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# Robot-assisted Social Narratives for Children with Diverse Developmental Conditions: A Pilot Study

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***Abstract*— Social Narratives (SNs) have shown promising benefits for helping children navigate diverse social situations. The use of SNs in Robot-Assisted Play (RAP) can offer creative ways to address social and communication challenges of children with functional needs. In this study, we evaluate the initial use of social stories in robot-assisted therapy to help 17 children with diverse conditions such as Down Syndrome (DS), Autism Spectrum Conditions (ASC), and speech disorders (SD) understand and act on real-world situations while interacting with the social robot Furhat. We developed educational stories based on six common professions to show how each professional works and interacts with people. We conducted a user study as part of their daily intervention in a rehabilitation center over two weeks. Overall results demonstrate that there were no significant differences in socio-emotional outcomes among children grouped by their diagnosis, age, and other characteristics. However, their communication skills played a significant role in their performance; in particular, children with verbal abilities had higher completion time in activities compared to their non-verbal counterparts. This result was supported by two therapists who reported higher engagement with the robot among verbal children. We suggest that the SN-inspired intervention could be used to support children with diverse special needs, without causing any negative impacts on their learning.**

## I. Introduction

Robot-assisted play (RAP) provides opportunities for children with developmental conditions to develop social learning and play skills in human-robot interaction (HRI) [1]. Social robots play the roles of assistants to therapists, and mediators between them and children to practice and learn new skills in engaging ways. Recent studies have emphasized the promising benefits of robots in engaging children with intellectual disabilities (ID) [2] and Autism Spectrum Conditions (ASC) [3] in social interventions.

Individuals with functional challenges such as ID and ASC may have difficulties with perspective-taking, theory of mind or the impaired ability to understand social behaviors and activities [4], [5]. Parents are usually concerned that their children do not respond well to different social cues and hence need a structured knowledge of what might happen around them in certain contexts. In this regard, one of evidence-based practices [6] known as social narratives (SNs) can address the theory of mind challenges faced by individuals with ASC. SNs, also named as social stories or story-based interventions, are stories that depict social situations, facilitate appropriate social behaviors and when to show such behaviors [7]. They usually include concise written narratives and visual cues for explaining social behavior standards, others' viewpoints, and the precise procedures for acting appropriate social skills [8]. Some examples include but are not limited to self-care routines (washing hands), social (learning to say "thank you") and academic skills. SNs have been used to address the social challenges that children with ASC face, yet some research has found its applicability in teaching children with ID and SD [9], [10]. More research is needed to investigate the efficacy of SNs for children without ASC [11].

We propose the use of social narratives to help children with diverse developmental conditions understand social behaviors in professional contexts. To this end, we evaluate the application of the social robot Furhat in an autism intervention center. We observe how robot-mediated intervention affects children's well-being in social situations and whether they can achieve socio-behavioral progress. In addition, the interviews with therapists allow us to identify practical challenges and recommendations for future RAP studies. Our novel contributions are first summarized briefly and then detailed in depth:

- Addresses a gap in HRI studies by focusing on social narratives for children with functional needs;
- Demonstrates the real-world application of SNs for RAP led by human therapists, supporting social learning in naturalistic contexts;
- Introduces the use of physical supports or tangibles to make activities more engaging and relatable for children;
- Explores a new application for the Furhat robot, examining its suitability for navigating social situations.

We contribute to the growing body of empirical evidence in the context of RAP by demonstrating their in-the-wild application. As most therapeutic tasks for children with special needs focus on social learning, it is important to situate such tasks in a naturalistic context to facilitate skills

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progression [12]. More efficient early behavior interventions for children are essential to promote progress at later stages, ultimately enabling adults to live more or less independent lives [13]. Most HRI studies to date focus on storytelling activities, which might seem abstract to children who lack imagination skills. To the best of our knowledge, only a handful of HRI studies [14], [13] have been conducted on the topic of social narratives for children with functional needs such as ASC. We address these limitations by suggesting the use of SNs to help children navigate real-world situations while gaining more confidence in less familiar environments.

Six activities have been designed to support knowledge and awareness of social norms, daily life contexts, and academic skills under the Professions theme. In contrast to common visual and written stimuli, we enhance each activity with physical supports or tangibles to improve their perception of real objects and situations. We measured children's socio-behavioral outcomes, such as engagement and valence, using ten validated social metrics based on our previous research [15]. Additionally, we employed medical specialists to independently conduct the SN-based RAP in the center. This approach enables a more naturalistic and real-world application of the intervention involving both children and human therapists. Finally, we use the Furhat robot in a new application area. Previous studies with the Furhat robot primarily included older adults [16] and, in some cases, typically developing children [17]. We suggest that this communicative robot is well suited to meet intervention goals since it can easily simulate social situations with custom-made verbal and non-verbal capabilities.

## II. Background: Social Narratives in HRI

Unlike traditional approaches to teaching social behaviors, robot-mediated interventions have maintained social narratives in engaging ways [14], [13]. The earliest study of social story intervention in HRI focused on teaching daily skills, such as how to share toys, greet others and show appreciation, to four children with the help of the Probo robot [14]. Here, the robot condition was compared against two other conditions - baseline and a human therapist. Their results found that robot-led intervention was more effective in reducing the level of prompting than when taught by human alone. In their exploratory study, Pop et al. [13] compared the computer-based social story delivery to that of robots. It was evident from their findings that using the social robot for teaching social story was more effective in improving the independence of children in expressing social abilities, than the computer screen. Other technological affordances can be useful for HRI. For instance, the most recent use of SNs in HRI suggested the use of object with playware technology (OPT) as an add-on to the social robot [18]. The use of the OPT resulted in better engagement with the robot, eliminating the need to have several visual cards, thus making the interaction more seamless. These studies highlight the significant added value of social robots in autism intervention, enhancing and supporting human efforts. They can facilitate the customization of social situations, allowing therapists and caregivers to create narratives tailored to the specific challenges and strengths of each individual.

It is important to note that the use of SNs has primarily been studied within the autistic population. Past reviews suggest that possible transfer of SNs' effectiveness in overcoming learning challenges across other populations should be regarded with caution as the learning needs and preferences of autistic children and those without ASC may be different [19]. Currently, there is limited evidence within HRI regarding the outcomes of SN-based interventions for children with functional conditions, other than ASC. Our work addresses this gap.

## III. Methods

Building on the presented evidence, our work integrates SN-based intervention with the Furhat robot to investigate its overall utility and effectiveness. This is a pilot study that offers evidence for the outcomes of children with diverse conditions when interacting with the social robot. The study was approved by the Research Ethics Committee of Nazarbayev University. The informed consent forms were collected from the parents of child participants.

### A. Rehabilitation Centre

We conducted an experiment in a rehabilitation center located in Oskemen in the east of Kazakhstan. The center offers full treatment programs, such as ABA therapy, speech therapy, music therapy and more. They are provided for free. Over 100 children aged 3-18 years old with special developmental needs, such as ID and ASC, attend the center in the morning and afternoon shifts.

### B. Recruitment

We first established contact with the representatives of the center. Our team recorded two recruitment videos explaining the study, which were then sent to the parents' chat. We created a separate online chat to update parents and stay in touch with them in the future. Before starting the experiment, our team traveled to the city and held a meeting with parents to collect informed consent forms. On the second visit, we set up the robot and trained the two therapists to conduct the intervention.

### C. Participants

**Overview of developmental conditions**. *Autism Spectrum Conditions* are associated with neurodiversity typically diagnosed during preschool years and that affects people lifetime [20]. People with ASC may need diverse levels of support with respect to social communication and interaction, while also having restricted and repetitive patterns in behaviors, interests, and activities [20]. *Down Syndrome* is a genetic condition that affects an individual's brain and physical capabilities. People with this diagnosis have an IQ in the mild-to-moderate ranges and are slower to speak than other children [21]. *Speech and language disorders* may affect both verbal or written communication characterized by difficulties with speech production, reduced language expression or reception [22].

**Demographics.** We obtained both demographic and medical data of participating children from the autism center. A total of 17 children (6 girls, 11 boys) aged 6-18 years participated in the study. We grouped children by their primary learning challenges to impact their intervention experiences. Of those, 7 were assigned to intellectual disabilities (ID) group including Down Syndrome (N=2) and ID (N=5), 10 were assigned to speech disorders (SD) group including SD (N=8) and ASC (N=2). Based on their medical backgrounds, we also grouped the children by their verbal abilities, verbal (N=14) and non-verbal (N=3), as these are also important factors in social learning. One child with Cerebral Palsy (CP) was excluded from the analysis because of technical malfunction of the robot. The mean age of the children was 9.94 years (SD = 3.46). Covariates such as children's primary diagnosis, age, gender, verbal abilities were collected to determine factors that might affect intervention outcomes.

### *D. Robot and its features*

In this study, we used the Furhat robot manufactured by Furhat Robotics. It has been rarely used in robot-assisted autism therapy before [23]. Furhat has a physical embodiment with a rotating head and a back-projected face. It is being referred to as one of the social robots with high human-likeness [16]. The robot's speech was generated using our bilingual native Kazakh-Russian Text-to-Speech (TTS) engine. Additionally, it has more than 20 built-in facial gestures that can be manipulated and over 35 controllable face muscles to design any number of new facial expressions [24]. The robot was able to swap its voice and face masks during various activities. The robots' voice and facial expressions were synchronised with each profession. The robot dialogues were scripted to ensure intervention consistency for all children.

### *E. Setup*

The intervention was conducted in a special room in the center. A child sat facing the robot on the table to make sure that each child can make eye contact with the robot. There were two recording cameras in the room: the first camera captured children's facial expressions, while the second recorded the entire room.

### *F. Furhat Activities*

Children are introduced to six distinct professions: a policeman, a doctor, a cook, a firefighter, a pilot, and a builder. Each profession has its unique uniform and tools, engaging young learners in hands-on activities to facilitate social understanding. These play activities immerses a child in a simulated environment of interacting with one of professionals. This approach not only provides everyday stories of professionals but also raises awareness of diverse occupational roles in society.

*Policeman*. Guided by the robot embodying a policeman, children learn about common traffic signs, and tips for crossing the street, while raising their overall safety awareness. The props include a policeman's headgear, uniform, a radio, and a wheel, they can choose how to navigate a particular learning topic. For example, by selecting a steering wheel, children play and learn traffic regulation, including the functions of traffic lights and directional guidance (e.g. left, right).

*Doctor*. Children engage with a medical professional during a simulated doctor's appointment. From checking body temperature to using a stethoscope, examining the mouth, and wearing a face mask, they gain a comprehensive understanding of basic medical procedures. This hands-on approach fosters awareness of medical instruments and procedures in a familiar environment.

*Cook*. Children explore common cooking scenario guided by the robotic chef through interactive storytelling and a purposefully designed children's book with national dishes on each page, with their ingredients being easily manipulated by children. This activity focuses on the vocabulary used in the kitchen such as ingredients as well as action verbs (e.g. cutting, mixing, rolling) used during cooking. The therapist demonstrates each verb action with her hands (e.g. cutting gesture) while the robot explains culinary instructions.

*Firefighter.* The role of a firefighter is presented through the tactile experience, like wearing a firefighter's uniform and handling tools such as a sturdy fireman's helmet, a fire axe, a firetruck, and a radio. Guided by the robot firefighter, children gain insights into the responsibilities of this profession as well as the use of each tool. They receive instruction on emergency protocols during fires, empowering them with useful knowledge and empathy for the profession.

*Pilot*. Guided by the robot as a pilot, they learn about the profession's tools used in aviation such as an altimeter, compass, headphones. They also learn about two common air transports such as a helicopter and plane. Children are also encouraged to wear a pilot uniform, fostering interest in this profession.

*Builder*. Guided by the robot as a builder, children gain insights into the profession's daily functioning. The story depicts builders' tools and various vehicles used on construction sites, their purpose and usage, children develop an understanding of the role of builders.

### *G. Procedure*

The session with the robot Furhat and one child lasted about 20-30 minutes. The child interacted with the robot while sitting at the table. The therapist conducted the intervention along the robot, while the activities were launched by the second researcher in the same room. Both were present in the room during interventions. Although each child was encouraged to complete an entire task, they were free to decide when to move on to the next profession or stop the activity. Throughout the intervention, the therapist needed to monitor the child's well-being. We interviewed the two therapists to learn about how the intervention went and to document their overall observations.

### *H. Measures*

We adopted social and behavioral metrics [25] to document children's intervention outcomes. One researcher inde-

Fig. 1. The Furhat robot setup for each presented profession

pendently watched and coded the video sessions. We did not calculate inter-rater agreement scores, which is a limitation of our study. We assigned an engagement score to each interval of engagement and then averaged these scores for each activity. The same strategy was used for coding valence scores. The following measures were used in the coding framework, following the same criteria by Zhanatkyzy et al. [15]:

***Engagement*** is a mean of total engagement scores per activity [26], [27]; ***Engagement Time*** is the duration of child engagement (scores 4 and 5) relative to an activity duration [28], [29]; ***Valence*** is an average of all valence scores per activity [26]; ***Eye Gaze Time*** is the duration when a child looks at the robot calculated relative to an activity duration [30], [27]; ***Curiosity*** is the number of actions (opening, rotating, touching the robot) computed relative to an activity duration [26]; ***Stereotyped Behaviors*** is the time when a child is flapping hands, and screaming that was calculated relative to an activity duration [27], [29]; ***Smiles*** is a total fragment of smiles per activity [31]; ***Words*** is a total number of words spoken in each activity [27], [29]; ***Completion Time*** is the amount of time spent to complete one activity. While we stated the completion time measure refers to the actual time taken to complete an activity, in our results, it is represented as a percentage of the total activity duration. ***Response Time*** is the time from the start of the activity until the first try to respond to the robot.

# IV. Results

This section provides qualitative (interviews) and quantitative (coded behaviors) analyses of the effects of children's diagnosis, verbal abilities, age, and gender on the measures. We reported the results with only significance levels.

## A. *Quantitative Analysis*

First, we conducted a series of one-way ANOVA tests with each independent variable. It revealed a significant difference in the completion time between children grouped by their verbal abilities, $F(1, 15) = 5.508, p = 0.003$. The verbal children were more eager ($45.5 \pm 32.6$) to complete the tasks during the sessions compared to the non-verbal children ($0.167 \pm 0.289$). The effect size, calculated as Cohen's d, was 1.49, indicating a large effect (see Table 1).

## B. *Interviews with Therapists*

A semi-structured interview was administered to the two therapists. The purpose of this interview was to collect the opinions of the therapists (T1 and T2) in respect to the implementation of RAP in their daily practice. The interview included seven open-ended questions regarding robot acceptance, benefits and challenges, intervention effects, possible improvements, and other relevant comments.

**Robot acceptance**. The two therapists were in general positive in response to whether the robot was helpful for the children. They also observed that the robot was perceived by children as an attractive toy, they liked to play with it, perform its tasks, and listen to stories. For instance, the intervention was found to encourage children after difficult or boring tasks in other therapy classes. Both agreed that the RAP was very engaging and in some cases, children ignored the human presence when interacting with the robot because they were happy to see it (T1). T2 mentioned that the robot was a good assistant and decreased human workload to some extent when children were passionate about positive reinforcement for desired behaviors.

**Benefits & challenges**. One of the main benefits reported is that the robot can keep most children engaged and that the designed tasks can greatly help children develop not only cognitive, emotional and intellectual abilities, but also fine motor skills. However, T2 emphasized that it depends on specific child characteristics, for it is quite challenging to work with hyperactive children to keep their focus. T1 showed concern that high-level responsibility is needed for the safety of the robot. That is, some children were really interested in the physical components of the robot and they usually wanted to touch it. This requires therapists to be cautious. As noted, for new therapists, it might be challenging to understand the program interface.

**Intervention effects**. Children with higher levels of communication skills interacted with Furhat for longer periods. In response to the question on the effect of tangibles, T1 mentioned that they might be the main reason why children often choose tasks. For instance, it was engaging for children to choose between different hats for each profession. Among the most favorite activities were Firefighter and Builder, while Pilot seemed boring for some children and they wanted to engage in the activities they were fond of. Although there are differences in the behaviors of children, in most cases, they showed positive emotions. Four children with disruptive and severe behaviors showed fear or a negative attitude at the sight of the robot. But T2 explained these children would

| Measures | Diagnosis | | Verbality | | Age | | Gender | |
|---|---|---|---|---|---|---|---|---|
| | ID | SD | V | NV | 6-10 | 11-18 | M | F |
| Smile | $1.53 \pm 3.35$ | $1.73 \pm 3.92$ | $1.05 \pm 3.29$ | $4.40 \pm 4.35$ | $2.20 \pm 4.19$ | $0.32 \pm 0.297$ | $1.37 \pm 2.78$ | $2.15 \pm 5.03$ |
| Curiosity | $7.83 \pm 12.3$ | $9.31 \pm 18.2$ | $7.70 \pm 15.7$ | $13.4 \pm 17.2$ | $11.6 \pm 17.8$ | $1.79 \pm 3.15$ | $8.88 \pm 16.5$ | $8.36 \pm 15.1$ |
| St. Behaviors | $0.389 \pm 0.687$ | $0.767 \pm 1.8$ | $0.468 \pm 1.48$ | $1.28 \pm 1.14$ | $0.639 \pm 1.65$ | $0.544 \pm 0.776$ | $0.293 \pm 0.698$ | $1.19 \pm 2.21$ |
| Words | $18.1 \pm 24$ | $47.6 \pm 69.4$ | $43 \pm 59.4$ | $0.333 \pm 0.577$ | $36.9 \pm 66.3$ | $32 \pm 21.6$ | $42.4 \pm 61.9$ | $22.8 \pm 45.8$ |
| Engagement | $4.08 \pm 0.968$ | $4.24 \pm 0.846$ | $4.12 \pm 0.937$ | $4.42 \pm 0.52$ | $4 \pm 0.985$ | $4.58 \pm 0.276$ | $4.20 \pm 1.02$ | $4.13 \pm 0.606$ |
| Valence | $4.03 \pm 0.617$ | $3.89 \pm 0.54$ | $3.94 \pm 0.593$ | $3.97 \pm 0.456$ | $3.81 \pm 0.594$ | $4.28 \pm 0.286$ | $3.97 \pm 0.589$ | $3.91 \pm 0.549$ |
| Eye gaze time | $30.6 \pm 27.1$ | $38.8 \pm 34$ | $33.7 \pm 31.5$ | $43.5 \pm 31$ | $39.5 \pm 33$ | $25.7 \pm 24.4$ | $37.5 \pm 30.9$ | $31.7 \pm 32.7$ |
| Eng. time | $69.6 \pm 34.4$ | $64.9 \pm 33.4$ | $69.6 \pm 34.9$ | $54.2 \pm 19.6$ | $60.4 \pm 35.8$ | $82.4 \pm 18.8$ | $71.6 \pm 33$ | $58.2 \pm 33.6$ |
| Resp. time | $1.8 \pm 1.7$ | $2.78 \pm 2.49$ | $2.50 \pm 2.32$ | $1.8 \pm 1.76$ | $1.77 \pm 2.15$ | $3.82 \pm 1.68$ | $2.32 \pm 2.28$ | $2.46 \pm 2.24$ |
| Compl. time | $32 \pm 32.5$ | $41.3 \pm 36.8$ | $45.5 \pm 32.6$ | $0.167 \pm 0.289$ | $38.4 \pm 38$ | $35.3 \pm 27.4$ | $40.2 \pm 33.9$ | $32.4 \pm 37.8$ |

TABLE I

MEAN VALUES OF CHILDREN'S MEASURES GROUPED BY DIAGNOSIS, VERBALITY, AGE AND GENDER. RESULTS IN RED DENOTE SIGNIFICANCE.

need some time and if they had come to a few more sessions, they would have gotten used to the robot and it would not have caused such complexities.

**Possible improvements.** In response to suggestions about possible improvements, both felt positive and ready to work with the robot in the future. For a better perception of the robot, T2 suggested reducing the speed of its speech and making it more intelligible and simple according to different levels of comprehension. Another therapist suggested shortening the introductory part, especially the welcome speech at the start of each activity was not needed as children usually did several activities. He further suggested using shorter stories and adding more time when the robot introduces new things like food ingredients. This is needed so that the therapist can reexplain to a child what to do.

## V. DISCUSSION AND FURTHER WORK

This study extends current knowledge of the effectiveness of the SN intervention and contributes to research exploring RAP for children with diverse functional needs. The overall results revealed no significant differences in socio-behavioral outcomes between children with ID and SD. This might indicate that the robot-assisted SN intervention may provide a similar social experience for children with different developmental conditions. Yet, the relatively low number of participants is likely to affect this outcome. The only significant result is that the verbal children spent more time completing the tasks compared to their non-verbal counterparts, with a large effect size. The low completion time among non-verbal children indicates that they interacted minimally with the robot and did not follow its prompts. In contrast, verbal children were more attentive to the robot's instructions and attempted more tasks. The initial suggestion [32], [33] to use SNs with children with the low levels of challenging behaviors and with some language skills tends to hold true for RAP as well. It appears challenging for children with language challenges to fully comprehend and engage with a highly verbal robot, even with additional support. Additionally, we observed that older children interact well with the Furhat robot, indicating that the age of participants is an important factor. We recommend considering both language abilities and age when evaluating the suitability of SN-based interventions for children with various functional needs.

The qualitative interviews were consistent with our assumptions yet presented some interesting observations by the two therapists. Both reported their experience with RAP positively and indicated various reasons like increased interest and task engagement in most children. The robot was perceived to reduce some workload of the human therapists because most children were excited about the robot and showed high enthusiasm. However, there is no guarantee that all children may be ready to interact with the robot, for instance, some with severe behavioral challenges might develop negative attitude toward the robot. These children should be given several attempts to meet with the robot to decrease the levels of fear and anxiety. For those with hyperactive behaviors and short attention span, the activities should be as short as possible with fewer words and actions which might be introduced through multi-stage and fragmented approach. According to therapeutic observations, the most favorite activity was Firefighter, which had the most variable profession-specific tangibles. The activities with complex terms or longer narratives were reported to be disengaging to those children with severe impairments, yet the children with higher communication skills tend to be exceptionally interested in such activities. A possible solution would be adjusting the robot speech and task content across different comprehension levels.

In general, the therapists showed greater intervention acceptability, suggesting possible improvements in activity implementation and therapist support. From their observations, it is obvious that the proposed RAP can be helpful in maintaining the children's interest in the activity and practice social skills. Further research is required to provide convincing evidence base for SN-based RAP. More randomized controlled experiments are needed, the lack of a control group limits our judgments. In addition, the long-terms effects of SN-based RAP should be explored in future studies.

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