Use of Technology in Interventions for Children with Autism

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A growing number of studies have investigated diverse applications of technology-based interventions with children with autism. The purpose of this paper is to review the growing empirical support for the efficacy of technology-based interventions with children with autism and to recommend future directions for research. This review will focus on five examples of technology introduced as a temporary instructional aid to be removed once the goal of behavior change has been met: (a) tactile and auditory prompting devices, (b) video-based instruction and feedback, (c) computer-aided instruction, (d) virtual reality, and (e) robotics. Future directions for research and practice with each technology are discussed.
Keywords: autism; technology-based interventions; computer-aided instruction; virtual reality; robotics.

A growing number of studies have investigated diverse applications of technology-based interventions with children with autism. The popularity of technology in the field of psychology is evidenced by the development of new journals in the area (e.g., the Journal of Special Education Technology, the Journal of Educational Multimedia and Hypermedia, the Journal of Computer Assisted Learning, etc.). In addition, clinical psychology journals are recognizing the importance of technology in service delivery and devoting special issues to the topic (e.g., Newman, 2004). Parents and clinicians regularly report that children with autism are drawn to technological devices and researchers have noted the importance of devising treatments that take advantage of this fascination (Colby, 1973). The purpose of this paper is to review the growing empirical support for the efficacy of technology-based interventions with children with autism and to recommend future directions for research.

A review of technology-based interventions must first clarify the use of the word technology. The term is broadly defined as “the practical application of knowledge” or “the specialized aspects of a particular field of endeavor” (Merriam-Webster’s Collegiate Dictionary, 1994, p. 1210). This broad definition encompasses virtually any information or object that has been used in application to a field of study. For example, the application of stimulus control is technology to a behavioral clinician. A more specific use of the term refers to use of mechanical or electromechanical processes that often increase productivity and reduce or eliminate manual operations or operations done by older technologies. In the twenty-first century, technology commonly denotes a variety of popular electromechanical devices such as cell phones, video recording equipment, and hand-held, desktop, and laptop personal computers. It is the use of these tools with children with autism that will be the subject of this review paper.

Some technology-based interventions are designed for indefinite use as an assistive tool (e.g., voice-output augmentative communication devices, microswitches, etc.) while others are introduced as a temporary instructional aid to be removed once the goal of behavior change has been met. This review will focus on five examples of the second category: tactile and auditory prompting devices, video-based instruction and feedback, computer-aided instruction, virtual reality, and robotics. Research support for the use of each technological advancement with children with autism will be reviewed, and directions for future research and practical application will be discussed.

Mechanical Prompts

Individuals with autism often need external stimulus prompts to initiate, maintain, or terminate a behavior. Commonly used prompts include vocal, gestural, physical, written/pictorial, and signed prompts, and each modality has been demonstrated effective for multiple purposes (MacDuff, Krantz, & McClannahan, 2001). Technological advancements in the last decade have created cost-effective automated prompting devices with the ability to deliver the same level of prompting with less human interaction and obtrusiveness and often less human effort in managing prompt delivery (e.g., Taber, Seltzer, Heflin, & Alberto, 1999). The two most commonly use mechanical prompts are auditory and tactile prompts.

Auditory Prompting

Taber et al., (1999) provide a notable example of using auditory prompts to decrease off-task behavior for a student with autism and moderate mental retardation. Using a multiple probe across settings design, a 12-year old male student with autism was taught to use a self-operated auditory prompting system. The system contained recorded music interspersed between auditory verbal prompts (e.g., “keep working,” “pay attention,” etc.). The result was a decrease in inappropriate and off-task behavior at home and school with a concurrent decrease in teacher-delivered prompts.

A more recent study used auditory prompts to cue in-class self-monitoring as an intervention for decreasing off-task behavior in a classroom setting (Coyle & Cole, 2004). For three children with autism (aged between 9 and 11), an auditory timer (available from Jadco®) was used to prompt self-monitoring of on-task behavior every 30 s of a 5 min work interval, with interval time increasing to 1 min for 1 of the participants. Using reversal designs, researchers were able to show that off-task behavior was significantly decreased during intervention phases.

Auditory prompting devices often require less manpower to result in positive change which is a critical benefit given the increasing number of children with autism served in local school settings where teacher resources may be scarce. Modern auditory prompts such as auditory pagers, portable compact disc players, and MP3 players are relatively small and unobtrusive and are used by enough children to minimize any stigma associated with carrying one for therapeutic purposes. Despite these apparent benefits, the paucity of literature focusing on technology-based auditory prompting for children with autism makes generalization of current findings difficult. Future research, as suggested by Taber et al. (1999), should continue to examine the effectiveness of self-operated auditory prompting systems with this population. Although Taber et al. (1999) & Coyle and Cole (2004) focused on decreasing off-task behavior, future investigations should also evaluate the effectiveness of auditory prompting for skill acquisition.

Tactile Prompting

Tactile stimulation in the form of manual gestural and physical prompts has often been used successfully for children with autism. However, the inherent limitation of manual prompting is the requirement for constant close proximity of a second person (e.g., parent, researcher, peer, etc.), which can be intrusive and demanding of human resources. As with auditory prompting, the development of electromechanical, tactile prompting devices is removing the need for the presence of a second individual. Although there are limits to the capabilities of existing prompting/vibratory devices, currently available products (e.g., Follow Through Inc., 2003; JTECH Communications Inc., 2004) provide researchers who lack design and manufacturing expertise the opportunity to conduct research in this area. Specifically, two studies have successfully utilized ready-made tactile prompting devices to promote increases in social initiations in children with autism (Taylor & Levin, 1998; Shabani et al., 2002), and one study has shown that such devices can be used by teens with autism to seek assistance when lost (Taylor, Huges, Richard, Hoch, & Coello, 2004).

Taylor and Levin (1998) used the Gentle Reminder (currently unavailable for purchase) to target verbal initiations of a student with autism. Although the device was manufactured for the purpose of prompting teachers to implement various schedules of reinforcement, this study utilized the programmable vibrating function of the device to prompt the child to initiate during play sessions. Specifically, the device was set to vibrate for several seconds after a preset elapsed interval. The authors compared conditions using a multielement design replicated across different play activities. The three conditions were no prompt, verbal prompt (i.e., adult modeled initiation every minute), and tactile prompt (i.e., vibratory prompt provided every minute) and each condition was assigned to a different activity. Compared to the no prompt and verbal prompt conditions, tactile prompting resulted in significant increases in verbal initiations. Shabani, et al. (2002) replicated and extended the Taylor and Levin study by evaluating the collateral effects of tactile prompting on participants' responses to peer initiations while attempting to fade the tactile prompt in terms of frequency of prompts. They used a ready-made JTECH Series 27 Pager (JTECH Communications Inc., 2004) activated by a remote control to deliver a 3 to 5 s vibration. Using an ABAB design, researchers were able to demonstrate increased verbal initiations for all 3 children during tactile prompting conditions and increased responses to peers' initiations for 2 participants when tactile prompting was used. When prompt fading was initiated for the 2 participants with treatment gains, the outcome was less dramatic with partial success for only one of the participants. These studies provide preliminary support for the use of tactile prompts for social initiations.

The most recent publication in this area focused on teaching teenagers with autism to seek assistance when lost (Taylor et al., 2004). Using a multiple baseline design across participants, researchers were able to demonstrate that participants were successful at soliciting help by handing a communication card to community members following a tactile prompt delivered via a remote activated JTech pager. Although initial training occurred in a school setting, training was extended to community sites, and generalization was assessed in nontraining, community sites and on outings with participants' parents. This study provides a promising strategy for increasing the public safety of individuals with autism. However, for this intervention to be practically applied, additional research is needed to determine if help-seeking will maintain in the absence of tactile prompts.

Given the efficacy demonstrated thus far, research utilizing tactile prompting should be expanded. One broad area for future research involves the application of technology-based prompts to other skill areas. Thus far, research has focused on increasing social initiations in play settings or as a means to solicit help. However, this technology could be applied to numerous skills. For example, tactile prompting could be used to prompt children to look before crossing the street, to take medication, or to increase eye contact. The second area for future research involves development of strategies or modified technology to allow more effective prompt fading. Researchers' ability to successfully fade mechanical prompts may be dependent on their ability to vary the prompts along a variety of stimulus dimensions such as volume or vibration intensity. For example, Shabani et al. (2002) decreased the frequency of prompts but were unable to alter the stimulus along dimensions that might have been more amenable to fading such as vibration intensity. If researchers collaborate with technology developers on design of future products, new and better options may become available that will more closely match mechanical technology (e.g., pagers) with behavioral technology (e.g., stimulus fading). Additionally, as children become frequent users of small, electronic devices for personal communication (e.g., cell phones, pagers, MP3 players, PDA's, etc.) the use of discrete auditory and tactile prompting devices becomes a more socially valid and economically feasible intervention for children with autism.

Video

Video technology is perhaps one of the most readily available technologies for parents, educators, and clinicians. In addition to being economically feasible and portable, many individuals can operate video equipment with very little instruction, making it the technology of choice for many clinicians and researchers. Video technology has proven useful as a tool for modeling appropriate behavior, providing feedback, and creating discrimination opportunities for the child's own behavior, and as a medium for presenting basic instruction that many children find engaging (Sturmey, 2003). In fact, a recent special issue of the Journal of Positive Behavior Interventions was devoted exclusively to the use of video with children with autism.

Two studies in the late 80's demonstrated the utility of video modeling for teaching children with autism purchasing skills (Haring, Kennedy, Adams, & Pitts-Conway, 1987) and conversational skills (Charlop & Milstein, 1989) suggesting that video technology held much promise in teaching children with pervasive developmental disorders. Several studies have since supported this claim by illustrating that video modeling can be effectively used to teach conversational speech (Sherer et al., 2001), increase task fluency (Lasater & Brady, 1995), increase play related statements (Taylor et al., 1999), improve social communication (Thiemann & Goldstein, 2001), teach daily living skills (Shipley-Benamou, Lutzker, & Taubman, 2002), improve perception of emotion (Corbett, 2003), promote spontaneous requesting (Wert & Neisworth, 2003), encourage social initiations (Nikopoulos & Keenan, 2003), increase imaginative play (D'Ateno, Mangiapanello, Taylor, 2003), and teach perspective-taking skills (Charlop-Christy & Daneshvar 2003; LeBlanc et al., 2003) and self-monitoring of off-task behavior (Coyle & Cole, 2004).

While there are several demonstrations of the effectiveness of video modeling, only one published study has directly compared the use of video modeling to live modeling. The preliminary results from this comparative study indicate that incorporation of video may result in superior intervention effectiveness. Charlop-Christy, Le, & Freeman (2000) compared the effectiveness of video modeling to in vivo modeling for teaching developmental skills to children with autism and found that video modeling led to faster acquisition of play, language, and self-help skills and generalization of skills that was not observed in the in vivo condition. The authors suggest that video modeling may result in more ready generalization than in vivo modeling because it (a) uses a relatively simple format to present concepts in a systematic way, (b) effectively gains and maintains children's attention, and (c) is a less "emotionally laden" way to learn. Additionally, video modeling offers the freedom to present a variety of exemplars to facilitate maintenance and generalization and allows easy repetition of the model without the requirement of repeated model effort and the risk of inconsistency in the model. Additional comparative studies are needed to support this preliminary finding.

Overall, video is an increasingly popular, economical, readily available, user-friendly technology that can prove beneficial for children with autism. Although the production of video modeling tapes may be initially effortful and time consuming, taped models can be used repeatedly with the same child and with other children who have similar deficits. Researchers and clinicians who create video models for children with autism should keep several design features in mind. First, video models should display clear and detailed behaviors. Second, make important stimulus features as salient as possible while minimizing irrelevant or distracting stimuli to combat potential problems with stimulus overselectivity (LeBlanc et al., 2003). Clinicians may want to create several versions of the model that includes progressively more distracter stimuli or decreased salience of the target stimulus. Additionally, video models should teach multiple exemplars to promote generalization and minimize the likelihood of rote responding (e.g., Sherer et al., 2001). Finally, one should combine video modeling with other treatment components (e.g., role-play, reinforcement, etc.) to increase the probability that efficient learning will occur.

As previously mentioned, additional comparative studies are needed to support preliminary findings that video modeling has advantages over in vivo modeling. Moreover, further research is needed to determine if video-based interventions have applicability for increasing communicative and social behavior and decreasing ritualistic and other aberrant behavior. Particularly for higher functioning children with autism or Asperger's disorder, video feedback of their stereotypical behavior may be incorporated into psycho-educational interventions. Also, tapes created for one child will often have applicability for use with other children so behavioral clinicians and researchers should foster the sharing of these resources perhaps by establishing publicly available or purchasable collections of video tools.

Public accessibility to video models may be key in making video modeling and feedback a tool with more widespread use and applicability.

Computer-Based Interventions

Computer-based interventions are perhaps the most studied technology-based intervention for children with autism. Computers have been used to teach a variety of skills, including how to recognize and predict emotions (Silver & Oakes, 2001), enhance problem solving (Bernhard-Opitz, Sriram, & Nakhoda-Sapuan, 2001), improve vocabulary (Moore & Calvert, 2000; Bosseler & Massaro, 2003), advance generative spelling (Kinney, Vedora, & Stromer, 2003), enhance vocal imitation (Bernhard-Opitz, Sriram, & Sapuan, 1999), increase play related statements (Taylor et al., 1999), and improve reading and communication skills (Heimann, Nelson, Tjus, & Gillberg, 1995). Additionally, researchers are working to present commonly used, low-technology interventions via computer. For example, social stories, an educational strategy developed by Carol Gray, have been presented in a multimedia, computer-based format (Hagiwara & Myles, 1999), and activity schedules are being developed in Microsoft PowerPoint and used to teach children with special needs (Rehfeldt, Kinney, Root, & Stromer, 2004). Although the results of these studies vary in terms of their positive gains for children with autism, the overall results are quite favorable. For example, Bosseler & Masaro (2003) developed and evaluated a computer-animated tutor to improve vocabulary and grammar in children with autism. In their investigation, eight children were given initial assessment tests and tutorials, and were then reassessed 30 days following mastery of the vocabulary items. Data showed that students were able to identify significantly more items during posttest and recall 85% of the newly learned items at least 30 days after the completion of training.

There is mounting evidence that computer-based interventions are beneficial for children with autism but the critical question is whether computer-based instruction is more beneficial than its low-tech counterpart. Several comparative studies have investigated this question. Chen & Bernard-Opitz, (1993) compared live personal instruction to computer-assisted instruction and found better motivation and fewer behavior problems with computer-assisted instruction for 3 of the 4 participants. However, they found no significant difference in the participants' learning rates. Despite the similar learning rates, the benefits of increased motivation and reduced behavior problems are notable. Moore & Calvert (2000) compared computerized instruction with a lower-tech behavioral program for vocabulary instruction for children with autism and also found that children with autism were more attentive and more motivated when presented with. Additionally, they found that their participants learned more vocabulary in the computer instruction condition rather than the lower tech behavioral program. Additional support for increased efficacy of computer-based instruction over more traditional methods was offered by Williams, Wright, Callaghan, and Coughlan (2002) who found that after computer assisted learning, 5 of the 8 children with autism could reliably identify at least 3 words when other methods had failed to promote such gains. Participants also spent more time on reading material when they accessed it through computer and were less resistant to its use.

These comparative studies indicate that computer based instruction typically results in benefits such as increased motivation, decreased inappropriate behavior, and increased attention and sometimes results in increased learning compared to traditional methods. Computers, including desktop, laptop, and handheld varieties, can be conditioned reinforcers for many children with autism resulting in task presentation that has inherently reinforcing characteristics. The next critical series of questions should focus on determining which characteristics of the computer based instruction children with autism find appealing and how which specific design features promote learning. In an initial investigation, Lahm (1996) examined software features used in commercially available programs for their effect on engagement, affect, and choice. Data from 48 alternating treatment design studies suggest that children with disabilities, including autism, prefer programs with higher interaction requirements, animation, sound, and voice features. They show more positive affect and engage more frequently with computer programs that use preferred features and actively choose between programs based on preferences for these features.

In addition to the previously mentioned benefits of computer-based interventions, several other benefits are worth noting. First, computer programming allows unlimited control of stimulus presentation that allows researchers and clinicians to present repeated learning trials in an identical or systematically varied format. Additionally, computer-based reinforcers can be delivered immediately following responses, and the delivery of reinforcement can easily be changed for schedule thinning purposes and varied to reduce the likelihood of satiation. Finally, although typically used as a single person technology, computers have the ability to permit concurrent, or “cooperative,” use (i.e., two children with two joysticks). Given that many parents are often concerned that use of technology will promote isolation and decreased interpersonal interaction, this is a notable feature.

Virtual Reality

Years of advances in the field of computer science have resulted in virtual reality technology that allows the opportunity to experience a three-dimensional, computer-generated world in which people can behave and encounter responses to their behavior. The applications of this interactive technology may prove endless and have already been substantially explored with non-autistic populations. Virtual reality has been used as a mode of exposure therapy for specific phobias (Rothbaum et al., 1995; Pyne, 1994), as an adjunctive treatment of burn pain during wound care (Hoffman et al., 2004), to assist in safe mastery of wheelchair use for children with cerebral palsy (Ira, 1997), and to restore skilled movement for children recovering from traumas and diseases (Andrae, 1996; Kuhlen & Doyle, 1994; Latash, 1998; Rose, Johnson, & Attree, 1997). Although the technology to support virtual reality was developed more than twenty years ago (Negroponte, 1995) and virtual reality has been applied within a variety of disciplines, its specific application to interventions for children with autism has been quite limited.

Two studies have examined whether virtually children with autism can tolerate reality environments. Strickland, Marcus, Mesibov, and Hogan (1996) published two case studies examining whether children with autism would tolerate wearing virtual reality equipment and could respond to the computer-generated world in a meaningful way. Wearing a “heavy, awkward helmet,” a 7-year-old female and 9-year-old male participant were asked to walk within the virtual environment, verbally identify cars and their color appearing in street scenes, and locate and walk toward a specific object. Each child was successful with these tasks indicating that these children with autism were able and willing to accept and interact within virtually created worlds. Max & Burke (1997) evaluated (a) whether children could interact with virtual environments for longer periods of time, ignore a variety of distracters, and acquire skills, and (b) which sensory components of virtual reality were appealing. Although durations varied, participants tolerated sessions up to 11 minutes successfully with improved attention and performance across sessions-- age was not a predictor of performance. When attending, children appeared focused and their bodies remained at rest. Sight & localized sound attracted attention to events and locations in the virtual environment. Children were drawn to more complex visual and auditory events and preferred listening to louder rock music as compared to softer chorale music. These studies provide preliminary support for the potential of virtual reality interventions with children with autism.

The benefits and potential applications of virtual reality for children with autism may be quite substantial but still need to be demonstrated empirically. Perhaps one of the most notable benefits is that virtual reality affords incomparable control over the environment, allowing researchers and clinicians to arrange environments to best promote learning and generalization. Access to virtual reality equipment and a knowledgeable programmer can allow removal and gradual introduction of distracting stimuli, exaggeration and gradual return to normal of salient stimulus features, and limitless creation of training exemplars to promote generalization. Another notable advantage is that it may offer a highly realistic but safe environment in which to teach skills that are associated with some level of danger (e.g., pedestrian safety, stranger safety, etc.) when taught in the natural environment. The current drawbacks to virtual reality are cost, programming requirements, and general lack of availability to clinicians and most researchers. However, technological advancements and the production and marketing of lower-cost systems may soon make virtual reality available as an invaluable tool to the behavioral clinician and researcher.

Robotics

Although it was suggested more than 15 years ago that future-oriented investigations of technologies in other fields, including robotics, be conducted to determine their potential utility for children with special needs (Yin & Moore, 1987), the application of robotics in therapeutic work with children with autism is considered a relatively new approach. Currently, robotics research with children with autism is primarily being published in computer science journals by researchers interested in bridging the gap between computer and behavioral study and creating novel tools for therapeutic change. Therefore, clinicians and researchers may be unfamiliar with this literature. Despite the problems associated with dissemination of this newly emerging line of research, studies conducted thus far indicate that robotics may prove promising in interventions for children with autism. Robotics can allow presentation of a simplified social environment and gradual increase in the complexity of social interactions. Robots can be used to teach basic social interaction skills using turn-taking and imitation games, and the use of robots as mediators and as objects of shared attention can encourage interaction with peers and adults.

The Aurora Project, started in 1998 and led by Kerstin Dautenhahn, consists of a multidisciplinary research team who are conducting most of the investigations in this area (Aurora, 2004). Described by both an independent reporter (Graham-Rowe, 2002) as well as the team leader (Dautenhahn, 2003), the Aurora Project's purpose is to study how robots can become a "toy" that might serve a therapeutic role for children with autism. The mechanistic qualities of robots that some may believe to be negative features of robots may be the very features which make robots preferred interaction partners for children with autism. In initial phases of the project, truck-style robots were designed in the hope that their non-human appearance would better facilitate interaction (Graham-Rowe, 2002). One of their first prototypes was a robot that resembled a large toy truck with heat sensors that could detect nearby children and bumper switches that allowed it to reverse upon impact (Graham-Rowe, 2002). The researchers programmed several basic commands necessary to play interactive games resembling "tag" and "follow the leader" (e.g., imitation, turn-taking, etc.). The truck was later modified to include a central point of focus resembling eyes. The robot was designed such that the children would have to face the robot in order for it to sense their movement and respond accordingly- thereby promoting sustained "eye contact." A more recent model, "Robota", is essentially an off-the-shelf doll with added motors, sensors, and a simple processor that allows the doll to move, sense movement, and even recognize gestures and respond to them. As a result, this humanoid robot can detect and copy movements such as arm raising and head turning. After initial instruction, children can play games involving imitation, turn taking, and eye contact (Graham-Rowe, 2002). Although it is too early to tell how useful these dolls will be, preliminary findings and anecdotal reports seem promising (Graham-Rowe, 2002; Dautenhahn, 2003).

Using the various robotic models, the project has progressed through three investigative phases (Dautenhahn, 2003). The first phase of the project established with 5 children that (a) robots are safe interaction partners for children, (b) children are not afraid of the robot, (c) children are sufficiently motivated to interact with the robot over a period of ten minutes or longer, (d) children are more interested in the robot in 'reactive' mode as compared to the robot showing rigid, repetitive, non-interactive behavior, and (e) children show no distress or behavior problems when the robot behaves reactively but not completely predictably. The second phase of the study included 18 children and investigated whether the children behaved differently towards the robot as compared to a non-interactive toy. Results showed that most children expressed more interest in the robot (in terms of gaze, attention, etc.) and were more engaged in interactions with the robot than with the toy. In the third phase, researchers investigated three pairs of children and found that the particular kind of social interactions among the children in the presence of and during interactions with the robot reflects their social interaction outside the research setting, establishing that interactions with the robot in the pair-trials were not artificial.

The Aurora project has begun interesting work designed to make the use of robotics in autism therapy a reality rather than a lofty ambition. Although still in its infancy, preliminary results from the Aurora project show that this line of research holds promise for the treatment of autism. They propose that robots may one day become therapeutic playmates designed to teach basic social skills and social mediators to encourage and facilitate social behavior (Dautenhahn, 2003). It is clear that this line of research has great potential. However, much work is needed to make the use of robotics in autism therapy a financially feasible and practical alternative to more naturalistic strategies.

Discussion and Future Directions

Research incorporating technology has consistently demonstrated good effects for the use of computers (e.g., Bernhard-Opitz et al., 2001; Silver & Oakes, 2001; etc.), video (e.g., Charlop & Milstein, 1989; Shipley-Benamou et al., 2002; etc.), mechanical prompting devices (e.g., Taylor & Levin, 1998; Shabani et al., 2002; etc.), and numerous other technologies with children with autism. The next pressing questions about technology-based interventions focus primarily on whether the interventions are more efficacious, cost-effective, or enjoyable than more traditional, low-tech interventions. Although preliminary results look promising (e.g., Chen & Bernard-Opitz, 1993; Moore & Calvert, 2000; Williams et al., 2002; Charlop-Christy et al., 2000) continued research is needed before a definitive answer can be given.

While technology may be perceived as sterile, foreign, or unnatural to some, technology is quickly melding into the societal mainstream with PDA's, cell phones, laptops, and MP3 players becoming increasingly common and affordable. With this increasing use may come increased acceptability for technological intervention aides for children with autism that will not result in children with autism standing out from the crowd, but rather, blending into our more technologically advanced society. An elementary school child with autism referencing his PDA based activity schedule between classes may appear quite normal. In addition, market competition and technological advances have made products affordable, eliminating the concerns of the 1970's that "a realistic objection to computers is cost; few people in the world have access to million-dollar computers for this sort of work" (Colby, 1973, p. 260). Some technologies are quite reasonably prices while other more cutting-edge technologies such as virtual reality and robotics are still unobtainable for many individuals. Although it may currently be more difficult to conduct research with these technologies, it is critical that we continue to explore and critically evaluate the utility of these tools to identify the most efficacious interventions and to create demand for more affordable technology within a consumer-driven market.

Research should investigate which design features are critical for producing therapeutic effects and how those design features create their impact (i.e., understanding of the mechanisms for change). Although the existing literature offers some suggestions, additional research is necessary to establish guidelines for technology development and use with children with autism. The use of technology in interventions often requires technical or programming expertise that many clinicians lack making it necessary to foster multidisciplinary research and clinical work. It is imperative that behavioral clinicians and researchers partner with programmers and engineers to become more comfortable with these technologies and assist in developing or modifying tools to examine the questions that interest us.

In summary, technology based interventions are often useful for and appealing to children with autism. A growing literature supports the general effectiveness of these tools although additional comparative research is needed. Interested researchers and clinicians have a wonderful opportunity for exciting collaborations with other technical disciplines to make technology-based interventions truly useful and accessible for children with autism.

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