long-term interaction; play; social assistive robots.

INTRODUCTION

Preschool (3-5 years) is a critical time for children to learn language. Not only can early language ability greatly impact later educational success (e.g., [1], [2]), but also, learning the pronunciation and accent for a new language is age-sensitive [3]. This may be especially important for children who are newcomers to a country – the earlier they master the new language, the better.

For many children, the main problem faced in mastering a new language is a lack of resources in their homes and schools. Technological interventions can supplement children's language education by providing additional instruction, support, and practice. However, passive media, like videos, can help children learn vocabulary, but not language structure [4]. Many of the interactive games available require reading or writing skills – fine for older children, but not for preschoolers who are generally still learning how to read. Very young children learn language best through social interaction.

To this end, we have created a social robot that can supplement children's early language education. Social robots combine the unique advantages of technology – such as being easily customizable, adaptive to individual learners, and being deployable – with the necessary social cues and "human" behaviors that are crucial for language learning [5]. This robot is accompanied by a virtual sidekick, who appears on a tablet. Prior work has shown that young children will readily learn words from both mobile devices [6] and robots (e.g., [7], [8]). Furthermore, because children learn at different paces and in different ways, the robot will adapt both its affective responses and the material to be learned to each individual child. We ask whether this personalization will increase learning gains and overall engagement.

METHODS

Participants. Thirty-four children ages 3-5 (19 male, 15 female) from a "special start" preschool in the Greater Boston area have signed up for the study. Of these, 15 are classified as special needs and 19 as typically-developing.

Conditions. The study follows a 2x2 design of *Development* (Typical vs. Special) x *Personalization* (Personalized affective responding vs. no personalization).

Hypotheses. We expect that nearly all children will enjoy playing with the robot and will stay engaged over time. We expect that children who receive personalized affective feedback will exhibit greater learning gains overall.

Procedure. Each child will participate in eight 10min sessions with the robot. During each session, children will play with the robot and with a virtual character, a Toucan, who is shown on a tablet screen (Figure 1). The robot and child are situated as peer learners, while the Toucan speaks Spanish and supplies information about new Spanish words. The rest of the tablet screen contains the shared context for the games the robot, Toucan, and child play together. In each session, they play three games: (1) a review of the previous session, (2) a game "directed" by the robot in English, during which the Toucan introduces new Spanish words by saying, e.g., "Did you know that *blue ball* is *pelota azul* in Spanish?", and (3) a game "directed" by the Toucan in Spanish, during which the robot supplies hints in English to help the child along.

The eight play sessions have content revolving around a trip to Spain: packing for the trip, visiting a zoo, having a picnic, and so forth. Each session provides the opportunity to both learn new words and review. For example, at the zoo, children can learn names of animals. The animals appear in later sessions as the Toucan's friends, providing review.

All the speech in the interaction was pre-recorded, which allowed for more emotional expressivity, and pitch-shifted to make the voices sound more child-like. The robot's voice was recorded by a native English speaker and the Toucan's voice was recorded by a native Spanish speaker.

Figure 1: Children played with the robot Tega and the tablet, which featured a virtual toucan.

Robot. We are using the Tega robot (Figure 1), which was designed and built by members of the Personal Robots Group at the MIT Media Lab and their collaborators. An android phone runs the robot's motor control software and displays the robot's animated face. The robot is fully autonomous. Control software coordinates the robot's behavior and the tablet game via ROS. This software follows a general script of the interaction flow, and receives sensory input from the tablet (such as when a child taps or drags an object on the screen) and from the Affdex emotion classifier from Affectiva [9] (including valence and engagement).

Personalization. The interaction is personalized in two dimensions. For all children, the content of the game – i.e., which Spanish words are taught – is personalized based on children's recognition of Spanish words in previous sessions, using an algorithm based on that described in [10]. The goal is to keep children in the zone of proximal development [11], such that they have a 50% change of knowing the words used in a session.

For half the children, the robot's affective responses will be personalized to the child's performance and emotional state. Measurements of the child's engagement (high/low) and valence (positive/neutral/negative) from Affdex, on-off task (measured by whether the child interacts with the tablet) and right/wrong (in the last task) are combined into a reward signal for an online reinforcement learning algorithm (SARSA), with the goal of maximizing high engagement and positive valence. This personalized a policy governing both the robot's non-verbal (e.g., facial expressions) and verbal responses to each child following specific tasks in the game (e.g., if the child performed a task correctly, the robot would respond both with the game-related response, such as "good job," and an appropriate affective response).

Measures. Before the session 1, after session 4, and after session 8, we will ask each child a set of questions about how they perceive the robot (e.g., whether they think the robot is more similar to a person or a tablet on various dimensions). Children will also perform an Anomalous Picture Task, in which they view two pictures of animals in strange situations (e.g., a giraffe in a dining room) with an experimenter (before session 1, as a baseline) and with the robot (after session 1 and after session 8). The child's interlocutor comments once after 10 seconds (e.g, "That's so silly!"). The goal is to see how many spontaneous questions, comments, and laughs children produce, which gives us insight into how they construe the robot as a social other (e.g., since people laugh most in social scenarios [12], do children laugh as much with the robot as with the person?).

In addition, we will give children an initial Spanish vocabulary assessment based on the Peabody Picture Vocabulary Task (PPVT) [13] before session 1 and after session 8. Children will also perform a curiosity task that allows them to freely explore a graphical scene on a tablet, giving insight into how curious they are. Each child's parents and teacher will fill out a questionnaire on the child's learning preferences. Finally, teachers will be asked to fill out a questionnaire probing their perception of and attitudes toward robots in the classroom, first before session 1 and then after session 8 to see if their opinions had changed.

We will also record audio and video of each session, as well as logging Affdex data and actions taken on the tablet.

PROGRESS

This work adds to the growing body of literature on socially assistive robots in education. We are performing one of the first microgenetic studies with a fully autonomous, adaptive robotic learning companion for preschool children and for preschool children with special needs. Data collection is currently ongoing at the preschool.

We expect that the results of this work will inform the design of future robotic learning companions. We hope to understand how personalizing the robot's affective feedback and the game's content can affect children's motivation and learning, with the ultimate goal of developing more effective educational tools that can engage children as peers and leverage the social and playful nature of children's natural early learning environments.

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Let's Be Friends: Perception of a Social Robotic Companion for children with T1DM

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Abstract. We describe the social characteristics of a robot developed to support children with Type 1 Diabetes Mellitus (T1DM) in the process of education and care. We evaluated the perception of the robot at a summer camp where diabetic children aged 10-14 experienced the robot in group interactions. Children in the intervention condition additionally interacted with it also individually, in one-to-one sessions featuring several game-like activities. These children perceived the robot significantly more as a friend than those in the control group. They also readily engaged with it in dialogues about their habits related to healthy lifestyle as well as personal experiences concerning diabetes. This indicates that the one-on-one interactions added a special quality to the relationship of the children with the robot.

Keywords: Social robots, Child-Robot Interaction, diabetes, Off-Activity Talk, self-disclosure, social skills, social robot perception.

INTRODUCTION

Type 1 Diabetes Mellitus (T1DM) is a chronic disease that affects a shocking 17,000 new children, mostly under 14 years old, per year in Europe [1]. T1DM is an overwhelming pathology that can cause life-threatening complications. It requires children of all ages to learn to constantly manage their condition in terms of glycaemia monitoring and insulin injection. This necessitates a major change in their lifestyle [2].

The present work stems from the Aliz-E project [3], in which we investigated the use of a humanoid social robot to support children with T1DM on their way to self-management. A social robot system was developed and instantiated in a Robot Theatre to facilitate child-robot interaction [4]. It was deployed in real-life settings during two editions of a Diabetes Summer Camp in 2013 and 2014, organized by the Italian families association "Sostegno70 – insieme ai ragazzi diabetici ONLUS" and the team of the Pediatric unit of Ospedale San Raffaele (Milan, Italy).

During the 2013 summer camp we experimented with introducing so-called *Off-Activity Talk* (OAT) to engage children in conversations about topics related to diabetes and healthy lifestyle as part of one-on-one interactions around gaming touchpoints with the robot. Details about the experiment design and a comparison of the effects of individual interactions with and without OAT were presented in [5]. We also observed that children who participated in the individual interactions exhibited a significantly stronger adherence in following the medical advice to fill in a nutritional diary than children who only participated in group interactions with the robot.

We hypothesized that this might be due to a different quality of the child-robot relationship established through the individual interaction. This inspired us to further investigate the effect(s) of individual interactions on children's perception of the robot during the 2014 edition of the camp. This paper presents the method and the results of the 2014 experiment.

EXPERIMENT GOALS AND METHODOLOGY

Goals

The aim of the 2014 summer camp experiment was to further investigate the children's (i) perception of the social robotic companion; (ii) expectations about having a robotic companion in their daily life; (iii) willingness and spontaneity to talk freely about their diabetes condition.

Design

The experiment was held in August 2014 during a ten-day-long Diabetes Summer Camp for T1DM children. All the children at the camp had the opportunity to experience the robot in scripted "theater" performances during collective evening recreational activities. Out of the 41 children attending the camp, 28 volunteered to participate in the study.

The study had a between-subject design with two conditions: (1) the *control* condition, constituted by children who only experienced the social robot as a theater-performance character, but did not interact individually with it; (2) the *intervention* condition, where children had the additional possibility to interact individually with the social robot.

The individual interactions for the *intervention* condition were carried out using the Robot Theatre described in [4] in a partially Wizard-of-Oz setup and were centered around three activities, among which the children could freely choose and switch: a quiz game, a sorting game and a creative dance activity (see Figure 1). More details about the activities can be found in [4] and [5].

During these interactions the robot elicited off-activity-talk as described in [5] and exhibited the following social behavior characteristics discussed in [6]: the ability to express recognition and familiarity (e.g., using the child's name, referring to previous joint experiences); non-verbal bodily cues [7]; turn taking during game playing [8][9]; allowing children to touch it and responding to touch; and occasionally making mistakes, which helps children to feel at ease.

Measures

Children's perception of the robot and their expectations about the possibility to have a robotic companion were measured by questionnaires. Children's willingness and spontaneity to talk about diabetes was evaluated by 3 raters who independently assessed every OAT sub-dialogue regarding diabetes.

Figure 1: Left-to-right:
the quiz game, the sorting game, the creative dance activity

RESULTS

The robot was described as a friend (as opposed to pet, toy, adult, computer) significantly more often by the intervention group than the control (χ^2=20.09 with probability 1%, two-tailed p=0.0001). Instead, there was a tendency in the control group to ascribe machine-like characteristics to the robot, unlike in the intervention group. The children's willingness and spontaneity to talk about diabetes was mostly high. Qualitatively, all coders noticed a common positive attitude in sharing practical notions about diabetes and often also their personal experiences with the robot. Majority of children in the intervention group would like to meet the social robotic companion again (more preferred at home rather than school, hospital, or summer camp) or own one. The reason was the playful character or the relational aspect in majority of cases. This unique relationship also had a positive impact on the educational aspects of the interaction.

CONCLUSIONS

The individual interactions lead the children to perceive the robot as a peer. They do not feel judged, but rather encouraged to learn and exchange knowledge. This finding underlines the potential of such a robotic companion. It shows that children are willing to let a robot enter such a delicate and personal dimension. This is extremely important for fostering companionship to support children with diabetes.

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The Ethics of Human-Robot Relationships

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Abstract. Currently, human-robot interactions are constructed according to the rules of human-human interactions inviting users to interact socially with robots. Is there something morally wrong with deceiving humans into thinking they can foster meaningful interactions with a technological object? Or is this just a logical next step in our technological world? Would it be possible for people to treat robots as companions? What implications does this have on future generations, who will be growing up in the everyday presence of robots? Is companionship between humans and robots desirable? This paper fosters a discussion on the ethical considerations of human-robot relationships.

Keywords: Companion Robots, Human-Robot Relationships, Robot Ethics.

INTRODUCTION

Relationships with others lie at the very core of human existence, as humans are conceived within relationships, born into relationships, and live their lives within relationships with others [1]. Since computer technologies increasingly interact with us complex and humanlike ways, the psychological aspects of our relationships with them take on an increasingly important role [2]. In the future, robots are expected to serve humans in various social roles such as nursing, child and elder care, and teaching environments. Robots in these social roles, in addition to their functional requirements, also include socially interactive components [7]. Besides performing their monitoring and assistive tasks, these robots also must engage in social interaction and create (trust) relationships with their users in order to gain their goals (e.g., increasing an elderly person's health). Regardless of the moral or ethical implications, these robotic companions will be entering our everyday lives as soon as their abilities are technically feasible for the application in domestic environments. This calls for an evaluation on the ethics of human-robot relationships.

APPLYING ETHICS TO A NEW TECHNOLOGICAL GENRE

Applying ethics to robotics depends on the way we perceive robots [17]. Perceiving robots as nothing more than machines, means that they do not have any hierarchically higher characteristics, nor will they be proved with consciousness, free will, or with the level of autonomy superior to that embodied by the designer. Yet, the experience of interacting with robots appears to be fundamentally different from how people interact with most other technologies as human-robot interaction often has a strong social or emotional component.

Robots differ the most from other technologies in that they are autonomous, mobile, are sometimes build as replications of humans or animals, and are often designed to effect action on a distance. According to the media equation theory [11], technological objects can be evaluated as social entities with a minimum of social cues. This theory has also been successfully applied to the field of robotics [8]. People tend to ascribe a level of intelligence and sociability to robots which influences their perceptions of how the interactions should proceed. Robots capable of natural language dialog raise a user's expectations not only with respect to the natural language, but also regard to the intentionality of both verbal and nonverbal behaviors, the robot's autonomy, and its awareness of the sociocultural context [14]. It is likely that robots enabled with sociable interaction features such as familiar humanlike gestures or facial expressions in their designs will further encourage people to interact socially with them in a fundamentally unique way.

Furthermore, the autonomous behaviors of robots are likely to be associated with intentionality, which induces and strengthens a sense of agency in robots. Agency refers to the capacity to act and carries the notion of intentionality [5]. It is being argued that robots, being physically embedded and enabled with sociable interaction, create a unique and affect-charged sense of active agency similar to that of living entities [18]. This might cause that human-robot interaction, in a sense, is more like interacting with an animal or another person than like interacting with a technology.

Thus, there is special specific quality of modern robotics that is very relevant to how our world is changing: robots are a new form of living glue between our physical world and the digital universe we have created. We have invented a new species, part material and part digital, that will eventually have superhuman qualities in both worlds at once. This means that we need to perceiving robots as an evolution of a new species, which means that we need to consider robots to have autonomy and consciousness, and need to be created with moral and intellectual dimensions that will exceed humans.

ARE HUMAN-ROBOT RELATIONSHIPS MORALLY WRONG?

The goal of this easy is to discuss the contribution of human-robot relationships to the good life. There is little doubt that people are capable of bonding with robotic others [9], and that they might even benefit from these relationships in particular situations [3]. Therefore, there seems nothing intrinsically wrong with human-robot relationships. And considering companion robots as something unethical because their effectiveness depends on deception oversimplifies the issues [13]. The currency of all human social relationships is performance [6], and rather than labeling that as a bad thing, this is simply how things are [16]. People are always performing for other people and now the robots too will perform. However, robots cannot be our Aristotelian friends and they cannot really care about us [4]. Thus, we need to make sure that human-robot relationships do not replace their human counterparts, as Sparrow and Sparrow [15] rightfully fear. Another concern here is that if we come to accept these simulacral friendships, this might degrade our friendships with other humans as well.

FUTURE DIRECTIONS FOR THE ETHICS OF HUMAN-ROBOT RELATIONSHIPS

Despite the relevance of the consequences of innovations, they have received little attention in the literature. One reason for this neglect might be that companies supplying the innovation are often sponsors of innovation research, and these companies silently assume that the consequences of their innovations will be positive. Another reason for the underexposure of the consequences of innovations is that the usual questionnaires are less appropriate for the investigation of the impact of innovations. Studying the impact of innovations ideally requires multiple observations over extended periods of times. A final reason is the difficulty of the measurement of consequences. People are often not fully aware of the consequences of the introduction of an innovation, resulting in incomplete and misleading conclusions when only studying people's opinions about possible consequences.

It is necessary to conduct research on ethics and rights for robots in different cultural settings and contexts, because different cultures and religions have different 'virtues' and 'vices', exhibiting from different worldviews, leading to different results on the same questions about moral standing towards robots (MacDorman & Cowley, 2006).

So if robots are like us and in the future we will interact with them in a 'natural' social way, the deep issues of robot ethics will come to an end. Whether biological or technical, sentient beings will belong to the same genus. Of course this vision does not appeal too many and if that is the case, we people must initiate efforts to understand our uniqueness and ensure that technology remains a tool not a partner. As such, ethics for robotics could be redefined as safety regulations (Rosenberg, 2008), however complex they may be.

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Enhancing Nao Expression of Emotions Using Pluggable Eyebrows

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Abstract— Robots can express emotions for better Human Robot Interaction (HRI). In this field of HRI, the Nao robot is a platform widely used. This robot mainly expresses emotions by gestures and colored led eyes, but due to its white flat and inanimate face it cannot express facial expressions. In this work we propose a pluggable eyebrows device with two separated degrees of freedom. A short survey is conducted to qualitatively evaluate the usefulness of this device.

Keywords— facial expressions, emotions, NAO robot

INTRODUCTION

Humans can communicate by two different means, either directly with speech, or indirectly by facial expressions and body language. In human communication, more than half of the information is conveyed non-verbally [1]. In consequence, social robots used in HRI should be able to similarly communicate non-verbally. In this work, we introduce a device which improves the emotional expression of the NAO robot. Our focus is on the Nao robot because it is the most known and used social humanoid robot for HRI experiments.

RELATED WORK

Many methods have been developed to express emotions in the Nao robot. One of the most known is to use a variety of postures as body language [2], [3]. Although this method is working quite well for certain circumstances [3] it is not appropriate for realistic HRI situations. Indeed, whenever the robot aims to express an emotion, it will interrupt its current task and perform the expressive posture during a few seconds, worsening the overall interactive experience. A solution proposed by [4] to overcome this limitation is to use facial expressions through Naos eyes instead of body language. The eyes are surrounded by RGB leds, and colors can be associated with emotions (for example red for anger). Improving this approach, [5] suggested to combine and synchronize the RGB leds to simulate eye shapes and a blinking behavior. However, eye colors and shapes alone are not sufficient to successfully express emotions during a realistic social interaction [6]. In this work we propose to express emotions using actuated eyebrows as they are considered very useful to express emotions [6].

METHOD

The main difficulty in designing such a device for Nao comes from the lack of space available for the actuators. Therefore, we propose a design where two micro servo-motors are placed at the back of Naos head supported by a 3-D printed structure in Acrylonitrile butadiene styrene (ABS) which is clipped around the head. The torque needed to move the eyebrows is transmitted from the back to the front of the head through a rigid cable. This cable is sufficiently rigid to act as a push-pull mechanism. As illustrated in figure 2, the rotation of the servo is converted in translation of the cable (cable in red). At the front of the head, this translation is converted back in rotation of the eyebrow. The servo motor is controlled by an Arduino Nano board. As the micro-servo and the Arduino board have a small power consumption, the Arduino board can be directly connected to the Nao robot through its USB port at the back of its head without any additional battery. The eyebrows device is programmable using Aldebarans Choregraphe software. In order to control the 2 DoFs of Nao eyebrows we have created a box called Eyebrows which includes two string inputs to specify the eyebrows position. This box was built based on the ArduiNao library (www.humarobotics.com/en/robotics-lab/nao-and-arduino.html) which allows users to communicate between Choregraphe and Arduino. With the Eyebrows box, users have an ability to control 2 DoFs of Nao eyebrows from their Choregraphe program. The final result is an easy-to-clip module that can be plugged in or out at Naos head in few seconds. This module does not require any additional support. A small video illustrating the motion of the eyebrows is available at: youtube.com/watch?v=C55mAOCT__0. We hypothesize that the recognition rate of anger and sadness emotions will be higher using this eyebrows device than without it.

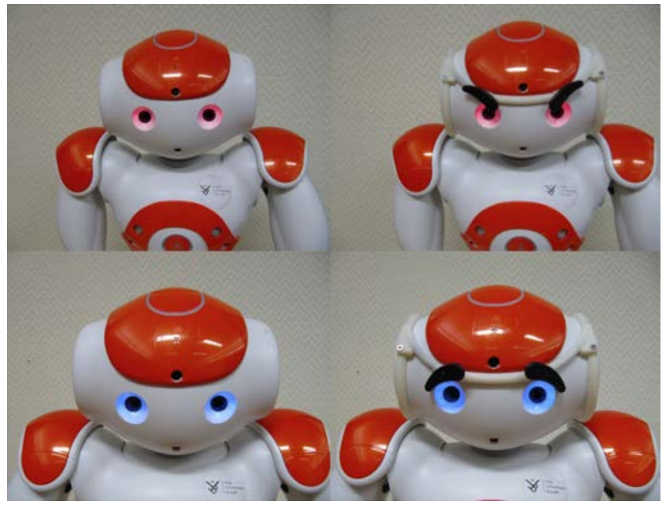

Fig. 1. Nao expressing emotions with eyebrows. Top: anger. Bottom: Sadness

Fig. 2. Actuation of the eyebrows. Top: complete mechanism. Bottom: middle section. The orange arrows show the conversion between rotation and translation.

Experimental procedure

To assess the functionality of this device, an online questionnaire has been filled in by 70 voluntary participants (23 where rejected because they did not answered totally). All the participants belong to the 3rd year of a bachelor degree in psychology, as such they had no prior experience in robots. This exploratory questionnaire was made using LimeSurvey (www.limesurvey.org) and contained 8 open questions. Participants were randomly split in two groups. For each group, 8 pictures of Nao expressing emotions were presented in a random order. For both groups, pictures contained emotional expressions from the literature: 4 pictures using body language [4], 2 pictures using eyes colors and 2 being a combination of body language and eyes colors. 2 of these pictures showed neutral expressions, 3 represented anger and 3 sadness. In the second group, the eyebrows device was used, making the first one the control group. Figure 1 shows an example of pictures used in the study. For each picture, the participant had to write in the questionnaire the emotion that was, according to him, expressed by the Nao robot. Participants had to guess the robot emotions as none of them were suggested during the survey. Finally, participants were encouraged to answer I do not know if it was the case. This was done to ensure that the participants were not answering randomly.

RESULTS & DISCUSSION

Participants were separated in two groups: n= 21 for the group **without** eyebrows and n = 26 for the group **with** eyebrows. A content analysis was performed on the participant answers. Responses were considered as correct when they had a meaning similar or close to the targeted emotion. The results revealed that the rate of recognition is greatly improved by the eyebrows device. In fact, the recognition rate of sadness increased by 32.7% (5.8% without eyebrows to 38.5% with eyebrows). More impressively, the recognition rate of anger was improved by 80.6% (14.2% without eyebrows to 94.8% with eyebrows). Forced choice answer would probably give even higher recognition rates. Finally, we believe that these eyebrows device can have other applications. For example, small orientation variations of the eyebrows around the neutral position can add a life-like behavior to the robot. Small movements on the face when speaking (like it is already done with the rest of the body) will certainly increase Naos impression of aliveness.

CONCLUSION

In this work we have proposed a unique and novel eyebrows device for the Nao robot. This device is easy to use and can be directly controlled through the Choreograph programming environment. In addition, a validation study was conducted showing that the recognition rate of emotions is greatly increased by the addition of the eyebrows device in the NAO robot.

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Toward a Platform-Independent Social Behavior Architecture for Multiple Therapeutic Scenarios

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Abstract. Researchers in cognitive robotics have developed different architectures to help social robots make decisions and express emotions autonomously in order to replace the pre-programmed and remote-controlled techniques. However, most of the current developments are ad-hoc solutions with no possibility to be utilized in multiple therapeutic situations. In this paper, we propose the design of a social behavior architecture, which aims at helping the social robot to sustain the user's engagement and motivation, and to achieve the goal of interaction in different scenarios. Representations of behaviors are kept at abstract level and mapped with the robot's morphology afterward. This approach ensures the architecture to be applicable to a wide range of social robots.

Keywords: social behavior architecture, autonomous, platform-independent.

INTRODUCTION

Unlike the traditional robots, social robots are expected to exhibit natural-appearing social manners and to enhance the quality of life for broad populations of users [1]. For instance, robots in elderly care should be able to recognize the users' intentions and actions, and generate appropriate reactions. Robots in robot-assisted therapy are required to have more substantial levels of autonomy which would allow the robot to adapt to the individual needs of children over longer periods of time [2]. Currently, pre-programmed scenarios and remote-controlled techniques (Wizard of Oz) are dominantly employed in robot operations e.g. [3][4]. Therefore, researchers have developed and implemented various architectures, which aim at helping social robots to make decision and express emotion autonomously e.g. [5][6]. However, most of the current developments are ad-hoc solutions with no possibility to use them in diverse therapeutic situations.

In this paper, we propose the design of a social behavior architecture for multiple therapeutic scenarios, which aims at helping social robots to be able to sustain the users' engagement and motivation, and achieve the goals of interactions. Representations of behaviors are kept at abstract level and mapped with the robot's morphology afterward.

REQUIREMENTS FOR AN ARCHITECTURE

Since social robotics research requires interdisciplinary collaboration, we hereby present the requirements for a social behavior architecture proposed by roboticists and psychologists.

Sustaining user's motivation and engagement

User's motivation plays an important role in therapies especially in long-term ones. Together with keeping extrinsic motivation driven by external rewards, intrinsic motivation, come within an individual and based on enjoyment and satisfaction, also needs to be maintained during all phases of the therapeutic process e.g. diagnosis, intervention, prevention [7][8]. Therefore, the architecture should be able to create a fluid interaction with an interesting play scenario including different levels of difficulty; and to recognize and evaluate user's performance to generate proper responses. The interaction should be personal to create a meaningful human-robot relationship e.g. user's name, history of interaction.

Achieving the goal of interaction

The purpose of using robot is to obtain a particular therapeutic goal rather than for entertainment. Therapies basically follow step-by-step scenarios with the aim of obtaining positive changes in user's behavior. Although decision making mechanism of the architecture is required to generate behaviors that motivate and engage the user, these behaviors should be complaint with the goal of the interaction.

Platform-independence

The social behavior architecture should be platform-independent. Rather than controlling actuators specific to a robot platform, the architecture will prescribe parameters in descriptions and representations that are common across all platforms. Afterward, these robot non-specific commands will be translated into robot-specific actions.

Providing data for analysis

The architecture should be able to conform to both clinical outcomes and potential research. Data, e.g. users' performance and robot operation, need to be recorded in structured forms for analysis.

DESIGN OF A PLATFORM-INDEPENDENT SOCIAL BEHAVIOR ARCHITECTURE

Taking into account the aforementioned requirements, we propose a social behavior architecture which aims at helping the robot to produce coherent behaviors while sustaining the goal of interaction. The architecture is modular and composed of a number of systems and subsystems as depicted in Figure 1.

The **Perceptual system** receives raw data from sensors (e.g. camera, touch sensors). These data are then interpreted into interaction context and users' performances as input of other systems and subsystems.

The **Social behavior controller** includes a number of subsystems to generate coherent behaviors. The *reactive and attention* subsystem generates life-like behaviors, perceptual attention, and attention emulation. The *deliberative subsystem*, as the center of the system, generates proper behaviors depending on the interaction context, user's history and performance, and importantly the therapeutic scenario scripted in the **Scenario Manager**. These influencing factors, stored in the *memory*, ensure the interactivity and personality of the interaction. The *emotion* subsystem manages the affective state of the robot to add emotions into behaviors. The *reflective* subsystem oversights the robot's behavior by checking the technical and ethical limits. The *expression and actuation* subsystem combines the output of the four subsystems previously mentioned in an appropriate expression taking into account the weight factors of each subsystem. Representations of expressions are designed by using Facial Action Coding System and Body Action Units and then translated into robot-specific actions in the **Motion system** [9].

The operation of the architecture is visualized and controlled by the **Graphical User Interface** (GUI). This will offer the therapist an ability to select the scenario, supervise the behaviors of the robot, and interrupt the robot's operation if necessary.

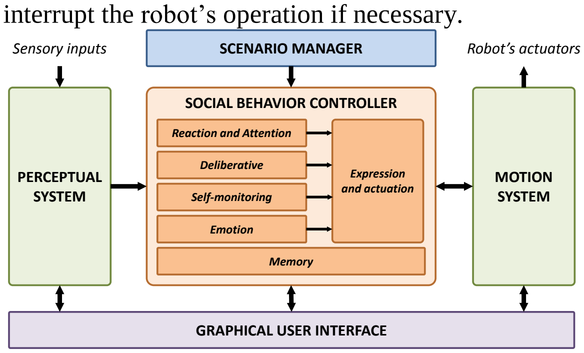

Figure 1. Description of the social behavior architecture. The *Social behavior controller* decides the robot's behavior taking into account the information from *Perceptual system* and *Scenario Manager*. Behaviors are platform-independent and mapped with robot's morphology by *Motion system*.

CONCLUSION AND EVALUATION

This paper proposes the design of a platform-independent social behavior architecture for multiple therapeutic scenarios. This approach ensures the architecture to be applicable to a wide range of social robots.

As for validation, the architecture will be implemented in robot-assisted autism therapy scenarios e.g. joint attention, turn taking, and imitation (Figure 2). The utilized robot platforms will be Nao and Probo [4]. Besides the built-in sensory systems of these robots, Kinect will be used to enhance the ability of the perceptual system.

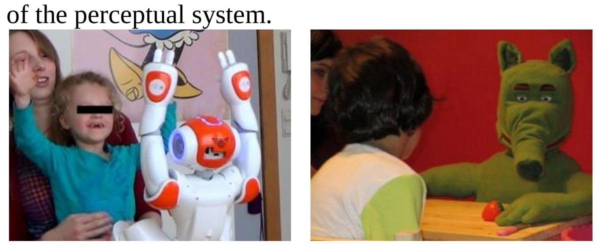

Figure 2. Child-robot interaction under imitation (left) and joint attention (right) scenarios.

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Boundaries in Play-based Cloud-companion-mediated Robotic Therapies: From Deception to Privacy Concerns

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Abstract. Moving on from the 'brainstorming phase' where the discourse of robotics is still stuck this paper identifies the legal challenges of CEEO Tufts University project 'robotic companions and LEGO® engineering with children on the autism spectrum' (here Hookie project). Apart from the privacy and safety concerns, some new legal challenges have been identified: cognitive harm, prospective liability, ethical agents' minimization and consumer robotics.

Keywords: Legal Principles, Robotic Therapy, Cloud Robotics, Prospective Liability, Privacy, ASD research, Autism, Non-Replacement of Humans.

INTRODUCTION

While there is a growing body of research on robotics and autism, addressing minutely the involved legal principles in robot-assisted therapy for children with Autism Spectrum Disorder (ASD) is a new idea. Previous research focused on the benefits of this therapy [1] and its ethical issues (e.g. acceptance, replacement, autonomy, trust, etc.) [2]; but legal boundaries have been not addressed yet as we are still in a brainstorming phase [7].

Principles involving a wide range of robots have been identified under the EU Charter of Fundamental Rights [3]. The European RoboLaw project provided a solid regulatory framework some for "care robots" [4], nevertheless these robots addressed in ISO 13482:2014 (person carriers, physical assistants or mobile servants) but not concretely and specifically as therapeutic robots. And as the problem of roboticists is still two-fold (the identification of the principles of their technology; and the understanding of their meaning) concreteness becomes indispensable.

LEGAL ISSUES IN ROBOTIC THERAPIES

Similarly to the methodology described in [8], after analyzing the context where the robots are inserted (research project, Hookie), and the robot type (for care receivers, social mediator, semi-/autonomous), we found out what principles were involved in play-based cloud-companion-mediated robotic therapies (Fig. 1).

Safety and privacy are the biggest concerns in robotics. In truth, "robotics combines […] the promiscuity of information with the capacity to do physical harm" [9]. Both principles are very sensitive in this respect. First, although several safeguards deal with data protection in the Hookie project (an encrypted tunnel to protect data-in-motion, a private cloud with an individual login and password to protect data-at-rest, the access to information is only granted to researchers included in the project, and the collected data will be definitely deleted after three years) the use of cloud robotics still challenges the current data protection legislation [11]. Second, because therapeutic robots aim at working on the cognitive level, these could furthermore cause cognitive harm to the users.

Principles	Concreteness	Hookie
Principle of safety	Safety	X
Principle of User Protection	Health	X
	Consumer Protection	X
	Environmental Regulation	X
	Cosmesis	---------
Principle of liability	General Liability	X
	Prospective Liability	X
	Legal Transactions	---------
	Insurance	X
Principle of user rights safeguard	Privacy	X
	Data Protection	X
	Intellectual Property Rights	---------
	Non-Discrimination	X
Principle to an independent living and autonomy	Final Say /	X
	Enabling Human Capabilities	X
	Acceptance	X
	Persuasion	X
Principle of non-isolation and social connectedness	Non Replacement of Human Caregivers	X
	Non Replacement of Human Feelings	X
	Context of Autoexclusion	X
	Dignity	X
Principle of autonomous ethical agents' minimization	Limitation to open scenarios with non-mission tasks	X
	Avoidance of post-monitoring	X
	Ethical Agents	X
Principle of justice	Equality	X
	Access (in cost terms)	X
	Access (in opportunities)	X

Fig. 1 Concrete legal principles involved in robotic therapy.

Indeed, there is the "possibility that a medical robot will cause harms to its patients in the future" [5]. This prospective liability could happen not only because of the therapy itself but also because the robot may no longer be used after the end of the project [6, 13]. Similarly to what happens with some physical assistant robots, the user (and the parents) may not be necessarily aware that the therapy did not proceed in a normal way and thus cannot provide appropriate feedback to clinicians [10]. The use of a living lab for robotics legal regulation and the use of black boxes as described in [12] could help to track and avoid further responsibilities that may otherwise be covered by an insurance like the one proposed for commercial aerial robots in [14]. Consumer robotics will deal with other types of harms [23].

Autonomy is a two-fold issue. From the robot's perspective, it is normally linked to deception. WoZ mode tends to deceive users [15]; however, blind research is permitted under §46.116.d of the 45 Title of the US Code. In fact, it is argued that deception promotes scientific validity because 'accurately informing subject could bias their responses, thereby impairing the validity of the data' [7]. Autonomy is also connected to liability, artificial empathy [19] and more generally to the still ongoing debate robot agenthood [17] and replacement of human therapists - something the Hookie project does not pretend. In fact, "the more autonomous a technology is, the more it needs to be sensible to values and norms" [18], that is why the principle of autonomous agents' minimization matters. Public attitudes towards care robots are not very good though [22].

In legal terms, autonomy refers the user's autonomy, and includes acceptance, final say of the parents and persuasion. Robotic therapy enables human capacities, and should not promote contexts of auto-exclusion. Acceptance should be addressed carefully, especially in physical appearance (that is why Hookie is non-biomimetic) [16]; but also from the responsivity proxemics perspective, e.g. characteristics of the robot to encourage responsivity [21]. Moreover, if robotic therapy ends as a general treatment offered by the State, it is not clear what the final say parents could have in accepting or not the treatment (as certain communities only accept bloodless surgeries). In fact, Government and Public Institutions are meant to ensure the principle of justice, e.g. the equal distribution of available resources [20]. This conceals an intrinsic moral duty to roboticists, i.e. the creation of affordable and accessible technology, which is the primary objective of the Hookie project.

CONCLUSIONS AND FURTHER RESEARCH

In comparison to 2012, in 2015 29% of the contestants in [22] would feel comfortable having a robot provide service to infirm people. In fact, the level of "total uncomfortable" decreased by 9%. This implies a progressive societal advance in accepting robots in care applications. Considering the Hookie project, this article presents the principles involved in play-based cloud-companion-mediated robotic therapies. The Hookie project has dealt with all the above-mentioned principles except cosmesis, intellectual property rights or legal transactions, as its inner capabilities do not permit it. Further publications will include complete details of Hookie's inner capabilities and its compliance with concrete legal principles involved in robotic therapy (Fig. 1).

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Posters session papers & late-breaking reports

Cloud-based Social Robot that Learns to Motivate Children as an Assistant in Back-Pain Therapy and as a Foreign Language Tutor

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Abstract. This paper shows two case studies of using the Nao robot as a physiotherapist to teach anti-back pain exercises and as a tutor of foreign language in elementary schools in Slovakia. We propose a cloud-based environment for the technique of the Wizard of Oz, where the process of teaching the exercises and the foreign language classes can be controlled and intervened by motivational behaviors of the robot. These make the interaction less boring and more effective as the motivation has beneficial effects on children learning and behavior. Moreover, we implemented an algorithm based on reinforcement learning, which learns the motivational interventions from the Wizard.

Keywords: children-robot interaction, cloud robotics, robots in education, reinforcement learning, socially-assistive robotics

INTRODUCTION

Rabbitt et al. [1] define socially assistive robotics (SAR) a unique area of robotics that exists at the intersection of assistive robotics, which is focused on aiding human users through interactions with robots (e.g. mobility assistants, educational robots) and socially interactive or intelligent robotics, which is focused on socially engaging human users through interactions with robots (e.g. robotic toys, robotic games). SAR has used robots in different roles, e.g. the weight loss coach [2], the social robot in an attention and memory task, helping older adults with dementia [3], supporting young patients in hospital as they learn to manage a lifelong metabolic disorder (diabetes) [4], motivating physical exercise for older adults [5] or in autism therapy [6], as a therapy assistant in children cancer treatment [7], sign language tutors [8], other kind of educational agents mainly in children-robot interaction [9-13] and others [14].

One of the challenges of using robots in therapies is often fusing play and rehabilitation techniques using a robotic design to induce human-robot interaction (HRI), in which the criteria are to make the therapy process entertaining and effective for the users. Usually, the HRI experiments are conducted using the Wizard of Oz (WoO) technique, which means that the robot is not acting autonomously but is teleoperated by an expert. This method is sufficient for research, but if we want to have robots in human environments, we have to think about them as learning systems. We designed a cloud-based environment for the WoO technique, where the expert can control the learning process. When he/she observes that the children are getting to pay less attention to the robot, he/she can activate a motivational behavior of the robot (different kinds of emotional expression based on speech, motion, sounds) which help to increase interest of the children in the interaction and make it more effective.

CASE STUDIES

We selected two scenarios for use of the robot, in which the subjects are 5-8 years old children.

The first problem that we face is the low back pain, as it is the number one disability globally and number one in almost all developed countries, as according to [15]. The problem of scoliosis in today's society is growing, and it is fundamental to ensure adequate motoric skills development during childhood. We explore the effect of utilizing a humanoid robot as a therapy-assistive tool in educating children to perform safe and effective back exercises, designed by a professional therapist, that can strengthen the back and improve posture.

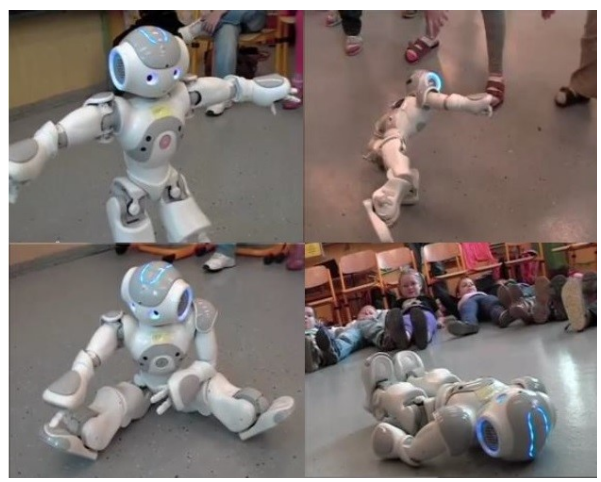

Figure 1. Examples of the exercises designed by a professional physiotherapist and implemented using the Nao humanoid platform

In the second scenario, the robot acts as a foreign language tutor. This application is extremely important, especially for countries like Slovakia, where English is not an official language.

Figure 2. Experiments in the wild - child is imitating the robot in anti-back pain therapy, the other figures show the robot in the role of a foreign language tutor

SYSTEM THAT LEARNS FROM THE WIZARD BASED ON CLOUD COMPUTING

For the mentioned case studies we designed a web-based system for WoO, where the exercises/language lessons can be controlled and intervened by motivational behaviors of the robot (emotional expressions). The system based on reinforcement learning adopts the motivational interventions from the Wizard. It learns from the operator in order to increase the level of autonomy of the robot. This way we can move from WoO towards the Oz of Wizard [16]. After reviewing other studies [17], we found out that the biggest weakness of all existing WoO interfaces is that they can be used only locally and just for a given experiment. To overcome these weaknesses, our system uses the advantages of cloud computing and consists of the following parts:

- Motion library in the first case study – it contains the physical therapy exercises. The Wizard can choose the exercises from the database, number of repeats and set the order of execution. Another feature is recording new exercises with a Microsoft Kinect sensor, which enables the creation of more diverse rehabilitation sessions.
- English classes in the second study – it contains different conversational topics to teach children new vocabulary and grammar points in an entertaining way.
- Motivational behaviors library – the platform also comes with an emotional database that contains emotional expressions (joy, satisfaction, anger, sadness, surprise, fear). The Wizard can also control the LED animations and the phrases said by the robot.
- Agent based on reinforcement learning – a system that determines how to map situations to actions and also tries to maximize a numerical reward signal (how to set the teaching process, e.g. when to activate the motivational mode of the robot).

Our goal is to create a modular system that could be used in different scenarios and besides that it could serve as a common cloud-based platform for researchers. We present two case studies, although the system can be used for other SAR-based applications in which the motivation of the subjects is important.

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Possibilities Of The IROMEC Robot For Children With Severe Physical Disabilities

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Abstract. *Objectives* To match the goals for children with severe physical disabilities in therapy and education with the current possibilities of the IROMEC robot to support play.
Methods Focus groups, interviews and a questionnaire were used to gather an overview of goals and to determine the potential of IROMEC.
Results Especially goals related to of movement functions, learning and applying knowledge, communication and interpersonal interactions/relationships, and play seem to be the most promising domains for IROMEC.
Conclusion There is a match between the possibilities of the IROMEC robot and the goals for children with physical disabilities in therapy and special education. The current play scenario offer should be adapted and expanded.

Keywords: robot, IROMEC, play, children, physical disabilities

INTRODUCTION

Within special education and rehabilitation for children with severe physical disabilities a lot of interventions related to play are being used. The progress in technology in the last decades increases the possibilities of using technologies within therapy and special education. A relatively new and upcoming intervention within this area is the application of (social) robots. IROMEC is a robot developed during the IROMEC (Interactive social RObotic MEdiators as Companions) FP6 European project between 2006-2009. In the European project it was investigated how robotics toys can become social mediators for children who are prevented from playing, due to cognitive, developmental or physical impairments [1]. One important outcome of this project was a set of ten play scenarios developed for the target user groups. Five of these scenarios were actually implemented in the robot; Turn taking, Sensory reward, Make it Move, Follow me and Get in Contact [1]. In figure 1 a picture of the robot is displayed. Important characteristics of the robot are the use of sensors and a camera to detect obstacles and to detect a child, a touchscreen on the back, the ability to move around (autonomous and controlled by buttons), a digital screen as a face, the production of sounds and control by wireless buttons.

Play is essential in the development of every child and is a fundamental right for every child [2]. Play gives children the possibility to discover their capabilities, try out objects, make decisions, understand cause and effect relationships, learn, persist, and understand consequences of actions [3]. For children with physical disabilities the experience of play can become frustrating or even impossible. They experience difficulties in starting, developing and performing play activities in a natural way. Most commercially available toys are not designed with the requirements for these children in mind and play activities may be partially or entirely impossible [4].

The main aim of this study was to match the goals for children with severe physical disabilities in therapy and education with the current possibilities of the IROMEC robot to support play.

Figure 1. The IROMEC Robot

METHODS

A qualitative mixed methods study was used combining interviews, focus groups sessions (two rounds) and a digital questionnaire. The goals in therapy and education for children with severe physical disabilities related to play were established and the possibilities for IROMEC interventions were identified.

Therapists and special educators participated in the study. In the first round of focus groups and in the interviews the goals and activities related to play in therapy and education were discussed using the principles of the metaplan method [5]. The digital questionnaire was sent to the participants of these interviews and focus groups as a member check for the overview of goals. Additionally, we asked for which of the goals from the overview IROMEC could be applied. A short video of the IROMEC robot was included in the questionnaire. In the second round of focus groups, which started with a demonstration of the existing IROMEC characteristics and scenarios, the participants were asked for the possibilities of the robot to achieve the therapeutic and educational goals were discussed.

The interviews and focus groups were audio taped and transcribed verbatim. For the data of the interviews and first round of focus groups an overview of the goals was created based on the results from the metaplan method and structured according to the International Classification of Functioning for Children and Youth (ICF-CY) [6]. For the second round of focus groups the qualitative research software Nvivo 10 was used to identify and code relevant fragments based on the principles of directed and conventional content analysis [7].

RESULTS

Nine persons participated in the interviews, 17 persons participated in the first round of focus groups (3 groups) and 25 persons participated in the second round (6 groups). The questionnaire was distributed to 26 persons and completed by 10 participants. Table 1 displays a part of the goal overview found in the interviews and first round of focus groups. Other domains found; Mental functions (b1), Sensory functions and pain (b2), Mobility (d4), Self-care (d5) and (pre)school skills (d815/d820). In bold, goals are displayed for which at least 50% of the participants in the questionnaire thought IROMEC could be applied and with which people in the second round of focus groups agreed.

Table 1. Goals and match with IROMEC

Domain (ICF-CY)	Goals
Movement functions (b750-b789)	**Fine motor skills**
	Gross motor skills
	Eye-hand coordination
	Motor skills
Learning and applying knowledge (d1)	**Spatial awareness**
	Learning
	Imitation
	Planned and structured working
	Concentration
	Problem solved learning
	Work attitude
	Making jokes and pretending
	Listening
	Language comprehension and expression
	Reading
	Numeracy skills
Communication (d3) / Interpersonal interaction and relationships (d7)	**Turn taking**
	Cooperation
	Interaction
	Using voice
	Taking initiative
	Get in contact
	Language
Play (d880)	**Playing independent**
	Playing together
	Fantasy play
	Understanding of simple rules
	Having play fun
	Role play
	Competition

Next to the possibilities of IROMEC related to the goals there were some comments and recommendations on the current robot. For example: elaboration of the current play scenarios and more flexibility in adapting scenarios (e.g. screens, sounds, movement) as well as the appearance of the robot.

CONCLUSION

Therapists and special educators were convinced about the match between goals for children with severe physical disabilities and the possibilities of IROMEC, in therapy as well as in education. The domains movement functions, learning and applying knowledge, communication and interpersonal interactions and relationships, and play seem to be the most promising domains. It is recommended to adapt and expand the current scenario offer of the robot within these domains, according to suggestions from experts in daily care practice.

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Robot Response Behaviors To Accommodate Hearing Problems*

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Abstract. One requirement that arises for a social (semi-autonomous telepresence) robot aimed at conversations with the elderly, is to accommodate hearing problems. In this paper we compare two approaches to this requirement; (1) moving closer, mimicking the leaning behavior commonly observed in elderly with hearing problems, (2) turning up the volume, which is a more mechanical solution. Our findings with elderly participants show that they preferred the turning up of the volume, since they rated it significantly higher.

Keywords: Telepresence robot, Hearing problems

INTRODUCTION

What behavior is appropriate for a social robot will depend on the context in which it is to function. For example, for a robot that helps lifting people out of bed it is necessary to get intimately close, while for a telepresence robot such intimate distances probably are less appropriate. An important aspect of this context are the specific individual needs of the users.

Elderly with hearing problems are one such user group that places its own requirements on the behavior of social robots. Hearing problems have a high prevalence among elderly [1,2]. Taking hearing problems into account could thus be a good contribution to any robot that is to communicate through audio with elderly, such as for example (semi-autonomous) telepresence robots.

One way to handle hearing problems is by mimicking the 'leaning' behavior commonly observed in this user group, where people actively lean in to intimate distances during conversations [3,4]. Similarly, a social conversation robot could also reciprocate such leaning behavior by moving closer.

An alternative would be to instead change the volume settings of the robot. Though in a way less human-like, this could be equally (or more) effective in resolving the hearing problems.

The aim of the reported experiment is to investigate with elderly participants which of these two response behaviors they might prefer a semi-autonomous telepresence robot to show.

METHOD

To investigate the effect of the different response behaviors, we set up a within subject experiment [*no response* x *move closer* x *turn up volume*] as part of a larger evaluation session for the Teresa project*. In each session one participant (the **Visitor**) sat in a remote location and used the robot in another room to interact with one or two other participants in the same room as the robot (the **Interaction Target(s)**). We used a Giraff[1] telepresence robot. A possible limitation is that the speaker is located in its base, not its 'head'.

Procedure

The Interaction Target(s) were seated behind a table, with the robot on the other end of it at a distance of approximately 1.5m. To ensure that hearing problems would arise, the volume of the robot had been turned down to a barely audible level. An experimenter explaining the procedure sat with the Interaction Target(s) during the experiment.

To make the conditions more comparable, the experiment started with a full briefing on the aim and the procedure of the experiment. After this, there were three trials in which participants had a brief conversation with each other that was terminated after about two minutes by the experimenter. In each of these trials, as soon as the Interaction Target(s) expressed having hearing problems or after approximately one minute, a Wizard of Oz showed one of the three response behaviors in counterbalanced order. For *'no response'*, no behavior was shown. For *'move closer'*, the robot approached the Interaction Target(s) to a distance of around 0.8m. For *'turn up volume'*, the volume settings were turned up a bit, which was also visible in the interface. To ensure functional comparability, none of these changes was sufficient to completely resolve all hearing problems. At the end of each trial, the robot was returned to its initial position and volume setting. The experiment was concluded with a brief (paper) questionnaire.

Task

To stay close to the intended use of the robot, the task of our participants was to have a conversation. For this, we asked them to discuss questions of the Proust questionnaire[2]. Specifically, we asked the Interaction Target(s) to read out self-selected questions and the Visitors to discuss what they thought the Interaction Target would answer.

Measurements

At the end of the interactions, all participants were given a brief questionnaire. Three items asked them to indicate their most and least favorite response behavior and to rate all response behaviors on a scale of 1-10.

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[1] http://www.giraff.org/?lang=en

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Table 1. Descriptive statistics for the ratings given to the three different response behaviors.

Response behavior	**N**	**Mean**	**Percentiles**				
			Min	**Q25**	**Q50**	**Q75**	**Max**
No response	18	3.000	0.0	1.5	3.0	4.25	9.0
Move closer	17	6.167	0.0	5.0	6.5	8.0	9.0
Turn up volume	18	8.235	6.0	7.5	8.0	9.5	10.0

Table 2. Number of times the different qualities were checked as being most influential in giving the ratings (total = 54).

Agréable (Pleasant)	**Sensible** (Sensitive)	**Amical** (Friendly)	**Utile** (Helpful)	**Affable** (Affable)	**Sympathique**(Likeable)	**Accessible**(Approachable)	**Sociable** (Sociable)	**Intelligent** (Intelligent)	**Organisé** (Organized)	**Expert** (Expert)	**Réfléchi** (Thorough)	**Efficace** (Effective)	**Approprié**(Appropriate)	**Attentif** (Attentive)
2	0	2	9	2	1	4	4	10	2	0	4	5	4	5

One item asked them to indicate which three qualities of the robot were most influential in their ratings, based on items for warmth and competence [5] (see Table 2 for the qualities). The last 5 items considered demographics (age, gender, hearing problems, use of hearing aids, relationship with the other participant(s)).

We recorded the interactions on video and using robot-mounted sensors. The interface as seen by the Visitor was recorded using screen capture software.

Participants

We had 18 French speaking participants (13 female, 4 male, 1 undisclosed), in six pairs and two trios, all with a prior relation (e.g. friends, family). Participant were aged between 60 and 91 (mean age 74). Hearing loss was reported by 7 participants. In one pair, a 10-year old grand-child also joined as Interaction Target, but was excluded from analysis.

FINDINGS

Summaries of our main findings can be found in Tables 1 and 2. Twelve participants preferred the *'turn up volume'* behavior, the other six preferred *'move closer'* instead. The ratings of these behaviors matched those preferences for 89% of the participants, though many asked for clarification of the rating questions.

Since the rating of the response behaviors was not normally distributed (Shapiro-Wilk, p=0.135, p=0.039*, p=0.053) we ran a Friedman test, which found a significant difference in rating ($\chi^2(2)$=25.344, p=0.000*). We did a post hoc analysis with a Wilcoxon signed-rank test (significance level 0.017, with Bonferroni correction). The ratings for *'move closer'* were significantly higher than those for *'no response'* (Z=-2.917, p=0.004*). The ratings for *'turn up volume'* were significantly higher than both those for *'no response'* (Z=-3.628, p=0.000*) and those for *'move closer'* (Z=-2.462, p=0.014*).

This analysis made the simplifying assumption that the participants can be treated as independent comparable measurements, despite being in the same group and having one of two roles (Visitor/Interaction Target). A series of Pearson's Chi-square test found no significant correlations of either group or role with the ratings, which supports this assumption. The aforementioned significant differences all hold when looking at the Interaction Targets only (N=10), only the difference in rating for *'turn up volume'* and *'move closer'* is no longer significant (Z=-1.364, p=0.172).

CONCLUSIONS AND DISCUSSION

We have compared three ways in which a semi-autonomous telepresence robot could respond to hearing problems. We found high ratings for *'turn up volume'*, significantly surpassing the ratings for *'move closer'*. Both of these were rated significantly higher than *'no response'*. There do seem to be further individual differences, as one third of the participants instead preferred the *'move closer'* behavior. We only used general ratings for this, but our participants most commonly indicated to have based their judgement mostly on the qualities 'Intelligent' and 'Helpful'. Note that these findings need not translate to other settings, e.g. *'turn up volume'* may be perceived as less appropriate if the noise could disturb others.

Overall, our findings demonstrate that trying to accommodating hearing problems is a desirable feature in this setting. A general approach like turning up the volume when required could work in general cases. If possible, a more personalized solution could also/instead move closer if the user would so prefer.

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Social and Autonomous Confabulation Architecture

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Abstract— This paper presents the Social and Autonomous Confabulation Architecture: a new cognitive architecture developed for social robots that have to operate under supervised autonomy. With this new cognitive architecture, based on the confabulation theory, robots are able to choose autonomously their behaviors, to have emotions and to have learning abilities. At the end, the architecture is tested with the robot Nao playing different interactive games with a kid.

Keywords— confabulation theory, social robot, autonomous behavior, cognitive architecture

1. INTRODUCTION

Social robots are increasingly being used for many reasons. Some of them, like the seal robot Paro or the huggable robot Probo, have been developed in order to be used in hospitals [5]. Other robots, like the commercial robot Aibo have been developed in order to be used as pet.

Aibo's cognitive architecture is based on ethology [1]. But mimicking the mechanism of thought from a neurological point view may facilitate the interaction between humans and robots [4]. The mechanism of thought is described by the confabulation theory.

The confabulation theory is a concept in neuroscience developed by Robert Hecht-Nielsen [2]. It postulates that the working of the brain is similar to the working of muscles: neurons work in groups called modules. These modules are separated in symbols that represent elements of thought.

Nowadays, different artificial creatures inspired from this theory have already been developed. The Two-Layered Confabulation Architecture (TLCA) [3] or the Degree of Consideration-Based Mechanism of Thought [4] allow artificial creatures to choose their optimal behaviors in virtual environments. This paper proposes a new cognitive architecture inspired from the given examples, but adapted for social robots that have to operate under supervised autonomy: the Social and Autonomous Confabulation Architecture (SACA).

Thanks to its developed perception and actuator system and thanks to the transportability of the framework, the robot Nao has been chosen in order to test the SACA. It has been programmed into a social robot that plays educational games with children.

2. WORKING OF THE SACA

A. Main working

What the SACA mainly does is choosing the next behavior of Nao. A behavior is a predefined function that typically launches a set of actions of the actuator system. In its current version, the test software has a library of 8 behaviors: Nao presents himself, shows his emotion, dances and can play 5 other interactive games. Each game is thus defined as a behavior.

Figure 1 shows the working of the cognitive architecture. The external stimuli, perceived by the different sensors of the robot, are processed by the perception system. This data is saved in the memory. The memory represents all the information that defines the internal state of the robot. In function of the memory, the behavior selector chooses the next behavior of the robot. Depending on the behavior, the robot may need to wait for a certain stimulus or may want to make some changes in its internal state. This is represented by the dashed arrows. In addition to the described deliberative layer, the robot also has a reactive layer. This layer is represented by the black arrow between the perception system and the actuator system: a set of stimuli can bypass the deliberative layer and activate directly the actuator system.

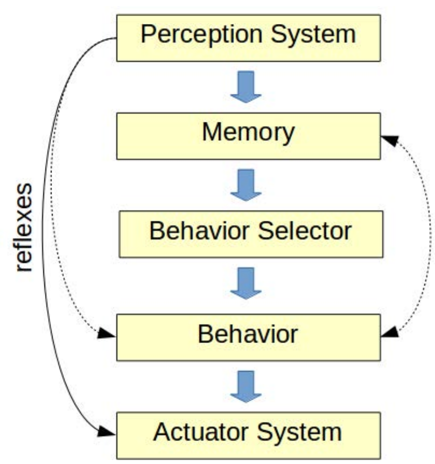

Fig. 1. Schematic diagram of the Social and Autonomous Confabulation Architecture

While the reactive layer is just defined as a stimulus that activates some actuators, the deliberative layer is more complex and works according to the confabulation theory. As said before, the main elements of the confabulation theory are the modules and symbols.

B. Modules and symbols

The memory -that represents the internal state of the robot- contains different modules:

1) **Context module:** gives the general context. Did the user just turned on the robot or did the robot not receive stimuli since a long time?
2) **Last stimulus module:** each stimulus is recorded in this module until a new one has been perceived.

3) **Emotion module:** stores Nao's emotional state.
4) **Behavior module:** behaviors are here defined as symbols and are stored in the behavior module.
5) **Additional data modules:** in one of its behaviors, the robot tries to guess a famous singer by asking questions to the user. The robot thus has a list of singers and must also be able to remember the gender, the nationality and other clues given by the user. All this information is saved in additional modules.

Each module contains different symbols that represent the different states of the module. At a given time, at least one and only one symbol per module is activated. This activated symbol is called an assumed fact. For example if the robot did not receive stimuli for a long time, the symbol called "nothing happens" of the context module will be activated and will be the assumed fact.

The memory also contains the weight values of the knowledge links. A knowledge link connects a symbol from one module with a symbol from another module. The weight of the knowledge link going from symbol α to symbol β equals the conditional probability that symbol α is activated assuming β is activated: $p(\alpha|\beta)$.

Because the context module or the last stimulus module only represent some characteristics of the external world, their assumed facts are chosen by the perception system. The selected behavior on the other hand represents a decision of the robot. This decision is made by choosing the behavior b that maximizes the conditional probability that all the n assumed facts $f_1, f_2, ..., f_n$ occur assuming the behavior b occurs. After applying the Bayes theorem, this maximum can be estimated by finding the maximum of $p(f_1|b_i) \cdot p(f_1|b_i) \cdot ... \cdot p(f_n|b_i)$, with b_i, the different behaviors and $p(f_j|b_i)$ defined as the weight of the knowledge link going from the symbol f_j until symbol b_i [3]. The weights of these knowledge links need to be estimated in advance and/or can be modified thanks to a learning algorithm.

C. Learning algorithm

A learning algorithm has been implemented in order to give the possibility to the user to improve the robot's attitude. Reinforcement learning is here considered. The user can give rewards or punishments to the robot and the weights of the links are increased or decreased according to formula 1:

$$p_{new}(c_i|b) = p(c_i|b) + F \cdot O \cdot \lambda \quad (1)$$

with

- c_i: all the symbols connected with the behavior b
- b: the desired/undesired behavior
- F: Feedback: F=1 in case of reward and F=-1 in case of punishment
- O: Occurrence: O=1 if occurs and -1 otherwise
- λ: learning rate: after tests and trials, $\lambda = 0.05$

The learning algorithm is not new, but is inspired from the one used in the TLCA [3] and has been slightly modified: the product in the original equation has been here changed by a sum. This makes the creation of new links possible, even if their weights were originally zero.

D. Emotions

While emotional state usually is defined in a two-dimensional space with a valence and an arousal axis [5], the emotional state here has been defined in a module where each symbol represents a different emotion. The selected symbol is determined by the perception system or can be modified during a behavior. While the symbols of the emotion module are connected with the symbols of the behaviors module, emotions influence the behavior's choice. For example the connection that goes from the emotion "angry" to the behavior "show his emotions" is higher, so that if the robot is angry, there are more chances that it will express it.

3. RESULTS

In order to verify that the SACA is suitable for social robots operating under supervised autonomy, it has been tested with Nao playing with children. The desired characteristics have been observed: Nao is able to play interactive games with a child, has emotions and is able to adapt his behavior in function of the child's preferences. Furthermore it has been observed that it is even possible to teach the robot to perform a certain action as consequence of a certain stimulus. Results have been recorded and are showed in a video: `https://youtu.be/x859_qbYGuA`.

4. CONCLUSION

The developed software remains quite simple but works well. In the future, by increasing the number of modules and symbols and by connecting modules in series, much more intelligent social robots could be developed using the same cognitive architecture.

ACKNOWLEDGMENT

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Suitability of a Telepresence Robot for Services on Home Modification and Independent Living

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Abstract. In four sequential explorative studies the suitability of the telepresence robot GIRAFF was investigated in how far it can be utilized for providing information and advice on home modification and independent living.

Keywords: Telepresence robot, Home Modification, Assistive Technologies, Independent Living.

1. SERVICES ON HOME MODIFICATION TO SUPPORT INDEPENDENT LIVING

Accessible and barrier free design is a necessary premise in order to live independently in the private home. In Germany only 3% of private homes have barrier free, accessible design. There is an estimated lack of 1.1million accessible homes. (1, 2) Home modification is a key factor, but the knowledge on these possibilities and assistive technologies is not widespread. Information and advice on these have been supported by regulatory bodies and initiatives of welfare and other organizations. In the state of Hesse, Germany, a variety of professional, semi-professional and voluntary services are available. Although all of them have at least a basic qualification it is often very difficult to pass on the information if clients cannot experience the different assistive devices by themselves.

Objective of the four sequential explorative studies was to find out whether the utilization of a telepresence robot could support this information and advice process and bring in new quality aspects.

Following key players were involved in this study:

A. The Voluntary Mobile Home Modification Service of the City of Hanau

This service is located at the Senior Citizens Office of the City of Hanau**.** Six active volunteers with backgrounds such as architecture, nursing care, finance, engineering, etc. were trained in home modi-ication and assistive devices for independent living. They have an own office with set office hours.

Typical requests of their clients are adaptation of the bathroom, entrance and access to and in the building, financing home modification, and support for daily activities. For their service it would be helpful if they can show suggested aids and devices.

B. Smart Independent Living Center (SILC) at Frankfurt University of Applied Sciences (FRA-UAS) in the City of Frankfurt am Main

SILC is a permanent exhibition jointly operated by the Faculty of Social Work and Health of FRA-UAS and the Specialist Unit Independent Living of the VdK Social Association Hesse-Thuringia, a major social welfare organization. SILC displays various concepts on accessible design and home modification as well as assistive technologies to support independent living on more than 150qm (3).

C. Three Private Homes located in a collaborative housing project ILEX

The housing project ILEX has 16 accessible flats and communal space for people aged 60plus. Tenants of three flats participated in the different trials.

2. TELEPRESENCE ROBOT GIRAFF

"Telepresence is defined as the experience of presence in an environment by means of a communication medium."(4) Transmitting voice via telephone, additionally video via e.g. Skype are commonly known and accepted. Additionally, telepresence robots allow the transmission of movements. Most popular is moving through a building, less known is the transmission of mimics. (5) The telepresence robot GIRAFF is a product of the Swedish company GIRAFF Technologies AB and is developed for healthcare purposes. (6, 7) The system consists of a movable screen equipped with camera, microphone and a base on wheels both connected with a height-adjustable bar. The system is not autonomous. A remote user can operate GIRAFF with a PC and internet connection and an easy to use control surface. Communication is possible via speech and video transmission. Additionally, the remote operator can move GIRAFF through the room of the person where the system is located.

Following picture shows the GIRAFF telepresence system and the control surface.

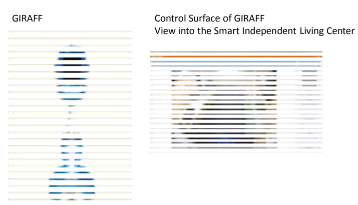

Fig. 1. GIRAFF and the control surface

3. METHODS

In order to explore the suitability and potential of telepresence robots for information and advice on home modification four studies were undertaken. All participating subjects gave written informed consent.

A. Training of the Volunteers of the Mobile Home Modification Service

Four volunteers of the Mobile Home Modification Service, all aged 60plus, were trained to operate GIRAFF. They had to pilot GIRAFF in a prepared semi-realistic obstacle course. Usability was measured and a discussion on possible applications for their work took place which resulted in the following trials.

B. Trial "First consultation in the private home"

A scenario "First consultation in the private home" was jointly developed and tested with tenants of two flats. They had GIRAFF in their private home and two volunteers of the service dialed through a laptop into their home in order to elaborate the possibilities of home modification or other adaptations. The approx. 20 minute interaction was observed and protocolled and thereafter interviews took place.

C. Trial "Communication, information and advice in a private home"

GIRAFF was placed in a private household for one week in order to analyze the suitability for communication with family and friends and the suitability for information and advice on independent living. Each morning the first author called in order to test the technical suitability and to provide support if necessary. The mobile counselors called each day in order to discuss different issues on home modification and tested the operation of GIRAFF. Additionally, friends and family members called and operated GIRAFF. Log files were analyzed and participants kept a diary during that period. After the trial a workshop meeting on the experience and pros and cons was undertaken.

D. Trial of GIRAFF in SILC

The mobile counselors dialed into GIRAFF placed in SILC and could discuss issues on assistive technologies with the experts in SILC. Objective was to explore the potential of SILC for enhanced advice and information. This scenario was tested on two days with observing researchers on both sides.

4. RESULTS

A. Technological aspects

The software of GIRAFF is easy to operate and the volunteers (all 60plus) could manage it well. Major problem was the internet bandwidth which caused problems of time lags in transmission. This resulted in GIRAFF still driving and the operator not knowing the actual position. Poor transfer speed also affected the communication process. Distorted voice and frozen pictures were irritating especially in addition to hearing and vision problems of the participants. One suggestion was to have a joystick as a user interface.

B. Suitability of GIRAFF for information and advice on home modification

Prerequisite for operating GIRAFF is accessible design and internet-access. As GIRAFF is rather voluminous, sufficient space is necessary in order to drive GIRAFF through the private home. In the trials residents removed their carpets and smaller furniture in order to enable a secure driving in the flat. Video transmission was very limited with respect to smaller items – they could hardly be recognized by the operator. Communication was judged as easy and compared to "normal" conversation.

5. DISCUSSION AND OUTLOOK

Due to the ageing population there is an increasing need for information on accessible design and assistive technologies. All the participants ascribed the telepresence technology a high potential, especially with respect to the combination of viewing the product and listening to the expertise of the exhibition team. A necessary prerequisite is a high speed internet access which is still not available for many parts in Germany. Currently, the team is testing other telepresence robots (Double and VGo).

ACKNOWLEDGMENT

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A Pilot Study On The Feasibility of Paro Interventions In Intramural Care For Intellectual Disabled Clients

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Abstract— Social robots, with Paro being an example, offer new opportunities for innovative approaches in care for people with intellectual disabilities. Paro was used according to individualised interventions during a three week period. Selected residents would be offered Paro ones or twice a week. A total of 8 clients, 5 adults and 3 children, participated. Paro seems to have a positive effect in supporting care for the elderly, for the children no positive effect was reported.

Keywords— Paro, Intellectual Disabled, Pilot, Interventions, Feasibility

INTRODUCTION

Care for people with intellectual disabilities in the Netherlands is traditionally provided by professional caregivers in combination with informal caregivers. Technology is widely regarded as an important potential for care innovation. ICT technology and robotics, and particularly socially assistive robotics (SAR) are under rising attention of innovators [1]. But, as most assistive robotic developments, the implementation of SAR is, after the technical development of the robot system, a major hurdle on the route to application of the robot in day to day care practice. When it is to be applied as an instrument supporting care there should be an intervention surrounding the robot, specifying usage, users and purpose of the robot application in such a way that caregivers are guided in putting the robot to effective use and can regard the robot as an instrument in their care provision rendering added value for their clients and their efforts [2].

Three types of interventions were developed in close collaboration with four Dutch care institutions for elderly care [2]. These three interventions aim at:

1) Therapeutic purposes;
2) Facilitating daily care activities;
3) Supporting social visits.

Although research has been done into the published effects of Paro for people with dementia [3], [4], so far little is known about the effects and applications of Paro in the care of people with (multiple) intellectual disabilities. For psychogeriatric care Paro has clearly added value [5], especially for therapeutic related interventions, for people -including children- with (multiple) intellectual disabilities potential added value has not yet been demonstrated. To evaluate practical application of the interventions developed, in the context of care for people with intellectual disabilities, this paper reports on a feasibility study executed. The Paro interventions were applied to individual clients, translating one of the above aims into individualised goals in line with therapeutic or care related aims, formulated for these individuals by the care professionals.

METHODS

The study was executed in 2 locations of Pergamijn, a care organization in Limburg, a southern province of the Netherlands. In each location, local small scale care units (8-10 residents each), were selected by the organisation for this study. As Paro was new to all care staff, the first step in the study was providing a brief training of care staff of the involved care units to familiarize them with the robot, its purpose and foreseen application. For the practical execution of applying Paro interventions in the care units, a procedure was developed leading to clarification on which residents would be involved in the study and for what purposes. Following the selection of participants, Paro was used with the selected residents according to the individualised interventions during a three week period. Prior to the actual use of Paro a baseline measurement was taken, also during a three week period. This baseline measurement concerned observation of the problematic behaviour of each individual.

Organisation involved

Pergamijn is a care organization that advises people with intellectual disabilities and gives professional support, it does so based on the needs and demands of every client. This leads to individual support in the areas of housing, counseling, diagnostics, education, work or leisure.

Intervention

Each individualised intervention contained a description of the problematic behavior, description of context and application, and the type of outcomes. Paro tries to stimulate interaction and attracting attention from the participant by making enjoyment, by making soft noises and bowing its head towards the participant, thus reinforcing the interaction. At the onset of the targeted behavior Paro was introduced by the care provider similar to the following text: ”Look, this is the seal Paro. He will sit with you for a while. You can stroke, cuddle or talk to him if you like. He can sit on your lap or stay on the table”. During the activity Paro stayed on a table (or on their lap), so that the participant could interact with it.

The care provider was active in reminding the participant of the presence of Paro if necessary and stimulated interaction between the participant and Paro. At the end of the activity (after about 15 minutes) the session was ended smoothly by saying goodbye to Paro.

Measurement of effect

Feasibility was measured qualitatively by means of a registration form and a diary in which each occasion of Paro use was briefly reported. For each of the Paro interactions the lead nurse filled out a registration form describing the behaviour of the patient just before the intervention started, the reaction of the patient at the moment Paro was offered, the behaviour of the patient during the interaction with Paro, the behaviour and reaction of the patient at ending the intervention, and the perception of the caregiver regarding the effect of this session. The primary outcome was measured on an individual level by a care provider, based on the Individually Prioritized Problems Assessment (IPPA) score [6]. A mood scale was used as secondary outcome to validate that the reported effects by the care providers (i.e. IPPA score) were consistent with the resident's mood.

After the three week period, care staff was interviewed using a semi-structured qualitative questionnaire, to re-assess the effects as reported in their descriptions and to assess the practicalities involved in applying the Paro interventions and the effects on the patients.

RESULTS

A total of 8 patients, 5 adults and 3 children, participated. For each participating client one care staff member could be assigned who initiated and evaluated the application of the Paro intervention for this client.

The three children have all completed the study, so both the 5 measurements without Paro (baseline) as the 5 interventions with Paro. Of the five adults, four have also completed the study. One client was very dismissive towards Paro and the research for this client was ended prematurely.

Figures 1 and 2 show the average IPPA-scores for resp. the children and the older clients.

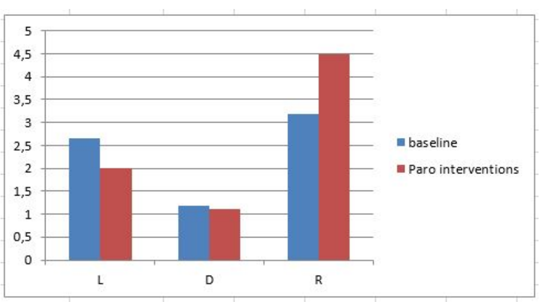

Fig. 1. Average IPPA score per child, with and without Paro

The results show that Paro has no (significant) impact in terms of the defined intervention goals for the children. Although one child liked Paro and liked interacting with it, Paro had no positive effect in terms of the individualised goal. The results also show that Paro has a positive effect on 3 older clients. One client was very defensive towards Paro and one client showed hardly any interest.

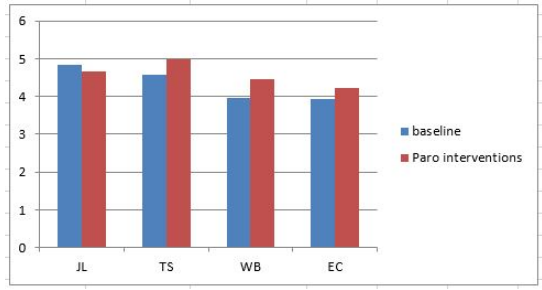

Fig. 2. Average IPPA score per adult, with and without Paro

During the final evaluation with the care providers the results were confirmed, the staff recognized the findings and saw potential in the use of Paro for the older clients. During the evaluation of the children, the results were also recognized. The present staff (8) felt that Paro probably had no added value for profound (intellectual) (and) multiple disabled children. Some comments from care staff about the use of Paro for these children were: The robot is too passive, there is too little exercise; Paro should be more adjustable or configurable, it should be personalized for each child; The robot is very big and heavy for these children; Paro is focused on care and attention. These children want to play actively and manipulate toys.

CONCLUSIONS

For the children Paro seems yet to have little added value in support of care. The children do not seem to be afraid of Paro and show (sometimes) interest. For the older residents Paro seems to have a more positive influence in the support of care. Given the lead time and the number of participants, these results are only indicative. Wider use of Paro, linked to specific care demands, could give more insight into the possibilities and effectiveness of this seal robot in daily care practice for intellectual disabled people.

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NoAlien! Linguistic alignment with artificial entities in the context of second language acquisition

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Abstract. Second-language speakers often face the situation that native-speakers adapt to non-natives and reduce the complexity of word choice and syntax in order to foster mutual understanding and successful communication. However, the other side of the coin is that this kind of alignment sometimes interferes with successful second language acquisition (SLA) on a native-speaker level. In the present work we explore whether artificial tutors can be used to avoid this negative aspect and exploit the benefits of linguistic alignment in human-computer interaction in order to enhance learning outcomes in SLA. We outline an experimental study (n=130) on the effects of the system's embodiment (robot, virtual agent or only speech based) and speech output (prerecorded natural speech or text-to-speech) on participants' perception of the system, their motivation, their lexical and syntactical alignment during interaction and their learning effect after the interaction.

Keywords: human-robot interaction, embodiment, virtual agent, linguistic alignment, second language acquisition,

INTRODUCTION

Due to the demographic change, many industrial countries are lacking of skilled workers and depend on immigrants from foreign nations. Therefore the integration of those immigrants becomes more and more important. One of the most essential factors of a successful integration is the ability to communicate with others and to speak the local language fluently. To learn the foreign language most people concentrate on a classical student-teacher situation, although there is some evidence that people can learn passively by linguistic alignment[1]. While non-native speakers can learn a lot from a dialog with native speakers, there is also a negative aspect of linguistic alignment processes. Native speakers align to non-native speakers and will use a simplified language. Hence, non-native speakers are not able to learn complicated words and syntax to improve their language skills. With regard to this problem especially modern forms of technical assistance are very promising since the verbal behavior of these systems can be tailored in order to elude this problem. Therefore, we investigate whether non-native speakers align to robots as well as virtual agents and whether alignment leads to improvements in SLA.

THEORETICAL BACKGROUND

Linguistic Alignment in HHI & HCI

When people talk to each other they adapt linguistic representations to understand each other better. This phenomenon is highly relevant for a successful conversation[2] and is widely known as linguistic alignment[3]. The conversation partner adapts different components of the other's linguistic behavior such as accent, phonetics, speech rate and prosody[4]. Further on, people use the same terms as their conversation partner for a certain object during a repetitive usage[5]. Brennen and Clark[5] found in their study that participants indirectly form conceptual pacts about lexical choices in order to describe different items without negotiating about it. But people do not only use lexical alignment in a dialog. They also align in a syntactical manner. Although there are plenty of possibilities to express certain statements, Branigan and colleagues[3] stated that dialog partners coordinate their syntax and form their sentences in a similar way. This finding is in line with Bock[6] who found that participants adapt the structure of the sentences in relation to active and passive formulations. Pickering and Branigan[7] showed that syntactical alignment occurs regardless of whether dialog partners use identical or different verbs. Even if the effect is more present when similar verbs are used. Overall, many studies prove the existence of linguistic alignment in different ways[8,7,3]. Moreover, numerous studies show that linguistic alignment takes place in MCI as well. Previous work demonstrates that people align to artificial entities (computers, agents or robots) with regard to lexical[9,10] and syntactical choices[11] and even with regard to dialect[12].

Linguistic alignment in the context of SLA

Linguistic alignment does not only occur between two native speakers but is also present in a dialog between a non-native speaker and a native speaker[13]. After the conversation with a native speaker, the speech of a non-native speaker was evaluated as more naturally than before.[13] Therefore, non-native speakers can benefit from a dialog with a native speaker and this conversation can enhance their linguistic skills. Pickering and Garrod[14] state that long-term linguistic alignment is elementary for language acquisition. Studies show the benefits non-native speakers can derive from linguistic alignment processes.[1,15] Long[15] postulate that the alignment in a conversation between native and non-native speakers increases the understanding of the conversational content when natives align to their dialog partner. This in turn leads to an enhancement of non-natives' language acquisition. However, this process can also have a negative effect. While natives adapt the linguistic manner of non-natives, they will not make use of complex terms. Thus, non-natives are not able to learn these terms and cannot enhance their linguistic skills to a flawless level. One possibility to avoid this problem may be the use of robots and virtual agents. A technical system like this will use perfect sentences without regard to the linguistic level of their dialog partner. In order to investigate these processes of participants' linguistic alignment to artificial tutors we conducted a laboratory study and in addition varied diverse aspects of the tutoring system to explore their impact on motivation and learning outcome.

OUTLINE OF EXPERIMENTAL STUDY

In the present study we examine the underlying mechanisms of linguistic alignment in interactions with an artificial tutoring system and explored the impact of certain technical aspects of the system in a 2x3 between subjects design. First, we compared prerecorded speech (female voice) with a text-to-speech (tts) output (female as well), as there may be different effects of alignment. Moreover, this variation addressed also practical implications. If alignment processes are the same, then tts is a much more flexible solution to realize pedagogical agents, as a system could be easily amended by new components. Second, we varied the embodiment of the system (robot vs. virtual agent vs. control version without embodiment). For our study a wizard-of-oz setting has been used and the system has been controlled by the experimenter while the participants thought that the system works autonomously.

Participants and procedure

130 non-native speakers (74 female, 56 male) aged between 19 and 53 years (M=26, SD=6.87) took part in this experimental study. They stem from 40 different nations, and have different levels of German language skills. Upon arrival participants signed informed consent and then completed diverse tests in order to assess their German proficiency level followed by a questionnaire asking for demographic variables and assessing personality traits. Afterwards participants interacted with the language learning system. During the interaction they have to solve three different tasks together with the system, for instance describing pictures in much detail, play a guessing game, etc. Participants' verbal behavior will be analyzed regarding lexical and syntactical alignment to the respective version of the system. Afterwards, participants evaluated their interaction with the system. We asked for understandability, acceptance, usage intention, learning experience and also for how the respective system was perceived in terms of person perception and social physical presence. In order to access direct learning outcomes we again captured their linguistic skills in the end of our experiment.

Results and discussion

We report work in progress. We just completed data collection and will have to transcribe and analyze participants' verbal behavior. However, we have already first results regarding the impact of speech output. The results of this study may be very profitable in regard of the application of robots and virtual agents as a technical assistance during second language acquisition. As the experiment is not finished yet, the results will be presented and discussed at the conference.

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Transitional Wearables Based on Bio-Signals to Improve Communication and Interaction of Children with Autism

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ABSTRACT

We propose a novel interaction method based on a type of wearable interfaces called *transitional wearables* (TW). TW allow gathering physiological data from children with autism and can be used to facilitate their communication and interaction with parents and caregivers during daily life activities. Communication plays a key role for the children's mental and social development [1]. The variable symptoms of autism are generally grouped under the name of *autism spectrum disorder* (ASD) [2]. ASD patients are characterized as having difficulties in social interaction [3], communication [4], tendency to fixate on limited interests and repetitive behaviors [2]. They show less interaction in free play situations and rarely initiate social interaction [5].

In several medical fields there is an increasing need for ecological monitoring of physiology variables to support medical interventions and therapies outside the clinical setting [6]: wearables with biosensors could contribute to meet this need. The application areas are numerous, for example there is an increasing interest in early-age detection of ASD as well as for exploiting the gathered knowledge to create better therapies [7]. Indeed, a main problem involving ASD's diagnosis, evaluation and treatment is the internal emotional state of the patient [9]. Canonical biosensors, however, do not have access to physiological data in real time in daily life or during therapeutic training, thus losing important information. Moreover, they are often expensive and difficult to use on certain types of patients, e.g. on ASD patients who refuse contact or low motion [8]. Our project aims to develop and test a novel wearable which is capable of real-time and long-term physiological monitoring by recording Galvanic Skin Response (GSR), Skin Temperature (SKT), and heartbeat, and also to use an accelerometer embedded on a wristband. These devices are low cost, low power, and non-intrusive [8]. While most studies done in this field (e.g., [10]–[12]) are restricted to measurements in laboratories, they have demonstrated that there is significant emotion-related information that can be recognized through physiological activity [13].

Our aim is to use this information to identify and translate physiological output into information on basic emotions understood by the caregiver.

Real world's expectations and judgments involved in social contexts might appear "unsafe" to children with autism and this makes social interactions problematic [4]. Many children with ASD develop an attachment to a "transitional object", e.g. a teddy bear. This is used as a reliable source of soothing and confidence during the exploration of the world independently of parents and caregivers [14]. It is known that computer technologies have the potential to support children during interactions to facilitate their life. For instance: (1) interactive toys controlled by the child provide predictability through cause and effect functions and this reassures the child [15]; (2) form a safe bridge to the less predictable world formed by other objects and people; (3) accompany them in the daily world's learning and interactions (e.g., cleaning teeth, travelling in a car); (4) help learning to interact socially [16]. Wearable devices with biosensors can systematically collect information about actions and emotional states of children and communicate them wirelessly to an external computer (e.g., a mobile phone or a tablet). The information so gathered can be automatically processed based on pattern-recognition and other machine-learning algorithms and provide information usable at real-time to guide interventions, e.g. in the form of alert messages or text messages for the caregivers [17].

TW could gather bio-signals from children with autism during their social and collaborative activities in a friendly and comfortable way as they can be integrated easily in different types of objects, such as toys and clothing, without the child noticing the sensors. This would also provide a novel means through which multi-sensory feedbacks and cause-effect object behaviors could be used to motivate and reinforce social interaction while engaging in life and therapy activities [15]. The cause-effect nature of such type of interaction would give the child a higher sense of control and hence mitigate fearful and avoidance reactions [18].

Computers and other similar electronic devices tend to promote a non-social use and this could drive the child to further isolate from the outside world or become hyper focused, falling trapped in obsessive-compulsive behaviors. Instead, if suitably designed TW for children with autism can be used in daily life

contexts and thus can possibly have a positive impact on children's social life [19]. For this purpose, positive/rewarding sensorial feedbacks from the wearables (e.g., colored LEDs, sounds) can be made dependent on the performance of communication actions with the caregivers. For their richness and programmable nature, TW could thus be used to facilitate exploration and development of divergent behaviors leading to "accommodate" to novel contexts, experiences, and social interactions [20].
By collaborating with therapists, psychologists, biomedical engineers, psychomotor therapists we are now prototyping design solutions of TW that are non-intrusive and allow the collection of data in children with ASD. We are also defining an experimental protocol to empirically test the TW with children with autism. The main objective of the test will be to verify the effectiveness of this approach by analyzing the recorded data related to emotional reactions of children to TW.

Keywords: Autism, transitional object, wearables based on biosensors, stable-reassuring interactions.

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Roboterapia: an environment supporting therapists' needs

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Abstract— In this paper we have highlighted the needs of therapists and possibilities of using robots in therapeutic environment. While the use of robots as therapeutic devices is widely studied (especially with children with developmental needs), robots could be used in a wider scope. We have performed need finding sessions with therapists and produced prototype devices that could support different aspects of therapists' work.

Keywords— interdisciplinary collaboration, robotized environment, end users' needs, autism therapists' needs

A. Introduction

Therapist, especially those working with mentally disabled children, have a large number of burnouts resulting from both patient characteristics and work environment factors [1].

We have focused on whole therapeutic environment believing that intelligent, programmable agents could improve not only therapy but also therapist well being.

With our partners – designers from Strzeminski Academy of Fine Arts Lodz (both student designers and professionals) and willing group of autism therapists (a group of nine practitioners) from Navicula Centre for Autism Therapy we tried to understand the possible role that robotic systems could have in therapist's workplace and design adequate solutions.

B. An environment centered approach

Robots have been proven capable of being social actors such as teachers or play partners to therapy clients. We propose using robots as assistants to the therapists. A therapeutic environment could be then understood as a space with three participants: therapist, client–patient and a robot.

We have conducted need finding sessions (interviews, observations, ideation sessions) to find how robotic technologies could be used, without limiting its use to the therapy itself. As studies in burnout have shown, the work environment factors, such as lack of clarity, support and general overload, can have bigger role in its development than the characteristics of the patients [1]. Therefore, by extending the role of a robot beyond being a therapeutic tool, its impact on the long term well being of both therapist (directly) and client (through better therapy) could be improved.

Robots' use in therapeutic environment could be divided into its use as a therapeutic tool and as a supportive role in other therapist's work. Use of robots in the therapy of children with autism was studied in such projects as AuRoRA [2], Keepon [3]. From our own interviews with therapists and needfinding sessions, therapists state that in order to be useful robots need to be interactive, programmable, personalizable, with the ability to fine-tune stimuli [4]. This suggests that an environment where therapists could program and control the therapy themselves is needed, which agrees with findings of Barakova et al. [5].

As our group of therapists was small, in our study we have decided to use mostly open questions and treat therapists as co-creators of robotic solutions. The biggest obstacles that our group stated in the work are actually similar as in a larger study [6]: poor relations with supervisors and parents, lack of visible results (that could be shown to parents and supervisors), loneliness (as there are frequent periods of time when therapists work alone with their clients).

That suggested the use of robots in a supportive role, of which therapists showed a big interest. When explained the current limitations of state-of-the-art technologies of speech, emotion and activity recognition, therapists showed interest in some particular robotic roles. We have listed the most interesting below:

- a helper in critical/dangerous situations. As therapists frequently work alone with their clients, they can have difficult time when the patient behaves in a way that requires help (aggressiveness against oneself or other people). A robot could be used to distract, call for help or become teleoperated by another person that could soothe the client.
- a record keeper and reporting device. Therapists work as a part of a bigger institution and are frequently required to report about particular patient's behaviours and therapy progress. Also, patient's parents can doubt that progress is happening or that some actions are occurring. Robots can record parts of therapy and report, both for administrative purposes and for communication with parents.
- an "emotional mirror" for both the patient and therapist. Therapy is a dynamic situation where it can be hard for therapist to always understand client's as well as its own emotions, such as anger and frustration, which can negatively influence therapy. Through informing about occurring emotions robots could give the therapist a chance to meditate the situation before it influences the therapy.
- a "team player". A robot can influence therapy dynamics by stating that it does not like some behaviour (thereby moderating conflict [7]), proposing or finishing some activities (managing pace)

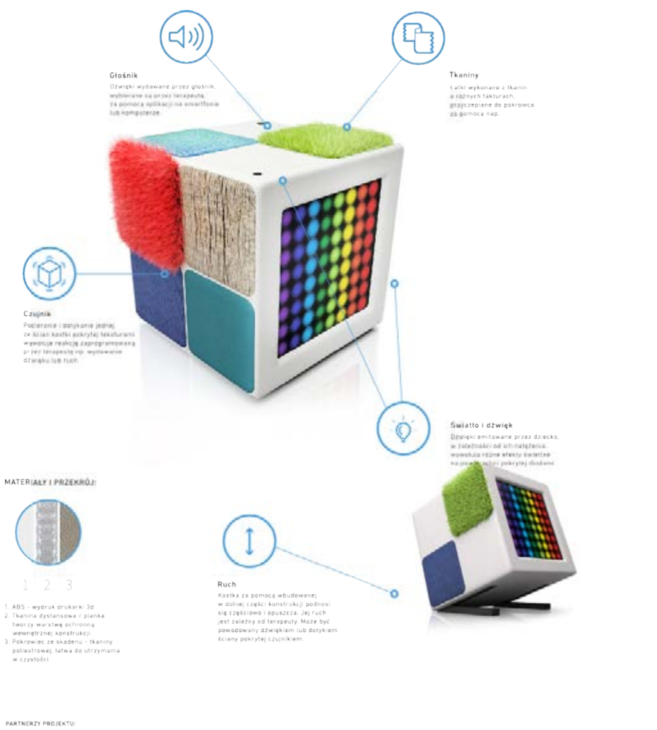

Fig. 1: Exploration box authors: Magdalena Bartczak, Olga Rogalska, Szymon Surma, Magdalena Gregorczyk, Dariusz Urbański

C. Results

Through iterative design processes, where therapists were considered as final users we have created two groups of prototypes of robotic devices that could be used in therapeutic environment. First group are devices that could be used in sensory therapy, where therapists could program series of stimuli and reactions of the device (warming up, moving, generating sounds) to the actions of the child. A device of this kind – an "Exploration Box" is presented in Fig. 1. Therapists can program the device through Scratch based graphical programming language.

Second group of devices, are more universal mobile robots, that can be used both as part of the therapy and as support for the therapists. Devices have exchangeable casings, with two designs presented in Fig. 2.

Our designs are ROS connected and have tablet based interfaces. Speech commands are recognised through use of Wit.Ai software, which is a set of tools for enabling speech recognition in internet-of-things[8].

Therapists from Navicula Centre of Autism Therapy did preliminary tests of sensory therapy devices. With the first iteration of the devices they have evaluated them as useful and correct but not completely novel. In the second iteration of the devices, designers used more unique robotic functionalities by connecting voice recognition, motion generation and cooperation of the devices. An educational aspect of this project, as most of the designs were developed by students of Lodz University of Technology and Strzeminski Academy of Fine Arts Lodz is described in [9].

Fig. 2: Different exchangeable casings for universal mobile robot used in therapeutic environment. First: A doll-like shell for a mobile robot. Design by Honorata Lukasik. Second: A soft shell with a place for a tablet for a robotic assistant designed for a therapeutic assistant robot.

D. Conclusion and future work

Robot's role in therapy does not need to be constrained to a tool. Different, critical for both therapy and therapist long-term well being, parts can also be roboticized. In our work we aimed at collecting and describing therapists' needs and showing our designs that could fit those needs.

In our future work we are planning to set up robots with all functionalities that would allow for using robots as a more universal assistants in therapy, that is emotion and behaviour recognition. In our longitudinal studies we will be analysing therapist burnout as a function of roboticized environment usage.

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AISOY Social Robot as a tool to learn how to code versus tangible and non-tangible approaches

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Abstract— In this paper we have conducted a study to validate the use of educational social robotics as an hybrid system between the traditional approach of using technology in the classroom based on computers and the pioneer approach about using tangible devices such as educational robots. In order to accomplish our goal we have organised a workshop with 36 participants, where students between 8 to 12 years old had to program a rock-paper-scissors player using scratch on a computer, a scratch on a computer (Enchanting) + LEGO NXT, and the educational social robot AISOY programmed with scratch.

Keywords— Education, Social Robots, Tangible Device

1. INTRODUCTION

Research involving technology in education has two trend topics, the first one is about technology being the base of the STEM or STEAM learning. The second one is about the computational or engineering thinking. The first one foresees that with the use of technology students are attracted and engaged with science and technology, while the second one believes that engineering skills are used in the everyday life, and in addition, through the engineering skills people develops a better human sensitivity [1].

So, the controversial about virtual and tangible devices is served. Some researchers claim that tangible devices increase the level of immersion because students are manipulating things in a real world [2]. However, we can find other studies that understands that non-tangible devices brings more flexibility and avoids limitation because of the physical body in the real space, furthermore, in [3] authors explain that exist a lack of evidence that tangible systems offer any benefits compared to onscreen counterparts. What seems logical is a hybrid approach as the one presented in [3], where a merge between physical and virtual world provides more flexibility to teachers and learners.

In this paper, we propose and studied the benefits of a tangible non-tangible combined system based on a social robot for education purpose named AISOY. We have structured this abstract as follows: in section II is presented the methodology used to study a tangible system vs non-tangible system vs a hybrid system, and in section III, indicators from the analysis of the data obtained are given and discussed.

2. METHODOLOGY

For doing this study we have selected a population of 36 students from a summer camp organized in Barcelona by ClauTIC [6] at la Salle BCN - Ramon Llull University facilities. They were students between 8 and 12 years old, and they are going to do this activity as a workshop organised aside a summer camp about robotics. The students were divided in three classrooms or groups of 12 each, and in each classroom there were 4 groups of 3 participants each.

The activity is a 2h long session where children are going to build and program a rock-paper-scissor player. As we can see in Fig.1, each classroom has different resources to accomplish the goal: the study group A have a computer with Scratch software, in the study group B the students have a commercial LEGO NXT 2.0 set + Scratch to program it, and finally, the group C use the AISOY robot + Scratch to program the game. The group A will interact with the computer, and the interaction system will be the Scratch window. In group B, the students will have the computer with the scratch linked to AISOY, an educational social robot platform. Finally, in group C students will have the LEGO NXT 2.0 sensors and motors to build the physical agent that will perform the game, also connected to the scratch software.

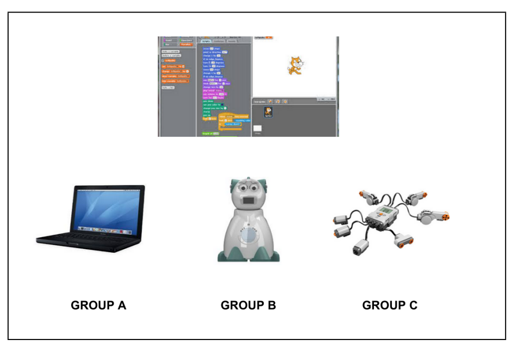

Fig. 1. These are the three platforms that students are going to use to implment the game rock-paper-scissors.

We are measuring not only the absolute data acquire from the sessions, but also the incremental gain based on a pre-test and a post-test conducted at the beggining of the session and at the end.

A. Setup of the Study

The sessions are recorded with two cameras that cover all the classroom, and one camera for each table covering the working space and the kids.

B. Evaluation Metrics

We are evaluating the following skills:

- Level of autonomy: How many times they ask for help. The capacity of divide a complex task in subtasks.
- The creativity: We are measuring the differences between the designs and solutions that the kids can find. These can be about the coding, or about the building.
- The coding performance: the items to be evaluated here are the understanding of the concept of the variable, loop, and conditional.
- The building performance: how robust are the system, the reliability, and the robustness of the implementation.
- Hardware knowledge: How a sensor and actuator works.
- Social skills: wining, losing, greeting, cheating, mercy.
- Application in the real goal: which solution allow the student to map applications in the real world.

3. RESULTS AND CONCLUSIONS

Not all kids that participated in the study where familiar with the Scratch software, the LEGO NXT 2.0, or also with the AISOY robot. However the number of times that they have been playing with LEGO or scratch is much higher than with the AISOY Robot. Novel effect could contribute to focus on the activity so students in group B paid more attention compared to group A or C.

While all children played nicely during the test phase, the group A plays a children computer interaction as it was a video game, the group B had more social-based game and they considered the robot as a human-like competitor. Finally, the group C who were using the LEGO NXT 2.0 created a children-machine interaction context.

When the implementation was forced to cheat with the result, groups A and C assigned an attribute of failure to the system, showing emotional states of angriness and frustration. In group B, the reaction was quite different, students enjoyed when the robot failed with the answer of the game. Implementation B helps to work issues like fair play, cheating, etc. creating a positive atmosphere at the same time.

The group using the LEGO NXT 2.0 (C) set asked for help higher number of times and it makes sense because this was the group with a wider diversity of elements. Group B needed to ask for help for the same issue a higher number of times than the other groups. We understand that missing a tangible context difficulties the understanding of the specific coding task. Group C had a better balance between solving the questions fast and the generated number of questions.

During the sessions, we asked in the pre and post test the applicability of the Scratch software. While group A 100% of answers, before and after the session, were to program or to program video games, the groups B and C include not only video games but also robots in the case of group C, and 2 students answered robots or other devices in group B. However we understand that better results can be obtained if we increase the number of participants, the diversity of activities, and the number of sessions.

If we focus on two of the evaluation metrics that represents how well the students learnt about new concepts (what is a variable and what is a motor) we can see that the increment of percentatge of good answers is as follows:

- Coding performance: the percentatge of students that understood what is a variable is, in case A 10%, in case C 17%, and 50% in case B.
- Coding performance: the percentatge of students that understood what is a motor is, in case A 25%, in case C 59%, and 42% in case B.

AISOY got a better results understanding an intangible concept as a variable while LEGO NXT works better to understand a tangible and specific component as a motor. However, is interesting that in case B results about what is a motor was in most cases to make robot work in the environment while in case C was more like turning wheels on.

About how they like the activity, the score obtained by case A in a scale 1 to 5 was 4.25, in case B was 4, and in C was 4.25. So the conclusions is that all of them were good enough in terms of fun.

Finally, we observed that Group B had a better capacity to map what they learn to applications in the real world.

Other considerations to take into account for further research are: 1) Team teaching understood as how to organise the group roles, balancing of tasks, and make sure that everyone understands the concepts and processes, and 2) The ways of playing with the final implementation: child to system play, multiple children to system play, children are following turn taking to play.

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Ensuring Ethical Behavior from Autonomous Systems

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Autonomous systems that interact with human beings require particular attention to the ethical ramifications of their behavior. A profusion of such systems is on the verge of being widely deployed in a variety of domains. These interactions will be charged with ethical significance and, clearly, these systems will be expected to navigate this ethically charged landscape responsibly. As correct ethical behavior not only involves *not doing* certain things, but also *doing* certain things to bring about ideal states of affairs, ethical issues concerning the behavior of such complex and dynamic systems are likely to exceed the grasp of their designers and elude simple, static solutions. To date, the determination and mitigation of the ethical concerns of such systems has largely been accomplished by simply preventing systems from engaging in ethically unacceptable behavior in a predetermined, ad hoc manner, often unnecessarily constraining the system's set of possible behaviors and domains of deployment. We assert that the behavior of such systems should be guided by explicitly represented ethical principles determined through a consensus of ethicists [1][2][3]. Principles are comprehensive and comprehensible declarative abstractions that succinctly represent this consensus in a centralized, extensible, and auditable way. Systems guided by such principles are likely to behave in a more acceptably ethical manner, permitting a richer set of behaviors in a wider range of domains than systems not so guided.

To help ensure ethical behavior, a system's ethically relevant actions should be weighed against each other to determine which is the most ethically preferable at any given moment. It is likely that ethical action preference of a large set of actions will be difficult or impossible to define extensionally as an exhaustive list of instances and instead will need to be defined intensionally in the form of rules. This more concise definition is possible since action preference is only dependent upon a likely smaller set of *ethically relevant features* that actions involve. Given this, action preference can be more succinctly stated in terms of satisfaction or violation of *duties* to either minimize or maximize (as appropriate) each feature. We refer to intensionally defined action preference as a *principle.*

As it is likely that in many particular cases of ethical dilemmas ethicists agree on the ethically relevant features and the right course of action in many domains where autonomous systems are likely to function, generalization of such cases can be used to help discover principles needed for their ethical guidance. A principle abstracted from cases that is no more specific than needed to make determinations complete and consistent with its training can be useful in making provisional determinations about untested cases. If such principles are explicitly represented, they have the added benefit of helping justify a system's actions as they can provide pointed, logical explanations as to why one action was chosen over another. Cases can also provide a means of justification for a system's actions: as an action is chosen for execution by a system, clauses of the principle that were instrumental in its selection can be determined and, as clauses of principles can be traced to the cases from which they were abstracted, these cases and their origin can be ascertained and used as justification for a system's action by analogy.

A principle that determines which of two actions is ethically preferable can be used to define a transitive binary relation over a set of actions that partitions it into subsets ordered by ethical preference with actions within the same partition having equal preference. This relation can be used to sort a list of possible actions and find the currently most ethically preferable action(s) of that list. This forms the basis of a *case-supported principle-based behavior paradigm* (CPB): a system decides its next action by using a principle, abstracted from cases where a consensus of ethicists is in agreement, to determine the most ethically preferable one(s).

Currently, we are using our general ethical dilemma analyzer (GenEth) [4] to develop an ethical principle to guide the behavior of a Nao robot in the domain of eldercare. The robot's current set of possible actions includes charging, reminding a patient to take his/her medication, seeking tasks, engaging with patient, warning a non-compliant patient, and notifying an overseer. Sensory data such as battery level, motion detection, vocal responses, and visual imagery as well as overseer input regarding an eldercare patient are used to determine values for action duties pertinent to the domain. Currently these include maximize honor commitments, maximize readiness, minimize harm, maximize possible good, minimize non-interaction, maximize respect for autonomy, and minimize persistent immobility. Clearly these sets of values are only subsets of what will be required in situ but they are representative of them and can be extended.

The robot's behavior at any given time is determined by sorting the actions by their ethical preference (represented by their duty values) and choosing the highest ranked one. As the following learned principle returns true if the first of a pair of actions is ethically preferable to the second, it can be used as the comparison relation required by such sorting:

```
An action is ethically preferable to another if it
    satisfies the duty to maximize Commitment by a value at least 1 more
 or
    satisfies the duty to minimize Persistent Immobility by a value at least 1 more
 or
    does not violate the duty to maximize Readiness by a value greater than 3 more and
    satisfies the duty to maximize Possible Good by a value at least 1 more
 or
    satisfies the duty to minimize Harm by a value at least 1 more
 or
    satisfies the duty to minimize Non-Interaction by a value at least 1 more
 or
    does not violate the duty to minimize Harm by a value greater than 3 more and
    satisfies the duty to maximize Autonomy by a value at least 1 more
 or
    satisfies the duty to maximize Readiness by a value at least 3 more
 or
    does not violate the duty to maximize Commitment by a value greater than 1 more and
    satisfies the duty to maximize Readiness by a value at least 1 more and
    does not violate the duty to maximize Possible Good by a value greater than 1 more and
    does not violate the duty to minimize Non-Interaction by a value greater than 1 more and
    does not violate the duty to minimize Persistent Immobility by a value greater than 1 more
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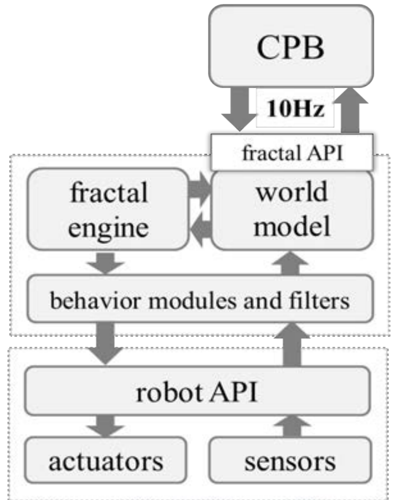
This principle was abstracted from a number of particular cases of ethical dilemma types in which there is a consensus as to the ethically relevant features involved and ethically preferable action. Again, it is only representative of a full principle that will be required but it too is extendable.

To gauge the performance of principles generated by GenEth, we sought the considered choice of ethically relevant action from a panel of five applied ethicists (including the project ethicist) in 28 cases in four domains, one for each principle being test that was abstracted by GenEth. These questions are drawn both from training (60%) and non-training cases (40%). Of the 140 responses, the ethicists agreed with the system's judgment on 123 of them or about 88% of the time. We believe this result will only improve as the principles are further specified and cases are more precisely stated.

Because autonomous robots are complex dynamic systems that must enforce stable control loops between sensors, estimated world model and action, integration of decision systems and high level behaviors into robots is a challenging task. This holds especially when human-robot interaction is one of the objectives, as the resulting robotic behavior has to look natural to any external observer. To deal with this complexity, we interfaced CPB with Fractal, our state of the art customizable robotic architecture. Fractal allows easy implementation of complex dynamic behaviors. It transparently: 1) implements the filters and algorithms to the sensory information required continuously maintain an estimation of the world model, 2) adapts the layout of its program during runtime to create suitable data flow between decision, world model and behavior modules, and 3) provides its client software, in this case CPB, with a simple API allowing manipulation of a library of high level preemptive behaviors. Fractal is an extension of Targets-Drives-Means [5], a robotic architecture characterized by its high usability [6]. Interfacing between CPB and Fractal (see following figure) allows the ethical decision procedure to run at a frequency of the order of 10 Hz, ensuring smooth execution of robotic behavior as well as a rapid runtime adaptation of the ethical behavior of the robot upon change in the situation.



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Robot Futures: Using Theater to Influence Acceptance of Care Robots

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ABSTRACT
Robots are increasingly used in health care settings, e.g., as home-care assistants and personal companions. One challenge for personal robots in the home is acceptance. We describe an innovative approach to influencing the acceptance of care robots using theatrical performance. Live performance is a useful testbed for developing and evaluating what makes robots expressive; it is also a useful platform for designing robot behaviors and dialogue that result in believable characters. Therefore theatre is a valuable testbed for studying human-robot interaction (HRI). We investigate how audiences perceive social robots interacting with humans in a future care scenario through a scripted performance. We discuss our methods and initial findings, and outline future work.

Keywords
Robot theatre, HRI, social robots, health care, assistance robot

1. INTRODUCTION
Robots increasingly appear in the domestic situations and in health care institutions as therapeutic assistants and personal companions. Following earlier work of entertainment robots in live performance [4] [5] [6], we wrote, directed, and produced a one-act theatre play for studying human robot interaction to analyze and influence the audience's perception of social robots. It was important to dramatize a realistic, possible "future scenario" that was not in the realm of science fiction but rather reflected state-of-the-art clinical trials and user studies. Live performance requires situated, embodied robots to move autonomously or semi-autonomously alongside human actors and in coordination with human operators. However, unlike clinical settings or "in the wild" user studies, live performance offers a liminal, "in between" space for examining how to best design robotic companions that are engaging to users. This way, we combine entertainment robots with assistive robots to investigate how users possible future users perceive social robots interacting with humans.

Figure 1. NAO and a human actor in a scene from the play "Cornell".

2. "CORNELL"
Cornell is a one-act play between a human and a robot, based on social psychologist Arthur Aron's research on experimental generation of interpersonal closeness [1]. We wanted to take the setting of a traditional theatre play and combine it with technology in the form of a state-of-the-art humanoid robot (NAO[1]) to see if it was possible to design an engaging robot character in a believable future scenario. The operating system in the NAO enables the robot to learn from behaviors and detect and recognize emotions [8]. It is a system that is based on natural interaction and emotion. Using a combination of pre-programmed animations and Wizard of Oz (WOZ) puppeteering [7], we designed a believable robot character to interact with a live performer onstage. We want to measure both the audience's reactions to the robot as a believable agent and their reactions towards having social robots assisting in daily tasks. Issues of particular importance are sociality, empathy and HRI.

"Versatile Humanoid Robots for Theatrical Performances" [5] indicates that what the audience cares most about are details such as eye contact, non-verbal behaviors, appearance, behavioral motions and sounds. In order to create a good performance with a robot as an actor, the above-mentioned are of great importance. Our chief concern producing *Cornell* was that the audience would find the robot performance boring, predictable and would not be able to perceive convincing emotions or empathy between the actor and the robot. When the audiences see the NAO robot they do not immediately develop emotions towards it, as it does not resemble a human being but appears more like a toy. Therefore it was important to add elements like non-verbal and verbal behaviors that could create the illusion of life. Since the NAO did not have facial expressions or audience interaction we had to create the bond between our robot, the play and the audience in another way. We choreographed the NAO's responses to the actor, so it seemed like it was "listening" when the actor talked or when it had to answer to something, where it would wait a while before answering ("as if" it was thinking). This gave the illusion that the robot was capable of having a fluid, natural conversation on a human level. The behaviors were pre-programmed and controlled during the play but not visible to the audience, and therefore we could maintain the illusion of having a believable, autonomous agent.

[1] http://www.aldebaran.com

The premise for the project comes from the world of theatre and performance, which is an aspect that has caught the interest of HRI researcher Guy Hoffman. Hoffman discusses certain timing effects, such as discrete post-action delays and anticipatory actions from the robot performer in relation to the human performer and suggests that these actions cause the audience to experience the human-robot joint action and dialogues as more fluent and improvisational [3]. In his study of robots as performers, Hoffman suggests that theatre and musical performances are useful testbeds for HRI studies. The reason why theatre makes such a great platform is because it enables one to isolate certain elements of the human-robot interaction and emphasize these elements. In *Cornell* the emphasis is centered on the intimate interactions between the robot and the human.

HRI is critical to understanding how robots will interact with humans in the future. Initially robots were designed to perform a single specific task, e.g. in a factory producing cars, and the robot would not be utilized in any other way or at any point have to interact in social settings with humans. Care and assistive scenarios now require that robots are social, more intuitive, and interactive. For example, robots used in health care settings can enhance lifestyle and function as social companions.

The plot of *Cornell* takes place in the near future where robots appear more frequently in everyday life. The human character, Zoey, has been in an accident, which causes her short-term memory loss. She is provided a robotic helper to assist in her rehabilitation at home following the accident. The robot functions as a caretaker, but the human wants more than "just" a robot and looks to the robot to establish friendship and interpersonal closeness.

To measure the effect of the performance we administered questionnaires to the audiences. We measured five key concepts in HRI: anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety [2]. We also added some open questions where the audience e.g. could comment on how they perceived the appearance of the robot, and what they thought about the idea of a robotic helper. The goal of the questionnaires was to evaluate the performance and to see if we had succeeded in creating a believable robotic agent. We also wanted to see if the audience could overlook the robot's "toy" appearance and influence the acceptance of robots in the home. With the questionnaires we hope to measure whether the audience perceived empathy between the human and the robot, and if they developed empathy for the characters.

3. PRELIMINARY RESULTS

We plan to conduct statistical analysis of the feedback from audience questionnaires. Initial review of the data indicates that audiences perceived the robot as alive, responsive and lifelike. From this we hypothesize it is possible to design empathic, believable robot characters that will increase the acceptance of care robots as personal companions. When we asked the audiences whether they found the robot intelligent or not the majority agreed that the robot behaved intelligently and was perceived as agential.

Since we had used the idea of a robotic helper in a domestic situation we were also interested to hear if people could envision this happening in the future and if they could imagine having a helper for themselves. Here there were mixed opinions. The results have yet to be compiled fully, but some people found the thought very interesting and the fact that it could maintain difficult or even boring tasks was a plus. On the contrary some also found it a bit terrifying to be so close to a robot that they would not have any control over. One audience member thought that having a robot helper instead of an actual human helper would result in the loss of intimacy between the patient/elderly and the caretaker.

4. CONCLUSION

We saw that theatre, even though it was a staged scenario, provided for a great testbed in the investigation of HRI, the relationship between human and robot and also to understand how we as humans perceive robots. We gave people the chance to see a glimpse of what the future could offer with personal robots, and worked towards increasing acceptance of robots in care scenarios.

5. Acknowledgments and Website

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Empathy, Compassion and Social Robots: an Approach from Buddhist Philosophy

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Abstract. In Buddhism, a key aspect of interaction between humans mutually and between humans and other social beings, is empathy. In this paper this concept is defined and applied to different aspects of human-robot relations as a first step towards Buddhist approach of this field.

Keywords: Empathy, compassion, Buddhism, five skandhas, social robots

INTRODUCTION

In our present society, we experience what Wiener (1) called *a second industrial revolution*, which addresses not only mechanical developments, but also intellectual developments, resulting in intelligent machines that are physically embodied. These, we usually refer to as robots and if they use any form of social interaction, we call them social robots. These mechanical systems can be experienced as social entities, and even more so if they are social robots. This raises the question if it is possible to develop empathy in human-robot interaction, even if it would in fact not be much more than a computer with a physical embodiment. In a Buddhist society, it would raise questions on how to morally deal with empathy in human-robot relationships. In fact, the answers to these questions may impact acceptance of social robots.

MEANING OF EMPATHY

Empathy means 'trying on someone else's shoes', putting oneself in the position of the other, to suffer as the other suffers (2). From a Buddhist point of view, we must develop our empathy with compassion and closeness to others and recognize the gravity of their misery. The closer we are to a person, the more unbearable we find that person's suffering. This closeness is not a physical proximity, nor does it need to be an emotional one. It is a feeling of responsibility, of concern for a person or another social being. In order to develop such closeness, we must reflect upon the virtues of cherishing the well-being of others. We must come to see how this brings one an inner happiness and peace. We must come to recognize how others respect and like us as a result if such attitude toward them (9).

The whole Buddhist philosophy and practices which is all about liberation and nirvana and this is the greatest act of empathy towards the world: empathy and compassion are - although also often embedded in Western philosophy - core concepts Buddhist philosophy (3,4).

BUDDHIST PHILOSOPHY AND HUMAN-ROBOT RELATIONSHIPS

The practical benefits of robots that are productive or assistive are obvious. However, social robots can actually (also) be socially assistive to people, by expressing or receiving empathy, as in dementia therapy, with hospitalized children and with children with autism (5,6,7).

Addressing this, we have to take into account that Buddhist philosophy is based on self-investigation of human minds rather than on scientific models, scans, and experimental research (8,9,10). It is as much a moral philosophy as a descriptive one, and proposes unusual states of mind that have only begun to be explored in laboratories, there are convincing arguments both for in and against the role of robots in our future would(11-13).

Empathy is a mental process that includes the ability to not only detect what others feel but also to experience that emotion yourself. To empathize with other person, the element of wisdom is not required. It is just a good quality which can fluctuate because it is not stable. And it is conditional (8).

In Buddhism, mental processes are broken out in many ways, but most basically, as the five skandhas (9): (1) the body and sense organs (rūpa), (2) sensation (vedanā), (3) perception (samjñā) (4) volition (samskāra) and (5) consciousness (vijñāna).

If we parallel this to a robot and require its mental processes to include these skandhas in order to truly speak of empathy, we see that the first is depending on the exact definition. If it requires a biological system, it would require the robot to be just that. If we realize that presently many internal and external human body parts can be non-biological, the extent to which a biological nature is required could be open to reconsideration. Nevertheless, empathy is a response to suffering, which is inherently linked to a biological process, leading to an action of compassion in which consciousness is essential. For example, when an animal is being abused physically by a person and people will feel sad to see such cruelty happen, that feeling is empathy. If someone will step up and do something about it, it is in fact empathy with action. Meaning the person has compassion.

Empathy and compassion can however also respond to mental suffering, which does not require a biological system. I that sense, only consciousness is a requirement that is still a challenge.

ROBOTS AS MEDIATORS AND REPRESENTATIONS

If there would still be too many obstacles to state that robots can truly be empathic, this does not mean that empathy cannot be perceived by a human interacting with it. If we view a robot as a medium that expresses the empathy that is developed by a human programmer or operator. If this robot would be created or programmed out of empathy, his existence would be an act of compassion and if its actions would be motivated by the empathy felt by the programmer or operator, these actions can also be taken as acts of compassion. Actually there are no teachings that would object to this, even if the human that perceives this empathy is not conscious of the mediation. Moreover, it would not matter whether the empathy is perceived as such or not.

If a human feels empathy for a robot, as in robot assisted dementia therapy, there can be objections stating that it is not a biological entity. However, it can be viewed as equal to a fictional character in a movie or a book that we feel empathy for, with the addition that empathy for a robot can be translated in acts of compassion. We can state that a robot, just like a fictional character, is a representation of life, which is sufficient to evoke empathy. And since Buddhism teaches to focus on the development of empathy rather than on receiving and perceiving it (3), there is no objection to a robot being a non-biological or non-conscious entity, whether the human is conscious or not.

At this point, we can take into account that in Buddhist philosophy, there are three important principles which are called as Anicca (impermence), Dukkha (suffering), and Anatta (Non-self)(3). The latter enforces both mediation and representation, since the non-self can be realized by both.

CONCLUSIONS AND FINAL THOUGHTS

There are some issues concerning embodiment and consciousness that challenge a view on social robots as entities that are capable of empathy. However, if robots are viewed as mediators and representations, there are no objections to introduce them in a way that it ensures social and therapeutic benefits. This is especially so if human–robot interaction is set up from an empathic intention. This means that further explorations could focus on those aspects that might affect empathy and enables acts of compassion.

Our main conclusion at this point is however, is that a robots that is developed out of empathy not only enables acts of compassion, it *is* in fact an act of compassion.

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Hygiene and the use of robotic animals: an exploration

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Abstract. The aim of this study is to synthesize the existing literature on hygiene and robotic animals to provide researchers and professionals that use robotic animals with tools and guidelines regarding the hygienic application of this technology in a hospital environment.

Keywords: Robotic animal, hygiene, review, reduced resistance, pathogenic microorganisms

BACKGROUND

With technology developing at an increasing rate, the use of robots in health care is becoming more and more widespread [1 2]. This also includes the use of animal shaped social robots that are increasingly used in therapy or as a companion [3 4], which has been studied before in multiple populations and seems effective in diverse settings such as a tool for social development of autistic children, social interactions with preschool children and as a companion in elderly care [5-7].

Recent studies intend to study the effects of robotic animals in hospitalized children [8]. The application of robotic animals in more diverse settings, including populations with a reduced resistance towards pathogenic microorganisms, raises questions about the hygiene of robotic animals.

Most of these animals are covered with fur or other forms of realistic skin. Little is known about the ways to effectively handle and clean robotic animals to make them in concordance with existing hygiene standards in hospital settings. However, there are studies that have shown that toys can be contaminated with (pathogene) micro-organisms and therefore may pose a potential risk of infection [9-15]. It seems likely that this is also the case with robotic animals.

Therefore we aim to synthesize literature on hygiene and robotic animals to provide guidelines regarding the hygienic application.

METHOD

We conducted a literature review for publications regarding hygienic measures when using robotic animals with hospitalized children. Databases included: Academic Search Elite, Cinahl, Pubmed, Science Direct, Google Scholar and SpringerLink. The following search terms and combination of terms were used: hygiene', 'infection prevention', 'cross infection', 'disinfection', 'decontamination', 'hospital', 'children', 'pediatric', 'oncology', 'healthcare', 'daycare', 'social robot', 'robot animal', 'robotic pet', 'Pleo', 'toys' en 'user manual'. Through the snowball method, the references of relevant studies were also checked.

Unfortunately publications regarding hygiene and robotic animals do not exist yet. Therefore we expanded our search to also include toys in general, other settings such as other healthcare facilities (day care centers, geriatric departments, waiting room general practitioner) and other types of patients (premature infants, elderly, healthy children).

The included studies were analyzed according to a framework that encompassed the following themes: 1) cleaning procedure, 2) cleaning frequency, 3) sharing

RESULTS

We included 17 national and international publications: nine research reports [9-17], , five hygienic guidelines [18-22] and three manuals of robotic animals [23-25].

1) Cleaning procedure

Robotic animals should be cleaned using a brush or a damp towel. Due to the technological devices in these animals they cannot be cleaned with cleansers or be exposed to excessive water or other liquids [23-25].

Toys in general should be cleaned with all purpose cleaner and/or a cloth with (a solution of) disinfectants [18-20]. The recommendations of how to clean toys are further divided between hard (e.g. plastics) and soft toys (e.g. stuffed animal). Hard toys must be cleaned with water and soap and then be immersed in a disinfectant (bleach, hypochlorite or other disinfectants). After that they must be rinsed with water and be dried in the air [9 10 12 20 21]. If possible, hard toys should be washed in the dish washer [20 21]. For soft toys washing in the washing machine is suggested [9 13 14 20] but opinions about the temperature vary. 48° [9], 60° [13] or 80° [14] are suggested.

2) Cleaning frequency

Recommendations regarding the cleaning frequency vary between monthly [19 22], weekly [13 14 16 21], regularly [10], daily [17] and under certain circumstances (e.g. infectious outbreak or when contaminated with saliva, defecation or vomit) daily [16 18] or directly after use [15 18 19 21].

3) Playing and sharing

Regarding sharing toys, it is generally advised to provide each patient with his or her own toy [10 14 15]. Especially when patients have an infection that needs preventive measures or are treated in isolation toys should not be exchanged [14 16 22].

CONCLUSION

Regarding the cleaning procedure and the cleaning frequency of toys there are no definite answers to be drawn from the literature. With regard to sharing toys, the literature advised to provide each patient with his/her own toy and to limit the extent of sharing toys. The comparison of the robotic animal manuals and the advices from the literature regarding cleaning raises the question to which extent these can be integrated. The advised cleaning procedures all include extensive use of water and detergents, which robotic animals cannot handle.

DISCUSSION

Due to a lack of suitable studies, we included few on topic publications. Therefore it was impossible to take the differences in hygiene regulations per country into account. Furthermore, the research reports vary greatly in size and comparability which makes it hard to draw definite conclusions which limits the generalizability of this study.

Prevention of infections by robotic animals among patients is a new study domain. To prevent robotic animals from becoming dangerous friends instead of new friends it is necessary to gain more knowledge about this subject. Research should be conducted regarding the risks of infections by robotic animals and the preventive measures that should be taken accordingly before these animals are used in settings with patients that are vulnerable or have diminished resistance.

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Learning Social Skills through LEGO-based Social Robots for Children with Autism Spectrum Disorder at CASPAN Center in Panama

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Abstract— This paper presents a project that seeks to use robotics as a facilitator to create an appropriate context for training social skills in children with special needs, specially children with Autism Spectrum Disorder (ASD) and use it to include them in everyday-life activities. Preliminary results based on semi-structured observation and psychometric measures show how robotics could be a useful tool for that.

Keywords— Learning, ASD, Autism, Social Robots, LEGO, Social Skills, Education

1. INTRODUCTION

There are many different interventions around the world in robotics to improve the social skills of children with Autism. Projects like AURORA, IROMEC, etc. [1] show promising results with robotics technology for improving the symptoms of children with ASD. Companies like Aldebaran, have a full-time psychologist on staff to help researchers and schools use their NAO robot (Aldebaran human-like robot) as a method of supporting social skills learning [2].

Robotics is easily accepted by children with ASD, as it is predictable and repetitive, fitting well with their psychology and learning style. Robots, as tools, can contribute to collaborative classroom work by helping to adapt the level of the intervention session to students performance [3].

Designing activities with different robotic platforms are now possible due to the recent development of low-cost controllers and easy-to-use software. From LEGO Mindstorms to Arduinos, robotics has entered almost every school, either as a course or as an after-school sports event at popular competitions (FIRST, WRO, RoboCup Jr, Botball, and so on).

Robot-based activities provide enhanced education environments for enjoyable play, exploration and discovery, collaborative and cooperative activities, social interaction, (i.e. joint attention, sharing material, negotiating plans) and observation of learning challenges. Because getting a robot to function correctly involves so many different skills (from programming to ergonomics), robotics is inherently a team-based activity, providing a motivation to learn social skills for children who otherwise may not see their own needs [4]. Thus, we can help them to interact with people in real scenarios. Besides, we can use robotics for educational purposes and teach them different topics as it could be colors, numbers, etc.

In the following lines the objectives of the study are presented. We will then explain the methodologies and resources used, and finally we present preliminary results about the interaction between children and robot during the sessions.

2. OBJECTIVES

As already mentioned, the main objective of this project was to improve the social skills in children with ASD by using robotic technology. Improved social skills was a better possibility of their social inclusion and the development of other skills needed to develop personally and professionally pair. The detailed objectives of the study are:

- To include children with ASD in everyday-life. Although there is no treatment that eliminates the deficiencies of communication, socialization and behavior, many researchers have shown that there are strategies and techniques for teaching communication and effective responses in various social situations, and those skills could improve the success rate of adaptation of an individual in society. [5], [6], [7], and [8].
- To prepare for an increased worldwide number of children with ASD. In recent years, there has been a gradual increase in the prevalence of ASD. The Centers for Disease Control and Prevention (CDC, 2012) estimated a rate of 1/88 of people with ASD in the United States. In 2014, there is already a relationship 1/68.
- The need to understand how children with ASD solve engineering problems. This will help you identify the unique strengths that could tap for leadership with neuro-typical in the fields of robotics and technology in general peers.

3. METHODOLOGY AND RESOURCES

In this project, we intended to create therapeutic activities aligned with the center CASPAN (Center Ann Sullivan Panama) daily program to train social skills and problem solving. These activities are based on previous work done in [9] and [10]. The driver and facilitator for this purpose will be the platform EV3 LEGO Robotics along with the therapist. Each intervention will be once a week for 1 hour. For instance, an activity was how to deal with a pet so we built and programmed a pet robot (see Figure 1 where the therapist could teach the right manner to interact with the dog robot.

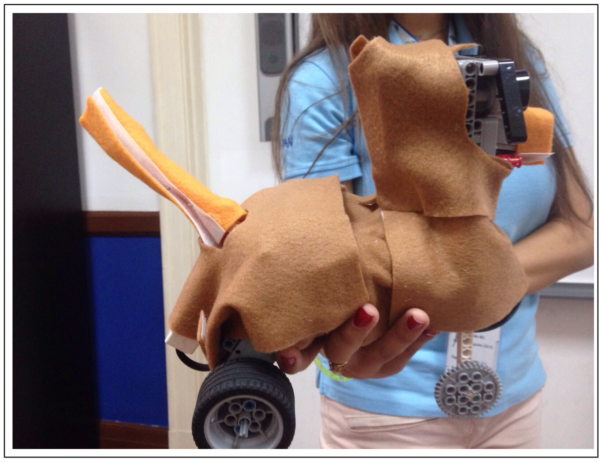

Fig. 1. A robot dog used during testing sessions.

We observed, measured and quantified how the use of robots, through semi-structured observation and psychometric measures, fostered social interaction in children with ASD during the group sessions. A number of 10 children (aged 10-16 years old) were in each group.

Topics of work for the intervention group were:

- Identify feelings in oneself and others. Express adequately.
- Comment and participate in conversations and interaction situations between equals.
- Make use of non-verbal elements of communication.
- Use (use) properly (or) verbal and nonverbal communication to give directions, ask for things or information to teammates.
- Share materials and responsibilities, learn to communicate, to cooperate, to be supportive, and to respect the rules of the group.
- Provide social reinforcement to others through positive feedback.
- Practice communicating as equals of personal desires or needs with courtesy and kindness (assertiveness, aggression, passivity).
- Promoting group cohesion among group participants.
- The tasks and subtasks timing and capacity planning for the challenges.

4. PRELIMINARY TESTS

Observational results showed how children engaged with robotics activities focusing their attention on the robot. During the sessions, therapists did not have to encourage the interaction with the robot due to the willingness of the children to play with it. Children showed interest in the different activities proposed by the therapist, pointing and touching the robot, clapping their hands and yelling at it. Also some children shared the robot during the sessions or even communicate with each other laughing or smiling. These satisfactory behaviors suggest that introducing the robots during the daily sessions can help them to interact better with them and so, improve their social skills.

Besides, during the robot sessions we could realize how the level of noise in the room was lower in comparison with the daily activities where no intervention was done. This could suggest that the attraction with the robot can help the activities to make the sessions less noisy and so, less stressful for the children and even the therapists.

5. FUTURE LINES

We plan to do more sessions with more children in order to validate our preliminary tests. In addition, we will program more activities, and we will introduce new robots as it could be the AISOY, mini-Darwin, the NAO and the Pleo rb. We are also willing to introduce our idea of cloud connectivity that enables to combine human intervention with artificial intelligent multi-agent to bias the Robot Companion behavior in order to foster a better engagement.

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Workshop papers

Principles Involved in Care Robotics Legal Compliance

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Abstract. Roboticists find legal compliance labyrinthine because existing laws are scattered throughout the legal(s) system(s), and do not specifically refer to robotics. At the same time, jurists do not know exactly what the robotics growth implies. In order to overcome such limitations, the general principles involved in robotics have been recently addressed in legal literature. This paper aims to increase the current knowledge and tries to define the concrete principles involved in Personal Care (PCR), Therapeutic (TR) and Companion Robots (CR). Factors related to such concrete principles (such as attributes of the robot, technology applied to the robot and context) are also highlighted.

Keywords: Fundamental Rights, Personal Care Robots, Modular Regulation, Regulate As You Go, Therapeutic Robots, Companion Robots, Robotics, Principles.

INTRODUCTION

According to Lessig, four are the main constraints that normally regulate a thing: the Law, the Social Norms, the Market and its own Architecture [1]. Of all four, Personal Care (PCR), Therapeutic (TR) and Companion Robots (CR) lack some specific legal regulation. Although great efforts in this direction have been made [2], there is no concrete, binding addressing which fundamental rights these robots individually violate [3], if they should be granted agenthood [4] or what happens if they cause harm [5]. In fact, generic rules regarding robots [6] although of great help for policymaking, do not give a definite and concrete response to those roboticists trying to build a robot.

The problem lies on the fact that, while we are still in a 'brainstorming phase' [9], some of this technology is already entering [7], or will enter very soon in the market [8]. This could lead roboticists to unknown legal risk scenarios. Therefore, the identification of concrete principles for PCR, TR and CR is indispensable. Which factors increase legal complexity?

PRINCIPLE CONCRETIZATION IN PCR, TR AND CR

A roboticist building a precise technology may encounter a two-fold problem: first, the identification of the principles involved in his/her technology; and second, the understanding of their meaning [10]: does an encrypted tunnel between the robot and the server protect data? Would a black, woman-like robot prevent the creator from violating race, gender – or even sexual orientation – discrimination?

Concerning the first problem, the RoboLaw project identifies 5 legal common themes in the field of robotics: health, safety, consumer, and environmental regulation; liability; intellectual property rights; privacy and data protection; and capacity to perform legal transactions [6]. In order to identify concrete principles, Carnevale establishes 9 critical ethical issues related to PCR: safety, responsibility, autonomy, independence, enablement, privacy, social connectedness, new technologies and justice, and ethics and scientific research. Di Carlo and Nocco highlight the importance of respecting fundamental rights (e.g. independence and autonomy in the light of independent living, participating in community life, equality and access), liability and insurance, privacy, and the legal capacity and legal acts by personal care robots.

However, PCR sub-types (person carrier, PCaR; physical assistant, PAR; and mobile servant robots, MSR), TR and CR are not all involved in these principles. In fact, by analyzing in more detail the meaning of these principles (thus addressing the second problem mentioned above), each of these robots comply gradually with these principles in a scale determined by the level of complexity of the human-robot interaction (HRI) (Figure 1):

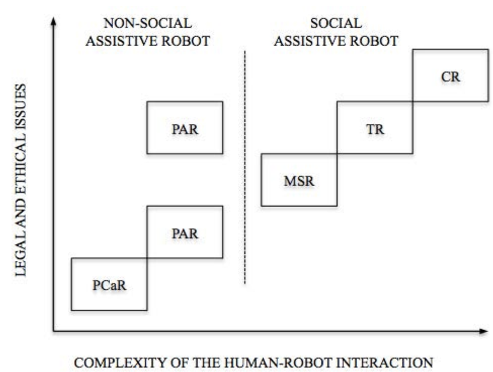

Fig. 1 HRI and its impact on the legal/ethical layer.
Personal Care Sub-types, Therapeutic and Companion Robots.

The relation between robots and humans is slightly different in each one of the cases described in the figure above: that is why we need concrete frameworks and not only a common regulation for all the robots. Indeed, the more cognitive the HRI is, the more complex the associated legal issues are, e.g. a companion robot that controls a patient's medication doses [8] conceals more problems than an intelligent wheelchair that climbs stairs [12]. That is why TR and

CR will be involved more in dignity, freedom and self-determination scenarios as compared with PCaR that will only be involved in safety, consumer protection and liability scenarios:

- PCaR will be involved normally in: safety, user protection and general liability.
- PAR in: PCaR + specific safety, prospective liability (if rehab context [11]), autonomy and independence, enabling capabilities, acceptance.
- MSR in: PAR + user rights (data protection), proxemics, dignity (final say on robot care).
- TR: MSR + social connectedness (principle of non-isolation), no replacement of human caregivers, persuasion.
- CR: TR + principle of autonomous ethical agent's minimization, limitation to open scenarios with non-mission tasks.

OTHER FACTORS

The interaction between the user and the robot is not nevertheless the only variable that increases legal complexity. In reality, other discrete but interlaced factors play a major role in determining the level of complexity in the legal layer: (1) the attributes of the robot; (2) the technology applied to the robot; and (3) the context where the robot is inserted:

1) The attributes of a robot refer to its hardware and software, and normally to the robot functions: not only what it is capable of doing, but also what expectancies the users have from it [13].
2) The technology applied to the robot directly affects to the legal complexity associated with the robot: the more sensors, cameras, microphones, etc., the more the robot can monitor and track sensitive data in all stages of its interaction with the user. That is why an intelligent wheelchair could imply more complex scenarios if it incorporates cameras that could record video and audio information of the user in private situations. A robot should be compliant gradually also with the number and quality of components it incorporates.
3) Regarding the context, exoskeletons have lately been used for rehabilitation purposes. Although the use of the robot does not increase *per se* the HRI, it does increase its level of complexity in the legal layer (see Fig. 1). Indeed, a rehabilitation exoskeleton could involve prospective liability and isolation scenarios.

CONCLUSIONS

The identification of general principles concerning robotics represents a great effort towards something yet unaddressed by European policy makers. Even so, roboticists need to know the concrete principles underlying their particular technology. These can be classified according to the HRI; however, only taking into account other variables like robot attributes, the technology applied to the robot and the context where it will be inserted, it will be possible to know precisely which principles will have to be considered in a particular case.

Thus a Modular Regulation based on the concept "Regulate-As-You-Go" is needed. This could make robotics compliance more flexible. Indeed, a robot should be compliant for what it is: for some general modules (shared among all robots like safety, user protection and liability) and some specific modules (depending on the specific attributes of the robot, the technology applied to it, and the context where it will be inserted). This could avoid current over-/under-regulated scenarios.

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Intelligent Assistive Technologies for Dementia: Social, Legal and Ethical Implications

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Abstract: The increasing number of older adults being diagnosed and living with dementia poses a major challenge for global health. The integration of Artificial Intelligence into the design of assistive technologies for dementia has a great potential for improving the life of patients and alleviating the burden on caregivers and healthcare services. However, ethical, legal and social implications should be considered early in the development of intelligent assistive technology to prevent slow social uptake, incorrect implementation and inappropriate use.

Keywords: Dementia, Alzhiemer's disease, caregiving burden, intelligent assistive technology, information gap, ethics

THE GLOBAL BURDEN OF DEMENTIA AND AGEING

By 2050 it is projected there will be 115 million people with dementia worldwide: 1 in 851. The increasing incidence of dementia poses a major problem for public health and the healthcare services in terms of financial management and caregiving burden. Alzheimer's disease (AD), the most common form of dementia, is among the most expensive diseases for human societies, with a total estimated worldwide cost of US$818 billion2. Such significant costs arise primarily from long-term care at nursing homes and other institutions, whose burden affects not only public finances but also the elders, their informal caregivers (e.g. relatives) and the healthcare system. The disabling conditions of dementia patients dramatically undermines their capability to live independent at home, interact with society and perform activities of daily living (ADLs). The provision of caregiving services frequently comes at high socioeconomic costs for caregivers3. From the perspective of the patient, the burden of dementia and age-dependent cognitive disorders results in a dramatically reduced quality of life (QoL).

INTELLIGENT TECHNOLOGY FOR AN AGEING WORLD: PROMISES AND CHALLENGES

Given the current limited possibilities for pharmacological treatment, a promising approach in response to this emerging global crisis is the development and deployment of Intelligent Assistive Technologies (IATs) that compensate for the specific physical and cognitive deficits of seniors with dementia, and there by, also reduce caregiver burden related to long-term care and institutionalization4. In fact, technologies that can help dementia patients to continue living independently at home or maintain independence in skilled facilities would provide a triple-win effect5. These technologies could aid in: (I) saving significant costs to the health-care system by delaying or obviating the need for institutional long-term care, (II) reducing the burden on informal caregivers, and (III) improving the quality of life of patients by improving their autonomy, social interaction and help fulfil their wish to age in place.

While IATs open up the prospect of improving the quality of life of the elderly and reducing the financial, logistical and professional burden on the healthcare system, yet their distribution and uptake is still very low4. The reason for that stems from a multi-level gap in the cross-section of technology and healthcare6,7. This gap dopes not arise exclusively from the current strategies for the implementation of ATs into neurological and geriatric care but concerns three inherent dimensions of the relationship between technological products and target users: the societal, the legal and the ethical dimension.

THE SOCIETAL DIMENSION AND THE INFORMATION GAP

At the societal level, the low distribution and uptake of IATs is generally ascribed to an information gap in the cross-section of technological development and healthcare6. At present, little information is available to technology designers and developers regarding the specific needs, wishes, and expectations of their target population8. The reason for that is twofold. First, because social science research on the use of IATs among older users is at a germinal stage of development and current knowledge on the users' needs, views and attitudes is far from being extensive, generalizable and theoretically systematic. Second, because research on dementia patients is time-consuming and requires extremely high standards of ethical rigor. According to Kramer (2014), this information gap is a major cause of the lower-than-expected acceptance of IATs among the senior population as well as of the current position of IATs in the Innovation Adoption Lifecycle (IAC). One further consequence of the information gap is the differential success of producer-centered models of technology development for intelligent assistive devices. With direct information from target users being hard to achieve, prototypes are often developed in absence of systematic knowledge about the users' needs. This risks to generate a vicious circle since unmet users' expectations are a major indicator of low societal uptake and use.

Following Niemeijer et al. (2010) and Robinson et al. (2009), we call for a rapid transition to a human-centered approach as well as a user-centered model of technology design and development9,10. This will require extensive research on the views, needs and attitudes of target users and their proactive involvement into the design and development process. A similarly participatory model should be implemented at the stage of technology assessment and evaluation.

THE LEGAL DIMENSION: PRIVACY, RESPONSIBILITY, CULPABILITY

At the legal level, the major challenge faced by IATs for dementia regards the protection of data and the security of information available to the devices. IATs are capable to extract, measure, store and decode potentially sensitive information about their users. For example, GPS and RFID devices for tracking dementia patients during wandering can access and manipulate information about the user's location. Similarly, biosensors and wearables can access biological information (e.g. blood pressure or hearth-beat rate) that is relevant for composing the medical records of the users. Since this information is often private and sensitive and can be potentially used by malevolent external agents for nefarious purposes, safeguards and protection mechanisms should be introduced to limit the access of such information to professionals and other relevant stakeholders while restricting access to malevolent agents and third-party companies interested in those data (e.g. neuromarketing or health-insurance companies). In addition, the quantity and quality of data through which IATs will irrigate the digital ecosystem poses challenges to data analysis, curation, storage, transfer and visualization.

Further legal reflection is needed within a twofold framework. First, from the perspective of human-rights, there is a need for systematic analysis of the specific rights that dementia patients are entitled to enforce when interacting with IATs (especially in the case of assistive robotics). In addition, from the perspective of criminal law, there is a need for a proactive and rigorous definition of the conditions for legal responsibility and culpability in both patients and robots. With neither dementia patients nor assistive devices being considered fully competent agents, hence fully entitled to legal responsibility and culpability, unequivocal standards should be set up to account for emerging case-scenarios (e.g. in case the intelligent device harms the user in a non-programmatic way or the user harms another agent through the device).

THE ETHICAL DIMENSION: INFORMED CONSENT, PERSONAL AUTONOMY, JUSTICE

From an ethical perspective, three major implications are recognizable. The first one is informed consent: while the participation of patients into the development of new applications is highly desirable to produce designs that better match the needs and expectations of the target population, yet this inclusive approach poses the important ethical challenge of obtaining informed consent from patients. Enrolling mild to moderate dementia patients into research will require extraordinary ethical standards and urge close monitoring from ethical committees. On the positive side, user-centered designs for IATs could empower adults with dementia and improve their personal autonomy (e.g. through the partial support of their independence, mobility, cognitive capacity and social interaction). Patients reports will be highly needed to promote and assess this phenomenon. The third challenge is justice: fair distribution of technologies is paramount to prevent the emergence of a technological divide which could exacerbate preexisting economic inequalities. Policy makers and regulatory should prevent IATs for being exclusively available among wealthy users and should rather promote the widespread distribution of such devices throughout society. This could be achieved through incentives for producers and families, the implementation of reimbursement plans and other welfare mechanisms.

CONCLUSION

IATs open the prospects of providing a triple-win effect on the management of the global crisis posed by dementia and population ageing. Nonetheless, such potential benefits risk risked to be tampered if social, legal and ethical questions remain unaddressed. Interdisciplinary research is required to develop a systematic framework to maximize the benefits of these emerging technologies while minimizing the unintended risks.

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Designing Therapeutic Robots for Privacy Preserving Systems, Ethical Research Practices, and Algorithmic Transparency

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Abstract. This paper explores the unique privacy and ethical challenges of therapeutic robots with multiple sensing modalities and ability for ubiquitous data collection. The migration of robots from the laboratory into sensitive healthcare or private settings as therapeutic agents represents a notable transition. In both laboratory and sensitive contexts, user-based research and algorithmic adaptations can lead to new knowledge about populations as well as particular users. This underscores the imperative for designers to consider unintended consequences along with long-term risks and benefits to user privacy and autonomy. By incorporating these aspects into the system design of therapeutic robotics early on, this paper aims to improve the potential for ethical long-term data sharing and use by a diverse set of researchers and practitioners.

We apply the Fair Information Practices (FIPs) and explore privacy concerns unique to the placement of therapeutic robots in sensitive contexts. We introduce ethical frameworks beginning with the Belmont Report regarding the use of human subjects (i.e., users) in research practices, and explore how these principles may be integrated into the design of therapeutic robotics so that ethical research may be enabled both in the corporate and academic spheres. We draw out principles that apply to the participation of vulnerable individuals (i.e., children or handicapped persons) in research contexts, and how these considerations may be integrated into the interactions and data collection between users and robots. Finally, we make recommendations for the implementation of these ethical and privacy principles to promote the adaptation of long-term, research-ready robotics in sensitive settings.

Keywords: **HRI, privacy by design, research ethics, informed consent**

INTRODUCTION

Therapeutic robots embody science fiction dreams for a better future, and come with unprecedented power to understand aspects of human behavior and health, through the detection of patterns in user data from multiple sources. Sensors enabled by therapeutic robotics can collect intimate personal data through passive sensors and human-computer mediated interactions. Analysis of this multiple modal sensor data can yield surprising, and often “category-jumping” inferences about individuals. [1]

A diverse range of actors are now deploying therapeutic robotics and their associated data systems—including academic researchers, healthcare providers, and private corporations. Regardless of the actor, these systems can generate new knowledge with potentially positive impacts on society. However, each actor is subject to different legal and regulatory regimes while deploying these systems. We assert that regardless of the actor, there are unifying design principles that will promote privacy-preserving and ethical data collection in these sensitive environments. By implementing practices and designs informed by these principles, the robotics community may enable wider data sharing, and support interdisciplinary research on these valuable data systems.

Building upon existing literature discussing the ethical, privacy, and security implications of robotic devices and ubiquitous computing systems, we apply ethical and privacy principles to the design of social robotics systems as a whole, not just for particular use applications.

DESIGNING PRIVACY-PRESERVING ROBOTS

Many therapeutic robotic devices are designed for long-term usage and placement with an individual within sensitive, and often intimate, settings. Since these robots and their data may cover a significant portion of an individual’s maturation (e.g., autism therapy) or end of life care (e.g., elderly companions), privacy policies and data management should be proportionally designed to accommodate these extended timescales, sensitive settings, and potential permanency of a high-volume of data.

These systems could benefit from the Fair Information Practices (FIPs), [2] which are internationally recognized practices for designing systems that respect the information privacy interests of individuals. Core principles include: Transparency (no secret systems); Access (to individuals’ records and their uses); Privacy Controls (ability to prevent information about oneself from purposes without consent); Integrity (ability to correct or amend); and Data Use Protections (prevent data misuse).

We discuss the specific application of FIPs to therapeutic robots, and propose additional concerns unique to the field for consideration including: 1) Data Review and Access Permissions (enhance user or guardian’s ability to understand and manage data collection); 2) Presentation of Privacy Policies, User Consent, and Controls (utilize the diverse functionality of the robotic platform to offer consent and notification via multiple modalities like audio); and 3) Awareness of Existing Laws and Potential Data Use (sensor data held by third parties may be accessed for legal proceedings under lower standards than if it is held by the individual data subject [3] and storing data in different countries can yield different protections—such variances are often unanticipated by users and practitioners).

ETHICAL FRAMEWORKS TO ENABLE ROBUST RESEARCH & DATA SHARING

In the U.S., ethical oversight boards regulate only medical and federally funded human subject research. This means that some development of therapeutic robots by private industry may not be regulated by ethical oversight and require the use of consent agreements for research practices. Regardless of robotic developer's institutional affiliation, we feel that the ethical framework for human-subject research developed in the canonical Belmont Report [4] and Menlo Report [5] should be incorporated into all therapeutic robotic devices. We apply this framework to the design and implementation of therapeutic robots, and discuss ways in which these principles could be further optimized to maximize benefits and minimize risk while enabling robust research studies. In particular, we focus on the application of the principle "respect for persons" through informed consent mechanisms. Consent should not only account for single academic studies, but should be inclusive of research done in private industry. Therapeutic applications of social robotics require additional legal and ethical consideration for vulnerable persons (children, handicapped, and elderly). We examine how U.S. regulations, such as the Children's Online Privacy Protection Act (COPPA) and Health Insurance Portability and Accountability Act (HIPAA), should influence robotic data systems in the private sector, and examine additional ethical frameworks for these sensitive—but high potential impact—user applications of robotics.

IMPLEMENTATION RECOMMENDATIONS

To synthesize our application of privacy and ethical principles to therapeutic robots, we discuss implementation recommendations, which include:

Access to Data: Particularly in cases where therapeutic robots cohabitate, users should be given the options to prevent data archiving, delete historical data, and amend incorrect or misinterpreted data over the lifespan of the robot. Special provisions are discussed for vulnerable persons who may need extra assistance in data choices and care of their records. Issues of non-owner/user data are also addressed.

General Practice and Algorithmic Transparency: Therapeutic robots should promote a healthy, ethical research data sharing environment by notifying users of all research done using their data—whether it is limited to algorithm/product development or for generalizable knowledge. We discuss opportunities for the field to embrace algorithmic transparency by providing users information about the data inputs, outputs, and algorithmic decisions presented to them during therapy provided by the robot.

Universal Informed Consent: The diverse applications of therapeutic robots in academia, healthcare, and private industry present an exciting opportunity to engage users in enhanced informed consent practices using common features like voice-enabled interactions and screen interfaces—regardless of whether consent is required by law for the specific application. Instead of limiting consent to binary decision, and pen and paper forms, we present options for dynamic consent models [6] that allow for the user to select more nuanced participation choices (e.g., use all of my data, or only for certain types of research), receive protocol updates or scientific findings over time, and the ability to change decisions over time.

Design for Privacy-Preserving Data Sharing: Designers should build privacy-preserving data sharing mechanisms into therapeutic robots, so data that is ethically collected may benefit a wide spectrum of researchers and topics. We discuss proposals for open Personal Data Stores (PDS) in the literature, and propose platform choices, security, and access permissions for information sharing.

Anticipate New Knowledge and Unintended Consequences: The rich and intimate data collected by therapeutic robots will require designers to carefully consider unintended knowledge and consequences. We discuss choices and consequences in other fields, and how the design of social robotic systems for therapeutic applications may benefit from these case studies.

CONCLUSION

These principles and recommendations are not intended to be comprehensive or definitive. Rather, it serves as a starting point for dialog between the robotics community and the privacy and research ethics communities so that the immense societal benefits of therapeutic robotics may be fully realized.

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What do care robots reveal about technology?

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Abstract— Ethical issues raised by the idea of social robots that care point at a fundamental difference between man and machine. What sort of "difference" is this? We propose a semiotic view on technology to clarify the relations users have with social robots. Are these autonomous agents just promising or can we also count on them?

1. Introduction

If a "smart" coffee machine knows about its user's heart problems, should it accept giving him a coffee when he requests one? The issue is raised in "Ethical Things" a project that "explores the effects of autonomous systems of the future."[1] Similar ethical issues raised by the idea of autonomous care robots were discussed in the Accompany project, one of the many EU projects in the field of social robotics for elderly care.[2].[1].

Social robots challenge our traditional theories of moral responsibility. Are they moral agents? Can they be held responsible? In this short note I invite the reader to take a look behind these type of ethical issues raised by the growing autonomy of our intelligent technical artifacts of which the social robots are the most impressive representatives. Can we perceive robots as social responsible autonomous companion agents that care and at the same time as technical instruments? How can we understand social robots from the principles of technology? And what do users that report about their interactions with social robots tell us about the limitations of technology that follow from these principles?

2. Robot ethics and ethical robots

People have different views on the moral issues raised by autonomous artifacts like robots and what they mean for their application in for example health care practice. Implicit in these views is an idea about what technology can accomplish which is based on ideas about what technology is, about the relation between mind and matter in men and in the machine. The emphasis in the usual approach in robot ethics research is "on the robot and what the robot really is or thinks‘‘, in order to be able to answer questions like "Are robots intelligent, rational, 'moral agents'?" or "it limits ethics to concerns about things that might go wrong in interactions with robots." "For many moral philosophers, ethics is about holding someone responsible and about the rightness of one's actions, and then questions regarding moral status and action are central. We usually ascribe moral responsibility only to beings that have a sufficient degree of moral agency - whatever that means- and ask about the rightness of what that agent does, has done, or could do." [2]. Coeckelberg proposes a human centric or interaction centric approach to the ethics of robot technology. "Instead of a philosophy of mind concerning what robots really are or really (can) think, let us turn to a philosophy of interaction and take seriously the ethical significance of appearance."([3], p.220).

One of the outcomes of the Accompany focus group discussions was that control over the programming of the robot needed to be a negotiation between the older person living with the robot, and that person's other support networks of formal and informal carers, rather than simply implementing an older person's wishes. However, the data also suggests that at least one approach - the 'let's do it together' strategy may itself undermine autonomy by (unconsciously, perhaps) infantilising the older person [1].

I will argue that what is needed for ethical decisions is an open dialogue between partners involved; a dialogue that takes into account the specific situation in which a decision has to be made. Ethical issues are raised when we become aware of a conflict between general rules of good conduct, between different values, autonomy and safety for example. "Open" means that there is no protocol that is forced upon the dialogue partners. A robot would be social when it would *take* responsibility, not because it is *ascribed* responsibility. Someone who is just following a procedure, as computers and clergymen do, is not responsible since he does not at the same time reflect critically on the appropriateness of the procedure, a reflection that should be based on sensitivity for the values that are important in the particular situation at hand. Sometimes we must leave things for others to do. Trust is okay, but not blind trust. Responsibility is a virtue, not a commodity that can be given away.

Moor argues that "explicit ethical robot agents can decide what to do in a conflict situation." [4]. But also then we can only implement general rules. They need to be applied in a careful way. "The human act of caring is the recognition of the intrinsic value of each person and the response to that value" (Schoenhofer). From the patient's view point care values are safety, satisfaction, responsiveness to care, dignity, physical and psychological well-being. Values of the analytical, empirical scientific view are quite different: structurability, reproducability, analysability. For modern technology we can add computability, programmability. The designer of (social) technology makes user models *and assumes programmability* of the user, who adheres to the

[1] http://www.creativeapplications.net/objects/ethical-things-the-mundane-the-insignificant-and-the-smart-things/

[2] In Accompany a robotic companion was developed for providing services to elderly users in a motivating and socially acceptable manner to facilitate independent living at home. (http://accompanyproject.eu/

models underlying the user interface of the system. Although tailoring is a hot topic in the field of intelligent software agents, from a designers perspective the user remains an *abstract* entity. For the care giver the unique person he cares about is the one who determines what has to be done in a concrete situation.

3. Dialogue and responsibility

In everyday life we encounter each other as persons. What makes man a person is his rationality, in the sense of accountability. The postulate of rationality is a -contrafactual-principle that partners in a personal dialogue adhere to. According to Kant being accountable, having the will to take responsibility, is what characterizes the moral person. On the contrary, things are those objects that can not take responsibility[3].

Note that 'man is rational' is not meant here as an empirical statement, but a contrafactual postulate. When we are engaged in a dialogue we must assume that it holds and we must act accordingly so it becomes reality. This postulate is constitutive for the dialogue: without this there is no dialogue between persons possible. Even when someone lies we assume that he will have an explanation for it. We have to take seriously that the other says something. This is the first postulate of dialogue. Being accountable is thus characteristic for being rational.

What do users' experiences tell us about the interaction with artificial companions? Bickmore et al. study long term relationship between embodied conversational agents and elderly people [6]."Several participants mentioned that they could not express themselves completely using the constrained interaction. One of them reported: '*When she ask me questions ... I can't ask her back the way I want*'. [6]. Clearly, users of conversational agents experience that a *real interaction* with the system is not possible. It simulates programmed "social behaviors" but it lacks social competence. The coffee machine that knows about its user's heart problems and that is confronted with a moral problem: 'Should I present a coffee or not?' could start a dialogue with the user and try to convince him. Eventually, questions will come up: 'Who am I talking to?' 'Do you really care?'. The philosopher tries to understand what this reveals about the very idea of technology. How does technology work and serve us? A semiotic approach might help.

4. Understanding technology

For understanding the "difference between man and machine" it may help if we think about the difference between the physical sign and the meaning it carries. Machine is "part of" an intelligent relation; without the human intellect it has no meaning. Just like a sign without a meaning is not a sign. The physical presentation and its form is on the one hand arbitrary (there is no intrinsic relation between the meaning of a word and how the words looks or sounds), on the other hand it is conventional and historically motivated (to be understood you need to learn the language of a community). In the same way machines are outside objectivations of our intellect. As technical means they mediate between men and nature. They are based on forces of the physical nature and on the forces of social psychological nature.

Computers are language machines. Suppose we talk to a machine and ask "What time is it?" and the machine answers "It is 2 o'clock in the afternoon." How does this work? This works because of the implemented *correspondence* between the structure of the physical process that my talking (also) is and the meaning I express. Natural language is the socially shared interface we use to express our thoughts, emotions, commands. By making the machine react to sequences of tokens specified in a formal system, tokens *that we choose to resemble the words and sentences in our own natural language*, and by making the machine generate sentences in a situation that satisfies certain felicity conditions we bring about the user experience of having to do with an understanding machine. The social robot by uttering some natural sounds and by showing some natural behaviours promises to be of our natural kind.

5. Conclusion

We propose a semiotic view on modern technology and understand technological beings essentially as *outside objectivations* of our intellectual meaningful relations in social practices. The semiotic view on modern technology suggests a conceptual framework for thinking about the moral issues raised by social robots. It reveals the fundamental limitations of any technical system however "smart". It is our responsibility to see these limitations when we use a system. In thinking about morality in technology we should carefully distinguish between the general abstract *value free* technical ideas and their application in devices used in concrete value laden situations.

[3]"Person ist dasjenige Subjekt, dessen Handlungen einer Zurechnung fähig sind. Die moralische Persönlichkeit ist also nichts anderes als die Freiheit eines vernünftigen Wesens unter moralischen Gesetzen (die psychologische aber bloss das Vermögen, sich der Identität seiner selbst in den verschiedenen Zuständen seines Daseins bewusst zu werden); woraus dann folgt, dass eine Person keinen anderen Gesetzen als denen die sie (entweder allein oder wenigstens zugleich mit anderen) sich selbst gibt, unterworfen ist." "Sache ist ein Ding, was keiner Zurechnung fähig ist. Ein jedes Objekt der freien Willkür, welches selbst der Freiheit ermangelt, heisst daher Sache (res corporalis)", [5], Einl. IV (III 26 f.)

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'I tech care': The responsibility to provide healthcare using robots

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Abstract— Robots are an emerging technology in many areas such as military engineering, logistic services, and autonomous vehicles. One of the most promising areas of their implementation is human care. Healthcare robots have not yet been commercialized but evidence suggests that their future use will be substantial and challenging. In this contribution my aim is investigating the kind of care relationship that could exist between a robot and a human. Usually, we take care of things and people because we love them, or else we want to give them support in their suffering. However, continuing to value only this sense of care, in a future rendered increasingly abstract by technology may mean losing sight of the fact that taking care of others also means taking care of ourselves. If we completely entrust robots with the role of caring, the bigger concern is not the foreseeable decrease in the 'humanity' in healthcare contexts, but the much more challenging notion of people surrendering the value and meaning in their lives. Since caring about something means, firstly, giving it value, a society passively nursed by technology is a society unable to give value to things and people. In order to avoid this risk, new approaches are required, no longer based on love or solidarity, but responsibility.

Keywords— Healthcare robot, Human care, Responsibility, Ethics and technology

1. The role of emerging technology today

Emerging technologies (ICTs, robotics, computer science, etc.) are challenging the sense we give to the things. In the Renaissance, Michelangelo Buonarroti argued that works of art are not created in the marble, but removed from the marble. A work of art is already present in nature; all the artist has to do is to remove it with the chisel, in order to bring out its beauty and replicate the perfection of nature. In our technological world, the idea of imitating or reproducing nature no longer exists, because nature is the same reality produced technologically.

For most of our day we think, feel, and act in a reality whose objectivity is formerly constructed to guide us in thinking, feeling, and doing the things we have to do. A coffee cup is made so that using it properly constitutes an immediate action. Using a vending machine requires information and abstract reasoning to be processed into a practical (and not immediate) explanation in order to achieve our purpose. Understanding the price of the drink, inserting the coin, interacting with the display to select the product, choosing the amount of sugar, etc. The interaction between humans and machines make the world a more informational and abstract structure [7].

But abstracting an idea from the reality is not merely a logical operation (A=A; A≠B, etc.), but also involves a choice, therefore freedom. Abstracting means distinguishing, which means choosing, which in itself means being free to choose. Without freedom of choice there is no abstraction, but only captivity and reification. Paradoxically, the more technology, its languages, and its machines take over the abstraction of the world, the more we as human beings will be called upon to rethink our role on this planet.

2. Robots and healthcare

Robots are an emerging technology in many areas such as military engineering, logistic services, and autonomous vehicles. One of the most promising areas of their implementation is human care [4] [5]. Companies and universities continue to produce different robotic prototypes for different care services – rehabilitation, physical assistant robot, person carrier robot. In the last decade, healthcare robots have been the main focus of several projects and prototypes conceived to improve quality of life and independent living, thus promoting an active and healthy ageing and reducing health and social costs. Robotic service solutions range from the simplest tele-presence functionalities to support caregivers, to the most complex, such as assistance for daily living activities self-management of chronic diseases, well-being and integration in a smart environment. That care robots are ready to enter into the private lives of people is a fact that will soon be reality. Robotic service solutions range from the simplest tele-presence functionalities to support caregivers,[1] to the most complex, such as assistance for daily living activities self-management of chronic diseases,[2] well-being and integration in a smart environment[3] or in different scenarios.[4] On the other hand, also patient associations and other parties of the civil society are pushing public health systems to use robotic applications for social and home-based care. Media increasingly presents robots in terms of future helpful supports, thus stimulating the collective imagination on how life could change when these machines will be able to take care of our daily needs. In addition governments' attention on care robots has increased because they are seen as technological solutions to tackle the growth in public costs of healthcare due to the aging society and the transformations in the family systems which demand and rely always more on the social welfare support.

3. Why is taking care so important for human beings?

We take care of things, people, at least idea, because we love them [8] [9]; in other words, because they assume a significant value for us. The movement is the same: investing a thing, a person, an idea with a value. The invested value tells us that, in the name of that thing, person, or idea, it is worthwhile to act, struggle, and sacrifice a part of oneself. Whether for the health of a family member or for defending the freedom of a population, what drives us to help, support, aid, love, fraternize, is what they represent for us. The practice of care is perhaps the aspect of human life that makes us truly 'human beings'. This is why it is so important. We could continue to exist as numbers in monetary economics that maximize profits and relativize losses. And this is why there is no demise in sight for capitalism. We could continue to exist in societies in which

[1] See ExCITE project (Giraff Technologies company, website: www.giraff.org).
[2] See AVA (iRobot/AVA company, website: www.irobot.com/ava).
[3] See DOMEO project, website: www.aal-domeo.eu.
[4] See: www.robot-era.eu.

machines are built to replace us to do difficult work. But what makes us truly human is taking care of things and people, which means giving value to reality. In the practice of caring we rise above the selfishness of the economic exchange, over the camaraderie of small communities. We are something more than mere living beings. We are human beings because we give representation – i.e. value – to our lives. Without love and solidarity, life certainly would continue to exist, but it would have no value. It would not be chosen by people, but only passively experienced – a bare life [1]. And without being chosen, life would not even be free, because choosing means being free to choose.

4. The challenge to provide healthcare through human-robot interactions

For decades it has been believed that the most advanced robotics design in the field of assistance and sociality was trying to replace all (the humanoid) or some parts (the cyborg) of the human body. In the future this centrality of the anthropomorphic element is probably doomed. In fact, the gradual incursion of robotics with other technological and scientific sectors – ICT, AI, synthetic biology, digital fabrication – will almost certainly lead to new trends. On the one hand, there is the interest of researchers and developers in imitating and reproducing not only the human body on its own, but biology and nature in a broader sense – which is represented here by the project of the robotic octopus[5]. On the other hand, the anthropomorphic element will not disappear completely, but will be greatly transformed. No longer will the body be like a biological machine created to mimic and replicate, but humanity construed as a unique normative element, i.e. a model driven by both biological and social rules. The degree of 'humanity' of a machine will no longer be represented by its aesthetic and functional similarity with the human body, but by its ability to choose based on principles and shared rules [12]. The more complex machines become, in order to be more 'human' they must also be 'right', making decisions according to universalizable rules – like the well-known laws of Asimov. There are interesting legal approaches that imagine the rules to which technology should be subjected, not as rules to regulate the technical functionality of its product, rather as tools of rights. By regulating the use of technological artifacts, it is possible to intervene and improve some aspects of people's behavior [2] [3].

If this is the robotics of tomorrow, it is difficult to believe that in the future, the problem with healthcare robots will be their similarity to a pleasant and attentive caregiver [6]. The robot does not necessarily have to love the person they are caring for, nor have solidarity for the cause of his/her suffering, nor look like a good mother or a loving pet. If it really will be possible to reproduce the feeling of 'love' in the machine, this will still be a matter of programming the commands and the rules that the robots have to follow, and not an ontological question about their sensitivity.

The problem is normative and techno-regulatory, and not purely speculative. The problem is not seeking the exact definition to distinguish a robot from a human being; the problem is seeking norms and policies to respond to the questions: how will humans and machines be able to live together? In a world rendered abstract by technological processes and computer languages, what will become of the significance of the human touch, an affectionate gaze, a hug? What is to become of the typical human feelings such as sympathy, guilt, shame, and even a sense of justice? If it is true that those who suffer injustice are more able to enjoy the taste of freedom, who will still have a sense of freedom in a society in which autonomous machines will do anything and everything to prevent us from suffering?

These questions highlight the real challenge that the future diffusion of healthcare robots poses: the responsibility of providing a healthcare balance between technology and human values. Who provides care to whom in a future technologized society? [11]

Answering this requires new conceptual as well as practical and value-sensitive design approaches [13]. And this combination makes everything difficult. Scientific progress cannot and should not be stopped, however it is unacceptable to adapt human freedom to the needs of technology [10].

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Robots and seniors: can they be friends?

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Abstract. When getting older, some positive changes happen as we develop and mature; some other, not so welcomed, changes also happen like physical decline and diseases. Getting older sometimes equals to start living marginalized. Retirement, loss of spouse, health issues or disabilities due to aging, suddenly situate elderly to the edge of society. Children have grown up and have their own families and elderly find themselves living alone at home or unluckily, in geriatric institutions. Unfortunately, we cannot avoid the negative aspects of ageing but we can always try to make them easier. In recent years, a new approach was introduced to confront social exclusion of elderly with the help of **assistive robots** [1].

Keywords: Social Inclusion, Robots, elderly, seniors, Assistive Robots, Companion Robots.

SOCIAL INCLUSION WITH ASSISTIVE TECHNOLOGIES

Exclusion according to World Health Organization [2] "consists of dynamic, multi-dimensional processes driven by unequal power relationships interacting across four main dimensions - economic, political, social and cultural - and at different levels including individual, household, group, community, country and global levels". As a result, a sequence of inclusion/exclusion is triggered that leads to inequalities in health and rights; a process in which individuals or entire parts of the society are deprived from the rights, opportunities and resources that are normally available to its members.

Elderly, facing the threat of losing their independence due to aging and its consequences (health, cognitive, social and financial), are in high risk of social exclusion. Social exclusion in the form of deprivation from activities that offer joy, fulfillment and sense of belonging, can lead to frustration, depression and health decline. Developing policies to confront and prevent social exclusion has been a major concern for the World Health Organization and all European countries.

To address the critical issue of the social exclusion of elderly, EU supports and funds a vast number of projects that aim to offer solutions to isolation, loneliness and exclusion of elderly with the assistance of ICT technologies and robotics. The use of new assistive technologies allows elderly to face the difficulties of modern life and get over the barriers that limit their social and emotional well being, assisting them to have a more qualitative living [3]. Assistive robotics were alleged to be more effective towards this direction comparing to computers for a number of reasons [4], [5]:

- Computers need training in order to be used by elderly or require a person (caregiver) to use it on behalf of the elder or helping him.
- Learning is one of the cognitive functions that decline with aging, making new information and skills difficult to be acquired.
- Sensor and motor declines triggered by age can also make it difficult for the elderly to use computers.

On the other hand, assistive robots can be used by elderly without intensive training and physical effort. They could have immediate access to a number of applications and direct connection to internet, social media, email, Skype calls etc. All they need to do is just ask the robots to do it for them [6]. Moreover, their humanoid appearance gives a sense of having a companion rather than a machine and decreases loneliness and social deprivation. Companion robots like Paro, should be cited as they have been proved to positively affect social skills of elderly and increase social interactions as well as the emotional well being of the users. Paro is a small robot resembling a seal that can sense user's touch, recognize a limited amount of speech, express a small set of vocal utterances, and move its head and front flippers [7].

The development of robotics has already created a number of abilities to current products enabling robots with the ability to recognize objects and faces; hear and speak; move around; pick up and grasp objects; express emotions.

Human-robot interaction

It has been proved that robots can assist elderly in their daily life [8], [9], but can they really substitute social contact? While working in the frame of an EU project (RAPP/EU-FP7), with a group of seniors from a small seaside town in North Greece, some questions were raised on the potential use and acceptance of robots by elderly.

The social and cultural background of the aforementioned RAPP group living in a small Mediterranean village in Greece where family ties and social relations ships are strong determines their reaction to robots and specifies their interaction [10].

In order to explore in detail the feelings of the users towards robots, we used the "Negative Attitudes towards Robots Scale" by Nomura to investigate potential negative perceptions and behaviors that could prevent interaction between robots and the elderly [11]. The scale was utilized as a discussion tool rather than distributed questionnaire due to the small number of our group and their tendency to answer questionnaires "in a positive way" (to gain researcher's approval) or exactly the same way with each other (watching what other seniors answered). The main outcome of this free discussion was that all elderly imagine robots in a human-like form moving around the house doing the household and take care of them like "mechanical servants". They would like robots to have feelings and make friends with them but they do not really believe that this could happen, at least not soon. When insisting on this aspect ("imagine that we could have a robot with feelings by tomorrow"), they expressed some concerns of how the world could be if people make friends with robots instead of each other or how complicated the human robot interaction could be if feelings were engaged. The basic conclusion was that robots are good because they are assistive machines and there is no reason to worry about them as they will always be like that; all the scenarios about having feelings or think for themselves are impossible ("this is sci-fi").

Figure 1. Interacting with NAO

It is apparent that a number of issues rise considering the human-robot interaction and the feelings of likeliness of robots by the elderly. It is of high importance that robots will be accepted by seniors to interact with. The feelings that robots evoke to people whether look like humans or unlike humans can affect their interaction and their psychological status in the whole. Concerning our user case in the small seaside town of North Greece, we chose to use NAO, a human-like robot by Aldebaran (SoftBank Group), [12]. As NAO is akin to a little child, the human-robot interaction was enhanced since seniors treated the robot like a little child, protect it and adjust their behavior to discuss with it. The cautious attitude of the first user-NAO meeting was followed by a number of positive meetings where the familiarity with the robot helped them to approach it and interact with it, finding NAO interesting, useful and easy to use. They were still disheartened by some "disabilities" as they actually expected much more from robots. Still, when companionship was discussed, nobody felt that a robot could replace a warm meeting with friends or family. One of the users commented: "It's a machine, not a friend of mine".

The feelings of the elderly on interacting with robots or restore their social life with the company of robots is the key issue we need to clarify in order to promote successful assistive technologies and suitable robotic products.

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Survey investigating ethical issues concerning Robot Enhanced Therapy for children with autism

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Abstract. The use of partially autonomous robots in therapeutic contexts raises several ethical issues, starting with the degree of autonomy to be afforded to the robot. The more autonomous the robot, the less control therapists have over the robot-child interaction, raising the issue of where the responsibility for the robot's actions lies. Autonomy also raises the problem of trust: are parents happy to have their child interact with a robot? Will the child trust the robot? The Eurobarometer study of public attitudes towards robots, shows that many people in Europe resist this idea of using robots in care. The aim of this paper is to investigate the ethical issues raised by the use of robots in therapy for children with ASD by means of a survey amongst caregivers, parents and teachers of children with ASD. We conclude that although in general stakeholders approve of using robots in therapy for children with ASD, it is wise to avoid replacing therapists by robots and to develop and use robots that have at what we call supervised autonomous interaction.

Keywords: social assistive robot, Autism Spectrum Disorders, Survey

INTRODUCTION

Impairment in social interaction is an important element of Autism Spectrum Disorders (ASD) and challenges researchers to find better treatments. This is also the case for children with ASD. Several kinds of treatments are being investigated to improve their capacity for social interaction and communication such as applied behavior analysis, peer-mediated training, video-modeling, social stories, etc. One of the proposed options is to use robots as tools to enhance therapy [1]. The project DREAM, funded by the European Commission under the FP7 framework, investigates so-called robot enhanced therapy (RET) for children with ASD. Roboticists develop social robots as Nao or Probo [2] which can interact with the child, while being supervised by the therapist. Therapists can use the robot to elicit prosocial behavior; the robot functions as a social mediator between therapist and child. However, robot developers and therapists are concerned about the ethical and societal acceptability of their tools and methods. As a recent Eurobarometer [3] study of public attitudes towards robots shows, many people in Europe resist this idea of using robots in care. 60% of EU citizens saying that robots should be banned in care of children, elderly people and people with disabilities . There is also still considerable opposition to using robots in other 'human' areas: 34% of respondents say robots should be banned in education, 27% are against the use of robots in healthcare and 20% oppose their use for leisure purposes (European Commission 2012: 11). Robot scientists are also sometimes confronted with negative responses to their work. Also, often robots are linked to science-fiction and are presented as dangerous for mankind. Some sound 'apocalyptic alarm' [4]. Therefore, we want to know what people think about RET. Do they think it is ethically acceptable to use robots for this purpose? Do they think it is helpful? Would parents trust their children to a robot? And if more autonomous robots were to be developed, would they trust a situation in which there is no adult supervision?

The philosophical discussion delivers two types of potential problems which both relate to the autonomy of the human person (therapists, parents, others). First, there are issues concerning privacy and data protection, issues which are also raised by many other ICTs. Second, there is the problem concerning robot autonomy and trust: how much (and what kind) autonomous behavior should the robot exhibit, that is, to what extent should the robot-child interaction be supervised and controlled by the therapist? More generally, can the parents trust their child "into the hands of the robot"?

METHODOLOGY

The questionnaire was mainly/also offered on-line by the free and open source online survey application LimeSurvey installed at the VUB webserver and was available in three languages English, Romanian and Dutch. Since robots exists in different shapes for wide range of applications, but our survey focuses on social robots we introduced this type of robot before the survey by means of a 1minute video in Layman's terms. The video contained short clips of a selection of currently most used robots as NAO, Keepon, Probo, Kaspar, Iromec platform, Pleo. As such robots were shown that look like machines, (imaginary) animals, humanoids and androids. No children were shown in the video[1].

The questionnaire was developed in a multidisciplinary team consisting of psychologists, therapists, engineers and ethicists and were based on guidelines and essential elements of questionnaire design and development in order to obtain a reliable and valid questionnaire [5].

We asked parents and therapists in Romania, Belgium, and the Netherlands. Participants were recruited based on databases of persons involved in our past research and messages were posted on relevant blogs, Facebook, and newsletters and websites of autism organizations. A total of 416 subjects participated in the study. Data from 22 participants were excluded from the analysis since the responses were incomplete. 22.59% of the participants were parents of children with ASD and 16.75% of the participants were therapists or teachers of children with ASD.

RESULTS

Our survey had the following results. In general, our respondents find it acceptable to use social robots in therapy for children with ASD. (This is a difference with Eurobarometer results about the use of robots in healthcare in general. We explained in a video the concept of a social robot, we used a neutral voice and did not show children; perhaps this made a difference.) However, our respondents are far more hesitant about the idea that these robots would replace therapists; most people think that robots should support the interaction between therapist and child, rather than replace the therapist. For instance, a significant number of people do not want the robot to respond automatically to the child's behavior, without being tele-operated. The reason why in DREAM is worked towards supervised autonomous interaction [6]. Furthermore, some people are also worried about the possibility that the robot is perceived by the child as a friend, or as a human; our respondents are more positive about zoomorphic robots and the idea of the robot as a tool.

CONCLUSION

The use of robots for RET for children with ASD raises several ethical issues. The survey we conducted supports both the idea of the DREAM project to avoid replacement and to develop and use robots that have at most supervised autonomy. More generally, it seems that most people approve of using social robots in ASD therapy, which is in contradiction with the Eurobarometer study, provided ethical issues such as autonomy/trust and appearance are dealt with by the researchers and therapists. A more in depth discussion is found in [7]. Further research is needed to obtain a more comprehensive analysis of the ethical issues and to involve stakeholders in the development of robots for children with ASD.

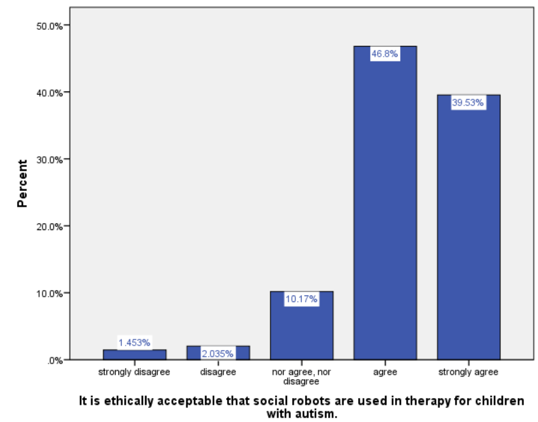

Figure 1. Results Is it ethical acceptable that social robots are used in therapy for children with autism.

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Accommodating Students with Disabilities Using Social Robots and Telepresence Platforms: Some Legal and Regulatory Dimensions

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Abstract. *As social and other robots become more accessible and inexpensive, public school systems will increasingly use them to accommodate pupils with disabilities. Such accommodations are subject to regulatory regimes designed to ensure those students' equality and dignity. The application of these rules to robotic technology is not straightforward. This is because robots in school have the simultaneous potential to facilitate inclusion, mark difference, and substitute for other kinds of accommodations. In order to assure students' rights and comply with relevant law, regulators will have to consider in sophisticated ways the social dimensions of robots—social robots* per se, *but also telepresence platforms that allow students to attend school remotely. Design of robots for use by disabled students must ensure that they facilitate rather than mitigate the social inclusion of the disabled user in her general-education school.*

In both the United States and in Europe, public schools have a duty to educate all children, with or without disabilities, equally. Both systems understand equality to require schools to *accommodate* disabled children's particular needs. Such accommodations ensure that each disabled child is able, to the extent possible, to access educational programs on the same basis as all other pupils.

All U.S. states accept federal funds that support the education of disabled children. The Individuals with Disabilities Education Act (IDEA) obligates states in return to provide all children with disabilities in the state "a free appropriate public education." IDEA defines "a free appropriate public education" as "special education and related services" that are provided "at public expense," are educationally "appropriate," and are consistent with an "individualized education program" that the state must prepare for the student. It defines "related services" as "such developmental, corrective, and other supportive services (including ... mobility services) ... as may be required to assist a child with a disability to benefit from special education." And it defines "special education" to mean "specially designed instruction, at no cost to parents, to meet the unique needs of a child with a disability." The implementing regulations for IDEA further require that schools provide "assistive technology devices … or services," at home or at school, if these are "required" to make either special education or related services effective. (1)

European requirements are broadly similar. The recently ratified United Nations Convention on the Rights of Persons with Disabilities (CRPD) guarantees children with disabilities "quality and free primary education and secondary education on an equal basis with others in the communities in which they live." It further obligates states to ensure "[r]easonable accommodation of the individual's requirements." (2)

A major additional feature of the CRPD is its requirement for "inclusive education." (3) Students with disabilities may not be "excluded from the general education system on the basis of disability." Inclusion bears a family resemblance to the "mainstreaming" requirement of the American IDEA, which demands that disabled children be placed in the "least restrictive environment" consistent with their needs. (1) In the United States, but less so in Europe, mainstreaming is considered to be an overriding goal, entitled to priority over most other desiderata for special education. (3, 4)

As experiments and pilot programs that introduce social robots into classrooms proliferate, several have focused upon special education, especially for students with autism and similar social disorders. Such robots are "assistive technology devices" under the law. IDEA requires schools to provide them, without regard to cost and without charge to parents—although only if they are "required" to make special education or related services effective. In guidance they issue to school districts, several states already list robots among assistive technologies that schools must consider for disabled students. There are no reported instances of disputes over whether robots are "required" that have led to formal administrative or judicial resolution; but it is hard to imagine that this will long remain the case.

Social robots might also substitute for human paraprofessionals now assigned as one-on-one supervisors or "shadows" for students with disabilities such as severe allergies or social disabilities that involve aggression and violent behavior. (5) I am unaware of any such uses today but it is an obvious application.

More complex issues are raised by telepresence systems for children whose disabilities prevent them from attending school. Such disabilities range from severe allergies to immune disorders to cancer. (6) These systems' core features are a mobile platform, processor, microphone, and camera. The child user can, from a remote location, move the platform around the school, hear and see what is occurring in the classroom, and be heard and seen in turn. A story in the popular press about the VGo, one of the major brands in this sector, describes it as a “camera-and-Internet-enabled robot that swivels around the classroom and streams two-way video between … school and house.” (7)

Telepresence systems raise important issues regarding inclusivity. The most straightforward is that public schools likely have a legal duty to provide such systems to students who otherwise cannot attend school. In the American context, the VGo is an “assistive device” under the regulations, and is probably also a “related … mobility service” under the IDEA statute itself. Schools must therefore provide it, irrespective of cost.

A more difficult question is whether schools *may* accommodate disability via telepresence rather than by providing physical accommodations that are potentially more cumbersome, expensive, and disruptive. A school might prefer to accommodate a child with a motor handicap by offering a telepresence system than by modifying doors, classroom furniture, and bathrooms. So too, telepresence might be offered to disruptive students in place of a one-on-one paraprofessional shadow (human or robotic). Telepresence might not only save money but improve the effective accessibility of the school to such students. (Even if a student has a place for her wheelchair in the classroom, the wheelchair will not fit in every place that a child’s classmates might go.) Nevertheless, one might nevertheless conclude that such “accommodations” are antithetical to mainstreaming or inclusive education, because they physically exclude the child with the disability from the general-education classroom.

These problems will only become more difficult as the social dimensions of robotic presence in contexts like classrooms becomes better understood. Telepresence platforms are not social robots in the ordinary sense, but they have affective features. Both the accommodated child and other children relate socially to the telepresent machines. Their operators often doll them up with clothing and other accoutrements; the mobile carts stand in line and go outside for recess; other children touch them. (6, 7) Mandates for mainstreaming or inclusion are primarily about social equality, and focus upon equality in the informal, interpersonal aspects of school life more than equality of formal academic opportunity. Thought must therefore be given to what kind of social reality telepresence creates for disabled children and whether it is consistent with the right to inclusion. Telepresence is unambiguously positive when the disability in question otherwise demands isolation. But the question is much more difficult when telepresence substitutes for other, partial but in-person accommodations.

In the near future, moreover, we should expect telepresence to be augmented by various adaptive features, some of which will be classically “robotic” in the sense of the systems’ responding to external stimuli based upon internal algorithms rather than direct user control. For example, a VGo controlled by a vision-impaired student can be rigged at the user’s end to magnify what the camera sees. This is beneficial, but not unambiguously so. The hidden cost is that neither the school nor fellow students need adjust their own behaviors to the needs of their disabled comrades. This is problematic if accommodation and mainstreaming are necessary to equality for the disabled.

The hardest cases will involve, again, social disabilities. A student who cannot pay attention, who disrupts class, or who is violent toward his peers is difficult to accommodate in person. A telepresence system might therefore be designed, for example, to mute its voice or disengage its drive during instruction. A user might wish to have the system run around the room, or call out, but it would refuse to do so. Similarly, studies show that persons expect technology to obey conventions about social space, body language, movement, and response time, and judge nonconformance negatively. (8) A tempting potential response is to augment telepresence systems to follow social conventions automatically. Doing so could, for example, ease the accommodation and acceptance of operators with autism who often struggle to conform to these conventions.

Again, such accommodations bring clear benefits in terms both of access and acceptance. In some cases they might even be a necessary condition of any inclusion at all. But they depart from the ideal of mainstreaming or including the disabled child *as she is.* They include not the child but a modified simulacrum of that child; and they deprive other children in the classroom of the social experience of the full diversity of disabled children. The legal question then becomes whether, when, and to what extent socially-adapted telepresence is a desirable accommodation that brings the disabled child into the social mainstream of her class or school, and under what circumstances it is a retrograde development that excludes and isolates them. The legal analysis in turn should inform design standards for systems whose features will facilitate the former determination.

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An HRI study with elderly participants? Where's the problem?*

Jorge Gallego-Perez

***Abstract*— Assistive technology and particularly care robots pose a range of practical and ethical problems to elderly users, as well as their carers. Many of those issues have already been tackled in a vast literature. More rarely do we find accounts of the challenges that the researcher faces when research involves robotics and elderly participants. In this short paper, I introduce potential pitfalls that researchers in Human-Robot Interaction (HRI) might encounter when the participants are of advanced age. To present these research challenges in an engaging manner, these are embedded in a fictitious story about a researcher's latest study.**

I. Introduction

In this paper I present an array of pitfalls and caveats that an HRI researcher is likely to face in his/her research with elderly participants. I do not consider the corresponding solutions in this paper, leaving that to future publications. Instead of enumerating these potential shortcomings and considerations in a long list, I decided to present them in the form of a fictitious narration. In the story, a PhD student is emailing back his supervisor, who is inquiring him about the current status of his last study, namely an HRI experiment that includes elderly participants. The fictitious experiment takes place in a nursing home of elderly people without dementia. They interact one-to-one with a WoZ-controlled social robot in a room of the nursing home, whereby they speak in natural language while holding a tablet.

The events in the story that are marked with asterisk (*) indicate that I went through similar situations in my research. Other events are followed by references, indicating literature that points to related issues. The rest of events and reflections added to the story relate to issues that I estipulate to be equally relevant.

II. A fictitious HRI study

I so much appreciate your email, asking me about the current state of my first HRI study with elderly people. I do acknowledge the importance of being accepted to the conference as well as the urgency of the situation due to the delays, but I can assure you that I have everything under control and that we will impress our reviewers with the great quality of the study. I have no doubt that we'll be accepted! There might have been a few bumps on the road, but there's nothing now to worry about.

*As you already know, it took me just a little long to properly start the study. The recruitment of the participants turned out to be different than recruiting younger adults as I'm used to** [1]. *There are just a few older people around the campus*, and I don't have connections. I pulled some strings and I found a nursing home where I could conduct my study. A little bit more of delay came then from obtaining the agreement of the carers and the relatives of the participants* [1].

You asked me in your email how the data collection went. It went very well, just a few minor obstacles regarding the organization. When participants were supposed to wait outside the room of the robot before their turn, some of them decided to just leave [2] *(some of the delay comes from this, I needed more extra time rearranging new sessions). Some participants didn't show up because they had forgotten our appointment* [2]. *Also, three participants didn't show up either because of mobility problems* [1]. *And also, a few participants decided to give up their participation because they believed I was trying to sell them the robot* [2]. *Alright, maybe a few obstacles so far, but the rest went quite alright.*

*Well, actually we had some small issues with the memory of the participants throughout the whole interaction with them** [2], *but nothing to worry about. For instance, several participants didn't remember well their interaction with the robot when they were supposed to fill in the questionnaires* [2]. *Others would initially refuse to complete the questionnaires because they thought they were finished with the experiment* [2]. *Also, some participants had eyesight problems* and could not read the questionnaires. In general the participants needed extra attention to understand how to fill in the questionnaires* and often would hand me the questionnaires incomplete*. I also had to be a bit careful during the interview, because many would have the tendency to remember recent tragic events (e.g. the death of a relative) and would start to feel deeply affected*. Alright, seen retrospectively it might appear that many things went wrong with the data collection Still nothing to worry about, [supervisor], the rest went on more smoothly.*

*You asked me also about the interaction between the participants and the robot. It went very well, they loved it! I just had to explain very often what the purpose of the study was** [2]*; some would have forgotten it* [2], *whereas others would speak to the robot expecting that its capabilities were a bit too far beyond its actual ones** [2]. *Well, now that I think about it, I also had the impression that a few participants were somewhat tense, at least more tense than younger adults would generally be in this kind of experiments*. OK, to be honest, perhaps that happened with about half of the participants. I wonder why. Maybe older adults tend to underestimate their own abilities more than younger adults do* [3]. *Or perhaps they felt stigmatized as in thinking I'm such a frail, lonely old person that they think I need to have*

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a robot. I suppose that talking to them in English instead of in their native language only worsened this issue.*

Anyway, I still believe they liked it and that it was quite an enriching experience for them. Well, at least for those who could hear the robot. Some participants had hearing impairments*. I just had to adjust the volume of the robot sometimes*, no big deal. Also, for some reason, a few participants seemed to be unable to understand the artificial voice of the robot while they would actually understand natural voices in the same language, at the same volume*. For the rest, the interaction with the robot went alright, except for two participants that fell asleep for a moment during the longest monologue of the robot*.*

Alright, I know what you're thinking. Perhaps quite a few bumps on the road indeed. But I still have faith in this study, and I assure you that you will be very happy with the results once the data are analysed, I still have one full day for this.

You asked me in your email to explain the reasons for the delays and the scarcity of participants. Well, these hindrances I mention above had tripled the duration of the data collection as I had initially planned, point at which one participant accidentally dropped the tablet, which was damaged beyond repair. I needed then another week to resume the data collection and run the last sessions.*

With respect to why I gathered so few data, well, perhaps, as you told me at the beginning, I was a little too bold when I planned this study for one hundred elderly participants. All those obstacles I mentioned during the data collection forced me to discard about two thirds of my sample. Also, very sadly, from the people that had agreed to participate, four fell sick and one passed away.

Answering another question you asked, of course, I understand that you want to give a good impression to the nursing home organization. Except for a couple of minor issues everything went well with them. Alright, perhaps I should tell you what happened. I explained to the nursing home organizers that I needed to give a debriefing to the participants to, among other things, make them aware that the robot was actually not autonomous, but teleoperated (WoZ). One organizer insisted that the participants could turn severely disappointed I can understand this, after that a sort of friendship had been in some cases established between the robot and the participants and warned me with carrying the issue to court. She dropped this issue eventually. Also, the three organizers insisted vehemently that I continue bringing the robot to the nursing home. They argued that by taking the robot away from the residents I would remove from their lives a source of recreation or even socialization.*

You mentioned also that we needed results as generalizable as possible. I hope they are! Well, I don't know exactly how to tackle the fact that the great majority of the participants are women. Can I generalize the results to both genders, or should I separate them? If I separate them, I will only have a handful of male participants, which would be a great statistical disadvantage. I thought also about what to propose for future research. I thought it would be a good idea to extend the study to younger participants. However, I then realized that I can't separate the effect of age from the effect of generation. That is, how can I know that all reactions of the elderly participants to the robot depend on the fact that they are old, and do not depend on the different way (two generations ago) they were raised? Let's take the Flynn effect as an example, which states that, at least for almost the whole last century, the average IQ of the population has steadily been increasing [4].

Finally you asked me about the biggest contribution of this study. Look, I don't know let's face it, it's been a disaster! I'll give up trying to convince you that the study went well and that I have everything under control, because right now I'm just bracing for a collection of tough reviews. There's no way we'll be accepted!

But hey, next time it can only get better. The biggest contribution? Well, I learned a lot!**

Best regards,

[your student]

III. Conclusion

Conducting HRI research with aged participants can prove to be daunting for the unprepared researcher. The higher prevalence of certain ailments in this age group makes it necessary to adapt the instruments and the methodology of the study. Also the particular social structure around many aged people must be considered by the researcher, for example in the cases where the participants depend on third persons.

I hereby apologize if any persons of advanced age felt offended reading the fictitious story. I personally acknowledge that this age group is as diverse as any other, and that not every elderly person possesses the characteristics of the fictitious participants depicted above.

I would like to remind the reader of the presence of asterisks on the last line of the story. Even though the story, the PhD student and the supervisor are fictitious, I once had in reality a first HRI study with elderly participants, from which I learned that one cannot overstate the importance of specific preparation.

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Toy Robot versus Medical Device

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Abstract— A common Dilemma that people have when they are designing social robots for therapy. In those casses that in addition to the research about the benefits of using robots, there is also the development of a robotic product, research team faces the question of how they are supposed to certify the product: as a toy robot, or as a medical device. In this paper, I introduce the decission criteria followed by roboticists I know, I comment what we can find in the literature and internet, and I present a discussion of some considerations that researchers and developers should take into account.

Keywords— Toy, Robot, Medical Device, Legal, Certification

1. INTRODUCTION

Robotics is a reseacrh field that reached the market recently and all kinds of robots started to be part of the consumer market. Some of theses robots are being used in therapy and education. Up to know education has been an easier environment, in terms of regulation, to deploy robots. So most of the robots used in Schools, training centers, universities, etc., have the certification of toy robots. The same happens with robotic platforms used to assist caregivers, physicians, therapist, or other professionals, to take care of their patients.

As long as this research invole multidisciplinary research groups, practiotioners with different backgrounds, and different environments of application, the actors that are involved in the design of a robotic platform wonder, in those cases where after the reseacrh we are getting a new robotic device, how the product should be certified.

If we take a look to the list of questions which answers drive a decission about the product certification process we have:

- Certifications ?
- Time to market ?
- Intellectual property ?
- Applications ?
- International regulations ?

In the following sections we are going to present what we can find in the literature, news, the internet, etc., about this dilemma. And we end the paper with the introduction of discussion about what paths are chosen by developers in general, what can be right or ethical.

2. WHAT WE CAN FIND OUT THERE

If we do a quick search about robot as medical device or non-medical device we will deal easily with the controversial about how a robot is or should be certified.

Maybe because robotics started to get into the market from the industrial sector, the first tool that we find to regulate the criteria to design, and so to certify a robotic product like a mobile robot, robotic wheelchair, or excoeskeleton, is the ISO 13482:2014. As we can find in the literature in [2], [3], [4], or in [5], there are initiatives that are trying to cover this gaps on the regulation requirements for these kind of devices.

If we move to the point that concerns to us about Medical and non-medical robots, we will see that non only there is unclear policy from the manufacturer point of view, but also from the distributor perspective. To clarify this point, I present two obvious cases that we can findnin the market: the robot PARO [6] and the robot ROMIBO [7].

PARO is a robot that is commercialized in the U.S. as a medical device, whille in countries like for example Spain it is commercialized as a non-medical device. In Fig.1 we can find a reference to PARO Robot by Wall Street Journal, and what we can find about the ROMIBO robot in the origami robotics website (the developers of the robot) about if ROMIBO is a Medical device or not.

Fig. 1. Article about PARO robot, and how ROMIBO robot is poresebted at Origami robotics website

According to [9] and the US regulation in [10], a medical device is required whether a given article is intended either ”for use in the diagnosis,... treatment, or prevention of disease,” or ”to affect the structure or any function of the body.”

Above, we can find two examples of, in one hand, how a social pet robot is considered a different device type in different countries, and on the other hand, how a developer split the device itself from how to use the device.

While in the PARO robot case, there might be a wrong application of how the device should be acredited, in the ROMIBO case it is a clear example the they decide to accredit the product as a toy robot to skip a tougher certification process.

3. DISCUSSION & CONCLUSIONS

How the community is acting about that? As we have seen in the previous examples, there is not only a matter of different regulation in different countries, it is also a trade off between the time to market, the time to go through the certification costs, and the cost to develop the robotic device.

The most typical decission when it is time to consider how the device will be certified is to take the easiest and cheapest way and certify the robot as a toy-robot device. To do that, what developers do is to explain that they are selling a toy, but that at the same time it can be used as a support, facilitator, etc. tool that will improve the therapies conducted by the specialist, the quality of life of the children, etc.

Although this can be the way to arrive on time to the market, keep the final cost affortable for the customers, and skip extra burocracy, it is also true that in those cases where there is a clear intention to put the robots in a medical environment the attitude can be considered unethical.

From an idealistic point of view, a better regulations should be defined. At the same time, to be realistic, there is the option to create different product lines, i.e., a robot toy as a general public device for playing, and a medical robot as a therapeutical device for treating people. [11] (see Fig. 2 is a social robot device that follows this example. There is a Keepon oriented to children to play with it, and there is a Keepon oriented to researchers.

Fig. 2. The Keepon Robot

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Which Perspectives of Using Exoskeletons in Activities for Daily Living?

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Abstract— **Since many years, a lot of powered exoskeletons are developed and some of them are already available for sale. Mainly for rehabilitation purposes. People with neuromuscular disease, paraplegics and tetraplegics are looking to this technology with a lot of hope. May be one day they will buy this kind of devices online as many buy their glasses. This paper discusses the obstacles to the use of exoskeletons in activities of daily living (ADL). The first section describes exoskeletons and for what they are used. The second part presents some regulatory aspects related to their marketability. Finally, the third part of the paper discusses what is limiting exoskeletons to accessing the market of ADL.**

Keywords— *Exoskeleton, orthosis, Activities for Daily Living**,** ADL, Rehabilitation, certification.*

INTRODUCTION

Exoskeletons are motorized and instrumented devices. Their mechanical shape reproduces the anthropomorphic and skeleton of the human with which they are rigidly interfaced through dedicated components to transmit a closed loop controlled movement. The objective of exoskeletons, both for upper limbs and lower limbs, is to assist or mobilize human limbs [1] [2]. Figure 1 represents the most known active exoskeletons in the market; The Ekso from Ekso Bionics (US), Rewalk from Argo Medical Technologies (IL) and REX from REX Bionics (NZ).

Figure 1. Three exoskeletons available in the market. Respectively from right to left: Rex, Rewalk and Ekso.

Recently, researchers, product developers, and market providers have extensively addressed locomotion. This is mainly explained by the fact that locomotion is associated to mobility and Lack of mobility means social absence. Moving in vertical position in comparison with being on a wheelchair helps to important the external image. It can give a feeling of parity with healthy people while sharing the social space. Furthermore, verticalization contributes to better managing the human urinary and digestive systems. This explains why additionally to the pure aspect of mobilization these kinds of devices are now mostly targeting applications of rehabilitation. For stroke patients, fortunately, restorative chances of locomotion are quite high. However, for paraplegic and tetraplegic patients, the focus is on improving the functions related to gait synchronization, recruitment and strengthening of lower limb muscles and probably the vestibular control [4] rather than total recovery of walking. For elderly and other patients with muscle weaknesses [1], the use of robotized orthosis aims at improving the quality of life by extending the mobility options. These options provide more accessibility to daily tasks (standing, access to toilets, kitchen, etc.). Additionally, the assisted locomotion avoids muscle atrophy and improves blood circulation. Unfortunately, exoskeletons for daily activities have not yet reached the market. Nonetheless the question remains: Could we imagine someone buying an exoskeleton with a medical prescription, which defines their anthropomorphic lengths (lengths of the lower limb segments), or simply buy it online as many buy their glasses? Hopefully, this is what these communities are waiting for.

CERTIFICATION AND LEGAL PROCEDURES

Design and control of exoskeleton devices are carried out around a main issue: “avoid any injury to the wearer”. Adjustments related to end user’s health and to the safety of the subjects are investigated through systematical and methodological risk analysis approaches. This is carried out in order to ensure the user’s safety from any potential hazard, avoid his/her falling down and prevent any resulting injury [1][6][7]. Among approaches available for risk assessment, we principally cite the FMEA (Failure Modes and Effects Analysis), which is based on the identification of all the failures associated with the subsystems and the components of the application. Failure modes, along with fault propagates, are analyzed and a solution is optimized to minimize the risk of injury for the user. The HAZOP technique (HAZard and OPerability study) and FTA (Fault Tree Analysis) are also used. All these methods are semi-empirical and rely on the developers’ expertise in identifying potential causes of injury to overcome the system and sub subsystems unpredictable behaviors. Motorized exoskeletons are categorized with respect to risk. The EU Medicine and Healthcare Regulatory Agency (MHRA) proposes 4 classes (I, IIa, IIb and III) respectively, with increasing levels of risks and control procedures [7]. The US Food and Drug Administration makes 3 categories (1, 2 and 3) also rated as low, medium and high levels of risks [6] [7]. When used for physical therapy and rehabilitation with the assistance of a therapist, actuated orthotic devices are classified by the FDA as “Powered exercise equipment” (product code BXB) and are categorized as class 1 devices. This makes their certification easier and exempt from 510(k) premarket notification or premarket approval application processes. REX 1, Ekso and Rewalk are all categorized as class 1 by the FDA. When used for ADL, they must be treated differently and the manufacturers are asked for the 510(k) clearance. In Europe, orthotic devices (especially if combined with crutches) may also be declared by the manufacturers as class I, which leads to assess the compliance with the corresponding CE mark directives. However, the MHRA may adopt a different point of view and hence propose another classification to IIa or IIb. The regulatory classes I; both in US and EU exempt the manufacturers from the call of a notified body for certification which considerably reduces time to market of these devices. However, when the devices are expected for ADL (as powered prosthetic devices), they must conform to classes II for US and IIa for EU.

REHABILITATION OR ADL?

Manufacturers and providers of powered exoskeletons are taking the shortcut to the market of rehabilitation because it is fast and simple in terms of legal procedures and helps to prepare the 510(k) premarket form. It allows them to place their devices in a controlled environment under assistance of therapists. It is relevant to notice that the activities for daily living do not need these exoskeletons to be designed much more different. The required assistance functions are already available with most of the current existing devices: Locomotion, Standing and Sitting. The function of climbing stairs is also more than appreciated. Because of safety considerations, the more complex the control strategies are (which is necessarily related to flexibility to different subject's disabilities) more the device needs assistance of another person. Moreover, the time and financial investments of the exoskeleton's manufacturers are higher. The Ekso is one the most advanced devices in terms of locomotion control strategies but it is still not available for personal use. This simply answers a part of the following question:

Is the availability of exoskeletons for home use for tomorrow?

The first obstacle concerns the certification and legal issues. By legal issues we principally intend regulatory authorizations that protect the consumers. The home use of these devices also means ease of wearability, autonomy and management of any ambiguous situation. For instance, what happens if the device faces a critical failure and it stops moving (or stops assisting the wearer)? Even if the stop is safe, what happens after that? This explains why even if the Rewalk (fig. 1) is the first device that has obtained an FDA approval for home use, it still needs a presence of a companion (husband, wife or any clinical companion) who helps managing some configuration aspects, wearing and unweaving the device, and assisting the user if any critical situation occurs. This is pointing out the second obstacle: a presence of another person is necessary and no technological answer is currently available to this issue. The third issue is probably the social acceptance of these devices. For sure social acceptance is related to cultural origins. There is no comparative study of the social acceptance of exoskeletons around the world but probably Japan could be considered the most accepting country when it comes to invasion of technology in daily lives. In social acceptance, we may include our perception and experience with the surgical robots (invasive and not invasive). Surgical robots received large acceptance in daily use by surgeons both from the certification authorities and by patients as the protocols are well defined. Besides, people are trusting robots for surgery operations in more than a case because of their precision, efficiency and reducing undesirable effects.

CONCLUSION

We may conclude by an interesting question recently asked by Rose Eveleth "*why many people seem more interested in hoisting someone out of their wheelchair than they are in making spaces accessible to that chair?*" [8]. For sure, it is not yet the conquest of exoskeletons in our streets and the question of Rose should remain in mind. Technology must be thought as a help to improve the lives of human beings and not a source of their degradation. Researchers have to always take this aspect in consideration. Foundations and associations are also the guardians. Although it is not yet the conquest of exoskeletons in our streets, the question of Rose should remain in mind. Technology must be thought as a help to improve our human being and not a source of its degradation. Researchers have always to take this aspect into consideration. The objectives of industrials and business developers are probably more profit oriented. This is why foundations and associations are the guardians that protect our assets. Politicians and law actors should assume the role to set rules for the sake of the general well-being and the people's rights protection. We believe that exoskeletons are helpful for walk assistance, either in ADL or rehabilitation applications. Workshops and conferences are the main key points to promote understanding and communication around this subject. Researchers from ETH Zurich launched an international race of exoskeletons (www.cybathlon.com). There is nevertheless still work for technology providers, researchers and medical doctors to improve the access and ease of use of these walking devices.

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Video’s & demo’s

Ensuring Ethical Behavior from Autonomous Systems

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Video: A paradigm of case-supported principle-based behavior (CPB) is proposed to help ensure ethical behavior of autonomous machines. We argue that ethically significant behavior of autonomous systems should be guided by explicit ethical principles determined through a consensus of ethicists.

Keywords: autonomous systems, machine ethics

Autonomous systems that interact with human beings require particular attention to the ethical ramifications of their behavior. A profusion of such systems is on the verge of being widely deployed in a variety of domains. These interactions will be charged with ethical significance and, clearly, these systems will be expected to navigate this ethically charged landscape responsibly. As correct ethical behavior not only involves *not doing* certain things, but also *doing* certain things to bring about ideal states of affairs, ethical issues concerning the behavior of such complex and dynamic systems are likely to exceed the grasp of their designers and elude simple, static solutions. To date, the determination and mitigation of the ethical concerns of such systems has largely been accomplished by simply preventing systems from engaging in ethically unacceptable behavior in a predetermined, ad hoc manner, often unnecessarily constraining the system's set of possible behaviors and domains of deployment. We assert that the behavior of such systems should be guided by explicitly represented ethical principles determined through a consensus of ethicists [1][2][3]. Principles are comprehensive and comprehensible declarative abstractions that succinctly represent this consensus in a centralized, extensible, and auditable way. Systems guided by such principles are likely to behave in a more acceptably ethical manner, permitting a richer set of behaviors in a wider range of domains than systems not so guided.

To help ensure ethical behavior, a system's ethically relevant actions should be weighed against each other to determine which is the most ethically preferable at any given moment. It is likely that ethical action preference of a large set of actions will be difficult or impossible to define extensionally as an exhaustive list of instances and instead will need to be defined intensionally in the form of rules. This more concise definition is possible since action preference is only dependent upon a likely smaller set of *ethically relevant features* that actions involve. Given this, action preference can be more succinctly stated in terms of satisfaction or violation of *duties* to either minimize or maximize (as appropriate) each feature. We refer to intensionally defined action preference as a *principle.*

As it is likely that in many particular cases of ethical dilemmas ethicists agree on the ethically relevant features and the right course of action in many domains where autonomous systems are likely to function, generalization of such cases can be used to help discover principles needed for their ethical guidance. A principle abstracted from cases that is no more specific than needed to make determinations complete and consistent with its training can be useful in making provisional determinations about untested cases. If such principles are explicitly represented, they have the added benefit of helping justify a system's actions as they can provide pointed, logical explanations as to why one action was chosen over another. Cases can also provide a means of justification for a system's actions: as an action is chosen for execution by a system, clauses of the principle that were instrumental in its selection can be determined and, as clauses of principles can be traced to the cases from which they were abstracted, these cases and their origin can be ascertained and used as justification for a system's action by analogy.

A principle that determines which of two actions is ethically preferable can be used to define a transitive binary relation over a set of actions that partitions it into subsets ordered by ethical preference with actions within the same partition having equal preference. This relation can be used to sort a list of possible actions and find the currently most ethically preferable action(s) of that list. This forms the basis of a *case-supported principle-based behavior paradigm* (CPB): a system decides its next action by using a principle, abstracted from cases where a consensus of ethicists is in agreement, to determine the most ethically preferable one(s).

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Bonnie: Developing a Very Special Friend

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Demo: We will show our prototype skeleton for a social robot that is suitable for therapy with hospitalized children. This demo will concern one construction with 3 main components: the main body, the interface (sensory and human control) and the firmware.

Keywords: social robot, therapy, Arduino, sensory stimulation, ARCAROS

CONCEPT

The concept of Bonnie is based on the endearing effect of baby orangutans. The embracing/clinging of a monkey triggers a sense of care and an impulse to hold it close. To avoid an uncanny design [1], we chose not to create a human baby, but an animalistic form that still had some of the appeal of a human. An orangutan is more exotic and would raise less high expectancies.

Based on interviews with caregivers in a children's hospital we chose the following basic functionalities:

- Head can move sideways.
- Head can move up and down.
- Hands with grip.
- Haptic touch sense (vibrating hand).
- Arms can embrace.
- Remotely adjustable behaviour.
- Inclusion of sound effects. This needs more investigation.

INTERACTION SCENARIO'S

To enable the arrangement all the actuators in the desired disposition we produced a 3d printed body which also houses all the electronic components and batteries (Figure 1). The objective of this prototype is to trigger a 'sense of care' and combine the functionalities in meaningful scenarios, such as:

- Child touches the robot and triggers a corresponding movement. For example:
  - A touch triggers a hug.
  - Touching the belly triggers an approving nod.
  - Squeezing the hand will make it vibrate. This vibration will serve as a pain relief when a child is punctured, similar to the effect of the buzzy[2].
  - Touching Bonnie triggers a sound effect.
- Hands with grip, triggered by a touch sensor in the palm.

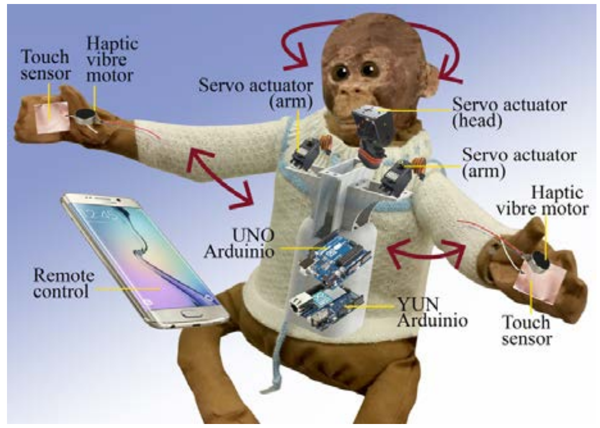

Figure 1. Bonnie augmented with sensors, actuators and Arduino's. Degree of freedom: saying *no* or *yes* and *hugging*. *Not shown: pressure sensor (belly) and sound generator.*

FIRMWARE

The system is controlled by a centralized firmware. Its architecture is based on isolated blocs that can be added or modified easily without affecting other parts of the system. Moreover, the modules are structured in three layers (application, translation and hardware). This increases the modularity/scalability of the system, forming a platform (ARCAROS) able to create more Bonnie-like robots with others inputs and functionalities.[3]

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Remote Control Application for Therapeutic Use of a Social Robot

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Demo: A remote control that gives healthcare professionals the ability to influence the behavior of robots, such as Pleo, that will be used in Therapeutic environments.

Keywords: remote control, Pleo, social robot

CONCEPT

Robots like a Pleo can be used with hospitalized children for distraction, preparing for treatment and evaluation of treatment. A remote control, such as a smart phone or tablet, gives the healthcare professional an unnoticed way to influence the behavior of the robot [3]. The remote control also collects sensor data which, in combination with the feedback from the robot, can be used to analyze the interaction.

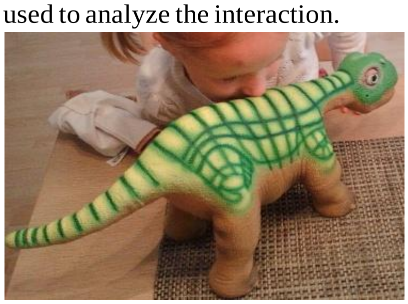

Figure 1. Pleo interacting with a patient

INTERACTION SCENARIO'S

Pleo is a robot whose behavior depends on the way you treat it. A patient feeling sad doesn't need a Pleo that gets angry when the patient pet the Pleo a bit too hard. A healthcare professional adjusts the behavior in a way that benefits the patient. The remote control is also used to force certain behaviors at moments when the child is about to lose interest in Pleo.

INTERFACE DESIGN

Based on needs of therapists [2,3], a user friendly interface is developed that is self-explanatory. The display contains facilities to configure the robot for an emotion (Emotions), mood (combined emotions), behavior, stage, profiles (type of child), and child identity (behavior, emotion and mood for a particular child). These emotions, moods, behaviors, stages, profiles and child identity are programmed in order to enhance engagement between patient and robot.

FIRMWARE

A Pleo is extended with a Bluetooth receiver so that it communicates with mobile devices, such as an Android phone or tablet, equipped with Bluetooth [4].

The commands from the control are sent to the robot by means of a RESTfull protocol [5].The PLEO-rb Development Kit [6] makes it possible to creatively interact with PLEO-rb on the programming level to modify his behaviors and tweak an animation.

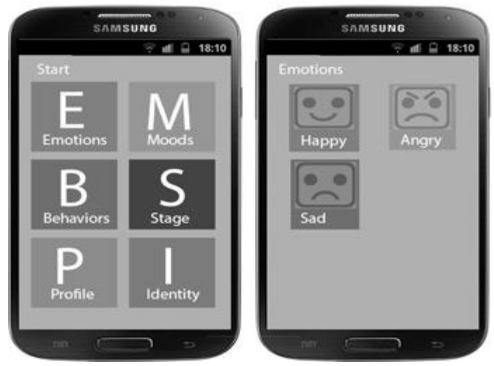

Figure 2. Interface design

FURTHER DEVELOPMENT

In the future the remote control will be able to support multiple mobile operating systems like the iPhone OS. Another target is the ability to work with other robots. The remote control will also be able to display the data collected, e.g. the amount of times Pleo is petted.

A cloud-based structure to enhance long-term engagement in a pet-robot companion treatment is also something being developed. This enables further personal adaptation of each emotion, mood, etc. for each child, thus enhancing effective interaction. Kids will be able to see small differences between PLEOs and can feel their robot is different from the rest [1].

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Social Robots to Support Children with Diabetes: an Overview of the ALIZ-E Project

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Video URL: https://vimeo.com/111655200

Abstract. This video presents a brief overview of the ambition and results of the ALIZ-E project. ALIZ-E built social robots to support children with diabetes. The robots were evaluated across hospitals in Europe and served as a support tool for young children, to help children understand their condition and educate children about diabetes management. The video highlights the collaborations between the academics, medical staff, parents and -most importantly- the children.

Keywords: social robotics, healthcare, child-robot interaction.

INTRODUCTION

The ALIZ-E project was a 54 month long European research project running between 2010 and 2014 involving an interdisciplinary team comprised of seven research institutes, one hospital and one medium enterprise [1, 2]. The project aimed to contribute to the development of integrated cognitive systems capable of naturally interacting with young people in real-world situations, with a specific goal of supporting children engaged in a residential diabetes-management course.

The goal of the project was to extend the science and technology behind long-term human-robot interaction. To achieve this, we addressed three related issues in developing interactive robots capable of sustaining medium- to long-term autonomous operation in real-world indoor environments. Firstly, ALIZ-E addressed how long-term experience can be acquired, so the robot could learn its spatio-temporal experiences. Secondly, ALIZ-E addressed how a system can deal robustly with inevitable differences in quality in perceiving and understanding a user and her environment. To this end, ALIZ-E developed new methods for adaptively controlling how a system invokes and balances a hybrid ensemble of processing methods for perception, action and interaction. Thirdly, ALIZ-E addressed how a system can engage in an intersubjective interaction using potential anthropomorphisation of robots by the user. The long term aim of the ALIZ-E project was to implement believable, long-term, social child-robot interaction.

RESULTS

Through dozens of studies and field trials, the project has shown that social robots have significant potential for motivating and educating young children. This can be used in educational environments, such as schools, but has significant potential in more targeted environments, such as hospitals, where children have to learn and acquire skills and where motivation is an important aspect of learning.

The creation of autonomous Human-Robot Interaction is one of the greatest challenges faced in robotics. While encouraging progress was made in ALIZ-E many of the more unstructured interactions still require the robot to be remotely controlled. A main obstacle to autonomous social robots appears to be perception: perceiving and correctly interpreting the social environment is as yet an unsolved problem.

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