Design Considerations for Child-Robot Interaction in Pediatric Contexts

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ABSTRACT

Social robots can improve quality of life for children undergoing prolonged hospital stays, both by offering a fun and interactive distraction and by providing practical assistance during procedure support and pain management. In this paper, we present important considerations for robots involved in pediatric contexts. These considerations are based on a need-finding interview conducted with a gaming technology specialist at a children's hospital. By summarizing their experiences, we identify considerations affecting the design of robot morphology and behavior for this unique use case, as well as the explore the role of parents, healthcare staff, and child life specialists.

CCS CONCEPTS

• **Social and professional topics** → *Children*; • **Computer systems organization** → Robotics; • **Human-centered computing** → *Interaction design process and methods.*

KEYWORDS

child-robot interaction, need finding

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1 INTRODUCTION AND MOTIVATION

It is well established that technology can improve quality of life for children during long hospital stays. Technological experiences can have advantages in pediatrics, including the ability to offer companionship, socialization, immersion, and progress measurement. Because many of these experiences involve either VR or traditional video game consoles, they often require space for monitors and sufficient fine motor control. [11].

Social robots stand to offer compelling advantages in this space, since they do not require monitors or fine motor control for interaction. Common target populations for pediatric social robots include children with cerebral palsy, cognitive and neurodevelopmental disabilities, diabetes, cancer, and even routine medical appointments [3]. The embodied interaction offered by a robot is distinct from the experience of playing a game on a screen or wearing a VR headset. Work with a teddy bear-like robot—the Huggable—showed that children are more physically and mentally motivated to engage with a robotic agent, compared to a virtual agent on a screen. Children perceived the Huggable as a peer worthy of emotional attention to a greater extent than a similar character presented on a tablet [9, 12]. Similarly, hospitalized children preferred listening to a story told by an embodied robot compared to an audiobook [14]. A relationship with a personalized robot resulted in higher rates of diabetes self-knowledge in elementary-aged children relative to solely-web interfaces [8, 19].

In light of the advantages of embodied agents over virtual agents and experiences, much research has been done into morphological design for robots in this context.

Humanoid robots are more often used for giving instructions or exchanging information, while zoomorphic robots are more often used to offer companionship [17]. Some robots specifically designed for pediatrics are soft and stuffed animal like; they provide interactive communication or screen-play while still being easily touched and moved [9, 18]. One notable zoomorphic platform that differs from this model is the MyJay —a mobile robot that allows kids to remotely collect and throw small balls, as well as customize the robot's morphology with modular accessories like ears and antlers [13]. Other research has used existing humanoid robots like NAO [5, 10, 14, 19]. Robot morphology effects the preferences and expectations of children through role attribution—a zoomorphic robot elicits affectionate, nurturing behavior and an anthropomorphic one elicits more conversational, exploratory interaction [1, 4].

Robots can offer children social support in a hospital environment in a variety of ways, including opportunities to play and motivation during rehabilitation activities [11]. The most common purposes for pediatric social robots include companionship, anxiety management, physical therapy assistance through demonstration and encouragement, and education [3]. Educational games with a social robot can help children learn and retain knowledge about diabetes self-management, an important step for their safety and independence. Even the companionship of video-calling a robot resulted in more consistent diary-keeping for children with diabetes [19].

A particularly compelling use case for pediatric social robots is procedure support. Procedure support refers to cases in which technology offers distraction in-the-moment during minimal procedures that may be a source of profound anxiety for children, including blood draws, bandage changes, and the administration of anesthesia [17]. Virtual reality is currently playing an important

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role in this context. Children who experience VR games and roller coasters reported lower pain and anxiety scores for blood draws and IV placements, both situations that can cause a lot of needle-related anxiety [6, 7, 20]. Distracting interaction with a social robot produces similar results. Such interactions include entertaining distraction and things like robot-led breathing exercises. Significantly lower pain and distress were reported by children, nurses, and parents for procedures ranging from routine flu shots to venipuncture procedures for children with cancer[2, 10]. For children undergoing burn-related procedures, success reducing self-reported pain has been shown using interactive technology to offer either or both distraction and preparation—where children are informed about the procedure they will experience through a story [15, 16]. The management of acute pain and anxiety is one of the most compelling use cases for pediatric social robots.

As roboticists continue to create pediatric robots, they can leverage the expertise of those who have a thorough understanding of how children process their time in the hospital, what their needs are, and where technology can best improve their experiences.

2 THEMES FROM A NEED-FINDING INTERVIEW

In order to understand what role robots might play in pediatrics, we conducted a semi-structured need-finding interview with a gaming technology specialist at a children's' hospital. Need-finding is an open-ended, flexible process that builds a narrative about the experiences of others. Gaming technology specialists have unique perspectives on how children process their world, especially during long-term hospital stays. While this paper only represents the content of this single conversation and work done at a single hospital, it can serve as a good springboard for further need-finding work.

Gaming technology specialists use video games and virtual reality to help children through procedure support, socialization, and play. The position was created to help teams at the hospital effectively use the technology they have access to —things like headsets that aren't on the market yet. Teams at the hospital find that using technology for procedure support already has material benefits that even go beyond a patient's emotions. For example, many children at the hospital go under anesthesia for lumbar punctures—a procedure that most adults can tolerate awake. The anesthesia brings additional risk and necessitates hours of fasting and prep time. However, with the help of a gaming technology specialist, many children brave a lumbar puncture awake while experiencing a calming distraction through VR.

A typical workflow for a gaming technology specialists involves meeting with children before a procedure to find technology that is interesting to them and help them understand how to use it. Technology specialists are then also present to facilitate procedure support. In addition, they provide general socialization and play for children in non-procedure contexts.

The interview we conducted with a local gaming technology specialist was open-ended and allowed the gaming technology specialist to guide the focus of the conversation. Afterwards, the interview was transcribed and statements from the interviewee were sorted into thematic categories. From this broad categorization, the themes were grouped into overarching recommendations.

One of the most important kinds of insight that people like technology specialists can offer to researchers is their understanding of how children process the world. More specifically, they can provide awareness of how children experience hospitalization—something far heavier and more intense than most childhood struggles. Leveraging the knowledge of experts means that robotics researchers can speculate less about how to design for children in a way that is sensitive to the trauma and seriousness of illness.

In this paper, we will first summarize important themes that arose in our interview. The first two relate to the the emotional experiences and needs of children: the way they process anxiety and their need for social self-expression. Lastly, we will also address the needs of other stakeholders, including parents and staff. After exploring these themes, we will offer some grounded speculation as to how our conversation can inform the direction of future work in child robot interaction.

2.1 Children Experience Pain and Anxiety Differently

Our interviewee is often involved in procedure support. They have valuable experience using technology in relation to a child's pain and anxiety. A prominent theme in our conversation was *"for kids, there's a lot more conceptual pain."* By this, they differentiate between the literal pain involved in a lumbar puncture or bandage change and the fear of anticipating such experiences. *"It's the anticipatory pain. I think it's harder for kids to uncouple the idea of what the pain will feel like and the actual sensation of the physical pain. With adults, that conceptual gap gets smaller."* The pain of anticipation can also be intense for children undergoing procedures that are mild for adults—like a single injection. *"For a lot of kids, needles aren't fun, getting poked with needles isn't fun, but they'll say that the painful thing is not even when the needle is in their arm, it's before the needle comes."*

The trauma of anticipation is exactly where technology—perhaps social robots—can be most beneficial. Immersive distractions like VR can bring in positive emotional associations which soften the pain of anticipation. Children seem to register immersive technological interventions as an experiential memory. *"Kids come into the hospital and can think, I went to the hospital. I got poked with some needles. I went to the Grand Canyon, and someone took my blood pressure."*

Technological interventions are more effective when a child has already experienced the procedure without them. Some interventions *"can actually be more successful if a kid has a painful experience and then an experience with some sort of technological intervention that's really positive, so they have the two to compare to each other."* In this way, children can re-conceptualize an experience and re-frame the anticipation of it to also include something positive.

The playful elements of such interventions are essential for their effectiveness and should be taken seriously. *"The whole essence of (procedure support) is based in play. We're kind of disguising these technologies as a game—as play. And on the surface that's exactly what they are. But applying them in different contexts, you have this twofold effect where the playfulness is what creates the positive outcomes. So, without the playfulness, there would be no therapeutic effect."*

Sometimes, providing a playful experience for children means being careful about including educational or analytical activities. Some children do develop a new interest in computer science, game design, or engineering. Gaming technology specialists are happy to help such children to explore this new interest. However, they also warn that the educational aspects of a technological experience can detract from its therapeutic side. *"if the kid analyses (the experience) too much, it almost loses its therapeutic aspect . . . you kind of lose that element of immersion and playfulness."*

Since children have a harder time uncoupling the pain of anticipation from the pain of experience, playful interventions have a big effect on the logistical outcome of a child's stay—*"If they have less anxiety and less pain, that means they will get to go home sooner. This means less anxiety and less stress on the family as well as on the patient. You know that it then translates to cost saving measures for the hospital."*

2.2 Children Miss Independence and Self Expression

In addition to procedure support, where the goal of technology is to alleviate acute discomfort, our interviewee also works to improve the general experience children have in the hospital. This provides a good perspective on the long-term needs of children in the hospital. Our interviewee puts the most emphasis on how social interaction returns feelings of control and independence. *"Games are how kids these days play, how they socialize. A game serves every need a kid has: to escape, to learn, to make friends. A teddy bear is awesome, but it's not going to talk back to you or be your friend or play games with you."* A big part of our interviewee's job is understanding a child's individual interests and offering them an outlet for their own curiosity. This element of personalization is tremendously helpful. At the hospital, sports-themed activities and the VR game Job Simulator are particularly popular, especially with the lack of real sports during COVD-19. *"Kids really enjoy being able to have their own basketball games or put on their own football games with their friends."* Of course, this also means understanding and adapting to a child's physical limitations—their diagnosis and mobility restrictions. The independence inherent to self-expression is a fundamental need of children—providing them this experience is a material way to impact their quality of life. *"If you're able to express yourself and communicate—basically if you're able to communicate with your team, your friends, your family. That's the biggest win. Socialization is huge for quality of life of little kids in the hospital."* To this end, the hospital's team has even been using easily-cleanable telepresence robots to facilitate family visits during COVID-19, which helps when siblings are isolated away from an immunocompromised patient.

2.3 Other Stakeholders Matter

Our interviewee's experience working with other stakeholders involved with hospitalized children is another dimension along which they can offer insight that is not readily reproducible in research. Other stakeholders include doctors, nurses, parents, siblings, and child-life specialists—general advocates for the well-being of patients. A piece of technology on its own may be effectively immersive and social, but will not be practically feasible if it is a confusing burden to these other stakeholders. For elementary-age children, the experiences of parents matter tremendously—especially during procedure support. *"Younger kids obviously get reinforcement from their parents, so they can really internalize how their parents are feeling about (the procedure). If their parents are supportive and not giving off any anxiety, the kids see that mom and dad are okay and they think that must mean I'll do okay too. They really look to adults to know how they're supposed to act."*

Parents are often interested in continuing to understand and use the technology. *"Nine times out of ten, they want to learn more; they want to get a VR headset at home or an adaptive controller. They really want to support their kids being playful."* Our interviewee needs to work well with various staff members too, often getting input from child life specialists and therapists doing physical rehabilitation or speech therapy. The comfort of these other staff members matters if a technological intervention is going to be consistently successful. *"We have lots of cool technology here. But if the practitioners aren't comfortable using it or aren't willing to use it, it just sits there. A lot of my work is focused on training staff to make sure they understand the tech."* Our interviewee also faces lingering skepticism about therapeutic uses of entertainment technology. *"They think of video games as just that they're a game. For people who aren't in the (video game) culture, it's hard to be on the outside looking in and to see how it could possibly have a therapeutic place within a children's hospital."* Making sure that all stakeholders are comfortable with technology is a key part of any intervention.

3 DESIGN IMPLICATIONS FOR HRI

The interview described in the previous section suggests a number of recommendations for HRI researchers and designers. These considerations may be worth exploring for those hoping to deploy robots in pediatric contexts, or in other contexts that involve long-term stress and anxiety.

3.1 Create Positive Memories

Having something to look forward to makes a big difference. A good social robot for hospitalized children will help them make positive and playful memories. Especially for procedure support, positive memories counterbalance the inherently stressful anticipation of painful experiences. Our interviewee emphasizes how fun, immersive technology interrupts a child's narrative of their personal hospital experience. In this way, an effective procedure support robot would leverage the pragmatic side of playfulness to create positive expectations. Our interviewee reminds us that, without playfulness, many of the therapeutic benefits of interacting with technology are lost. A social robot for procedure support should also be designed in a way that is sensitive to children's anxiety. Recall that many children struggle to 'uncouple' the pain of anticipation from the physical pain of an experience. Within this dynamic, social robots can help address the pain of anticipation. A good procedure support robot will give children something fun to anticipate, helping them re-frame the inevitably painful experience that is outside of their control.

3.2 Personalize Social Interaction

Outside of a procedure support context, one of hospitalized children's most critical needs is to feel a sense of independence and self-expression. Not only does this apply to how children miss out on social interaction while in the hospital, but also to the loss of control they experience in their day-to-day. Our interviewee builds relationships with children by offering them the opportunity to follow their own interests: sports, animals, etc. In this, the children get to express their curiosity and control a choice in their lives. Robotics researchers and designers can consider systems that are adaptable and personal. Personalization can be achieved through the algorithmic design behind a robot's interactions, but does not necessarily need to be so complicated. The customizable accessories of the MyJay robot are a good example of a computationally costless design choice that could be very exciting to children [13]. Independence and self-expression are good guidelines for roboticists to imagine the sorts of interactions that are most meaningful to children. Worthwhile HRI for long-term pediatric patients would benefit from a system that allows children to express themselves. Though this could involve direct self-expression, it could also be as simple as providing an activity where children can follow the general expression of something they're curious about—especially if it also allows them to socialize with peers. Social robots that have a material effect on the quality of life for hospitalized children should give the children something to control or something to express. A high-level goal of independence, control, and self-expression also encourages research questions about how best to facilitate such experiences for children.

3.3 Balance Immersive and Informative Experiences

Designers and researchers building an experiences for children should be sensitive to the trade-off between the immersive and educational sides of an interaction. Technological interventions—especially for procedure support—are effective when they are more immersive. It is the playful magic of the interaction that contributes to pain management and anxiety reduction. So, a good social robot, even one with an educational purpose, should be sensitive to the fact that it should not be informative at the expense of playfulness.

3.4 Think About Accessibility

The accessibility of specific technological features is an essential design concern that goes a little beyond the high-level conceptual scope of this paper. However, it is worth mentioning a couple of things that came up repeatedly in our interview. The first is to consider a child's mobility and position during procedure support. Many procedures are done lying down, which can cause problems—especially with VR and traditional gaming setups. Social robots are compelling in this case, since a child can interact verbally with a robot regardless. Another concern our interviewee mentioned is language accessibility. At their hospital, this means that its sometimes difficult to find Spanish language options. In general, lack of language options can diminish the options available for a child that could otherwise be capable of interacting with technology. These concerns certainly do not cover all of the accessibility issues that should be considered in design for pediatric patients. However, since they are some of the most salient issues for our interviewee, we mention them here as a suggestion that they should be included in a design's accessibility plans.

3.5 Design for Staff and Parents Too

The users of a social robot go beyond the children themselves—they include therapists, parents, child life specialists, and siblings. A successful pediatric social robot must be tuned to the needs of these other stakeholders as well. For parents, this means making a system easy to understand and use so that it does not bring extra anxiety into the room and may even be taken home after a child's hospital stay is over. For hospitafl staff, this means taking the time to build relationships that frame the technology in a comprehensible way. Regardless of the technology itself, it is essential for designers and researchers to empower other adult stakeholders to feel comfortable with and capable of using the technology on their own. Making a plan to build relationships and facilitate training with these other stakeholders should be part of any design process or implementation. Parents, siblings, and child life specialists also represent an important direction for further need-finding work.

4 CONCLUSION

Social robots are promising interactive companions. While they may never replace the truly-immersive experience of VR for intense procedures like lumbar punctures, their use for small procedures like ventripuncture is compelling. In addition, they are a great way to provide playful interaction and socialization in non-procedure contexts. Currently, the children's hospital relies heavily on VR and traditional gaming consoles in practice. However, as social robots become more available, hospitals will have the opportunity to incorporate them into how they support children's quality of life.

In this paper, we present high-level considerations for the design of social robots in pediatric contexts. Our considerations are based on the experiences of a gaming technology specialist who works closely with children, therapists, and child life specialists. Even though our interviewee was in the position to provide a unique and relevant perspective, this paper only represents the content of a single interview. However, the insights gained from our need-finding encourage additional interviews in the future with others in similar positions —gaming specialists, child life specialists, and therapists. We synthesize broad observations and important challenges faced by a gaming technology specialist. Several major themes arose, including the importance of addressing the 'pain of anticipation,' giving children the opportunity to feel independent and expressive, and working well with other stakeholders.

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