Parental Attitudes, Trust, and Comfort with Using Robots for Providing Care to Children with Developmental Disabilities

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***Abstract*— Parents of children with developmental disabilities face significantly higher workloads than parents of neurotypical children due to their higher care giving demands. Consequently, parents of children with developmental disabilities often face emotional, physical, mental, and social health declines. Currently there has been significant research and development of robots for providing care to children with developmental disabilities to address a variety of care giving scenarios. However, it is presently unclear whether parents would be comfortable with robots interacting with their children in these different child-robot interaction scenarios. In this paper, we investigate parental comfort toward robots caring for children with developmental disabilities in a variety of interaction scenarios and the influence of parental negative attitudes toward robots as well as trust on their comfort toward robots in these scenarios. Overall, our findings suggest that US parental attitudes, trust, and comfort toward robots caring for children with developmental disabilities are neutral. Parents were most comfortable with a robot serving as a teaching assistant to children with a developmental disability and least comfortable as a bus driver. Furthermore, trust for robots had a medium positive association with comfort with child-robot interactions and negative attitudes toward robots had a medium negative association with comfort with child-robot interactions.**

I. Introduction

Parents in the US have reported that 1 in 6 children between the ages of 3-17 years old have been diagnosed with developmental disabilities [1], [2]. Children with developmental disabilities have different needs than neurotypical children and often require additional education, healthcare, and supervision in comparison to their neurotypical individuals [3]. This additional workload often falls on the parents and leads to parents of children with developmental disabilities having greater emotional, physical, mental, and social health declines than parents of neurotypical children [4], [5]. Consequently, parents of children with developmental disabilities are often looking for relief or support services to aid in the care of their children.

Researchers are currently exploring the development of robot technology to support parents in caring for children through a wide variety of robot-based services [6]–[11]. These services have included supporting activities such as assisting with telling stories, teaching children, childcare, physical rehabilitation, and language learning. In general, parents of neurotypical children have been found to accept the use of robots to provide these services. Although there has been investigation on parents of neurotypical children's perceptions toward robot-based services, there has been less investigation on the perceptions of parents of children with developmental disabilities.

Parents of children with developmental disabilities have different needs for assistance as well as concerns for their children than other parents, and, consequently, their perceptions of new technologies are often impacted [5-6], [11]-[16]. For example, children with autism spectrum disorder (ASD) have been found to utilize technology more than typically developing children and parents of children with ASD often have concerns regarding the amount of time their children use technology [15], [16]**.** However, at the same time parents of individuals with developmental disabilities are accepting of new technologies because they have the potential to improve the lives of their children [17], [18]. Whereas perceptions of neurotypical children's use of technology is more straightforward as it is often recommended by medical professionals to reduce children's technology use due to their negative effects on children's physical, cognitive, language, social, and emotional development as well as increases in behavioral problems [19], [20]. Parents are also often concerned with the negative effects of technology on parent-child relationships, children's safety as well as privacy, children's social interactions, and addiction [21]. Due to these differences, it is necessary to specifically investigate parental perceptions of technology designed for children with developmental disabilities.

Investigating parental trust toward robots providing care to children with developmental disabilities is especially important because parents would be putting themselves in a vulnerable position by enabling a robot to care for their children. This is because robots could be considered as an external autonomous agent whose behaviors are not directly controllable by a parent [22]. Parental perceptions of trust could specifically be impacted in robot applications where robots are interacting with children with developmental disabilities because parents of children with developmental disabilities are often concerned with their children's safety, treatment, and interactions when their children are not under their supervision [23]–[27]. Hence, there is presently an urgent need to investigate parental trust toward the use of robots for the care of children with developmental disabilities as they will be the mediators of their children's use of the technology.

The overall aim of our research team is to develop robot-based technologies to support individuals with developmental disabilities and their parents. Our current goals have been to develop robot-mediated interventions for children with ASD and tools to improve the usability as well as ease of use of these technologies for healthcare professionals within clinical settings [28]–[31]. Our studies have demonstrated that the robot-mediated interventions were effective for teaching children with ASD socially relevant skills and healthcare

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professionals were capable of effectively as well as efficiently developing new interventions utilizing robot technology.

The objective of this research was to investigate how parents would perceive using robots to care for children with a developmental disability. Namely, we seek to answer two primary research questions: 1) would a parent who learned that their child had a developmental disability be comfortable with a robot interacting with their child in different interaction scenarios and 2) how does parental trust in robots mediate their general attitudes toward robots and comfort with child-robot interactions? We investigated these research questions by surveying parents within the United States on their attitudes, trust, and comfort toward robots providing services to children with a developmental disability in a variety of child-robot interaction scenarios.

II. Related Works

To date, there has been some research focusing on investigating parent perspectives on utilizing robots to provide a variety of care services to their children.

In [6], parental acceptance of storytelling robots for the home were investigated through semi-structured interviews. Parents were first introduced to the zoomorphic Luka and humanoid Trobo storytelling robots. They then had the opportunity to choose how to use the robots during two five-minute storytelling sessions with their child and interviews with the parents were conducted after the sessions. Overall, parents were willing to accept storytelling robots and considered them a better replacement for human storytelling than screen-based technologies. The predictors for parent acceptance were the context of use, perceived agency, and perceived intelligence of the robot while robot adaptive and affective capabilities were concerns.

In [7], the perceptions of Korean parents, teachers, and researchers that have previously interacted with teaching assistant robots (e.g., iRobi Q, EngKey, Kibot, Robosem, Roti) was investigated through a survey administered via e-mail. The Technology Acceptance Model (TAM) based survey aimed to investigate parental attitudes toward teaching assistant robots and their perceptions on the ease of use, usefulness, enjoyment, and service quality of teaching assistant robots. Overall, the study findings demonstrated that perceived usefulness, perceived enjoyment, and service quality of the robot were key contributors to future intentions to use teaching assistant robots.

In [8], US and Japanese parents and childcare worker perspectives toward a childcare support robot system were investigated via an online survey and compared to existing childcare support technologies. Namely, participants were provided a brief text-based explanation as well as illustrations of child support technologies including baby food, anesthesia during labor, and an intelligent playroom. The intelligent playroom consisted of two educational robots, Sphero and Romo, for entertaining children and a microphone as well as depth sensors to monitor the children. Surveys were then administered to investigate their intention to use, perceived trust and safety, negative attitudes, and perceptions of workload for the technologies. Overall, their results suggested that robots were less accepted than other child support technologies and Americans had higher intentions to use the technology but were more negative toward the other factors. Furthermore, a follow-up study with Japanese parents that interacted with the intelligent playroom had higher intentions to use, higher perceived trust and safety, lower negative attitudes, and higher perceptions of decreased workload than those who did not interact in the space.

In [9], parents were surveyed on their attitudes toward robot-assisted pediatric rehabilitation after their children participated in a two-week posture correction exercise program with the MARKO humanoid robot. Parents were administered the Frankenstein Syndrome Questionnaire to evaluate their negative attitudes, positive expectations, and social acceptance of the robot-assisted pediatric rehabilitation program. Overall, parents had a neutral attitude, positive expectations, and socially accepted robot-assisted rehabilitation. Furthermore, participants with a university degree had more positive attitudes than those without a degree and older individuals had more negative feelings toward robots than younger participants.

In [10], parents perceived advantages, disadvantages, motivations, and hesitations toward autonomous vehicles transporting children were investigated via an online survey. Participants in the study were administered a questionnaire investigating their attitudes toward autonomous vehicles in general, attitudes toward autonomous vehicles transporting children, usage of safety seats and restraints, readiness to adopt the technology, and daily car usage behaviors. Overall, parents varied in their autonomous vehicle acceptance and could be grouped into either curious parents who were interested in trying new technologies and parents who considered the practical benefits of autonomous vehicles supporting children's transportation needs. Furthermore, enhancing mobility was the largest motivation for adoption and parents had concerns related to cost, security, privacy, and giving up control of the vehicle.

In [11], German parents' perceptions of the acceptability of socially assistive robots for language learning was investigated after observing their child interacting with the robot over multiple sessions. Namely, parents were administered a questionnaire focusing on their perceptions of the language learning activity, child-robot interactions, and how their child felt during the interaction. Overall, they found the attitudes of parents toward the long-term interaction with social robots to be positive from their own perspective and their children's perspective. However, there were concerns regarding the adaptability and smoothness of the robots' interactions during the language learning task due to the technical limitations of the robot.

In [32], it was investigated whether there were differences in parental attitudes toward using robot therapy for children based on their gender or education. Parents were administered two questionnaires which investigated their general attitudes toward robots and their attitudes toward robots in therapeutic settings. The results of the study found that parents had more positive general attitudes toward robots than negative attitudes and were more positive toward using robots in therapies with children than robots in general. Mothers were also more afraid than fathers that the children would be afraid of the robot as well as damage the robot and did not trust the robot to complete the therapy autonomously. Furthermore, parents with higher education levels were more positive toward using the robot in therapy and believed their child would enjoy interacting with it.

To date, current research has primarily focused on investigating parental perceptions toward the use of robots for providing care to typically developing children [6]–[8], [10] or children with physical impairments [9], [32]. However, despite the significant research and development toward using robots to provide care to children with developmental disabilities (e.g., ASD, intellectual disability, attention deficit hyperactivity disorder, and learning disabilities), there has been minimal exploration on how parents would perceive the use of these robots to care for children with learning, language, or behavior impairments. Parental perceptions of trust toward robots are particularly important because they mediate their children's technology use and if they do not trust the technology, then it will not be used [16], [21]. Hence, this research aims to investigate parental attitudes, trust, and comfort toward using robots to care for children with developmental disabilities.

III. Methodology

We conducted an online survey investigating US parental perceptions toward the use of robots to care for children with developmental disabilities. Namely, we investigated parental attitudes toward robots, trust in robots, and comfort toward using robots in a variety of interaction scenarios with their children after they were presented with a video demonstration of robots providing instructions to children with ASD.

A. Participants

Participants were 206 community members from the United States who had at least one child and were recruited through Prolific in exchange for financial compensation ($3.50 USD). Only a single parent from each family completed the questionnaire. The sample size was determined by using a financially-based stopping rule for data collection such that we collected data from participants in small batches until the funds for the study were exhausted. Participants were asked to complete measures concerning their negative attitudes toward robots, trust for robots, and comfort with child-robot interactions via a secure website. Data were excluded for six participants due to careless or inattentive responding: two participants were excluded due to large amounts of missing data (i.e., more than 5% of responses), two participants were excluded for failing to successfully complete two or more of the directed response items that were included in the instruments to identify inattentive responding (e.g., "If you are reading this item, then choose '4' as your response"), one participant was excluded for being a multivariate outlier as assessed by Mahalanobis distance [33], and one participant was excluded due to inconsistent responding as assessed by inter-item standard deviation [34]. We also examined the data for univariate outliers, unusually fast completion times, and invariant response patterns as assessed by long-string analysis, but no participants were excluded for those reasons (see [35], for a review of methods for detecting careless or inattentive responding). The final 200 participants (107 women, 93 men) had a mean age of 38.66 years (SD = 11.12 [range = 19-68 years]) and a racial/ethnic composition that was 63% White, 26% Black, 5% Hispanic, 4% Asian, and 2% other. The mean number of children for the final participants was 1.82 (SD = 1.01 [range = 1-6 children]) and the romantic relationship composition of the sample was 66% married, 27% single, 6% divorced, and 1% widowed.

B. Video Introduction on Social Robots

An eight-minute and 30-second video was presented to all participants to provide them with an introduction on robots and context prior to administering the measures to obtain their perceptions toward robots caring for children with developmental disabilities. In the video, two faculty members gave an introductory statement explaining the purpose of the video was to demonstrate the capabilities and potential use cases of robots during individual and group instructions for children. Following the introduction, scenarios were presented which included two children interacting with robots in both one-on-one and group instruction activities. The SoftBank NAO and Pepper robots were used because they are commercially available and commonly used robots with children. The first scenario presented the NAO robot as a group instructor that was facilitating a "find the object" game with two children. The second scenario presented the Pepper robot acting as a teacher to a child. In the scenario, Pepper and the child were working on learning to follow directions and answering general knowledge questions. The third scenario presents Pepper progressively providing less assistance to teach a child a new skill to minimize frustration and maximize motivation. The fourth scenario demonstrates Pepper as an assistant to a human teacher by providing instructions to one child while the teacher is focusing on the second child. In the final scenario, Salt as a companion plays a game of "hide and seek" and a "copy me" with the children.

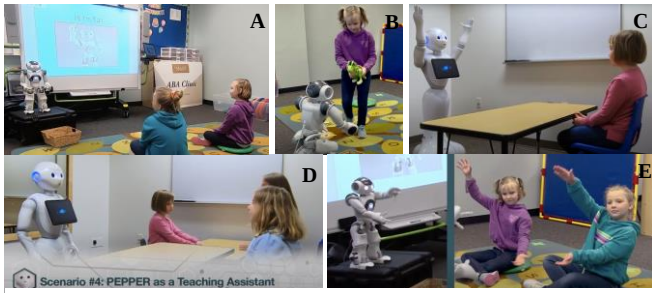


Figure 1. Clips from the video: a) robot greeting the children, b) children playing "find the object" game with the robot, c) robot providing individual instruction to a child, d) robot acting as a teaching assistant to a teacher, e) children playing a "copy me" game with the robot.

C. Measures

We used three measures to investigate participants' negative attitudes toward robots, trust for robots, and comfort with child-robot interactions.

We used the Negative Attitudes Toward Robots Scale [36] to measure negative attitudes toward robots. The scale consists of 14 items which measures three different factors associated with negative attitudes toward robots (e.g., "I would feel very nervous just standing in front of a robot" [α = .90]). These factors include negative attitudes toward situations of interaction with robots, social influence of robots, and emotions in interaction with robots. Participants were asked to rate their level of agreement with each statement using scales that ranged from 1 (strongly disagree) to 5 (strongly agree). We then utilized the final mean score across the 14 items to provide an overall negative attitude toward robot score for each participant.

The Human-Robot Trust Scale [37] was used to measure participant trust in robots. The Human-Trust Scale consists of 40 items which measure a participant's trust toward a robot

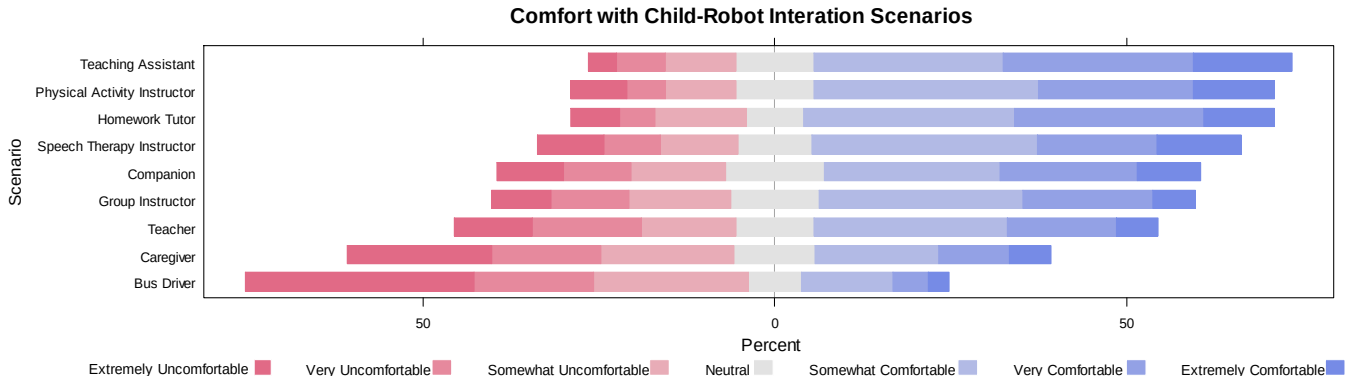


Figure 2. Summary of parent responses to their level of comfort towards robots interacting with children with developmental disabilities in different interaction scenarios.

based on factors related to the human, robot, and environmental elements (e.g., "What percentage of the time will robots be responsible?" [α = .96]). Participants were asked to respond to each item using a scale that ranged from 0 (0%) to 10 (100%) in intervals of 10%. The final mean score across the 40-item scale for each participant was then used to provide an overall score on a participant's trust toward robots.

To measure parental comfort with child-robot interactions for individuals with developmental disabilities, we provided a brief definition of ASD to participants and asked them to envision that they had a child who was diagnosed with ASD. They were then asked to consider their comfort with their child interacting with robots across nine situations (e.g., "Envision that a robot acts as a peer to your child with autism. The robot and child would build a long-term friendship where they would engage in educational, play, and social activities together"). The participants were instructed to immerse themselves in each described situation and to consider how comfortable they would be if they experienced situations in which robots interacted with their child in the following capacities: companion, teacher, teaching assistant, homework tutor, caregiver, bus driver, group instructor, physical activity instructor, and speech therapy instructor. Participants were asked to rate their level of comfort with each scenario using scales that ranged from 1 (extremely uncomfortable) to 7 (extremely comfortable). The internal consistency for these items was α = .93. Each participant then received an overall score on their comfort with a robot interacting with their child with developmental disabilities by obtaining the mean score they provided across nine scenarios.

IV. Results

Parental comfort toward robots interacting with children with developmental disabilities in different interaction scenarios is summarized in Figure 2 and Table I. Parents were most comfortable with having a robot serve as a teaching assistant and least comfortable with robots providing services as a bus driver. Overall, parental comfort toward each of the presented child-robot interaction scenarios were neutral with a broad range of comfort levels amongst parents.

Table I Parents average comfort level for different child-robot interactions for children with developmental disabilities

Scenario	Comfort Level	
	Mean	Standard Deviation
Companion	4.31	1.77
Teacher	3.99	1.78
Teaching Assistant	4.86	1.62
Homework Tutor	4.71	1.66
Caregiver	3.44	1.86
Bus Driver	2.79	1.71
Group Instructor	4.22	1.69
Physical Exercise Instructor	4.65	1.69
Speech Therapy Instructor	4.47	1.77

Descriptive statistics and zero-order correlations for the three measures are also provided in Table II. Negative attitudes toward robots had large negative correlations with trust for robots and comfort with child-robot interactions, whereas trust for robots had a large positive correlation with comfort with child-robot interactions. We examined our hypothesis that the association between negative attitudes toward robots and comfort with child-robot interactions would be mediated by trust for robots using the PROCESS macro [38] which uses a bootstrap resampling process that was repeated 10,000 times to generate 95% percentile bootstrap confidence intervals for the direct and indirect associations. Each variable was standardized in order to increase the interpretability of the resulting coefficients. The results of these analyses are depicted in Figure 3. The Variance Inflation Factor (VIF) values were less than 1.74 which suggests that multicollinearity was not an issue for this analysis.

The analysis revealed that negative attitudes toward robots had a large negative association with trust for robots (a = -0.65, t = -12.12, p < .001, CI95% [-0.76, -0.55], f^2 = .74). In turn, trust for robots had a medium positive association with comfort with child-robot interactions (b = 0.43, t = 7.55, p < .001, CI95% [0.32, 0.55], f^2 = .29). Negative attitudes toward robots had a negative indirect association with comfort with

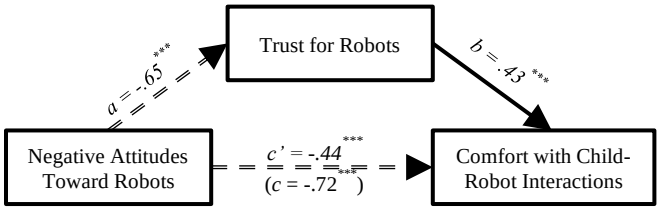
Table II Intercorrelations and Descriptive Statistics

	1	2	3
1. Negative Attitudes Toward Robots	—		
2. Trust for Robots	-.65*	—	
3. Comfort with Child-Robot Interactions	-.72*	.72*	—
Mean	2.68	5.80	4.15
Standard Deviation	0.79	1.68	1.38

*p < .001

child-robot interactions through trust for robots (ab = -0.28, z = -6.39, p < .001, CI95% [-0.37, -0.20]) as well as a medium negative direct association with comfort with child-robot interactions (c' = -0.44, t = -7.68, p < .001, CI95% [-0.55, -0.33], f^2 = .30).

There were small gender differences for negative attitudes toward robots (t[198] = -2.07, p = .04, d = .28) and trust for robots (t[198] = 2.25, p = .03, d = .32) which showed that women reported more negative attitudes toward robots and less trust for robots than were reported by men. No gender differences emerged for comfort with child-robot interactions (t[198] = 0.46, p = .65, d = .06). As a result of these gender differences, we conducted an exploratory analysis that included gender (male = 1, female = -1) as a potential moderator of the indirect association that negative attitudes toward robots had with comfort with child-robot interactions through trust for robots. However, gender did not moderate the indirect association that negative attitudes toward robots had with comfort with child-robot interactions through trust for robots (i.e., no support for moderated mediation).



*p < .05; **p < .01; ***p < .001

Figure 3. The results of the mediation analysis with trust for robots mediating the association that negative attitudes toward robots had with comfort with child-robot interactions. Note: The significant positive association is indicated by solid black arrows and the significant negative associations are indicated by dashed black arrows.

V. Discussion

Overall, the responses from parents concerning their negative attitudes toward robots, trust for robots, and comfort with child-robot interactions were neutral. There was also a wide range of responses on parental comfort with robots interacting with children with developmental disabilities in different child-robot interaction contexts. These results may suggest that similar to other innovative technologies, parental adoption of robots to care for children with developmental disabilities follow the diffusion of innovation theory proposed by Rogers [39]. According to Rogers, there will be a small group of parents who will fall into the category of innovators who actively adopt robots while being comfortable with the risk of these innovative child-robot interactions (i.e., those responding as extremely comfortable) and laggards who view all child-robot interactions as high risk (i.e., those responding as extremely uncomfortable). There are then a larger body of parents who fall under the categories of early adopters (i.e., very comfortable), early majority (i.e., somewhat comfortable), and late majority (i.e., somewhat uncomfortable) which increasingly expect more evidence that child-robot interactions will bring value to their lives.

Parents were in general more comfortable with children with developmental disabilities interacting with robots during educational and therapeutic tasks under the guidance of a human professional (e.g., teacher, doctor, therapist) than scenarios without human supervision such as group instructor, teacher, caregiver, or bus driver. This aligns with existing studies which have found that parents as well as educators prefer that children with ASD interact with socially assistive robots in educational/therapeutic settings under the supervision of a human professional and do not see robots as the primary educator [40], [41]. We hypothesize these results suggest that parents become progressively less comfortable with roles where robots are the primary decision makers for their children's welfare.

We further investigated how general negative attitudes toward robots and trust influence parental comfort with robots interacting with children with developmental disabilities in a variety of interaction scenarios. Our results suggest that both negative attitudes and trust toward robots were associated with comfort with respect to children with developmental disabilities interacting with robots. Namely, negative attitudes toward robots were associated with a lack of comfort toward child-robot interactions. This coincides with current studies which found that parental negative attitudes toward technology lead to restrictive access to digital technologies [42]. Trust was also positively associated with parental comfort toward child-robot interactions and mediated the association that negative attitudes toward robots had with comfort toward child-robot interactions. We postulate that trust is an influential factor in parental comfort with robots interacting with children with developmental disabilities because robots are autonomous with their own independent decision-making capabilities which may not be completely controllable by a parent. Hence, it would be pertinent to improve both the transparency and controllability of robots that care for children with developmental disabilities as it may improve parental trust toward robots and, consequently, their comfort toward the use of robots. Improving trust could also serve to reduce the effects that negative attitudes robots have on parental comfort toward the use of robots with children. Lastly, similar to other studies investigating parental perspectives on robot technology [8], [32], mothers reported more negative attitudes toward robots and lower trust than by fathers.

VI. Conclusions

The present work investigated parental attitudes, trust, and comfort toward the use of robots in the care of children with developmental disabilities. Overall, our findings suggest that parents currently have neutral attitudes, trust, and comfort toward the use of robots with individuals with developmental disabilities. Parental comfort toward the use of robots was associated with their negative attitudes and trust toward robots. Many of our findings align with prior studies and suggest that parents have a similar perception toward a robot caring for children with developmental disabilities as they would with neurotypical children. In the future, we will investigate which traits make a parent an early or late adopter of robots and how transparency of robot behaviors influence trust in robots as well as comfort with child-robot interactions.

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