

Quantitative Results of Robot-Assisted Therapy for Children with Autism, ADHD and Delayed Speech Development

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ABSTRACT

This paper presents an ongoing work that aims to provide a quantitative analysis of a large clinical study that was conducted with 21 children aged 4-8 years old. Children were diagnosed with various forms of Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD) or Delayed Speech Development (DSD) with autistic traits. Each child participated in four to six Robot-Assisted Therapy (RPT) sessions that lasted for fifteen minutes each. We manually video-coded the videos from the sessions to find behavioral patterns, engagement and valence scores, and we are now in the process of statistical data analysis to understand whether children's exposure to a robot had a significant effect over time.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; • **Social and professional topics** → **Children**; • **Computer systems organization** → **Robotics**.

KEYWORDS

Human-Robot Interaction; Robot-Assisted Therapy; Autism Spectrum Disorder; Attention Deficit Hyperactivity Disorder; Delayed Speech Development; Social Robot; NAO

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Figure 1: Experimental setup

1 INTRODUCTION

A number of recent research efforts investigating robot-assisted therapy for children with Autism Spectrum Disorder (ASD) has increased over the last decade. Although previous studies yielded advantages in using the robot for children with autism, Huijnen et al. (2019) [1] stated that not all children would perform the same due to their diversity of autism forms and co-existence with ADHD and DSD. Tapus et al. (2012) [5] examined a series of 4 single case experiments for that reason: a large spectrum of individual nuances, heterogeneous behavioral issues and conditions present in children make it difficult to compare them as a group. David et al. (2019) presented a series of 5 single-subject experiments in [2].

A critical review by Diehl et al. (2012) [3] examined empirically-based evidence on the clinical applications of robots in treatment of Autism Spectrum Disorders (ASD) and concluded that most studies are exploratory and have methodological limitations that make it difficult to draw firm conclusions about the clinical utility of robots [4].

This research is motivated by the challenges of conducting generalizable research of robot-assisted therapy for children with diverse forms of ASD that often co-occur with ADHD and DSD symptoms. With a goal of a large-scale deployment of such robotic interventions as an additional kind of therapy, this research aims for autonomy and generalization at the same time.

2 METHODOLOGY

The work presented in this paper exploits a previously proposed methodology tailored for the therapy of children with various forms of ASD co-occurring with DSD and ADHD that was based on an iterative design with fourteen children [4]. Similarly, this work was conducted at the Republican Children's Rehabilitation Center in the capital of the country. Each participant interacted with a robot a number of times (from four to six sessions) over a two-week period. Every session was video recorded for later evaluation. Qualitative results based on observations and parents' interviews were discussed in [6–8], while this work involved video-coding all video sessions to extract quantitative metrics.

During each session children were offered to interact with a robot through robot applications such as "Follow Me", "Touch Me", "Dance with Me", "Transport", "Animals", "Emotions", "Storytelling", and others implemented on a humanoid NAO robot. These games are designed to tackle the issues that ASD and ADHD children usually face. Each session ended in 15 minutes by the robot telling goodbye to the child. The study was approved by the University's ethic committee and the consent forms were collected from the parents or guardians.

The therapy sessions took place in a small room (Figure 1) that does not contain distracting furniture or toys. The robot and a child were on the floor in order to have the same level of eye contact and to allow free movements. The therapy sessions were recorded by a web camera for further analysis and each application was played in a particular order that was under researchers' control.

2.1 Participants

There were 21 children (3 female) aged 4–8 years old, who were diagnosed with the Autism Spectrum Disorder only, in combination with ADHD or Delayed Speech Development. Most of the children were non-verbal with the ADOS-2 test score between 3–7. The children with the parent were hospitalised at the Center for 21 days and at the same time participated in the required therapy sessions.

2.2 Measurements

We used ELAN software to video code the interactions: we coded the engagement scores from 1–5 (1-Intense Noncompliance, 2-Non-compliance, 3-Several Prompts, 4-One/Two Prompts, and 5-Immediate Reaction), valence scores (1-Sad, 2-Below Neutral, 3-Neutral, 4-Interested, and 5-Happy/Excited), and eye contact duration. We also coded each application duration and child's compliance to robot's instructions.

3 FUTURE WORK

A series of repeated-measures analysis will be conducted to explore single subject cases as well as independent measures analysis grouping children according to their ADOS-2 scores and co-occurrence with ADHD or DSD. Figure 2 presents an example of one child's metrics. Engagement score of this child increased from session to session (Figure 2 top). In the beginning, the engagement rate was less than 2.5 but slightly increased in the last session. The valence score (Figure 2 middle) shows that the child was mostly positive towards the robot during the sessions. Figure 2 (bottom) demonstrates that the child improved his eye contact with the robot as

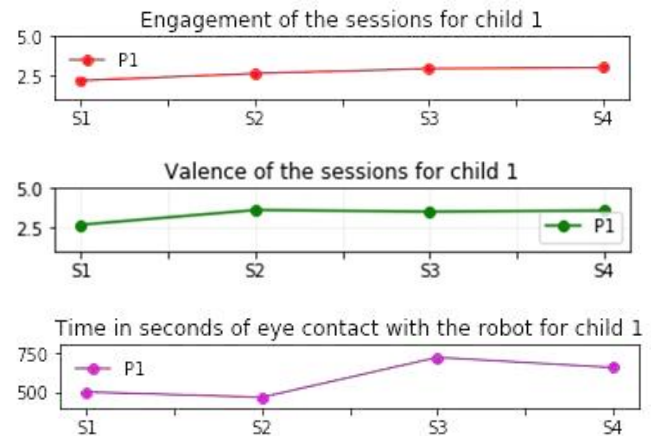


Figure 2: Engagement, valence scores and duration of eye contact for Child 1.

the latter two sessions demonstrate the increase in duration of eye contact. Statistical analysis is undergoing and we expect to have quantitative results ready to be presented in a poster session at the conference in March 2020.

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