Building up child-robot relationship

From initial attraction towards social engagement

Marta Díaz, Neus Nuño, Joan Sàez-Pons, Diego Pardo, Cecilio Angulo, Amara Andrés
CETpD Technical Centre for Dependency Care and Autonomous Living
Barcelona Tech
Neàpolis Building Rbla. Exposició, 59-69
08800 Vilanova i la Geltrú, Spain
(+34) 938967271
{marta.diaz,neus.nuño,joan.saez, cecilio.angulo,diego.pardo,amara.andres}@upc.edu

ABSTRACT

To explore social bonds' emergence with robots, a field study with 49 sixth grade scholars (aged 11-12 years) and 4 different robots was carried out at an elementary school. A subsequent laboratory experiment with 4 of the participants was completed in order to explore social engagement. At school, children's preferences, expectations on functionality and communication, and interaction behavior were studied. In the lab, recognition, partner's selection, and dyadic interaction were explored. Both at school and in the lab, data from videotaped direct observation, questionnaires and interviews were gathered. The results showed that different robots' appearance and performance elicit in children distinctive perceptions and interactive behavior and affect social processes (e. g., role attribution and attachment). The preliminary results will help in the design of robot-based programs for hospitalized children to improve quality of life[1]

Categories and Subject Descriptors

J.4 [**Computer applications**]: Social and behavioral sciences---Psychology.

General Terms

Human factors, design.

Keywords

Social Assistive Robots; long-term interaction; interdependence theory; role attribution.

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1. INTRODUCTION

Social robots, defined as platforms capable to engage people in natural social exchange, have already been proposed as supplementary tools for rehabilitation [1], autism therapy [2] [3] treatment adherence and compliance, and for entertainment, enjoyment and comfort [4] [5] [6]. These studies show very promising results with children. To fulfill therapeutic goals, robot's effectiveness depends strongly on its ability to elicit long-term engagement in children.

A severe disease is a serious event that dramatically affects children and their family's lives. Hospitalized children are confronted with stressful conditions including physical pain and fear. Social support becomes almost limited to hospital staff and relatives, who often are affected themselves by feelings of sorrow and concern. Therefore, another therapeutic-related application of social robots is to help children to cope with the harmful consequences of illness and long-term hospitalization. In this context, we identify two different therapeutic interventions that may be provided by Social Assistive Robots: rehabilitation monitoring and companionship, corresponding with two different social situations. In the case of rehabilitation the relationship between coach and pupil is goal-oriented and focused on the task. In the context of companionship the relationship is needs-oriented for levering feelings of isolation and stress. Both roles –coach and companion- require context-specific social competences to engage children in long-term interaction. Beyond novelty effect, robots have to remain compelling over a long period of time to achieve the therapeutic goals. Provided that robots have different social affordances (e. g., facial expression) and interaction capabilities (e. g., conversational skills) we assume that they are not equally suitable to take a specific role and to engage with specific target users. Matching between role demands and robot competences is a central criterion for believable and effective social robots design [7] [8]. To address this challenge, interdependence theory offers a useful situation-based understanding of interaction [9].

This work – whose results are shown partially- explore social bonds' emergence between children and robots applying models and techniques from social psychology. The aim of the present work is to observe and understand the interactive behavior between (non-patient) children and social robots in order to design further in field research involving hospitalized children. Our main assumptions are that (i) social situated specific skills and behavior are required to assume effectively social roles in coaching or companion interaction, and (ii) salient robots' features as appearance (i.e. lifelikeness, baby or adult likeness) act as social cues that elicit prosocial behavior in children. Based on observable features, perception is a complex subjective process of *making sense* mediated by cultural and contextual factors [10]. This paper describes a study developed in two phases. The first one took place at an elementary school where a workshop with 4 different robots (under the supervision of teachers) was carried out. The second phase took place two months later in a behavior research lab at the University. It consisted on a series of play sessions for evaluating some features of long-term engagement. The present study will focus on PLEO and NAO results since they are the most employed robots for coaching and companionship purposes as it is shown in the next section.

2. DESIGNING ROBOT'S SOCIABILITY

Health related social robots are supposed to take long-term assistive and companionship roles in children's everyday lives. Therefore, the essential challenge is to develop robots that keep children engaged over time after the initial novelty effect has worn off.

2.1 Robots for coaching

Pupil-Coach Interdependence: This relationship is based on the social bond (i.e. affective involvement), task, and goals. Obtaining patient collaboration is an essential issue in therapy and requires an agreement about the relevance and usefulness of tasks and goals. To fulfill the therapy's goals, the coach must provide ongoing supervision, encouragement, feedback, counseling, and support. Furthermore, to enhance children agreement and compliance is necessary to create an affective bond. Rehabilitation is usually hard and motivation must come from an affective bond of trust and intimacy (*alliance*) between pupil and coach. The coach must be responsive to pupil needs and emotions in an empathic way and find an acceptable balance between goals commitment and concern for pupil's wellbeing.

Required social skills: For task monitoring it is required an engaging communication and contingent feedback. For empathic rapport is necessary affective communication and awareness of child's psychological and physical state [11].

Selecting a coach-robot. A humanoid robot elicits a more consistent role attributed to authority, competence, expertise, and reliability. We selected the humanoid robot Nao. Nao (see Figure 1) is a state-of-the-art human-like robot platform produced by Aldebaran[2]. Endowed with 25 degrees of freedom for great mobility it features embedded software allowing text to speech, sound localization, visual pattern and colour shape detection, obstacle detection and visual communication through different LEDs. Nao has been used successfully in different European projects within different contexts due to its communicative and motor skills. The KSERA[3] project aims to obtain a successful, effective interaction between humans and robots to guarantee acceptance and adoption of service robotics technologies, although it focuses on elderly. In the French project ROMEO[4], Nao was used as a comprehensive assistant for persons suffering from loss of autonomy. In Feelix Growing[5] project, Nao has been used to mimic the emotional skills of one-year-old child and it was capable of forming bonds with people who treat it kindly. The robot is able to use the expressive and behavioral cues that babies learn to interact with others. In these studies Nao has shown to be highly skillful for social multimodal interaction with elderly people and children. Moreover, Nao has all the robots' skills identified in [11] for successful coaching: eye-contact, look-at behaviors, head, arm and hand gestures, speech and speech recognition. In addition, Nao's articulated anatomy and movement accuracy allows for direct imitation by children, especially applicable in motor rehabilitation cases. Considering these results, Nao has been the robotic platform selected to play the role of coach in the in field study.

2.2 Pet-robots for companionship

Recently, pet-like robots have been introduced to reproduce the social-emotional benefits associated with the interaction and the emotional bond between children and companion animals such as entertainment, relief, support and enjoyment [2]. This social bond is supposed to provide therapy relevant effects to hospitalized children in the way real pets do. However, animal-assisted activities, that have been proven to be effective for pediatric purposes [1], are not possible in hospital environment.

Owner-Pet Interdependence: The relationship between master and pet is based on hierarchy and attachment. We assume that a sort of master-pet bond may emerge between a child and a pet robot with social skills according to these two dimensions. Hierarchy means that children have an obvious higher status that could be enhanced if the robot-pet has a baby appearance [12]. The social situation defined by the master/pet interdependence, will naturally produce engaging activities (i.e. teaching new skills, learning to understand, care giving, playing together) and expressions of affection and concern.

Required social skills: In this context, the robot, besides considerations of appearance, life-like, and baby-like features, must be able to deploy (or acquire) social skills for effective communication (i.e. orientation, attention, responsiveness), for hierarchy submission (i.e. recognition, obedience), and to express and generate attachment (i.e. affective expressiveness).

Selecting a pet-robot. For the companionship role we used the robot Pleo, a robot platform that fulfils the above stated requirements of appealing baby-likeness, expressiveness, and an array of different behavior and mood modes. Pleo is a commercial entertainment robot developed by UGOBE[6] equipped with different tactile sensors beneath its skin, ground sensors in the feet, speakers and microphones. Among its features, it presents a set of creature-like personalities and develops internal drives like hunger or sleep, and several mood modes: happy, extremely scared, curious. Pleo has been tested in several research works [13], [14], [15]. These studies focus on the effect of Pleo in a long-term interaction, especially with children. In this sense, [16] conducted a long-term studio with six families, which were given a Pleo for a minimum of two months and a maximum of ten.

[2] www.aldebaran-robotics.com

[3] ksera.ieis.tuel.nl

[4] www.projectromeo.com

[5] www.feelix-growing.org

[6] www.pleoworld.com

Similarly, [17] carried out a study based on the opinions of a blog users about Pleo. The main results are related to initial engagement due to the novelty effect, the care behaviors and the long-term disappointment effect. Even so, the majority of studies identified the development of a social bond with the robot.

Figure 1. The robots Nao, Aibo, Pleo and Spykee

3. FIELD STUDY AT ELEMENTARY SCHOOL

To explore the factors influencing bond emergence between children and social robots, a preliminary study with no patient children was carried out in an elementary school. The main objective was to understand which robot's features regarding appearance and behavior were more salient to children and contributed most to create the first impression. Specifically, children interaction with different kind of robots and eventual robot-related differences were studied. Children attribution of competences and skills based on appearance and previous knowledge were explored. Children attitude, preferences, and emotional behavior were analyzed.

3.1 Method

3.1.1 Participants

The experience involved 49 sixth grade scholars. The children -29 girls and 20 boys- were aged between 11 and 12 years old.

3.1.2 Setting

The activity was presented as a workshop on robotics prepared together with the sixth grade tutors and displayed as a curricular complementary activity to Sciences lessons. The activity took place at school during ordinary class time and under continuous supervision of teachers.

3.1.3 Robots

The robots presented were a mechanoid functional robot (Spykee), a humanoid platform (Nao), a baby dinosaur robot (Pleo) and a mechanic-like puppy (Aibo). These four robots let us study and understand the role of appearance (e. g., animal vs. humanoid and functional vs. biomorphic) in a first impression situation. However, in this paper we focus on interaction with Nao and Pleo, the two robots selected for therapeutic contexts in our ongoing research.

3.1.4 Activity

Robot choice and group assignment: The four robots in off state were exposed together on a stage and children were encouraged to observe them freely and choose the one they prefer to play with during the workshop (Fig. 2). Children were not allowed to touch them and no further explanation was given. Children were assigned to one of the four workshops according to the expressed preference. The workshops took place simultaneously in two classrooms, the gymnasium and in the hall.

Self-presentation: The robots were activated and performed non-interactive behavior, i. e., pre-defined routines. Self-presentation behaviors were deliberated designed in order to show and suggest an engaging but realistic robot motor and interaction skills and competences. Nao's self-presentation started with a short introduction, speaking loud, waving hands, and showing its arms, legs and head mobility. It continued displaying its colored LEDs eyes in an entertaining way followed by playing a song and dancing accordingly. It ended the presentation with a Tai Chi dance, where Nao exhibited great balance and mobility skills. Pleo's skills were shown through some examples of human robot interaction. Firstly, it wakes-up by touching its contact sensors, next it goes sleep again by rubbing its back. Again wake-up, it became angry hanging it by the queue. Walking was shown when standing on a desk a head movements were performed while it was embraced.

Interactive behavior: Children were encouraged to play with the robots in a semi-oriented way. Conductors proposed interactive activities, answered children's questions and asked them about perceptions and expectations in an informal way. Conductors also monitored children to prevent robots damage, and even explored robots functionality boundaries under children request.

3.1.5 Techniques

Direct observation: The whole session was videotaped (still cameras were placed in the 4 settings) and a photographer covered the activity. Additionally, in two of the workshops the sound was digitally recorded.

Questionnaires: Participants answered a post-experience questionnaire to assess satisfaction and perceptions about robots. The questionnaires were composed by yes/no questions (i.e. 'Would you like to have a robot at home?'), multiple choice items (i.e. 'If you had a Nao robot, what would you use it for?: Playing/Helping with homework/Helping with housekeeping/Connecting to the Net/Others'); and open questions (i.e. 'What do you think engineers should improve in Pleo robot?').

Facilitators: Every workshop was conducted by a robotics engineer and an assistant who took notes on observation sheets, supervised the recording and passed the questionnaires.

Figure 2. Robots exhibition for selection

Figure 3. Interactive behavior with Pleo and Nao

2.1 Results

According to the research question and the aim of this paper, further results will only be referred to workshops with Pleo and Nao. Although the whole experience was videorecorded (for future analyses), in this work we focused on initial perceptions and expectations, interactive behavior and utterances observed in the workshops with the robots from a qualitative approach. 33 children selected Nao and Pleo. Pleo was the most selected robot with 18 choices -surprisingly all the children who chose it were girls- followed by Nao (4 girls and 11 boys).

Tables 1 and 2 summarize the results of workshops with Pleo and Nao, respectively.

Table 1. Initial perceptions and behavior with PLEO

	Observed behavior and utterances
Reasons for preference	Nice aspect *So cute!* Animal likeness Baby likeness
Expectations (before performance)	Love and affect responsiveness Baby likeness behavior Emotional expressiveness Make sounds
Liked most after Self-presentation	Seems a baby How it moves
Interactive behavior	Baby talk Affection giving Taking care activities
Wish it could do/have/be	More life-likeness /*Talk /Eat / Grow up* Responsiveness/*Not so sleepy*

Table 2. Initial perceptions and behavior with NAO

	Observed behavior and utterances
Reasons for preference	Seems/is a person Seems an ape Seems more articulated Is the biggest robot
Expectations (before performance)	To walk To grasp things To speak To move hands To dance To do *Matrix* To follow instructions To sing
Liked most after self-presentation	*Thai Chi* routines Dancing
Interactive behavior	Spontaneous imitation Admiration Spontaneous Applause Amazement/ *Wow!* Curiosity about technical issues /*That in the head is a USB plug?/ What's for?* Exploring Nao's physical , cognitive and social capabilities and constrains/*Is he hearing me now?/Does he see me?*
Wish it could do/have/be (From questionnaires)	Hold a conversation Capability to communicate in natural (children's native) language Non verbal communication skill: gaze and intonation/ *When looking at people should look in the face.* Talk about itself/ *Say what he is thinking* Improve motor competences/ *Play football/hockey and perform moonwalk* Assist/ *Help with my homework*

4. Interaction in the lab: meeting again

A second meeting was designed to explore social bonds emergence. After the school experience, a series of play sessions with Pleo was conducted in the lab. The aim was to observe children behavior when they met Pleo again and explore how the previous contact with the robot in the school affects –it's projected on- subsequent interaction. Specifically, differences and similarities on interactive behavior at laboratory and at school were assessed. Children interaction in a controlled situation under different social conditions (with a facilitator, alone, with a peer, and in a focus group) was explored. Finally, the role adopted by the participants during the interaction with Pleo was explored.

4.1 Method

4.1.1 Participants

At the end of the activity in the school, volunteers' participation for a second activity was requested. The interested children were given a form to be fulfilled, signed and sent back by their parents or tutors in case they consent participation. Eight parents consents were received and finally four children were selected for availability criteria. Three of them had the role of the owner and the fourth girl interacted with them as a part of the lab experience (see below *Playing with Pleo with peers*).

4.1.2 Setting

The experience was carried out in a behavior research lab at the University two months after the school experience. The play session took place in the test room and the group interview in a meeting room.

4.1.3 Robot

Two Pleo robots were employed for the experience. One of them was programmed to exhibit purring and slow smooth movements, and the other one was growling and agitated.

4.1.4 Activity

Choosing a Pleo: The participants were encouraged to choose between two identical Pleo robots that were performing the above mentioned behaviors.

Playing with Pleo in adult presence: The instruction given by the conductor was *"You can stay here with Pleo as long as you want. When you want to give up, just tell me"*.

Playing with Pleo alone: The facilitator leaves the lab and the child stays alone with the robot.

Playing with Pleo with peers: The participant received another classmate in the lab to create a situation that enhances talking about the experience and contrast opinions. The participant was encouraged to talk freely about Pleo to her classmate.

Group Interview: When all the participants finished their laboratory experience, a group interview was made with the four participants, a facilitator, and a robotic engineer. During the interview the Pleo robots were activated on the table.

4.2 Results

The four participants chose the Pleo that exhibited calm behavior to play with. The girls manifested that Pleo reminded them the robot in the school, so they seemed to recognize it as a familiar robot which had been with them before. They wanted to know and asked the facilitator which of the four Pleos in the lab was the one they *have met* at school.

The role they took was consistent with the one adopted in the school, but in this case the difference was that the participant had more time to interact with the robot and she was alone with it during a while. The interactive behaviors observed were petting, lovely hugging, stroking, and baby talk. When the participant played with a peer, she adopted neatly the owner's role interpreting Pleo's behavior and showing understanding of what it likes and likes not (i.e. "It's difficult for him to fall asleep", "It's not hungry now"). Finally, in the group interview, the girls shared their impressions about Pleo and compared it to a real pet companion. They expressed their enjoyment with the robot and agreed with the vision that they could have a closer bond with him similar to the owner-pet relationship.
Table 3 summarizes preliminary results with Pleo in the Lab experience, grouped in five situations: selecting Pleo, in the lab with facilitator, alone with Pleo, with a classmate and group interview.

Table 4. Interactive behavior in the lab

Situation	*Observed behavior and opinions*
Selecting a Pleo	All the participants chose the 'nice' one, picked it up and took in their arms
In the lab with facilitator	Petting, hugging and feeding behavior
Alone with Pleo in the lab	New activities appeared /Putting him into the doghouse/ Grabbing by the tail / Insisting on feeding
With a classmate	The presence of a peer helps the girl to express her feelings and reinforce her role of owner.
Group Interview Remarks	Similar to real pets Owner feelings Differences/similarities with the one in the school (more active and fun)

5. DISCUSSION

This study shows that robots' salient features as humanoid, mechanic, or animal appearance affect children preferences and are social cues in role attribution. According to appearance and performance children ascribe both functional and social characteristics to robots and interpret their behavior.

Consistent with the literature reviewed, two different interactive behavior patterns emerged in Nao and Pleo workshops. Interacting with Nao, children show spontaneous imitation, admiration and amazement. Nao autonomous behavior (i.e. seeking faces to orient interaction) elicits immediate children attempts to catch its attention and to draw Nao into interaction by waving, saying hello, or approaching to its face. Nao performance provokes curiosity and willingness to explore and investigate. The expectations about robot capabilities are high (i. e. conversational skills, gait) as a result of its human-like appearance and athletic performance. On the other hand, Pleo generates in children need-oriented affective behavior (e. g., giving affection) and involve in taking care activities. Children expect animal-like behaviors such as 'making sounds' and eating and ascribe Pleo animal characteristics such as internal drives (i.e. sleepiness, anger, hunger), reasoning and intention. In the lab session, children resumed the relationship and reinforced the initial social bond built during previous experience at school. Children asked for *their* baby dinosaur -the one they met at school-, and interpret recognition in Pleo's responses.

6. CONCLUSIONS

Children's perceptions and expectations about robots as social actors affect interactive behavior through role attribution. Robots appearance and primary performance should be carefully designed to elicit role consistent engaging but realistic expectations as a first step in long-term relationship emergence and maintenance.

Considering children suggestions after the interaction experience, some orientations for interface and technical specifications could be proposed. For instance, Pleo should show more life-likeness behaviors (e. g., talk, eat, grow up, sleep) whereas Nao should present more human skills (e. g., verbal and non verbal communication skills, motor competences and assistive tasks).

Understanding of social processes of interdependence and relationship dynamics in specific social situations seems necessary for optimizing matching between robot affordances and context-specific social demands. To achieve this objective is necessary to assess human-robot interaction in terms of role consistency.

Provided that interactive behavior is strongly context dependent, further field studies with target users, i. e., long-term hospitalized children are required to investigate the establishment and maintenance of children-robot companionship in health related scenarios.

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8. REFERENCES

[1] C. Plaisant, A. Druin, C. Lathan, K. Dakhane, K. Edwards, J.M. Vice, and J. Montemayor, "A storytelling robot for pediatric rehabilitation", Proceedings ASSETS-00, Washington, Nov. 2000, pp. 50-55. New York, NY: ACM Press.

[2] M. Davis, B. Robins, K. Dautenhahn, C.L. Nehaniv, and S. Powell, "A comparison of interactive and robotic systems in therapy and education for children with autism", Proceedings Assistive Technology from Virtuality to Reality?, 8th European Conference for the Advancement of Assistive Technology in Europe (AAATE-05), Lille, France, 6-9 September 2005, pp. 353-357. Amsterdam, The Netherlands: IOS Press.

[3] H. Kozima, C. Nakagawa, and Y. Yasuda, ”Interactive robots for communication-care: A case-study in autism therapy”, Proceedings IEEE Workshop on Robots and Human Interactive Communication (ROMAN 2005), Nashville, Tennessee, 13-15 August 2005, pp. 341-346. Piscataway, NJ: IEEE Press.

[4] J. Saldien, ”ANTY: The development of an intelligent huggable robot for hospitalized children”, 9th International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines, September 12 - 14, 2006, Brussels, Belgium.

[5] T. Shibata. Mental Commit Robot and its Application to Therapy of Children 2001 IEEUASME International Conference on Advanced Intelligent Mechatronics Proceedings, 8-12 July 2001.

[6] Okamura, A.M.; Matarić, .J.; Christensen, H.I., ”Medical and Health-Care Robotics, Achievements and Opportunities”. Robotics & Automation IEEE 2010 Vol. 17 Issue:3 pp.26 – 37.

[7] R. Gockley, A. Bruce, J. Forlizzi et al., “Designing Robots for Long-Term Social Interaction”, Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2005), August, 2005, pp. 2199 - 2204.

[8] A. Tapus, C. Tapus, and M.J. Mataric, “User-Robot Personality Matching and Assistive Robot Behavior Adaptation for Post-Stroke Rehabilitation-Therapy“, Intelligent Service Robotics: Multidisciplinary Collaboration for Socially Assistive Robotics, 1:169-183, Apr 2008.

[9] Rusbult, C. E; Van Lange, P. A.M., “Interdependence, Interaction and Relationships”, Annual Review of Psychology, 2003.

[10] Coeckelbergh, M. (in press) ‘Humans, Animals, and Robots: A Phenomenological Approach to Human-Robot Relations’, International Journal of Social Robotics, in press.

[11] C. D. Kidd, C. Breazeal, International, “Robots at Home: Understanding Long-Term Human-Robot Interaction”, International Conference on Intelligent Robots and Systems, 2008. IROS 2008, 3230-3235.

[12] M. Díaz, J. Sàez, D. Pardo and C. Angulo, “Pet robots with social skills for satisfactory interaction with hospitalized children”, Proceedings of RSS 2010 Workshop Learning for Human-Robot Interaction Modeling in Robotics: Science and Systems Conference, 2010.

[13] K. Pitsch, B. Koch, “How infants perceive the toy robot pleo. an exploratory case study on infant-robot-interaction”, Second International Symposium on New Frontiers in Human-Robot-Interaction (AISB), SSAISB: The Society for the Study of Artificial Intelligence and the Simulation of Behavior, Leicester, UK, 2010.

[14] Y. Fernaeus, M. H˚akansson, M. Jacobsson, S. Ljungblad, “How do you play with a robotic toy animal?: a long-term study of pleo”, IDC ’10: Proceedings of the 9th International Conference on Interaction Design and Children, ACM, New York, NY, USA, 2010, pp. 39–48.

[15] M. Jacobsson, “Play, belief and stories about robots: A case study of a pleo blogging community”, International Symposium on Robot and Human Interactive Communication (RO-MAN), IEEE, IEEE, Toyama, Japan, 2009.

[16] S. Fransen, P. Markopoulos, “Let robots do the talking”, IDC ’10: Proceedings of the 9th International Conference on Interaction Design and Children, ACM, New York, NY, USA, 2010, pp. 59–68.

[17] P. Markopoulos, Y. Verschoor, W. Ijsselsteijn, B. de Ruyter, “Testing interactive products with the robot intervention method”, IDC ’08: Proceedings of the 7th international conference on Interaction design and children, ACM, New York, NY, USA, 2008, pp. 117–120.