Evaluation of the CASTOR social robot in children's therapy with ASD in social skills

María Gaitán-Padilla, María J. Pinto-Bernal, Juan C. Maldonado-Mejía, Carlos A. Cifuentes, Marcela Múnera, Escuela Colombiana de Ingeniería Julio Garavito, Colombia.

{maria.gaitan-p, maria.pinto, juan.maldonado-me}@mail.escuelaing.edu.co, {carlos.cifuentes, marcela.munera}@escuelaing.edu.co

Abstract

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects social and communication skills. According to the WHO, it is the third most common developmental disability globally, and according to the Colombian Autism League, 1 out of every 160 children has ASD. Therapies target different developmental skills such as language, proprioception, attention, and social skills. These therapies have been adapted to the benefit of patients, which is why social assistance robotics (SAR) has begun to be implemented in these treatments. A study in long-term ASD therapies with the CASTOR social robot of five boys and one girl with ASD in social skills activities is carried out. The results show significant differences in the spontaneous and the therapist-provoked physical interactions. However, the time of visual attention to the therapist increases comparing the first session and the third session. This suggests that physical interaction with the robot is essential during ASD therapies and generates more interest from the participants in the treatment.

Keywords: Autism Spectrum Disorder, Social Robotics, Long-term studies.

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disability that affects social skills. According to WHO, ASD is the third developmental disability globally, and the Colombian Autism League estimates that 1 in 160 children have ASD (WHO, 2021). Humans have different methods to interact socially. Social robotics replicates this behavior, with robots promoting interaction (Liu et al., 2016). The applications of social robotics are vast, as they are implemented with the population with ASD (David et al., 2018), accompanying older adults (Miklósi & Gácsi, 2012), and in educational environments (Konijn et al., 2020). The CASTOR robot (Center for Biomechatronics, Colombia) was developed with CompliAnt SofT Robotics. CASTOR is a low-cost open-source platform created for therapies in children with ASD (Casas-Bocanegra et al., 2020). This study evaluates the application of the CASTOR social robot in long-term ASD therapies.

2. Development

This study presents the implementation of a social robot in children with ASD in five basic social skills. The methodology and partial results of five sessions of long-term research are presented. In addition, a discussion of the partial findings is shown.

2.1 Background

Social functions and skills are affected in children with ASD, and recently social robots have been implemented to improve them. Thus, Joint Attention is an essential social skill treated through learning sessions with SAR (David et al., 2018). On the other hand, emotion recognition using SAR is also used

(Conti et al., 2019). SAR is implemented to recognize moods with images, and an increasing behavior in emotion recognition was found. Another skill is physical imitation with object manipulation with the commercial robot NAO (SoftBank Robotics, France), a high-cost robot highly used in ASD therapies (Petric et al., 2017). Long-term studies have been conducted, such as (Pakkar et al., 2019) and (Scassellati et al., 2018) implemented at home in uncontrolled environments for one month, both using games to motivate children to perform their therapies. In these works, the robot used is Kiwi (University of Southern California, United States), a low-cost robot made by 3D printing.

2.2 Problem statement

Considering the limitations found in validating the impact and performance of low-cost social robotics in the long term, we propose a study implementing this technology in therapies for children with ASD for two months to validate the use of the CASTOR social robot.

2.3 Method

A total of 6 subjects diagnosed with ASD linked to the Howard Gardner Clinic (5 boys, 1 girl, 11.66 ± 2.49 years) participated in the study. All legal representatives of the individuals were informed about the scope and purpose of the study, and consent was obtained from each of them. The ethics committee has approved this project of the Colombian School of Engineering. The study consists of 8 weeks; however, the results of the first five sessions of 20 to 30 minutes per participant are presented.

The study is conducted in 4 phases, the familiarization, the pre-test, the use of the CASTOR robot, and the post-test. The familiarization stage is a session where free interaction with the robot is performed. The pre-test stage is a therapy session conducted without the robot and in which the participants are classified into the four levels of functionality. The use stage is when the CASTOR robot is implemented evaluating 12 variables: seven variables scored by the therapists of speech therapy, psychology, occupational therapy and physiotherapy(Focused Attention (FA), Following Instructions (FI), Working Memory (WMP), Emotion Identification (EI), Physical and Verbal Imitation (PI_VI), Emotional Response (ER) and Performance (P)), two visual attention time variables (time of visual attention to the robot (RT) and time of visual attention to the therapist (TT)), and three physical interactions variables (Spontaneous Physical Interactions (SPI), Robot-provoked Physical Interactions (RPI) and Therapist-provoked Physical Interactions (TPI)). The post-test stage is a therapy session conducted without the CASTOR robot to evaluate the children's final progress in their performance and social skills. This stage will be completed at the end of the eight weeks of application.

The Shapiro-Wilk test and the Wilcoxon Mann Whitney test were applied to the 12 variables to determine normality and significant differences.

2.4 Results

The Shapiro-Wilk test showed that not all the results had a normal distribution. Then the WMW test was performed to demonstrate significant differences over time, in which no significant differences were obtained in the variables scored by the therapist involved in each session.

On the other hand, the physical interaction results show significant differences over time. These results are shown in Figure 1. Spontaneous interaction with the CASTOR robot increased when comparing session 1 with session 3 ($p = 0.05$) and session 1 with session 5 ($p = 0.04$). In addition, an increase in therapist-elicited interaction was obtained between session one and session 3 ($p = 0.04$). In

this case, the number of spontaneous interactions is higher than the rest from the second session onwards.

Figure 1. *Spontaneous Physical Interaction (SPI), Therapist-Prompted Physical Interaction (TPI), and Robot-Prompted Physical Interaction (RPI).*

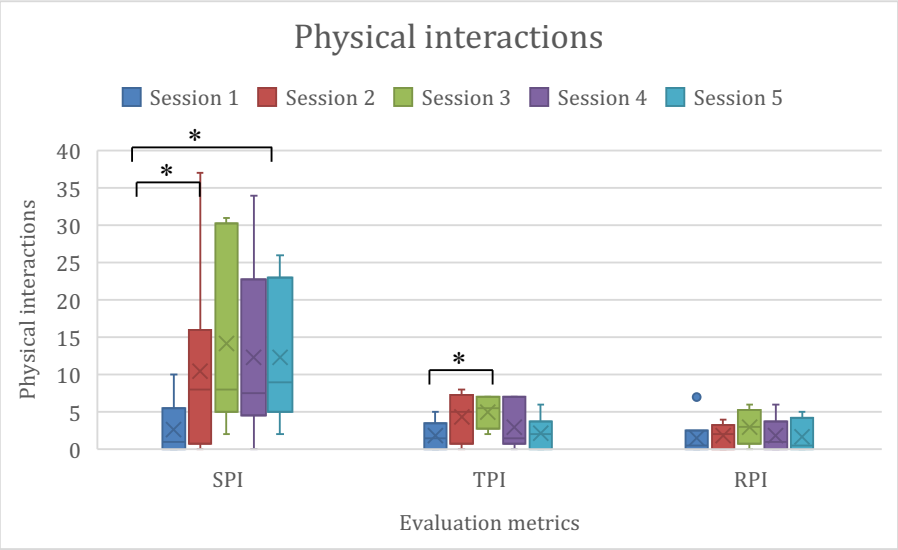
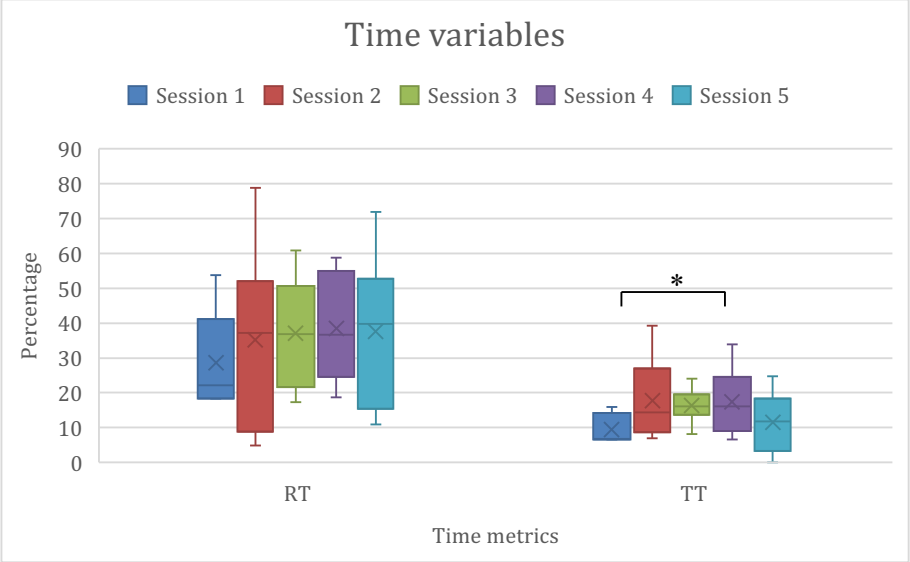


Figure 2. *Visual attention time variables during the five therapy sessions. Time of visual attention to the robot (RT) and time of visual attention to the therapist (TT).*



Finally, the time variables evaluated in percentage show an increase in the time of visual attention to the therapist between session one and session 3 ($p = 0.02$). These results are shown in figure 2.

2.5 Discussion

In these partial results, differences are seen between sessions, demonstrating progress over time in some variables; spontaneous physical interaction has increased for session three and session 5, indicating the motivation and comfort of the participants towards the sessions with the CASTOR robot. Social robots have previously been found to motivate participants to perform their therapies at home within a month (Pakkar et al., 2019), as seen in this partial analysis. In addition, attention time to the

therapist increases, demonstrating the robot's contribution in attention to therapies and visual attention to the robot with high percentages of time.

3. Conclusions

The results indicate the importance during therapies of physical contact with the CASTOR robot due to the curiosity and motivation it generates in children with ASD. The robot also induces an increase in attention to the therapist and the therapy in general. However, no significant increase was obtained in the variables evaluated by the therapists so far, so a more detailed analysis will be carried out in the study in the rest of the sessions. Considering this, it is concluded that according to the opinions of the therapists and the variables of time and physical interactions, the CASTOR robot contributes to the sessions and the attention and motivation of children with ASD during these. In addition to ASD therapies, the CASTOR robot can be implemented in other SAR areas, such as older adults accompaniment, interaction in school environments, and physical human-robot interaction as an emotional accompaniment because it can give reciprocal hugs.

References

Casas-Bocanegra, D., Gomez-Vargas, D., Pinto-Bernal, M. J., Maldonado, J., Munera, M., Villa-Moreno, A., ... & Cifuentes, C. A. (2020, September). An Open-Source Social Robot Based on Compliant Soft Robotics for Therapy with Children with ASD. In *Actuators* (Vol. 9, No. 3, p. 91). Multidisciplinary Digital Publishing Institute.

Conti, D., Trubia, G., Buono, S., Di Nuovo, S., & Di Nuovo, A. (2019). Affect Recognition in Autism: A single case study on integrating a humanoid robot in a standard therapy. *Qwerty - Open And Interdisciplinary Journal Of Technology, Culture And Education*, *14*(2). https://doi.org/10.30557/qw000018.

David, D. O., Costescu, C. A., Matu, S., Szentagotai, A., & Dobrean, A. (2018). Developing joint attention for children with autism in robot-enhanced therapy. *International Journal of Social Robotics*, *10*(5), 595-605.

Konijn, E. A., Smakman, M., & van den Berghe, R. (2020). Use of robots in education. *The International Encyclopedia of Media Psychology*, 1-8.

Liu, P., Glas, D. F., Kanda, T., & Ishiguro, H. (2016). Data-driven HRI: Learning social behaviors by example from human–human interaction. *IEEE Transactions on Robotics*, *32*(4), 988-1008.

Miklósi, Á., & Gácsi, M. (2012). On the utilization of social animals as a model for social robotics. *Frontiers in psychology*, *3*, 75.

Pakkar, R., Clabaugh, C., Lee, R., Deng, E., & Matarić, M. (2019). Designing a Socially Assistive Robot for Long-Term In-Home Use for Children with Autism Spectrum Disorders. *2019 28Th IEEE International Conference On Robot And Human Interactive Communication (RO-MAN)*. https://doi.org/10.1109/ro-man46459.2019.8956468.

Petric, F., Miklic, D., Cepanec, M., Cvitanovic, P., & Kovacic, Z. (2017). Functional imitation task in the context of robot-assisted Autism Spectrum Disorder diagnostics: Preliminary investigations. *2017 26Th IEEE International Symposium On Robot And Human Interactive Communication (RO-MAN)*. https://doi.org/10.1109/roman.2017.8172498.

Scassellati, B., Boccanfuso, L., Huang, C., Mademtzi, M., Qin, M., & Salomons, N. et al. (2018). Improving social skills in children with ASD using a long-term, in-home social robot. *Science Robotics*, *3*(21), eaat7544. https://doi.org/10.1126/scirobotics.aat7544.

WHO (2021). *Autism spectrum disorders*. From https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders.