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Humanoid robotics in health care: An exploration of children's and parents' emotional reactions

Tanya N Beran[1], Alex Ramirez-Serrano[1], Otto G Vanderkooi[2] and Susan Kuhn[2]

Abstract

A new non-pharmacological method of distraction was tested with 57 children during their annual flu vaccination. Given children's growing enthusiasm for technological devices, a humanoid robot was programmed to interact with them while a nurse administered the vaccination. Children smiled more often with the robot, as compared to the control condition, but they did not cry less. Parents indicated that their children held stronger memories for the robot than for the needle, wanted the robot in the future, and felt empowered to cope. We conclude that children and their parents respond positively to a humanoid robot at the bedside.

Keywords

human–robot interaction, immunization, pain management, pediatric, robotics, vaccination

Introduction

Research in pediatric procedural pain has increased exponentially since the late 1980s, and yet quality assurance of pain management has not yet been established (Zhou and Thompson, 2008). Given the often inadequate pain reduction achieved with the isolated use of pharmacotherapy, and the relative noninvasiveness and general ease of most non-pharmacological approaches, more and more attention has turned to non-pharmacologic interventions. Distraction, as such, is a method of pain management that redirects attention away from a painful stimulus. Strategies such as health-care professionals wearing distracting designs on their clothing and the use of clown doctors are emerging as effective approaches by encouraging children to attend to playful stimuli (Dionigi, et al., 2013; Fernandes and Arriaga, 2010; Tsumura et al., 2013). Listening to music or watching cartoons also show some evidence of reducing children's reported pain and anxiety (Cohen, 2002; DeMore and Cohen, 2005).

Despite evidence that these distractions work, their effects are not consistent (Cassidy et al., 2002; Megel et al., 1998). For example,

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although music and cartoons have shown effectiveness in reducing pain and anxiety among children undergoing a variety of medical procedures (Cohen et al., 1997; Klassen et al., 2008), other studies reveal that their results are not consistent (Cassidy et al., 2002; Downey and Zun, 2012). It would appear that these distractions are not always strong enough to turn children's attention away from the pain. It is now believed that multisensory strategies, which combine visual, auditory, and tactile senses, may have a greater impact on pain than single-sensory strategies (DeMore and Cohen, 2005). Given the mixed results mentioned above, it stands to reason that stronger and more engaging forms of distraction, which invite the child to engage in an activity, may be necessary for medical procedures. The goal is to turn children's attention away from the pain of the needle toward an enjoyable activity. Indeed, one of the principles of attentional capacity theory is that the distraction stimulus must be stronger than the pain stimulus to gain the child's attention (McCaul and Malott, 1984). As such, novel, interactive, and multisensory distractions are needed. In view of children's growing enthusiasm for technological devices, we propose that the use of technologically enhanced devices may create a strong distraction to gain children's attention, and have a positive impact on their emotions during medical procedures as exhibited by increased smiling and decreased crying.

Method

A three-foot tall humanoid robot (Aldebaran Robotics®) was programmed with several actions (see Figure 1). As soon as the child entered the room, a researcher pressed a button for the robot to say, "Hello, my name is MEDi," talk about movies, and ask for a "high five." Once the nurse had prepared the needle, the researcher touched a button again. The robot then picked up a rubber duck and asked the child to help blow off the dust before it put the duck into the bucket. While the nurse positioned the child, raised the child's sleeve, cleansed the skin overlying the deltoid muscle, and administered the vaccine, the robot repeated the request to blow. The purpose was for the child to blow to relax the arm while the needle was administered. Then the researcher pressed the button one last time for the robot to thank the child for helping clean the duck, commented on the child's bravery, and waved good-bye. For full details of the humanoid robot, see Beran et al. (2013).

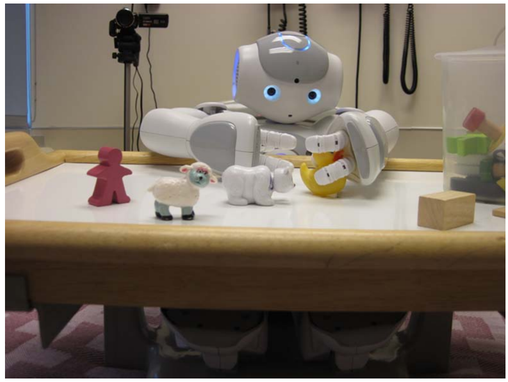

Figure 1. Position of robot.

A total of 57 children aged 4–9 years (30 boys and 27 girls) receiving influenza (flu) vaccination at a local hospital were randomly assigned to the robot group ($n = 28$) or the control group ($n = 29$) and received the vaccination under standard guidelines with minimal or no distraction. This sample size was selected based on an estimate for two groups, a power of 0.80 and two-tailed alpha of 0.05 (Cohen, 1988). Flu vaccination was chosen because it is an annual procedure. All vaccination sessions were videotaped, and the mean of the session time was 2.67 minutes (standard deviation (SD) = 0.83 minutes). Children were assigned to a condition when they arrived at the clinic using a computer-generated random-number sequence stratified by gender and age. Unsolicited comments and e-mails were received by researchers, and requests for feedback about the experience were sent to families several days after the visit if they had not initiated contact.

To measure children's and parents' emotional reactions, the duration of smiling and crying behaviors was recorded from the videos. Smiling was coded from the time the corner of the lip raised to the time it lowered. Crying was coded when a depressed lip corner was observed. Neutral expressions were not included. The total amount of time these behaviors were observed was divided by the duration of the procedure (from the time the child entered the room to the time the adhesive bandage was placed on the arm).

Results

An analysis of variance (ANOVA) revealed that children in the robot condition smiled for a longer proportion of time in the procedure (41.32%) as compared to the control condition (18.52%), $F(1, 52) = 11.25$, $p < 0.01$, Cohen's $d = 0.18$. Similarly, parents in the robot condition smiled for a greater proportion of procedural time during the interaction (64.80%) than were parents in the control condition (38.10%), $F(1, 49) = 12.53$, $p < 0.001$, Cohen's $d = 0.20$. The proportion of time children cried did not significantly differ between the two groups, however, $F(1, 49) = 0.13$, $p > 0.05$. Children's age and gender were not related to crying or smiling behaviors. Feedback received from the parents was categorized into three groups by using a grounded theory approach (Silverman, 2006). That is, emerging themes were created through an initial review of all the responses and then were used to code each response (Table 1).

Researchers also made several observations. They noted that the most extreme behaviors occurred in the comparison condition. That is, a boy kicked and hit his mother and kicked the nurse, another licked his mother's cheek, and a third boy punched his mother. In addition, one parent had heard about the robot and drove from another city for her sons to have the vaccination with the robot.

Discussion

Psychological-based treatments are now recommended and recognized as a primary intervention in the management of pain caused by a medical procedure. This study follows our introduction of a "techno-psychological" distraction for pain and distress reduction (Beran et al., 2013) by examining children's emotional reactions to a humanoid robot during a medical procedure. It showed that children are more likely to smile when encountering medical procedures with a robot. Although not less likely to cry, perhaps children recovered more quickly or the robot minimized, without eliminating, their distress. Indeed, some parents commented on the faster recovery they observed and the sense of strength children expressed in their comments when reflecting on the experience. These preliminary insights suggest that when robots are designed and programmed with humanistic characteristics, they are highly engaging to children, eliciting a positive response in the form of smiling. Thus, a humanoid robot shows promise of reducing procedural pain and distress in children. Indeed, our first study using validated behavioral measures of pain and distress shows that child, parent, nurse, and researcher ratings were significantly lower for children who interacted with the same robot used in this study, as compared to a control group (Beran et al., 2013). According to Mitchell and Boss (2002), pain experienced as young children can alter the formation of neuronal networks resulting in these networks becoming overstimulated when encountering a noxious stimulus, and culminating in a hypersensitive and elevated behavioral response. This may explain why some adults do not access health care when needed (Pate et al., 1996). This combined with the positive results of our research calls for systematic research in the use of humanoid robots for pain reduction.

With its ease of operation, pre-programmable speech and actions, versatility with children of all ages, and potential benefit for other medical procedures, it behooves us to explore the

Table 1. Parents' statements.

Requests for a robot in the future	Neutral comments	Empowering comments
My son wants to have the robot for every needle until he's a grown-up. (5-year-old son)	*She still is afraid of needles but at least this time with the robot I was able to get her on my lap!* (5-year-old daughter)	*He didn't flinch, and it was very positive. The recovery was quicker. Last time he cried before, after and during!* (6-year-old son)
On the way home she asked if she could have all her needles done with the robot! I also heard her tell Grandma that it didn't hurt at all with the robot. I think it was great and that it worked excellent!!! (8-year-old daughter)	*She liked the robot (though personally I did not see that it influenced her experience receiving the shot). It might have made a positive impression for receiving future shots, though.* (6-year-old daughter)	*My daughter usually goes "ballistic" when knowing she has to take the vaccine. Last year she was terrified and tried bolting out of the room but none of that happened this time [with the robot]. I didn't even have to hold her. I'd say there was 90 percent improvement.* (8-year-old daughter)
I wish my 16 year old daughter could experience something such as this, in order to get blood work done. (11-year-old son)	*My son had a nose bleed last year but didn't this year because of the robot. It was different this time. At one point he was really engaged with the robot and was smiling. Then he remembered the needle and became anxious again. If I had a choice, I'd pick the robot again.* (10-year-old son)	*My son has been talking about it with just about everyone he has met since. His classmates, teachers, cousins, and others. What he talks about is the robot as he makes a passing mention of the flu vaccine. He usually starts by saying that he had gone to get his flu shot and they had a robot that talked and played with blocks and a rubber ducky and … His post flu shot description of the experience does NOT include any mention of his unwillingness to get the shot, or any mention of pain or discomfort.* (4-year-old son)

potential of humanoid robotics for pediatric patient care. Perhaps the days of passive, low-tech entertainment are moving behind us, with children even at a young age now expecting captivating computer-driven technologically enhanced special effects. Nevertheless, feasibility, durability, and cost require careful consideration. The robot used in this study costs approximately CAD$12,000 and can be programmed to exhibit a wide range of distraction strategies including telling stories with sound effects, playing games, and dancing that can be created by selecting specific behaviors from a menu and clicking and dragging icons. By changing its actions, children who have already interacted with the robot can have a novel experience each time. In terms of space, it can walk on its own, but placing it on a cart with a safety strap allows clinicians to move it quickly from one room to the next. Or, it could be programmed to walk on its own throughout a clinic or hospital. Maintenance requires recharging the battery and sanitizing the plastic shell between visits with patients.

This study demonstrates how human–robot interaction can be used as a medium for pediatric care. First, as a pain coach, humanoid robots can be designed to use cognitive-behavioral, distraction, and coaching strategies to support children during various types of medical procedures such as tissue repair and intravenous starts. Second, research can explore how a humanoid robot can educate children about health. Perhaps children's propensity to engage with a robot makes them willing to listen to general information and instructions about health presented by one. Third, with considerable time spent in waiting rooms, a humanoid robot can be tested for interacting as a companion with children and their parents to entertain and ease their anxiety while waiting. Finally, a humanoid robot can serve in a coordinating capacity to greet families and collect demographic and health-related information from them to assist with administrative duties. The exploration of these types of roles and the identification of underlying mechanisms of a humanoid robot that impact children—whether it is the robot's novelty, appearance, and/or actions—beckon systematic research.

Some limitations of our research are identified. We were not able to contact all parents; therefore, we do not know whether the responses here represent those of all families who participated. In fact, we did not anticipate that children's recounting of the vaccination would yield new insights, and so we had not begun contacting parents until part way through the study. In addition, the child's proximity to and actions toward the robot did not allow blinded ratings of the videos.

This study spotlights the potential for humanoid robots to support children during medical procedures in several hospital clinics including burn, dental, diabetes, hematology/oncology, infectious disease, orthopedic, and surgery clinics. In addition to the short-term impact on patients' and families' quality of life, more research is needed to examine how these types of interventions impact children's memories of medical procedures in the long-term.

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