Feasibility of SAR Approaches - Helping Children with Learning Tasks

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***Abstract*— This paper gives an overview of two projects using a socially assistive robotics (SAR) approach to teach children about nutrition and problem solving, respectively. The first project describes a three-week long study designed for children aged 5 - 8 to interact with a robot that teaches them about making healthy food choices. The study is presented in detail in [1]. This paper gives an overview of the project, describing the results indicating that the children were engaged in a six-session interaction with a robot, that they took less time to respond to the robot towards the end of the study, and that the children had a very positive impression of the robot both before, and after the study. The results show promise for the feasibility of using SAR in one-on-one long-term interactions with children. The second project describes the feasibility of using a robot as part of a problem-solving activity for children. The project is ongoing, and so the paper describes the protocol, and some expected results.**

I. INTRODUCTION

Learning through an interactive and innovative way can be achieved by allowing children to engage in one-on-one interactions with socially expressive robots. Socially assistive robotics (SAR) has been identified as a research area that focuses on helping people through social interaction, rather than any other type of interaction [2], [3]. The two projects we present explore how well a SAR approach is capable of keeping children engaged with the task they are given. The first study explores longer-term exposure to a robot, while the second study focuses more on integrating the robot as part of an already well-established process of teaching.

II. BACKGROUND

Techniques that use widely available technology can be used for the purposes of helping children with various learning tasks. The question, however, is how engaged are the children throughout the learning task and how much better can we do with a system that employs human-robot interaction (HRI) in order to constantly keep children focused on the task? Literature on the topic shows that HRI within a SAR approach can be beneficial for learning. Leyzberg et al. showed that the time it takes people to solve a puzzle decreases when they receive the same hints in the embodiment, i. e. the robot is physically present, versus the on-screen condition [4]. Kidd and Breazeal show that people maintain their diet and exercise habits for longer when guided through the process by a socially assistive robot than when employing other types of intervention, namely a standalone computer method and a paper log method [5].

In our first project, we employ SAR to teach children about nutrition and to inform them about how they can make healthy food choices. Our topic choice stems from the importance of mitigating childhood obesity: "Obesity among children and adolescents has been shown not only to lead to a higher risk of being overweight in adulthood [6], but also of numerous diseases later in life, including high cholesterol and triglycerides, hypertension, and type 2 diabetes [7]. Educating children about healthy food and beverage choices, and motivating them to make healthier choices, can help to lower rates of obesity [8]." [1, p. 1]

Our second project is geared towards teaching children how to problem-solve. The data to be obtained in this study will be used to later inform the development of a study involving children clinically referred for behavioral difficulties. Statistics show that 50% of the American population meets criteria for a diagnosable mental disorder at some point in their lives, while in a given year, one in four Americans meets criteria for a such a condition [9], [10]. Most people in this category, however, do not receive any type of treatment [11]. As a consequence, various treatments have been suggested, including some novel models (e.g., task shifting, best-buy interventions; see [12]). Social robots can be used within various such types of therapy sessions to keep patients engaged in the interaction and focused on the task.

III. NUTRITION STUDY

A. Overview and Platform

The study focused on nutrition investigated the use of a robotic platform to teach children about healthy food choices. The study is part of a multi-site collaboration between Yale University, University of Southern California, the Massachusetts Institute of Technology, and Standford University under the umbrella of an extensive project with the overarching goal of developing robots that interact autonomously with children, helping them with various learning tasks. [1] We ran the study at two different sites, Yale and USC, using a Wizard-Of-Oz system, with a teleoperator choosing the relevant dialogue item for the children's answers. The interaction flow, however, was autonomous, and not controlled by the teleoperator. Our goal for the future is to move towards a fully autonomous platform.

The platform we used during this study is a robot called DragonBot, a socially expressive dragon-like robot with five degrees of freedom, developed at MIT [13], which can be seen in fig. 1. USC designed the skin in collaboration with an expert puppeteer to make the creature as appealing as possible to children. The robot has four different sized wings to allow it to "grow" from week to week, as it gets stronger

[1]This study was ran under the Expedition on Making Socially Assistive Robots funded by the NSF. We thank everyone from Yale University, University of Southern California, MIT, and Standford University involved in developing hardware and software for this study, and in running it.

Fig. 1. Participants' view of DragonBot.

and stronger, as an effect of the children choosing healthy food items for it to eat.

In order to keep the children engaged in the interaction, we created a backstory that spans across the entire course of the interaction. The story is that the robot is about to take part in a dragon race, which he very much desires to win. In order for the robot to win the race, it must become strong and fast, and that can only be accomplished by eating healthy. Children can choose items from a series of fake foods to feed the robot every week. They are thus drawn into this game of helping the robot become stronger each week so that it can ultimately win the big race.

B. Design of the Study

The study spans across three weeks, each week covering a different food topic (e. g. lunchbox, snacks, meals). Each week consists of two one-on-one 10-15 minute sessions. During the first session, the robot acts as an expert, conveying information to the children about the foods presented that week (we call this the Expert Session or ES). During the second session, the robot acts more as a peer, asking the child to make food selections to help it become strong and fast (we call this the Cooperative Session or CS).

C. Data Collected

We collected several types of electronic data, including information about the teleoperator's dialogue choices, as well as video and audio data. In order to measure the level of engagement of the children with the robot, we administered three different questionnaires to the children. The first two types were interaction questionnaires, one that included questions about the perceived value or usefulness of the interaction, and one that included questions about how the children perceived the social presence of the robot (used to quantify the effectiveness of the robot's social capabilities). These questionnaires were administered twice, once after the first interaction, and once after the final one. The third questionnaire asked the children to rate the robot's features, such as bad/good, cuddly/not cuddly, etc. It was administered before the intervention, but after a brief group introduction to the robot, and after the intervention. We also collected information about child temperament by asking the parents to fill out a Child Behavior Questionnaire. This questionnaire contains a 4-point Likert-type scale asking the parents to rate their children's behavior and personality.

D. Results and Conclusions

This section gives an overview of the multiple aspects of the interaction we considered when analyzing the data. These results are presented in detail in [1].

Based on the questionnaire asking children to rate the robot's features, we found that children in the study had an extremely positive perception of the robot, both before the intervention, and after the final session. Our next significant result was that children engaged with the robot and immersed themselves in the story. This is suggested by the decrease in the mean response time (time it took a child to respond to the robot's prompts) from day 1 (4.3 seconds on average) to day 6 (3.5 seconds on average). Due to the short period of the intervention, we found limited evidence showing that children learned about nutrition over the course of the three weeks. Children do show more nutritional knowledge, but this might also be due to the increase in cognitive demands related to making food choices over the weeks. In fact, children took longer to choose food items as the intervention progressed, suggesting they become more thoughtful and thorough in giving their answers over time.

More results indicated that the children engaged more and more with the robot over time since their type of responses changed from week to week: they started off with simple answers (e. g. "Yes", "No", "Hmm"), and continued to use expanded answers ("This is what I fix for dinner..."), and even relational answers (suggesting the children were beginning to relate to the robot, e. g. "You said you didn't like it!"). We also did not find a link between child temperament and social interaction with the robot, meaning that children with diverse temperaments could develop a relationship with a robot.

IV. PROBLEM SOLVING SKILLS STUDY

A. Overview and Platform

The problem-solving skills study is an undergoing project in collaboration with the Yale Parenting Center [14]. The ultimate goal of this project is to integrate a robotic platform into a problem-solving skills training process for children clinically referred for behavioral difficulties. The initial study aims to use the same robotic platform described in the previous study (DragonBot) for a single session within the problem-solving skills training method with children who are not clinically referred.

B. Design of the Study

Children who participate in the Problem-Solving Skills Training (PSST) program at the Yale Parenting Center go through a 12-session process to learn ways to cope with real-world situations that may prove difficult for them. These sessions focus on a 5-step method of how to appropriately deal with an everyday problem a child may encounter. The five steps are designed to help children come up with different potential behavior options, evaluate the consequences of each, and make a decision based on this.

Children become highly engaged and motivated while interacting with robots. Based on this observation, we are integrating DragonBot as part of this process, so that children can learn the steps through interacting with a robot. We change the above-described design to be able to control for the multitude of variables associated with a 12-session process and to evaluate the feasibility of using such a technique.

All participants will initially take part in a 30-minute PSST session with a member of the study staff, focusing on teaching the child a series of three problem-solving steps, a subset of the steps used for children with disruptive behavior problems [15]. After having completed this training session, the participants will either be assigned to the practice-with-DragonBot or the practice-alone condition. Children in the former condition will be introduced to DragonBot and told to ”teach” the robot the same problem-solving steps they just learned. Similarly to the previous study, DragonBot has a backstory of being a baby dragon that needs help with problem-solving. Through this teaching task, the children will be able to practice working with the steps alongside a robot by creating a peer-to-peer relationship with it. Children in the latter condition will be instructed to review the steps that they just learned on their own.

C. Data to be Collected

We are interested in assessing how well-suited the use of a robotic platform in such a context is, and in assessing the acceptability of this kind of treatment.

Children will complete different questionnaires, based on the condition they are assigned to. Children assigned to the robot condition will complete the Child Reaction to the Robot Interview, to assess their reaction to the robot (including questions on likability, animacy, physical appearance, and utility), and a Child-Robot Alliance Interview (to assess the child's relationship with the robot). Children assigned to the practice-alone condition will complete the Child Reaction to the Practice Task Interview, containing questions designed to obtain the children's feedback about the task. All children will complete the Child Version of the Treatment Evaluation Inventory, containing questions to assess how acceptable the treatment is from the perspective of the child.

Parents will be given the opportunity of watching the sessions their children are participating in, through a video monitor system. After having observed the sessions, the parents will be asked to complete the Child Behavior and Temperament Questionnaire. This data will help in later analyzing whether temperament is linked to the type of interaction we will observe between the child and the robot. Parents will also complete the Parent Version of the Treatment Evaluation Inventory to assess whether they view the treatment as acceptable.

D. Predicted Results

We predict that children in the robot condition will be more engaged in the task than children in the practice-alone condition. We also predict that the children interacting with DragonBot will be highly engaged in the task and in teaching the robot the steps, leading to their better understanding of what they had previously learned.

V. CONCLUSIONS

This paper gave the overview of two projects using HRI within a SAR approach to help children with learning tasks. The projects show the feasibility of using such approaches given the high level of engagement children demonstrated throughout one of the presented studies and the expected level of interaction as part of the ongoing study. This encourages us to continue using such techniques and to continue exploring the benefits of using interactive ways of helping children gain educational knowledge on different topics.

REFERENCES

[1] E. Short, K. Swift-Spong, J. Greczek, A. Ramachandran, A. Litoiu, and E. C. Grigore, “How to train your dragonbot - socially assistive robots for teaching children about nutrition through play,” 2013.

[2] D. Feil-Seifer and M. J. Mataric, “Defining socially assistive robotics,” in *Rehabilitation Robotics, 2005. ICORR 2005. 9th International Conference on*, 2005, pp. 465–468.

[3] A. Tapus, M. Mataric, and B. Scasselati, “Socially assistive robotics [grand challenges of robotics],” *Robotics Automation Magazine, IEEE*, vol. 14, no. 1, pp. 35–42, 2007.

[4] D. Leyzberg, S. Spaulding, M. Toneva, and B. Scassellati, “The physical presence of a robot tutor increases cognitive learning gains,” in *Proc. of the Annual Meeting of the Cognitive Science Society (CogSci)*, no. 1, 2012, pp. 1882–1887.

[5] C. Kidd and C. Breazeal, “Robots at home: Understanding long-term human-robot interaction,” in *Intelligent Robots and Systems, 2008. IROS 2008. IEEE/RSJ International Conference on*, 2008, pp. 3230–3235.

[6] A. S. Singh, C. Mulder, J. W. R. Twisk, W. V. Mechelen, and M. J. M. Chinapaw, “racking of childhood overweight into adulthood: a systematic review of the literature.” *Obesity Reviews*, no. 9, pp. 474–488, 2008.

[7] D. S. Freedman, W. H. Dietz, S. R. Srinivasan, and G. S. Berenson, “The relation of overweight to cardiovascular risk factors among children and adolescents: The bogalusa heart study,” *Pediatrics*, vol. 103, no. 6, pp. 1175–1182, 1999.

[8] D. Spruijt-Metz, “Etiology, treatment, and prevention of obesity in childhood and adolescence: A decade in review,” *Journal of Research on Adolescence*, vol. 21, no. 1, pp. 129–152, 2011.

[9] R. C. Kessler and P. S. Wang, “The descriptive epidemiology of commonly occurring mental disorders in the united states*,” *Annu. Rev. Public Health*, vol. 29, pp. 115–129, 2008.

[10] R. Kessler, S. Aguilar-Gaxiola, J. Alonso, S. Chatterji, S. Lee, J. Ormel, T. Üstün, and P. Wang, “Special articles. the global burden of mental disorders: an update from the who world mental health (wmh) surveys,” *Epidemiologia e psichiatria sociale*, vol. 18, no. 1, p. 23, 2009.

[11] R. C. Kessler, O. Demler, R. G. Frank, M. Olfson, H. A. Pincus, E. E. Walters, P. Wang, K. B. Wells, and A. M. Zaslavsky, “Prevalence and treatment of mental disorders, 1990 to 2003,” *New England Journal of Medicine*, vol. 352, no. 24, pp. 2515–2523, 2005.

[12] A. E. Kazdin and S. M. Rabbitt, “Novel models for delivering mental health services and reducing the burdens of mental illness,” *Clinical Psychological Science*, vol. 1, no. 2, pp. 170–191, 2013.

[13] A. Setapen, Master's thesis, Massachusetts Institute of Technology, Department of Architecture, Program in Media Arts and Sciences, 2012.

[14] [Online]. Available: http://childconductclinic.yale.edu/

[15] A. E. Kazdin, T. C. Siegel, and D. Bass, “Cognitive problem-solving skills training and parent management training in the treatment of antisocial behavior in children.” *Journal of consulting and clinical psychology*, vol. 60, no. 5, p. 733, 1992.