Month-long, In-home Case Study of a Socially Assistive Robot for Children with Autism Spectrum Disorder

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ABSTRACT

Research in socially assistive robotics (SAR) has shown potential to supplement expensive and sometimes inaccessible therapy for children affected with autism spectrum disorder (ASD). However, due to practical constraints, most SAR research has been limited to short-term studies in controlled environments. In this report, we present a 30-day, in-home case study of a fully autonomous SAR intervention designed for children with ASD and discuss its insights into the value of personalized, long-term, and situated interaction.

KEYWORDS

Human-robot interaction; autism spectrum disorders; early childhood development; long-term; in-home; personalization

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1 INTRODUCTION

The Center for Disease Control estimates that approximately 1 in 68 children have been diagnosed with autism spectrum disorders (ASD) [2], a group of developmental disorders characterized by delays in communication and social skills. Early diagnosis and regular therapeutic intervention are critical factors impacting the potential impact of therapy with children on the spectrum. However, these services for children with ASD are not universally accessible nor affordable–the annual cost in the United States alone is estimated to be between $11.5 and $60.9 billion [7].

Emerging research in socially assistive robotics (SAR) seeks to reduce the disparity between need and access to ASD therapy through individualized therapeutic human-robot interaction (HRI) that supplements and augments the work of clinicians, therapists, and caregivers [4]. Specifically, long-term SAR interventions provide the benefits of personalization [5], reduce the effects of novelty and discomfort [6], and strengthen human-robot attachment [1]. To illuminate some of these long-term effects, we conducted a case study of a fully autonomous SAR system deployed for 30 days in the home of two young siblings, one diagnosed with ASD. In this report, we present the system, study design, and preliminary results.

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2 SYSTEM OVERVIEW

We designed and built a fully autonomous SAR system specific to the needs of long-term, in-home interventions with children with ASD. The physical SAR setup included a Stewart-platform robot [8], a touchscreen computer on which participants played educational games, and a forward-facing camera to record the interaction. The system was powered on or off at the discretion of the participants.

The SAR intervention was centered around 10 space-themed educational games designed by education specialists and iteratively tested in preschool classrooms [3]. The games focus on numeracy skills such as counting, ordering and sequencing, and pattern matching, with a total of five difficulty levels.

3 STUDY DESIGN

In this initial case study, we deployed our system for 30 days in the home of a family with one primary guardian with full-time employment and two sons. One sibling was a six year old male affected with ASD and the other was a five year old typically developing (TD) male. Though dissimilarly affected and of slightly different ages, the child participants were in the same school year.

The participating family was encouraged but not required to interact with the system five times per week. During each session, the child participants were encouraged to play through at least 10 games, one of each type at a randomized difficulty level. For each game, the child participants had a maximum of five tries to answer correctly before the system moved on to another game.

We administered a post-session survey to the parent that included the following 5-point Likert scale questions: 1) "How did your child feel about interacting with the robot today?", 2) "To what degree did you have to motivate your child to interact with the robot and games today?", 3) "How independently did your child interact with the robot and games today?", 4) "How do you think your child performed on the activities today?". The parent was also requested to report the child's general mood using positive terms (i.e., "content", "happy", "focused", "calm", "energetic", or "excited") or negative terms (i.e., "tired", "low energy", "distracted", "frustrated", or "anxious") to compute an average daily mood score. Lastly, we conducted weekly semi-structured interviews to gather any additional high-level insights.

4 PRELIMINARY RESULTS

We found that the participating family adhered to the above guidelines without our strict enforcement. Over the 30-day period, the

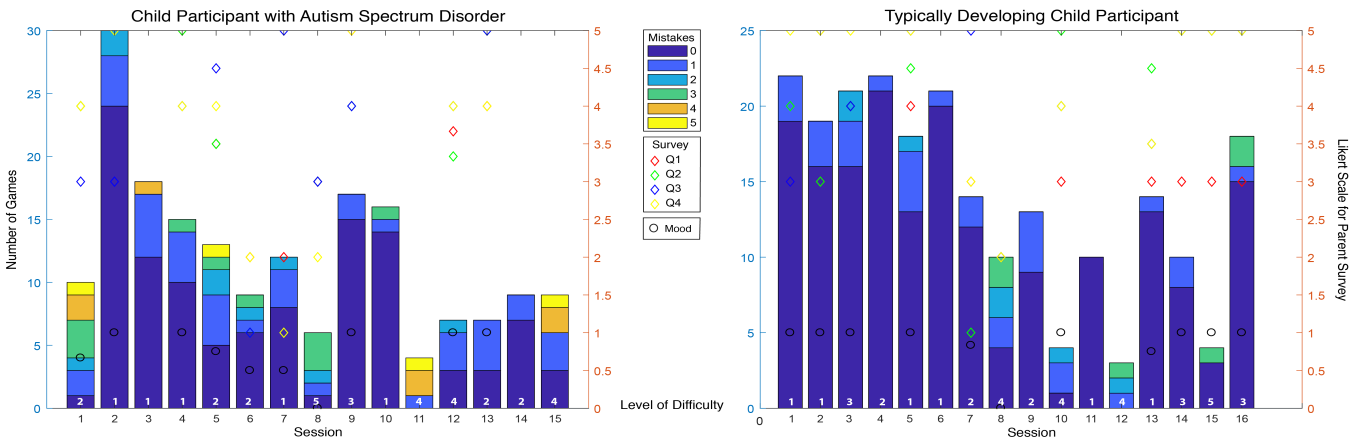

Figure 1: The bar graph shows the mistakes made for each sibling per interaction session as well as the total number of games and difficulty level played in that session. Overlaid are the results from the five-point Likert Scale parent surveys and the child's computed mood.

child with ASD interacted with the SAR system 15 times for 9.904 ± 4.002 minutes and the sibling interacted 16 times for 10.142 ± 4.403 minutes. The study produced over five hours of recorded interaction, a comprehensive analysis of which would extend far beyond the scope of this report. Thus, we focus our analysis on the child participants' longitudinal performance and survey data; namely, we discuss the need for personalization and the value of long-term, situated interaction.

Though the child participants were in the same school year, Figure 1 shows that there were clear differences in their aptitude with respect to the games. Overall, both children completed a similar number of games at similar difficulty levels with a generally positive mood. However, the child with ASD made three or more mistakes more frequently than the TD sibling ($p < 0.05$). Additionally, for both children, we found the number of games completed to be negatively correlated with the difficulty level ($p < 0.01$) and positively correlated to games completed with no mistakes ($p < 0.001$). While this result is intuitive, as it takes less time to complete easier games, it is important to note that difficulty level was the only significant factor found. Over the course of the intervention, both children completed fewer games ($p < 0.05$) and with fewer than two mistakes ($p < 0.05$). This may indicate increased aptitude as well as decreased interest in the games over time.

Through our weekly interviews, we found that the parent felt increasingly more comfortable leaving the children to interact independently with the SAR system. The parent also reported that the SAR system afforded time to focus on other tasks while the child remained socially and educationally engaged with the SAR system. However, only 51.79 percent of the intervention was annotated as purely dyadic ($k > 0.9$); the child participant and SAR system were in frequent presence of other people. This argues for conducting SAR research in realistic environments, outside the context of dyadic interaction and laboratory settings.

In our post-intervention interview, both child participants reported that they would like the SAR system to stay in their home for longer, even after a month of interacting with educational games. Such positive feedback from participants supports the promise of long-term engagement through SAR.

5 CONCLUSION

In this report, we presented some preliminary results of a month-long, in-home case study of a fully autonomous SAR system designed for children with ASD. Specifically, this case study demonstrates the importance of personalization for children with varying needs and illuminates some effects of long-term, family-situated interventions on user acceptance. The deployment of a fully autonomous SAR system in a home for 30 days pushes the boundaries of SAR, HRI, and broader robotics research. We are continuing to deploy long-term, in-home case studies with this system to gain further insights into the potential of SAR for children with ASD.

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