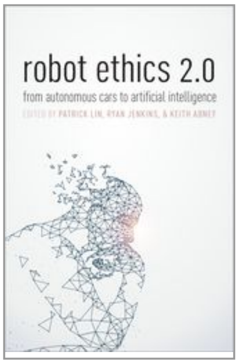

Robot Ethics 2.0: From Autonomous Cars to Artificial Intelligence
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Pediatric Robotics and Ethics

The Robot Is Ready to See You Now, but Should It Be Trusted?

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Abstract and Keywords

As robots leave the lab and are deployed in hospital or other healthcare settings, the community of users may become overreliant on and overtrust such technology. Thus, there is a pressing need to examine the tendency to overtrust and develop strategies to mitigate the risk to children, parents, and healthcare providers that could occur due to an overreliance on pediatric robotics. To overcome this challenge, we seek to consider the broad range of ethical issues related to the use of robots in pediatric healthcare. This chapter provides an overview of the current state of the art in pediatric robotics, describes relevant ethical issues, and examines the role that overtrust plays in these scenarios. We conclude with suggested strategies to mitigate the relevant risks and describe a framework for the future deployment of robots in the pediatric domain.

Keywords: robots, autonomous systems, ethics, overtrust, pediatrics, risk, developmental disabilities, occupational therapy, user complacency, positivity bias

People tend to overtrust autonomous systems. In 1995, while traveling from Bermuda to Boston, the *Royal Majesty* cruise ship ran aground because the ship's autopilot malfunctioned after having been left on for thirty-four hours (Charette 2009). On June 1, 2009, Air France flight 447 crashed into the ocean, killing all 228 passengers. Accident investigators would eventually conclude that the crew's confusion after disengaging the autopilot and reliance on faulty airspeed measurements doomed the plane (BEA 2012). On July 6, 2013, Asiana Airlines flight 214 crashed on its final approach into San Francisco International Airport, killing 3 people and injuring 180. According to the U. S. National Transportation and Safety Board, overreliance on automation played an important role in the crash (NTSB 2014). Research by two of the coauthors has shown that during certain emergency situations, some people will still follow a robot's directions, in spite of the risk to their own well-being, even though doing so has obviously failed during previous interactions (Robinette et al. 2015). As robots continue to leave the lab and enter the hospital or other healthcare settings, these examples show that people may become overreliant on and overtrust such technology.

Certain populations, such as children with acquired or developmental disorders, are particularly vulnerable to the risks presented by overtrust (Yamagishi et al. 1999; Yamagishi 2001). Because children lack extensive experience and have a limited ability to reason about the hazards of complex technological devices, they may fail to recognize the danger associated with using such devices (Kahn et al. 2004; Sharkey and Sharkey 2010). Moreover, parents themselves may not **(p.128)** fully assess the risks, either because they are too preoccupied to examine the limitations of a technology or because they are too emotionally invested in it as a potential cure (Dunn et al. 2001; Maes et al. 2003; Wade et al. 1998). As the domain of pediatric robotics continues to evolve, we must examine the tendency to overtrust and develop strategies to mitigate the risk to children, parents, and healthcare providers that could occur due to an overreliance on robots.

To overcome this challenge, we must first consider the broad range of ethical issues related to the use of robots in pediatric healthcare. This naturally leads to conceptualizing strategies that can be employed to mitigate the risk of their use. These strategies must be motivated by the desire to develop robotic systems that attend to a child's needs and by the importance of safeguarding against placing too much trust in these very systems. This is not to imply that pediatric robots are inherently unsafe or that the medical research conducted with these systems is inadequate. We only wish to discuss the effects prevalent in introducing robots into pediatric care settings and analyze the potential impacts of children's and parents' reliance on technology in which they may have considerable trust. Thus, this chapter provides an overview of the current state of the art in pediatric robotics, describes relevant ethical issues, and examines the role that overtrust plays in these scenarios. We will conclude with suggested strategies to mitigate the risks and describe a framework for the future deployment of robots in the pediatric domain.

9.1 A Review of Pediatric Robot Types and Studies

Many different robotic systems are currently being developed and deployed for use with children (e.g., Scassellati 2007; Feil-Seifer and Matarić 2009; Kozima et al. 2008; Drane et al. 2009). The focus of research over the past ten years has ranged from adapted robotic manipulators to robotic exoskeletons to social robotic therapy coaches. Tyromotion's Amadeo provides arm and hand rehabilitation in a virtual game environment for children and adults (Hartwig 2014). Motek's GRAIL system provides gait analysis and training in a virtual environment and is being used with children (Mirelman et al. 2010). Virtual and robotic technologies for children with cerebral palsy are also being evaluated in various rehabilitation scenarios (Chen et al. 2014; Garcia-Vergara et al. 2012).

Estimates suggest that about one in six, or about 15%, of children aged 3–17 years in the United States have one or more developmental disabilities (Boyle et al. 2011). Adapted robotic manipulators can provide therapeutic interventions for children with upper-extremity motor impairments; they typically engage children in physical activity that will aid in increasing their functional skills (Chen and Howard 2016). PlayROB enables children with physical disabilities to manipulate LEGO bricks (Kronreif et al. 2005). The **(p.129)** Handy Robot can assist individuals with disabilities in accomplishing daily tasks, such as eating and drinking (Topping 2002). Children can also perform play-related tasks by controlling a robot arm; they can select from a series of interface options, including large push buttons and keyboards (Cook et al. 2002, 2005). A separate type of robotic arm was used during a pilot project to determine if it could foster certain cognitive or other skills in students with severe orthopedic disabilities (Howell 1989).

Many children who have neurological disorders may have limited movement of their upper and lower extremities. Robotic exoskeletons can provide a means of therapy for such children. Robotic arm orthoses (Sukal et al. 2007) and robot-assisted locomotor trainers have also been used in this domain. A growing body of literature shows that robot-assisted gait training is a feasible and safe treatment method for children with neurological disorders (Borggraefe et al. 2010; Meyer-Heim et al. 2009; Damiano and DeJong 2009). To counter concerns raised by findings that task-specificity and goal-orientedness are crucial aspects in the treatment of children versus passive training for motor learning (Papavasiliou 2009), researchers have begun to investigate the coupling of robotic orthotic systems with scenarios involving play. For example, a pilot study with ten patients with different neurological gait disorders showed that virtual reality robot-assisted therapy approaches had an immediate effect on motor output equivalent to that of conventional approaches with a human therapist (Brütsch et al. 2010). Another case study showed that using custom rehabilitation video games with a robotic ankle orthosis for a child with cerebral palsy was clinically more beneficial than robotic rehabilitation in the absence of the games (Cioi et al. 2011).

Occupational therapy can be used to help improve a child’s motor, cognitive, sensory processing, communication, and play skills with the goal of enhancing their development and minimizing the potential for developmental delay (Punwar 2000). In other words, it seeks to improve a child’s ability to participate in daily activities. Interest is growing in research involving occupational therapy through play between robots and children with developmental disorders, such as Down syndrome and autism spectrum disorders (Pennisi et al. 2016). Passive sensing used in conjunction with robots could potentially help provide metrics of assessment for children with disabilities (Brooks and Howard 2012). Metrics associated with the child’s movement parameters, gaze direction, and dialogue during interaction with the robot can provide outcome measures useful to the clinician for diagnosing and determining suitable intervention protocols for children with developmental disabilities.

Cosmobot is a commercially available tele-rehabilitation robot that was designed as a tool to promote educational and therapeutic activities for children with and without disabilities (Lathan et al. 2005). The current configuration was used in a pilot study with three children with cerebral palsy, ages 4–11, with **(p.130)** upper-extremity limitations (Wood et al. 2009). IROMEC (Interactive Robotic Social Mediators as Companions) is a robot designed to engage three groups of children—those with autism, those with cognitive disabilities, and those with severe motor impairments—in various social and cooperative play scenarios (Patrizia et al. 2009; Marti and Giusti 2010). The Aurora project is focused on aiding the therapy and education of children with autism (Dautenhahn and Werry 2004). In one associated project, scientists utilized a humanoid robotic doll, named Robota, in behavioral studies involving imitation-based games to engage low-functioning children with autism (Billard et al. 2007).

A robot named KASPAR (Kinesics and Synchronisation in Personal Assistant Robotics) is the size of a young child and was created to be a social mediator; its facial expressions and gestures were designed to encourage children with autism to interact with other people (Robins et al. 2009). Roball is a spherical-shaped robot with intentional self-propelled movement that aims to facilitate interaction between young children (Michaud 2005). Keepon, a robot designed to engage children with developmental disorders in playful interaction, was assessed in a two-year study involving twenty-five infants and toddlers with autism, Asperger's syndrome, Down syndrome, and other developmental disorders (Kozima and Nakagawa 2006). Furthermore, Scassellati, Admoni, and Matarić (2012) provide a review of the common design characteristics of robots used in autism research as well as observations made on the types of evaluation studies performed in therapy-like settings using these robot platforms.

9.2 Healthcare Robots: Consequences and Concerns

Given the number and diversity of healthcare robots under development and their potential use with pediatric populations (as the preceding section illustrates), consideration of the ethical aspects of using these robots to provide care for children becomes imperative. Numerous ethical issues are emerging, especially considering how diverse pediatric populations are in terms of their healthcare needs. Obviously, the threat of physical harm to a patient is an ever-present concern. For example, a robot that delivers drugs to a patient could accidentally run into someone; or alternatively, a robotic prosthetic, such as an exoskeleton, could cause a user to fall due to factors such as its weight or size. Given that children are a relatively vulnerable population, harm prevention takes on increasing importance. Healthcare robots should ideally enable patients to experience some form of meaningful therapeutic benefit, but they could also generate unintended health-related consequences (such as muscle atrophy associated with prolonged use). Along related lines, the use of an exoskeleton or other robotic device could potentially lead to patients' overreliance on the technology (e.g., an unwillingness **(p.131)** to try walking without it), especially as such technology might empower them with new, or augment previously lost, abilities.

An alleged virtue of many healthcare robots is their ability to monitor patients in a large variety of ways; for days at a time, they could constantly check vital signs and observe whether medications have been taken or notice whether a patient is awake, which goes beyond the limits of what human caregivers can feasibly provide. Yet a counterbalancing concern is that this functionality could unduly intrude upon the patient's privacy. An additional complexity here is whether, and to what degree, pediatric patients should be entitled to keep information private from their parents or healthcare providers.

Unintentional or deliberate deception can also occur in the deployment of healthcare robots, which in many cases could amount to the user projecting traits or characteristics onto robots that they do not genuinely possess. Humans can form strong emotional ties to robots and other technological artifacts (Levy 2007), and designers can intensify, and arguably exploit, this human psychological tendency with their aesthetic choices (Pearson and Borenstein 2014). Some scholars argue, for example, that the use of robots in nursing homes and other care environments is deceptive and displays a lack of respect for persons (Sparrow and Sparrow 2006; Sharkey and Sharkey 2010). However, one can ask whether deception is always wrong (Pearson and Borenstein 2013), especially if it serves a therapeutic purpose in a healthcare setting.

The effect that child–robot interaction has on human psychology and socialization also warrants examination. For example, would the introduction of robotic technology into pediatric environments cause the patients to have fewer human–human interactions? Turkle (2015) extensively discusses the impact that technological devices, especially mobile phones, are having on social dynamics; she suggests that as a result of their use, the human ability to have a meaningful and extensive conversation is dissipating. Analogously, handing a meaningful portion of a child's care over to a robot might lessen opportunities for interpersonal engagement. Arguably, if a child spends less time talking with doctors, nurses, or other care providers, it could be to the child's detriment. Although some scholars suggest that robots could facilitate conversations between humans (Arkin 2014), Turkle (2015, 358) argues that using robots (like Paro) to assist with a person's care may cause the human care providers to become spectators.

9.3 Bringing the Robot Home

When one considers that some of these robotic technologies may go home with the patient, new and possibly more challenging ethical issues must be resolved. For example, a child using an exoskeleton in a hospital would presumably not be **(p.132)** climbing stairs or walking across uneven floors, but once the system is brought home, these conditions become distinct possibilities. Furthermore, the child may try to use the system in the rain or in environments where the temperature (and system performance) may fluctuate rather significantly. Granted, hospitals or other care facilities can be somewhat chaotic and unpredictable environments, but the number of variables affecting the interaction between children and robotic systems will increase as these systems are introduced into various and dynamic "external" settings (places where these systems might not have been directly tested).

Admittedly, there are many ways to prevent a child or the child's parents from placing too much faith in a robot. For instance, healthcare providers could require that parents remain in the room with their child while therapy is being performed or simply record and limit the time that a robot is operational. These types of solutions might suffice for well-defined tasks and in well-defined environments. But as healthcare robots move from the hospital and clinic to the home environment, this type of oversight is not enforceable. For example, the Cyberdyne Corporation (2016) currently allows people to rent their HAL exoskeleton and actively promotes its use by children with disabilities in their homes. In this case, it is impractical to believe that a parent will constantly monitor their child; doing so might make using the technology overly burdensome. Furthermore, limiting the use of such technology to controlled environments could greatly diminish the benefits of such technology for children and other users.

9.4 The Potential for Overtrust of Healthcare Robots

Although the aforementioned ethical issues are important to examine, our focus is how the increasing use of robotic systems in healthcare settings might lead patients, parents, and others to place too much trust in these systems. We use the term “overtrust” to describe a situation in which (1) a person accepts risk because that person believes the robot can perform a function that it cannot or (2) the person accepts too much risk because the expectation is that the system will mitigate the risk. Concerns about overtrust are, for example, saliently illustrated by the aforementioned cases where pilot overreliance on autopilot systems may have contributed to airplane crashes (Carr 2014; Mindell 2015).

Research has shown that increased automation typically leads to increased user complacency (Parasuraman et al. 1993). This complacency may result in the misuse of the automation and in the user’s failure to properly monitor the system, or it may bias the person’s decision-making (Parasuraman and Riley 1997). It is important to note that the failures that derive from automation, including induced complacency or overtrust, tend to be qualitatively different from the typical errors, or mistakes, one encounters when interacting with systems that **(p.133)** lack automation. When automation is trusted too much, the failures that occur can be catastrophic. In some instances, drivers placing their trust in GPS have followed its instructions into lakes, into the ocean, off cliffs, and on a 1,600-mile detour (GPSBites 2012).

Historically, discussions about overtrust as it pertains to robotics have focused on factory automation. Recent research, however, extends the scope to the use of mobile robots in emergency situations; researchers examined how people would react to a robot’s guidance during an emergency evacuation (Robinette et al. 2016). A mobile robot was used to escort subjects to a meeting room. In different conditions, the robot either guided the person directly to the room or incorrectly made a detour to a different room. In previous virtual studies, participants who observed the robot make a mistake would predominately choose not to follow the robot during the emergency (Robinette et al. 2015). In the real world, however, the researchers found that people followed the robot in spite of increasingly poor guidance performance. When asked why they chose to follow the robot, participants often stated that they thought the robot knew more than they did or that it was incapable of failure (Robinette et al. 2016). Furthermore, after the experiment concluded, many of the participants explained that because they chose to follow the robot, they must have trusted it. These findings suggest that people may view a robot as infallible and blindly follow its instructions even to the point where they ignore signs of a malfunction. This research has implications for pediatric robotics in that parents or others may be inclined to defer judgment about a child’s well-being to a robot.

Along these lines, healthcare providers will have a range of reactions to new robotic technology that is being integrated into their work environment. In this context, an issue that warrants particular attention is the circumstances under which professionals might defer to the technology instead of relying on their own judgment. For example, suppose a patient is wearing a robotic exoskeleton for rehabilitative purposes and the system is programmed for twenty repetitions; as the session proceeds, the patient begins to express a fair amount of discomfort. Will a physician stop the session or will the default mindset be that the machine knows best? Similarly, physicians and others may be tempted to let their attention stray from a patient if they believe that the system can be trusted to monitor the situation. In fact, studies have shown that the use of automated systems by healthcare providers can result in certain types of cancers being overlooked (Povyakalo et al. 2013).

9.5 A Child's and a Parent's Trust in a Robot

Monitoring the trust that a child places in a robot is an important area of concern. Research studies and common sense suggest that children may be particularly **(p.134)** likely to overtrust a robot (Yamagishi et al. 1999; Yamagishi 2001). Young children may lack extensive experience with robots, and technology more generally, and what little experience they have is likely to have been shaped by the internet, television, and other media; hence, they are particularly susceptible to attributing to these systems abilities the systems do not have. Furthermore, their youth may limit their ability to reason about the hazards of complex technological devices, with the result that children may fail to recognize the danger of using such devices (Kahn et al. 2004; Sharkey and Sharkey 2010). When this is combined with the fact that children, especially teenagers, tend to be at a rather risk-seeking stage of life, the likelihood of unintended harm increases. This propensity may encourage these children to push the limits of a robotic technology and/or misuse it.

Of course, parents may not fully assess the risks either. For example, parents may overtrust a robot therapy coach if they allow the system to dictate their child's routine, even in spite of signs of the child's distress; they might believe that the robot is more knowledgeable about when to end the therapy protocol than they are (Smith et al. 1997; Skitka et al. 1999). Parents of children suffering from a chronic disease or impairment may elect to use a robotic device despite the availability of equivalent or even better options simply because they think that a robot must be better than the alternatives. Moreover, because they may view robotic devices as more trustworthy than non-robotic devices, the level of their engagement in monitoring their child's treatment plan might decline.

9.6 Possible Factors Influencing Overtrust and Methods for Mitigating It

As the domain of pediatric robotics evolves, we must continue to examine the factors that contribute to overtrust and craft strategies to mitigate the risk to children, parents, and healthcare providers that could occur due to an overreliance on robots. Since this is largely a nascent area of inquiry, the strategies suggested may change as additional insights from research are uncovered. Some of the pertinent factors could include the psychological makeup and other characteristics of the person using the robot (Walters et al. 2008) and cultural differences (Kaplan 2004). Some individuals may be too trusting and accepting of risk when using a technology. Moving forward, it may be important to identify these individuals early and perhaps provide training that reduces complacency. Moreover, “positivity bias,” a psychological phenomenon where the user’s default assumption is to trust even in the absence of information to justifiably make that judgment, should be taken into account as well (Desai et al. 2009).

Overtrust is also likely influenced by the robot’s design and behavior. Designs that promote anthropomorphism, for example, can affect a child’s bond with and **(p.135)** trust of a robot (Turkle 2006). Movable eyes, a human-like voice, and speech control all tend to promote one’s belief that the robot is human-like and hence can be expected to promote the child’s welfare. Human-like behavior tends to promote anthropomorphic evaluations and is likely to promote overtrust. For instance, properly timed apologies and/or promises can repair a person’s trust in spite of the fact that an apology or promise may have no inherent meaning to an autonomous robot (Robinette et al. 2015). Apologies, an emotional expression of regret, influenced the decision-making of study participants even though the robot’s expressions of regret were limited to messages on a computer screen. Moreover, the promises made by the robot were not supported by the robot’s conviction or confidence. Still, hollow apologies and promises alone were enough to convince participants to trust the robot again in spite of earlier mistakes.

Even if roboticists avoid the use of anthropomorphic features in their designs, consistent and predictable autonomous systems tend to generate overtrust. When a system is reliable, people tend to ignore or discount the possibility of a failure or mistake. Furthermore, the level of cognitive engagement that the robot demands from the user can have an influence. For example, if users can proceed with a treatment routine without much conscious effort, then presumably they may not be fully aware of the risk.

No failsafe strategy exists that will completely eliminate risk, including when children and their families interact with a robotic system. To the greatest extent possible, the goal is to mitigate and promote awareness of the risks that users may encounter. Early research related to overtrust of automation demonstrated that occasional mistakes by a system could be used to maintain user vigilance (Parasuraman et al. 1993). Thus, it may be possible to design healthcare robots that actively engage a user's "reflective brain," reducing complacency and overtrust and perhaps lowering the risk. The use of warning indicators is one design pathway, which could be implemented in various ways. For example, a warning could take the form of a flashing light, a verbal cue that danger is ahead, or vibrations that the user feels. The process of deciding which one(s) to implement has to do, in part, with the physical and mental capabilities of the intended user.

Another kind of strategy to consider is one that demands the direct attention of the user. For example, in order for the robot (e.g., an exoskeleton) to function, the user would have to perform a specific action (e.g., press a button after a certain amount of time). On a similar note, a robot could be designed to function only if the primary caregiver of the patient were within a given proximity and/or granted the robot permission to proceed with a task. Alternatively, a system could be designed with adjustable autonomy; for example, once the robot seemed to be operating reliably, the parent could decide to receive fewer notices.

Warnings and message systems may help to lessen overtrust, but these mechanisms are unlikely to fully prevent it. In some situations, the robot may need to **(p.136)** selectively fail to reduce complacency. The possibility that a robot may deliberately fail or behave suboptimally in order to increase the vigilance of a user presents complex ethical issues. A better understanding of how selective failure will affect the overall safety of the user must inform design strategies. Consider, for example, a child using a robotic exoskeleton to climb a ladder. Though it may generate user frustration, selective failure before the climb begins may reduce harm to the child by averting the possibility of a fall from a great height. Yet selective failure after the climb has begun would almost guarantee injury.

Perhaps the most extreme method of mitigating overtrust would be for the robot to refuse to perform specific actions or tasks. This is a design pathway that roboticists, including Briggs and Scheutz (2015), are starting to explore. An overarching ethical quandary in this realm is how much freedom of choice pediatric patients should be granted when they may place themselves at risk, an issue that is compounded by the fact that patients are not a monolithic, static population. Numerous factors, including age, experience, and physical and mental well-being, can complicate an assessment of whether self-determination should supersede beneficence.

When it comes to harm prevention in the case of a pediatric user, one option would be to program a robot in accordance with an ethical theory like Kant's or utilitarianism (assuming that such a thing is even possible). Presumably, a "utilitarian" robot would try to promote the greater good of a given community, and alternatively, a "Kantian" robot would seek to uphold the tenets of the categorical imperative, including the principle of respect for persons. Yet human beings are not typically strict utilitarians or Kantians, so would it be justifiable or prudent to demand that robots behave in such a manner? Taking into account that the way humans make ethical decisions can be multifaceted, situational, and messy, it may take some time before consensus is reached about how robots should behave in ethically fraught circumstances. Nonetheless, if robots are going to continue to be deployed in healthcare or other settings, roboticists need concrete and actionable guidance as to what constitutes ethical behavior. In this context, the hope is to "operationalize" ethics in such a way that it prevents harm to pediatric patients and others.

9.7 Conclusion

Numerous types of robots are currently being deployed in healthcare settings, and many more are on the horizon. Their use raises numerous ethical issues that require thorough and ongoing examination. Yet one issue to which we sought to draw particular attention is the likelihood that children, their families, and healthcare providers might begin to overtrust robots to a point where the **(p. 137)** potential for significant harm emerges. We endeavored to outline strategies for mitigating overtrust in the hope of protecting children and other users of robotic technology. Roboticists and others must continue to diligently investigate what it means for a robotic system to behave ethically, especially as the public starts to rely more heavily on the technology.

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