

Chapter 39

Robots and Autism Spectrum Disorder: Clinical and Educational Applications

Amie Senland
Fordham University, USA

ABSTRACT

Technology featuring robots is a promising innovative technological intervention for treating and educating children with Autism Spectrum Disorder (ASD). This chapter reviews, critiques, and presents future directions for research on clinical and educational applications of robots for these children. Specifically, this chapter reviews current research on: (1) robots that act as social mediators for children with ASD and (2) robots that assist them in developing social skills such as joint attention and imitation. A critical review of the research suggests that robots may have the capacity to assist some of these children, but additional rigorous studies are necessary to demonstrate their efficacy and effectiveness. Future research must (1) examine whether robots have differential effects for specific subgroups of children with ASD and (2) contribute to a deeper understanding of robots' potential use in educational settings.

INTRODUCTION

During recent decades, the prevalence of autism spectrum disorder (ASD) has increased dramatically (Centers for Disease Control and Prevention, 2012) and technology has become progressively influential and widespread in society. Once considered an uncommon disorder consistently characterized by intellectual disability, poor social skills, and an inability to speak (Lord & Bishop, 2010), the heterogeneity of ASD is now recognized; some individuals remain non-verbal and dependent on supports throughout life, and others continue to struggle with social communication skills despite adequate language and intelligence (U.S. Department of Health and Human Services, 2011). Regardless of varied symptoms and outcomes, all children with ASD have impaired social communication and restricted, repetitive behavior, interests, or activities (American Psychological Association, 2013). The current prevalence rate for ASD is 1 in 88 children (Centers for Disease Control and Prevention, 2012), ten times that of

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the 1990s (U.S. Department of Health and Human Services, 2011). As prevalence rises, the societal and familial cost of ASD also increases. The annual cost to society for ASD is approximately \$90 billion, and in addition to the typical costs of raising a child, a family of a child with ASD pays an extra \$3 to \$5 million across the child's lifespan (Lord & Bishop, 2010).

Given the considerable rising impact of ASD on children, families, and society, the U.S. Department of Health and Human Services (2011) has continued to emphasize the need for evidence-based interventions for children with ASD. Alongside its broader societal advances, technology has become increasingly important in treating and educating children with ASD (Bölte, Golan, Goodwin, & Zwaigenbaum, 2010; Ploog, Scharf, Nelson, & Brooks, 2013), with robots proposed as one of many innovative technological interventions for such children. Robots might be a valuable intervention because many of these children are interested in computers (Ploog et al., 2013), and the simplicity and predictability of robots might be particularly effective in engaging such children (Bölte et al., 2010; Scassellati, Admoni, & Matarić, 2012; Thill, Pop, Belpaeme, Ziemke, & Vanderborght, 2012). Excitement about the potential use of robots for children with ASD is reflected in the media (Diehl et al., 2012). Since 2012, news clips about robots for these children have been featured on the *NBC Today Show*, *PBS News Hour*, *The Stan Simpson Show*, and *ABC News*, and numerous news articles have been written about the topic. Furthermore, in April 2013, a French robotics company, Aldebaran Robotics, announced their ASK (Autism Solution for Kids) NAO initiative (Aldebaran Robotics, 2013). This initiative allows schools and special education teachers to acquire NAO, a commercial robot, for use with students with ASD. NAO comes equipped with games designed to enhance social and communication skills in children with ASD (Aldebaran Robotics, 2013).

While the potential for using robots in treating and educating children with ASD is exciting, larger more rigorous studies are necessary to evaluate the efficacy and effectiveness of this approach and to determine whether robots have differential effects for specific subgroups of these children (Diehl et al., 2012). Most current research on robots and children with ASD originates from the field of socially assistive robotics (Diehl et al., 2012). Socially assistive robotics is a relatively new interdisciplinary field that uses robots to help people through social interaction (Feil-Seifer & Matarić, 2009; Scassellati et al., 2012; Tapus, Matarić, & Scassellati, 2007). For example, in socially assistive robotics, robots are used to facilitate social interaction and/or emotional expression, teach social skills, and/or provide companionship (Feil-Seifer & Matarić, 2009; Scassellati et al., 2012; Tapus et al., 2007). This field has several application areas, such as using robots as companions for the elderly or assistants in post-stroke recovery, but one of its largest potential application areas is ASD (Tapus et al., 2007). For children with ASD, social robots, or robots that use verbal and/or body language to socially interact with people, could potentially facilitate social interaction or foster social skills such as joint attention and/or imitation (Dautenhahn, 2003; Scassellati et al., 2012).

Accordingly, various types of social robots have been used in research with children with ASD, including mobile robots, creature-like robots, dinosaur robots, and humanoid robots (robots built to resemble humans) such as NAO. Some research teams develop and design their own robots (e.g., Duquette, Michaud, & Mercier, 2008; Vanderborght et al., 2012), while others program and adapt commercially available robots (e.g., François, Powell, & Dautenhahn, 2009; Kim, Berkovits, Bernier, Leyzberg, Shic, Paul, & Scassellati, 2013). Examples of robots used in ASD research are shown in Figures 1 and 2, including a creature-like robot, Keepon (Figure 1), and a humanoid robot, NAO (Figure 2).

Most social robots used in ASD research are controlled through a Wizard of Oz (WOZ) technique, where the experimenter controls the robot without the participant's knowledge, providing the impression that the robot is acting autonomously (Kim et al., 2013; Vanderborght et al., 2012). This control allows

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