Parents Can Teach Their Children with ASD Pedestrian Safety Skills Using Virtual-Reality and Behaviour Skills Training

By

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Abstract

Teaching skills to individuals with autism spectrum disorder (ASD) is an effective way to promote independence and enhance quality of life. Persons with ASD may have less access to existing community programs and are at higher risk of injury. The acquisition of pedestrian safety skills assists in removing barriers associated with travel and can also help foster safety. Virtual Reality (VR) combined with evidence-based techniques such as Behaviour Skills Training (BST) offers unique advantages to expand an individual's repertoire of abilities. This study evaluated the effectiveness of using VR combined with BST to teach pedestrian safety skills to individuals with ASD, facilitated by remotely trained parents. Two individuals with ASD were recruited and taught pedestrian safety skills using components of BST; instructions, rehearsal, and feedback. This was accomplished through the safety of simulated Virtual Environments (VE) where participants were taught specific street-safety discriminations by a designated parent according to a task analysis. An AB design was used for participant 1, and a multiple baseline design across settings was used for participant 2. Results across both participants and across settings for participant 2 showed an immediate improvement in the proportion of task components performed correctly during intervention compared to baseline. Data from participant 2 provides supporting evidence that a BST intervention is effective at teaching pedestrian safety skills to individuals with ASD in a VE.

Keywords: Autism Spectrum Disorder, Virtual Reality, Behaviour Skills Training, Pedestrian Safety.

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Personal independence entails the ability to navigate safely in the surrounding environment. Street-crossing is among the most dangerous situations for the general population (Schwebel et al., 2012; WHO, 2008). Individuals with cognitive impairment and motor deficits, including some individuals with autism spectrum disorders (ASD) are especially at risk (Jain et al., 2014; Lee et al., 2008). Behaviour Skills Training (BST) is one effective method for teaching this population specific skills crucial for independence with activities of daily living. Growing evidence suggests Virtual Reality (VR) offers several benefits for teaching safety skills over traditional instructional methods. Benefits include a safe, immersive, controlled and realistic environment for at-risk individuals to practice within. Evidence suggests that a combined approach that utilizes BST and VR is a successful way to teach individuals with ASD safety skills (Goldsmith, 2008; Wright & Wolery, 2011). However, relatively few studies have used VR to deliver BST to promote pedestrian safety in this population. Furthermore, procedures have generally not applied prompts and prompt fading within a detailed task analysis of street-crossing. Studies to date have also employed limited measures of procedural integrity and have not assessed the acceptability of BST combined with VR. Therefore, the purpose of this thesis was to address those gaps in the previous literature by evaluating a virtual environment to teach safe street crossing to individuals with ASD.

Globally, more than 5 million injury-related deaths occur each year and injuries are the leading cause of disability in children and youth (Mock et al., 2004). According to a report from the World Health Organization (WHO) in 2008, approximately 950,000 children under the age of 18 years died in 2004 with 87% due to unintentional injury. Furthermore, non-fatal injuries leave tens of millions of children in hospitals (WHO, 2008). Canada is no exception: the leading cause of death and disability among children is unintentional injury (Public Health Agency of Canada, 2008). Beyond death and disability, injuries are costly to the medical system, cause pain and discomfort in victims, inhibit participation in regular activities, impact mental health, and negatively affect quality of life (WHO, 2008).

Injuries related to road and pedestrian safety are among the leading causes of death and injury for children under the age of 18 (Schwebel et al., 2012; WHO, 2008). In 2007 in the United-States, a total of 17,342 serious injuries and 219 deaths were reported among children aged 4-12 related to pedestrian injury alone (Schwebel et al., 2012). Statistics for pedestrian injury among children with ASD and/or disabilities population are unknown.

Autism Spectrum Disorder (ASD)

The Diagnostic and Statistical Manual of Mental Disorders (DSM-5, 2013) describes ASD as a complex neurodevelopmental disability that is characterized by persistent deficits in social communication and interactions, restricted or repetitive patterns of behaviour and activities and rigidity of habits. The difficulty with social and communicative skills often inhibits learning, hindering the acquisition of skills that occur through social interaction and within peer settings (DSM-5). Persons with ASD often engage in challenging behaviours as a result of their behavioural deficits and excesses (Centres for Disease Control and Prevention, 2016), which can further obstruct the acquisition of important life skills. Strong rigidity towards routines and difficulty adapting to change, along with hypersensitivity towards sensory stimuli may interfere with regulatory body practices such as eating and sleeping (DSM-5). Difficulties with imaginative play and problem solving are also common for persons with ASD.

The characteristics that define ASD along with factors that are associated with it (e.g., increased comorbid diagnoses) make children more likely to sustain unintentional injuries as compared to typically developing children (Jain et al., 2014; Lee et al., 2008). According to Lee, Harrington, Chang, and Connors (2008), their risk of injuries requiring medical attention is more than double that of children without disabilities. The researchers suggest the increased risk of injury may be due to behavioural excesses and deficits along with characteristics frequently found in those with ASD such as impaired motor control (Fournier et al., 2010), cognitive impairments, or anti-social behaviour (Lee et al., 2008). Behavioural challenges such as elopement, that is, running or bolting from a supervised and safe setting and is thereby exposed to environmental dangers, also contributes to the increased risk of traffic injury for those with ASD (Anderson et al., 2012). A study by Jain et al. (2014) also found that children with ASD experience more injuries than children without ASD. For example, they found that children with the co-occurrence of ASD and seizures are at 40% greater risk of injury. This finding suggests that increased injury risk for ASD goes beyond the characteristics that define it (Jain et al., 2014).

The frequency and severity of injuries, the potential for life-long disability or death, along with financial burdens, make injury among one of the leading public health issues worldwide. Prevention is emphasized frequently in literature that has examined injury either in the general population or a more vulnerable one (Lee et al., 2008). Recommendations and strategies are often aimed at the broader systemic and general population levels. For a more vulnerable group such as those with ASD, more specialized interventions can be found in the literature. These specific interventions illustrate the need to teach individuals specific skills to foster their safety and independence (Gardner et al., 2015; Hong et al., 2016).

Behavioural Interventions to Teach Safety

Applied Behaviour Analysis (ABA) is a scientific discipline that applies techniques associated with the principles of learning to change a desired behaviour (Baer et al., 1968). A rich body of literature demonstrates the use of various behavioural interventions for increasing desirable target behaviours. For example, individuals with disabilities have acquired functional daily living skills such as: employment, self-help, house-chores, and access to the community (Gardner et al., 2015; Hong et al., 2016).

Behavioural Skills Training (BST) is a type of behavioural intervention that teaches the learner a specific target behaviour and the context within which it should occur. The intervention incorporates multiple behavioural procedures such as modelling, role-play, prompting and prompt-fading, reinforcement, and corrective feedback (Dixon et al., 2010; Wiseman et al., 2016). A number of safety skills have been taught to children with disabilities through the implementation of BST: emergency situation response, accident prevention, pedestrian crossing, first aid skills, responding to strangers and fire safety (Batu et al., 2004; Dixon et al., 2010; Harriage et al., 2016; Mechling, 2008; Miltenberger & Olsen, 1996; Wiseman et al., 2016). Safety skills have been taught within the classroom, in the natural environment, and using computer-generated environments such as VR (Wiseman et al., 2016).

Previous research reveals that the need for safety skills instruction is greater among individuals at higher risk for injury (Agran & Krupp, 2010; Ivey, 2004). Parents of children with disabilities were surveyed and indicated that safety skills are critically important for their children to acquire (Agran & Krupp, 2010; Ivey, 2004). Over 80% of 121 parents surveyed also indicated that safety skills were not being taught to their children in school (Argan & Krupp, 2010). These results suggest that the development and implementation of teaching methods for safety skills to individuals at risk of injury requires further improvement.

A review by Wright and Wolery (2011), summarized the research involving instructional interventions for street crossings with individuals with disabilities. A total of 8 studies were included. Findings demonstrated that individuals could be taught street crossings skills through classroom interventions, roadside instructions, or VR through various instructional methods (Wright & Wolery, 2011). Only a study by Goldsmith (2008) specifically evaluated BST. However, the remaining studies utilized components of BST such as modelling, rehearsal, role-play, prompting, feedback and praise. Given that it is currently unknown which instructional practices are superior to others (Wright & Wolery, 2011), a comprehensive approach such as BST may be most appropriate.

Teaching pedestrian safety skills to vulnerable children poses some safety issues. When learning this skill in the natural environment, errors can result in serious injury and this potential risk is extremely concerning. Furthermore, some children's behaviours are unpredictable (such as children who frequently run away) and too great a risk is associated with teaching the skill in the natural environment. Removing children from the natural environment to facilitate teaching is a reasonable solution. In their review of instructional street crossing interventions for individuals with disabilities, Wright and Wolery (2011) found three effective types of interventions; classroom based, roadside training, and VR.

Virtual Reality

VR is a technology that provides the user with an immersive exploration with a realistic or fictional 3-dimensional simulated environment (i.e., a virtual environment, or VE) (Saiano et al., 2015). VR systems typically consist of a powerful computer and specialized software that creates and maintains the VE. Output devices such as video displays and headphones allow the user to perceive the VE. In a VR system, the video displays are specially designed and arranged to promote an immersive experience. They may be especially large or mounted directly in front of the user's eyes and wrapped around his/her field of view. Input devices such as keyboards, mice and joysticks are needed for the user to interact with the VE. VEs refer specifically to the generated environments of the technology and create a unique platform or setting for the application of educational methods.

There are some principal features of VR that make it advantageous as a tool for intervention with the ASD population. It facilitates rigorous experimental control and the reliable manipulation of environmental variables. The natural environment consists of countless extraneous variables that pose threats to internal and external validity—VEs offer instructors control over many of these. When teaching pedestrian safety in the natural environment, the ability to control variables such as traffic volume or driving speed can be challenging. The ability to ensure the safety of participants through the use of VEs is another major benefit.

Interaction with VR in these controlled environments offers further benefits. It does not necessitate face-to-face interaction for interventions, which may be frightening for individuals with ASD (Parsons & Cobb, 2011). The user has active control over their participation (Parsons & Cobb, 2011). Scenarios can be repeated as often as necessary (Saiano et al., 2015). Learning can occur through play (Saiano et al., 2015).

Josman et al. (2008) examined whether a VE was effective at teaching children with ASD the necessary skills needed to cross a street safely and whether the skills would generalize to real-life situations. Six children ranging from 8-16 years diagnosed with ASD comprised the experimental group and were compared to grade- and age-matched, typically developing children as the control group. The VE consisted of a program operated on a desktop computer where the child's avatar was manipulated using three keys on the keyboard; allowing a subject to look left, right, and begin street crossing. Subjects were tasked with successfully crossing the street through nine stages varying in difficulty where difficulty increased as the number of cars appearing on the right and left increased and moved faster.

The researchers also used a within-subjects reversal design (ABA) to examine the effectiveness of the VE for the children from the experimental (ASD) group. In phase A, participants met with a tester three times to establish their baseline performance within the VE. They began at the first stage and progressed through to the most advanced stage they were able to complete. During intervention phase B, they progressed through the levels at their own pace until the final stage (stage 9) was completed. Once they completed the final stage, the final phase (return to phase A), consisted of completing three additional sessions. To assess the transfer of skills learned within the VE to the natural environment for the experimental group, a pedestrian safety checklist was used to measure street crossing performance on a real, yet protected sidewalk, before and after implementing the VE intervention.

Results from the group comparison revealed a significant difference between the experimental (ASD) group and control (typically developing) group for the number of VE stages completed in baseline. All six participants from the control group successfully completed all nine VE stages during a single 45-minute session, in contrast to participants in the experimental group who only completed a maximum of one to four levels in phase A. Results from the within-subjects ABA design demonstrated that all six participants improved while operating within the VE and succeeded in completing the nine levels. Five of the six participants with ASD learned to operate the VE within the first two sessions. Regarding the transfer of skills learned through the

VE intervention into real-world situations, three of the six participants showed significant improvements from pre- and post-performance scores in a protected street crossing scenario.

Goldsmith (2008) evaluated the effects of a BST intervention delivered in a partially immersive VR to teach safe street-crossing skills to 5 children with ASD ranging from ages 9-13 years. Experimenters used a nonconcurrent multiple baseline design across participants. They also employed a within-subjects repeated measures design (pre-test phase) which consisted of probing performance in a naturalistic context prior to baseline and repeated after the instructions and modelling phase of BST to evaluate the effects of training on skills in the natural environment. The VR software program ran on a desktop computer and projected the VR on a white wall where manipulation was accomplished using a joystick. The primary dependent measure was the number of steps observed associated with safe street crossing from predetermined responses: (a) stop and wait a safe distance from the curb; (b) look left and right for cars; (c) walk and continue looking; and (d) use the crosswalk. BST sessions were conducted which included the following components: Instructions, Modelling, Rehearsal, and Feedback. Pre- and post-treatment sessions occurred outside in two different restricted traffic areas.

Results demonstrated that all five participants were able to master the street crossing skills within the VE. The study found mixed findings regarding the generalizability of skills learned through the VE enhanced by BST to natural settings. Some of the participants were able to transfer the skills they had learned in the VR to real-life situations, others were not.

Two studies conducted by Saiano et al. (2015) sought to teach pedestrian safety skills to adults with ASD and specifically evaluated the learning outcomes related to using two different modalities; Natural Interfaces (e.g., Microsoft Kinect©) and a more classic gamepad-based interface (e.g., analog controller). In the first study, participants used a marker-less motion caption device (Microsoft Kinect©) to navigate in an open-source VR environment by using a specific vocabulary of gestures. Their performance was measured in terms of navigation and number of errors committed. Navigation was measured through their application which automatically recorded indicators such as average speed, path length, and displacement from the optimal path. To evaluate generality outside the VE, questionnaires designed to assess the understanding of the practiced skills were completed by the subjects themselves, their parents/legal guardians, and each subject's personal caregiver. The second study replicated the same method, but had two groups to compare the Natural Interface with the gamepad interface.

In both studies, participants learned to navigate the VE using the proper gestures or operating the gamepad. Participants did not display a significant reduction in the number of errors committed in the VE, but did improve their navigation performance. Although they did not reduce the number of errors made on the questionnaires, both parents and caregivers reported a significant improvement in their street-crossing performance, suggesting the transfer of skills learned in a VE to real-world settings. The authors also found that the gamepad was easier to use and lead to faster interaction/better performance, but the Natural Interface led to better generalization of skills to natural contexts.

Statement of the Problem

One of the most effective ways to empower individuals with ASD is to help them acquire skills that increase their independence. Pedestrian safety skills enrich their quality of life by permitting individuals to travel freely in their surrounding environment. Furthermore, these skills promote the safety of the ASD population, which is at greater risk of injury and death due to the specific characteristics associated with the disability. VR offers compelling advantages for clinical applications, including controlled and safe environments, opportunity for repeated practice, interactive and realistic environments, and more. However, despite the fact that this technology originates back to the early 1960's, relatively few studies have used VR to deliver BST to promote pedestrian safety.

The available studies of BST and VR are limited in several important ways. In order to teach a complex skill such as pedestrian safety, the literature supports "task analysis" as a behavioural based strategy that breaks down steps and links them for prompting (Odom et al., 2010). In studies to date the task analyses have all been relatively simple. Further, the importance and acceptability for society of the interventions (i.e., social validity; Schwartz & Baer, 1991; Wolf 1978) were never investigated, an important measure to understand if these interventions are practical and acceptable to stakeholders. The demonstration that VR interventions for teaching safety skills is acceptable and important for consumers is vital information for researchers and clinicians. The current study addressed these deficits by reporting procedural integrity measures and assessing the acceptability of BST and VR as a teaching strategy among parents. The purpose of this thesis was to gain a better understanding of the use of BST in a VE to teach specific task components of safe pedestrian crossing to individuals with ASD.

Method

Participants

Two families were recruited to participate in the study using an advertisement (Appendix A) that was posted on St.Amant's social media pages (e.g., Instagram, Twitter). Once the researcher was contacted by a family, the family was provided with more information about the study and answered any questions. If a family agreed to participate, they were sent the "Project and Description & Consent Form" (Appendix B). Written consent was required prior to beginning any further involvement with the study. The current study received ethical approval from the University of Manitoba's Research Ethics Board and was conducted as approved.

Each child participant had been diagnosed with ASD, and it was determined that teaching pedestrian safety skills was an appropriate goal after completing a questionnaire with the parents (Appendix C). Prerequisite skills for children included: compliance with instructions (e.g., "watch this video" or "now you try crossing the street"); and sufficient motor skills to engage with a virtual simulation on a computer by interacting with it using a keyboard and mouse. The questionnaire (Appendix C) was used to gather information about age, gender, diagnosis, any special needs or requirements, current educational placement (e.g., regular education, special education), whether the child received any previous pedestrian safety training, their responsiveness to thorough instructions, child's previous experience with technology, and whether the child had any previous history of potentially dangerous roadside behaviours (e.g., running away). This questionnaire also included questions about known reinforcing items, activities, or food items for the participant. Parents of the children were also asked to participate in the study by facilitating sessions with their children. For Participant 1 (P1), the father facilitated sessions, for Participant 2 (P2), it was the mother. Neither parent reported having any prior experience with BST, implementing prompting procedures, or implementing trial-based teaching. However, we did not explicitly solicit this information.

P1 is male and was 13 years old at the time the primary experimenter began initial contact with the family. He is diagnosed with ASD and Obsessive Compulsive Disorder (OCD). At the time of initial contact, P1 was attending a public school in grade 7, and was receiving 1:1 support from an educational assistant. He had never received any previous training or education relating to street safety skills. When asked if he had a history of dangerous roadside behaviours, the family described how he had run away down the street when younger, but stated that he had not engaged in this behaviour in about 9-10 years. When asked about his level of experience using technology, the parents described how he was very comfortable using computers and had used a laptop since he was two years old. In terms of reinforcers, the family noted that access to a tablet was the most powerful reinforcer. They also described how he has free access to this tablet and did not want to restrict his usage as this would often result in challenging behaviours. The family identified certain DVD’s and books as reinforcers but described how he would not be motivated enough to earn access to them by completing tasks. They noted how P1 gets angry when he is praised, and that edibles were not effective as he is tube fed.

P2 is male, he was 15 years old at the time the primary experimenter began initial contact with the family, and he is diagnosed with ASD. At the time of initial contact, P2 was attending a public school in grade 9. Parents stated that he had an adapted learning plan in school, and that he was not funded to receive any additional support from an educational assistant. When asked if he had ever received any previous training or education relating to street safety skills, parents stated that he had been practicing with a worker to take public transportation (bus) to a local shopping mall. Parents also described how they had taken bike rides together to practice crossing certain intersections. Both bike rides and practice trips taking the bus were done four times each with him. When asked if he had a history of dangerous roadside behaviours, the family described how when he was very young (i.e., pre-school/toddler), he would run out towards the street and onto the road. When asked about his level of experience using technology, the parents described his experience as very familiar. They stated that he’d been using an iPad since the age of five, that he currently had his own cell phone, was enrolled in a computer class at school, and was familiar using programs such as Microsoft

Word, Excel, PowerPoint, Teams, Discord, and YouTube. In terms of reinforcers, the family identified a variety of food items (e.g., chocolate, candy, potato chips), entertainment (e.g., YouTube, movies, comic books), and noted that he responds very well to praise. The family described him as a "people pleaser" because he is very compliant with instructions, especially when receiving praise from adults.

Setting and Materials

Sessions were conducted in the family's respective homes and were facilitated by a designated parent. The families ensured that a quiet space was available for all sessions. Families were provided with the following required materials: a laptop, a mouse, a token board, an iPod, and a tripod. Installed on the laptop was the software that ran the simulation. Sessions were video recorded using the iPod which was held in place with the tripod. Sessions were also recorded using a screen recording software called Xbox Game Bar that is automatically installed using Windows. Families were asked to provide reinforcers (e.g., small edible treats) and an appropriate space to run sessions (e.g., quiet area with seating for 2, and minimal distractions).

The primary experimenter provided ongoing training and feedback to parents throughout the study, all done virtually through phone or video meetings. Parents were systematically trained on various aspects of the experiment as outlined in Appendix D. Parents were initially introduced to the purpose of the project, how to use specific equipment and software, and general requirements for setting up a session. Parents then received training for each respective phase of the experiment as the child progressed through them (e.g., Pre-Baseline, Baseline, and Intervention). For each phase, the parents referenced the appropriate task analysis document (Appendix E, F, G) and reviewed it with the primary experimenter to ask questions and clarify how to implement the procedures. Parents were also given an opportunity to implement a practice session with a confederate prior to conducting sessions with their child. The primary experimenter monitored caregivers' adherence to the outlined procedures by examining the data and the recordings. Regular virtual meetings between sessions allowed opportunities for the primary experimenter to provide any necessary feedback and give caregivers the chance to ask questions.

Participants interacted with a pedestrian safety training VR program developed by BehaviorMe©. The VE setting titled "HeadQuarters" was designed as a tutorial for navigation. It was utilized to expose and teach participants the computer controls in the pre-baseline phase. This scene is an indoor environment with two rooms that include familiar household objects such as chairs, couches, tables, bookshelves, etc. The tutorial has built in auditory and visual prompts to guide the user to "look right at the sofa", "look left at the flowerpot", "look up at the ceiling", "look down at the rug", "press W to move forward", "press S to move backward", "press A to move left", and "press D to move right" to navigate through the virtual environment.

The virtual setting used for the baseline and intervention phases for P1 was "Crosswalk," a simulation of crossing a two-lane, two-way residential street at a crosswalk. P2 was exposed to two additional settings; "Stop Sign", and "Street Lights". The stop sign setting is a four-way stop sign intersection, and the street lights setting is a four-way intersection with traffic lights. In all settings, the vehicles behaved the same; they did not react to the pedestrian's behaviour, they would continue toward them until the point of contact and then the simulation trial ended.

In all settings, the player viewpoint in the VE was operated via the keyboard and mouse and the VE was displayed on the laptop screen. The simulation has built-in settings that can be changed. Some of the key settings include the amount of traffic, the presence of verbal prompts, and visual prompts such as guide arrows and a glowing portal indicating the target end goal.

Families were instructed to keep the settings consistent. The children did occasionally make changes to these settings. For example, they occasionally changed the environment from day to night, or changed the size of their avatar to be short or tall. At the beginning of a trial, the participants were instructed to click a large green button that read “START TRIAL” which marked the start of the trial within the VE. The participant then saw the VE’s depicted in Figure 1, Figure 2, and Figure 3, where the goal was to cross the street safely without getting hit by any of the moving cars. If the participant did not complete this objective, a white screen appeared with the message “try again”. If the participant crossed the street successfully, the same white screen appeared reading “Hooray! you crossed the street safely. Nice job!”.

Experimental Design and Measures

An AB design was used for P1, where he was exposed to baseline then intervention, using the crosswalk setting only. A multiple baseline across virtual settings (e.g., crosswalk, stop sign, and street lights) was employed for P2. Tables 1 and 2 summarize the data collected in each phase and setting for participants 1 and 2, respectively.

The independent variable was a BST intervention to teach specific behaviours that promote safe street crossing. The primary dependent measure was the percentage of task analysis components performed correctly on each trial. The six component behaviours were: (a) stop/wait at the curb, (b) look left, (c) look right, (d) begin walking, (e) continue walking and glance left, and (f) continue walking and glance right. Appendix H describes these components further, along with the prompts that were to be used by parents at each step as part of the BST intervention. Appendix I indicates how each step was scored by the primary experimenter. Although P2 was exposed to three different street crossing settings, the same task analysis was used for all settings. The first trial of each session during intervention was an unprompted probe trial.

A secondary measure was the amount of time required for the participant to cross the street. The primary experimenter used the screen recordings to track this data. This secondary measure was important because the participant could correctly respond to all occasions of discriminations but take an inappropriately long amount of time to cross the street. This type of behaviour would be problematic in real-life situations. For example, if a car stops at a crosswalk for a pedestrian, some confusion will occur if the pedestrian does not initiate crossing for a prolonged period.

Social validity questionnaires (Appendix J, K, L) were used to assess the acceptability of VR combined with BST as a method to teach pedestrian safety. The questionnaires were distributed to the parents via email and returned to the primary experimenter. Questions prompted respondents to rate their satisfaction regarding the aim of the study, the appropriateness of the procedure, and the importance of any observed change in target behaviours.

Procedure

Pre-Baseline. Prior to baseline, the parents followed the Task Analysis for Pre-Baseline (Appendix E) to teach their child how to move in all directions and orient their gaze in the virtual surroundings of the “Headquarters” simulation. Token training also occurred for P2 in this phase, as he earned tokens for engaging in behaviours prompted by the simulation and by the parent to learn the movements. Once participants had mastered the controls of the simulation, they proceeded to baseline trials. Mastery required the child to perform the actions of the tutorial using only the prompts from the simulation, without any additional parental prompts.

Discrete Trials Procedure. In both baseline and intervention phases, discrete trials were implemented during each session. The parent and their child were both seated at a table where the simulation was initiated on the computer. A trial began once the participant clicked the “start” button in the VE simulation and ended once they had either crossed the street safely, failed to cross it safely, or if 2 minutes has elapsed (although the 2 minute time-limit criteria was never reached). Parents were asked to collect data for each discrete trial using the datasheet (Appendix M). For each trial the caregiver was asked to record the following: if any prompting was provided (in baseline there was to be no prompting), if the participant crossed safely, if the 2-minute time limit was reached, and if mastery was achieved. The mastery criterion required the child to cross the street having successfully and independently completed the 6 steps from the task analysis across 3 successive trials. The purpose of these data was not to be used as primary data for analysis. The data was only to help parents maintain a higher degree of procedural reliability, and for the primary experimenter to reference while providing feedback after a session. No data was collected from P1, whereas P2 sent data for 2 baseline sessions, and all 10 intervention sessions.

Tokens and backup reinforcers were not used for P1. During initial contact with the family, access to P1’s tablet was thought to be the only reinforcer motivating enough to encourage engagement. However, P1 had free access to his tablet, and parents were not willing to restrict his access. The family expressed that they wanted to implement sessions without using any tokens or additional reinforcers. The primary experimenter revisited this conversation with the family after the first intervention session, as parents often had to encourage P1 to continue to engage with the simulation during sessions. Once again, the family thought it was best to continue sessions without tokens or additional reinforcement.

Although token training occurred for P2 during pre-baseline, tokens were not used during the baseline or intervention phases. Instead, reinforcers (e.g., candy) were initially delivered after two successful trials. As P2 progressed through the baseline, his engagement and interest with the program were high. The parent shared that additional reinforcement wasn't critical to maintain his engagement. Starting at the fourth baseline session, P2 began receiving a reinforcer at the end of a session rather than after every two successful trials.

Baseline. Baseline data on participants' ability to cross the street safely and engage in behaviours from the task analysis was collected for both participants prior to BST intervention until stable performance was observed. Parents followed the Task Analysis for Baseline (Appendix F) for each baseline session. Parents were asked to collect data during live sessions in their home. Parents also used screen recording software to record the screen of their computer during sessions. These recordings captured the behaviours of participants within the simulation and were used to score their performance based on the task analysis. Prior to each session, parents were asked to tell their child the following: "This looks like a game, but in this program, you are supposed to try to cross the street safely. Try to walk to the other side without getting hit by a car." For subsequent trials, parents were instructed to simply tell their child to "Try again, hit the "start" button when you're ready." During baseline, parents were instructed not to provide any additional instructions or prompts related to assistance to crossing safely, not to provide feedback other than a neutral statement such as "thank you." Parents were instructed to provide any necessary prompts if their child had difficulty with the controls. For example, P1 frequently used a single hand to control the mouse and keyboard. The parent was encouraged to prompt P1 to use both hands, one for the keyboard and one for the mouse.

BST Intervention. During the intervention phase, each discrete trial was identical to the baseline, except that a BST package was applied whereby parents incorporated verbal, gestural, and modelling prompts, and feedback for specific trials. Parents were instructed to deliver verbal prompts, gestural prompts, and feedback, at each step of the task analysis (unless otherwise specified), as needed.

Parents were instructed to implement the following prompting procedure (Appendix G): The first trial during all intervention sessions were unprompted. Subsequent trials remained unprompted unless the child made an error (e.g., did not follow all the steps outlined in the task analysis). Errors from a previous trial resulted in parents providing prompting for the current trial. If errors continued, subsequent trials remained prompted. If no errors occurred, subsequent trials were performed independently by the child (e.g., without prompts by the parent).

Parents received training on how to provide each specific type of prompt. Feedback consisted of descriptive verbal praise for correct responses (e.g., “Good watching,” or “Good waiting.”) and corrective feedback for incorrect responses. A neutral “no” statement followed by a repetition of the prompt was the recommended procedure for administering corrective feedback for incorrect responses (e.g., “no, look left”). Immediate feedback was also provided by the software where a session was automatically terminated for failed attempts (e.g., getting hit by a car).

Gestural prompts involved pointing to indicate to the child desired behaviours such as looking left or right and walking forward. Raising a hand was used to prompt them to stop and wait. Parents were instructed to use verbal prompts to compliment gestural prompts and to describe to their child the desired behaviours such as “look left” and “wait for cars to pass”.

Modelling was only used once, during the second intervention session for P1. This consisted of showing him a recorded video of a safe street crossing attempt performed in the simulation prior to his first trial of this session. The modelling video was only showed once to P1 because repeated showings of the video would have been too disruptive during sessions, and P1 did not appear interested in watching the video.

At the end of the intervention phase, questionnaires were administered to child participants (Appendix K) and parents (Appendix J, L).

Tables 1 and 2 summarize the dates of when sessions were run for each participant, including the number of trials for the session, which phase the session was currently in, and the session scores for procedural reliability.

Procedural Reliability. In order to evaluate the accuracy with which the procedures were being implemented as intended, the primary experimenter and a secondary observer watched the video recordings and used checklists (Appendix N, O, P) to gauge if the parents were engaging in the intended behaviours for all sessions.

Interobserver Agreement. Data from the primary experimenter was compared to data from a second trained observer who conducted inter-rater reliability observations on all sessions for the baseline and intervention phases using the same scoring instructions (Appendix I). Data from the 6 steps of the task analysis were evaluated. Task steps were considered an agreement if both the experimenter and observer had recorded the same response on whether or not a participant emitted a correct or incorrect response. Discrepancies between observers were counted as disagreements. Interobserver agreement for each session was calculated by dividing the agreements by agreements plus disagreements and multiplied by 100. Overall, the experimenter and observer agreed on 96.1% of data points for P1 and 98.5% for P2.

Data Analysis. Analysis of the data involved visual inspection of the graphed data in order to detect key features such as stable responding and trends. Implementation of the multiple-baseline design across settings (P2) assisted in detecting any effects of the intervention as described by Kazdin (2011). This was achieved by presenting the intervention to P2 in different settings at different points in time. Inference of an intervention effect was made if performance changed only in settings where the intervention was applied, yet remained stable in settings still in baseline. Greater internal validity would be shown if scores improved at the onset of the intervention phase, and if baseline data had little overlap with data obtained during intervention (i.e. if the lowest intervention data points were higher than the highest baseline data points).

Results

Participant 1

Figure 4 displays sessional means of the percentages of task components completed correctly on each trial for P1. Table 1 reports the numbers of trials that P1 completed in each session and phase. During baseline, his average session scores ranged between 30–70.8% across 21 trials in this phase. During intervention, his overall session scores increased to 50–100% across 12 trials in this phase. Notably, his scores for the last three sessions in baseline were stable, ranging only between 44–50%, and his scores increased immediately to 89–100% during the first three intervention sessions, scores that were never obtained during the baseline phase. His scores were not maintained in subsequent sessions and dropped below 60% for the final two intervention sessions.

During the first baseline session, P1 failed to cross the street on all five trials. During the second baseline session, he failed to cross the street on the second trial only. For the remainder of the study, P1 crossed the street on all subsequent trials.

Figure 5 displays proportions of trials per session in which P1 performed a given task component correctly. For example, if the "walk across" component were performed correctly on 3 out of 4 trials in session 2, Figure 5 would present a data point of 75% for that component in that session. During baseline, P1’s scores were below 33% for all sessions except one for “glance left” (range 0–100%) and were below 67% for all sessions for “glance right” (range 0–67%). His scores for “stop at the curb” were 100% for all baseline sessions except for the first (range 60%–100). Meanwhile, his performance for all other behaviours was highly variable throughout the baseline phase. Once the intervention was applied, P1’s performance increased for all behaviours for the first three intervention sessions, achieving 100% for all behaviours in sessions 8 and 9. In sessions 10 and 11, P1’s performance declined for the “look left”, “look right”, “walk across”, and “glance right” behaviours, and the “stop at curb” and “glance left” behaviours were maintained at 100%.

Participant 2

Figure 6 displays sessional means of the percentages of task components completed correctly on each trial for P2. Table 2 reports the numbers of trials that P2 completed in each session, phase, and setting. In the street lights setting, he scored below 50% during baseline for all sessions except session 2 (range 17–63%). His scores increased to above 80% for all sessions except two during intervention (range 66.7–100%). In the crosswalk setting, his baseline scores were consistently between 66.7–77.8%. During intervention, his scores increased to above 80%

except for session 15 (range 77.8–100%). In the stop sign setting, baseline performance ranged between 50–67%, and increased above 71% during intervention (range 71–100%).

During the entire study, P2 only failed to cross the street once during the crosswalk setting, and made it across during all trials for the street lights setting. For the stop sign setting, he failed to cross the street a total of 14 times.

Figure 7 displays proportions of trials per session in which P2 performed a given task component correctly. In the street lights setting (Figure 7, top graph), P2 consistently "stopped at the curb" 100% of the time during all baseline sessions and scored lower for all other behaviours. The intervention was initially applied to only target his "glance left" and "glance right" behaviours for the street lights setting only. "Glance left" and "glance right" that had not been observed in baseline increased to 33% during the first intervention session and remained above 67% for the remainder of the intervention phase (with the exception of session 11; range 0–100%). Meanwhile, his "glance left" and "glance right" remained below 33% in the crosswalk setting and at 0% in the stop sign setting, which both remained in baseline until sessions 11 and 12, respectively. During sessions 13, 14, and 15, he maintained perfect (i.e., 100%) scores for all behaviours in the street lights setting. Session 16 was a secondary phase of the intervention where all behaviours were targeted. In this session, P2 scored 75% for three of the behaviours (look right, walk across, and glance left), and 100% for the other three behaviours (stop at the curb, look left, and glance right).

In the crosswalk setting (Figure 7, middle graph), P2's scores were 100% for eight out of nine baseline sessions for all behaviours (stop at curb, look left, look right, walk across) except for "glance left" and "glance right". His scores for glancing behaviours were consistently below 40% in the baseline phase. The intervention was then applied to target the glancing behaviours only in the crosswalk setting in session 11. During intervention, his scores improved immediately to 80% for both glancing behaviours and remained above 60% for all sessions except for one (session 15). Meanwhile, P2's glancing scores remained at 0% in the stop sign setting during session 11, which was still in baseline. His scores for all other behaviours remained very high throughout the intervention phase in the crosswalk setting. During session 16 (the secondary intervention phase with all behaviours targeted), he scored 100% for all behaviours.

In the stop sign setting (Figure 7, bottom graph), P2's baseline scores for glancing behaviours were consistently 0% except for session 2, and his scores for "walk across" were all under 67%. The baseline scores for all other behaviours were consistently 100% except for session 2. P2's parent began delivering the intervention during session 12, although this was not the primary researcher's intent. In the first intervention session, "glance right" and "glance left" behaviours increased to 29% and 43% respectively, and both behaviours remained above 60% for all other sessions. "Walk across" steadily increased from 57–100% throughout the intervention phase. All other behaviours (stop at curb, look left, and look right) remained at 100% except for one session in the intervention phase. During session 16 (secondary intervention phase), P2 scored 100% for all behaviours except for "glance left".

Figure 8 compares P2's performance for prompted versus unprompted trials specifically for glancing behaviours across all settings. During baseline, all trials were unprompted and his scores for glancing behaviours remained below 10% across sessions. Prompts were added during intervention, beginning at session 7. During intervention, his performance on prompted trials was consistently above 67%, except for session 12. His scores for unprompted trials during intervention steadily increased ranging from 0–100%.

Procedural Reliability

Since parents implemented the sessions with their child, I evaluated the degree with which they implemented them accurately. Data was obtained by scoring whether the parents completed specific elements of each session during each phase by using checklists (Appendix L, M, N). Table 1 shows these data for P1, where parents' procedural reliability scores ranged from 58.3% in the pre-baseline session to 100% during three of the intervention sessions and averaged 86.7%. During baseline, P1's father lost procedural reliability points for providing prompts (when trials should have been unprompted) for 10 of the 21 trials and provided corrective feedback (when no feedback should have been given) for 4 of them.

Table 2 shows how P2's procedural reliability averaged 97.9%, ranging from 75% in the pre-baseline session, to 100% during one baseline session and four intervention sessions. During the first intervention session, P2 was supposed to receive prompts only for glancing behaviours in the street lights setting. P2's mother provided prompts during two of the five trials in this setting to "look left" and "look right" prior to crossing the street. His scores for "look left" increased to 100% for the remainder of the study after these prompts and remained at least above 50% for "look right" (see Figure 7).

Social Validity

Parents that facilitated the research sessions and their children who engaged with the simulations were asked to complete questionnaires (see Appendix J, K, L). Table 5 shows the average scores from the respondents of these questionnaires (P1's father and P2's mother). The Caregivers Satisfaction Questionnaire (Appendix J) prompted the parents to give feedback on questions related to goals of the study, the methods used, and their interactions with the primary researcher by using a five-point Likert scale. In the goals and the methods section, respondents scores ranged from 4 (agree) to 5 (strongly agree). In the personnel section, both respondents scores were 5 (strongly agree). The Caregivers Child Street-Crossing Behaviours Questionnaire (Appendix L) prompted parents to evaluate their child's current behaviours related to street safety. Respondents' average scores ranged from 3.5 (occasionally - often) to 4.5 (often – always). The children who participated in the study also completed a Satisfaction Questionnaire (Appendix K) and were prompted to answer "yes" or "no" questions. Both participants felt that the program was easy to use. P1 did not find the simulation to be fun, whereas P2 did. Both participants did not feel they would want to use the simulation again, and both participants felt they would be able to cross the street safely in real life.

Discussion

The purpose of this study was to gain a better understanding of the use of BST in a VE to teach six specific pedestrian behaviours for safe street crossing to children with ASD. The original intent of the current study was that sessions be facilitated by the primary experimenter on a one-to-one basis with participants, but restrictions imposed by the Covid-19 pandemic suspended in-person research activities at the onset of data collection. Therefore, the study methods were adapted, and procedures such as the prompting sequence were simplified to examine remotely delivered instruction and training provided to parents to teach their children with ASD safe street crossing with BST in a VE. Across both participants, and across settings for P2, an immediate improvement in the proportion of trials performed correctly was demonstrated with the introduction of intervention compared to baseline performance and generally maintained. The results of this study provide supporting evidence in the application of BST in a VE to teach pedestrian safety skills to children with ASD and can be effectively implemented by a remotely trained parent.

The intended experimental design was a multiple baseline across participants in the crosswalk VE setting. However, P2 crossed the street during all his attempts in the first baseline session and achieved above 90% for all target behaviours except for glancing left and right, leaving little room for improvement. However, a successful crossing does not necessarily mean a safe crossing. An individual could cross the street successfully without looking around their surroundings, but doing so would be dangerous. Since P2's baseline scores were so high and an evaluation of performance simply based on his ability to cross the street would have been too rudimentary, I implemented a multiple baseline across settings (crosswalk, stop sign, street lights) for him. Therefore, it was no longer possible to employ a multiple baseline across participants, as P1 and P2 were not being exposed to the same VE's any longer.

After the two settings (stop sign and street lights) were added to employ a multiple-baseline-across-settings experimental design, P2 continued to successfully cross the street even in the new settings, but consistently failed to "glance left" and "glance right" as he crossed the street in all settings. His performance in the street lights setting was also poor during baseline for the "look left" and "look right" behaviours. I first targeted P2's "glance left" and "glance right" behaviours for intervention in the street lights setting only. P2's glancing scores in this setting improved for the remainder of the study, while his glancing scores remained low during baseline phases of the other two settings. This effect was demonstrated again when the intervention was added to glancing behaviours for the crosswalk setting during session 11. P2's glancing scores increased for the crosswalk setting but remained at 0% for the stop sign setting, which was still in baseline. Finally, P2's glancing scores increased in the stop sign setting in session 12 when intervention was added for these behaviours to this setting. This replicated effect provides evidence to support the intervention was responsible for the change in glancing behaviours because his glancing performances improved in the setting(s) receiving the intervention only.

P2's average baseline scores were lowest in the street lights setting, likely due to a unique characteristic of the setting. In this setting only, P2 could rely on the visual cue of the street light indicator showing either a hand when it was not appropriate to cross, or a person walking when it was appropriate. By relying on this visual cue, he did not need to look both ways to assess oncoming traffic to determine when it was safe to cross. His scores reflected this as he scored much lower for the "look left" and "look right" behaviours in the street lights setting when compared to the other settings. As mentioned, P2 was able to cross successfully during all his attempts in the street lights setting. By only relying on the traffic light indicators to cross the street, P2 was less aware of his surroundings (e.g., failing to look left and right before leaving the curb) before crossing. This strategy is successful as long as the traffic abides by the rules of the road, and, in a simulation, this is indeed the case. The same cannot be said in the real world, and looking both ways before crossing, in addition to relying on street light indicators increases safety.

The effectiveness of the intervention is further supported by P2's scores for unprompted and prompted trials for glancing behaviours (see Figure 8). During prompted trials, and except for session 12, his scores were consistently above 67%. This result is to be expected, as an effective prompt should lead to the desired behaviour if the participant is compliant. More interestingly, P2's performance for unprompted behaviours during intervention showed a steady increase. Although the prompts that P2 received followed a simplified sequence, these results would suggest that he was learning, as he was increasingly able to perform glancing behaviours independent of any prompting.

Despite his limited participation, P1's results demonstrated that the BST was temporarily effective at improving his performance. Overall, his scores during baseline were between 30% - 71%, and in the first three intervention sessions, they increased to 89%, 100%, and 100%, before dropping off to 50% for the final two intervention sessions (see Figure 4). Some of the results for P1 are further discussed in the limitations section.

The results from the current study are consistent with previous literature that demonstrate that safety skills can be taught to individuals with ASD using a BST approach (Batu et al., 2004; Dixon et al., 2010; Harriage et al., 2016; Mechling, 2008; Miltenberger & Olsen, 1996; Wiseman et al., 2016). Findings are also consistent with other research (Saiano et al., 2015; Josman et al., 2008; Goldsmith, 2008), showing that teaching within a VE is an appropriate environment for individuals with ASD to learn pedestrian safety skills. Additionally, this study is consistent with other studies that surveyed parents about the importance of teaching safety skills to their children with ASD (Agran & Krupp, 2010; Ivey, 2004). The current study also received positive feedback through questionnaires answered by parent and child participants, suggesting that BST and VR are viewed as acceptable methods towards teaching pedestrian safety.

Several strengths of the current study distinguish it from other similar research. The primary dependent measure evaluated the participants ability to cross the street safely by scoring them based on six predetermined behaviours from a task analysis (Appendix H). To date, this task analysis is the most rigorous evaluation of behaviours associated with safe street crossing. A study by Goldsmith (2008) used a similar task analysis, but it was only comprised of four steps; (a) stop and wait a safe distance from the curb; (b) look left and right for cars; (c) walk and continue looking; and (d) use the crosswalk. The six task analysis behaviours were helpful in determining which specific behaviours to prompt a learner when teaching the skill of crossing the street. Also, this same task analysis was effective at teaching P2 to cross the street safely in three different environments, suggesting that learners may be able to generalize their skills to various street settings.

Another unique characteristic of the study is that the procedure was delivered entirely remotely with the assistance of families. The is the first study to demonstrate that a secondary instructor, such as a parent or a teacher, can implement basic BST components through minimal training to teach pedestrian safety in a VE. Other similar research such as Goldsmith (2008), Josman et al. (2008), and Saiano et al., 2015, were led by experienced researchers who met directly with participants to teach pedestrian safety skills using VR. The current study was able to employ similar teaching strategies to teach pedestrian safety skills, by meeting with the families exclusively through virtual meetings (e.g., video meetings and phone calls).

A final strength of the study includes the evaluation of the social validity of the procedures and the VE by both parents and child participants. This helps provide insight towards the acceptability of using VE and BST to teach pedestrian safety skills to individuals with ASD.

Limitations

It is important to recognize several potential limitations of the results of the study, some of which relate specifically to P1. First, the experimental design that was employed with P1 was a simple A-B design. This was partly due to P1's limited interest in the study, and partly due to switching to a multiple baseline design across settings for P2 (described previously). The A-B design makes it difficult to analyze the effect of the intervention without a point of control such as a reversal back to baseline or a comparison to another participant such as in a multiple baseline design.

Another limitation for P1 was his overall engagement and willingness to interact with the simulation. Parents struggled to keep P1 engaged with the simulation as he frequently refused to participate, or only completed a small number of trials per session (see Table 1). The use of tokens and reinforcers was intended to be used in situations where engagement might be an issue. However, since no suitable reinforcers could be identified and the family was not willing to make his only known reinforcer, his tablet, accessible contingent on engagement with the study, it was decided that the family would try their best to encourage him to participate verbally, but terminate sessions when he expressed a desire to stop.

In addition to the absence of a reinforcer, P1 was less receptive to prompts from his father during sessions, as compliance was a challenge. Given that the father was attempting to prevent or manage challenging behaviours, I suspect that this may have contributed to poorer procedural reliability to the intended methods on his part. This was evident in baseline as the father provided prompting and corrective feedback to P1 despite having received training and been given reminders not to do so during this phase.

Another limitation for P1 was how he operated his avatar with the hardware. P1 occasionally used one hand to look around in the VE with the mouse, and then used that same hand to move around with the keyboard. This made it especially challenging for him to “glance left” and “glance right” as he moved across the street, as he would need to stop moving the avatar to take his hand off the keyboard and look around with the mouse. The father was instructed to prompt the use of both hands despite compliance being a challenge.

A general limitation of the study was that the primary experimenter was not present during live sessions and could only provide assistance or corrective feedback to the parents after sessions were over. This circumstance contributed to several procedural errors or difficulties.

One issue was that it limited the experimenter's control over session scheduling. Tables 1 and 2 show that sessions occurred somewhat irregularly for both participants, and sometimes at intervals of several weeks.

For P2, data for session 3 were lost due to equipment difficulties. During intervention, P2's mother provided prompting at incorrect times. Three program settings were also altered by the participants between trials that were intended to remain consistent throughout the study. While the manipulation of two of these settings likely have little impact on their performance, it is an additional variable that must be mentioned. These two settings were changing the VE to look like daytime to nighttime, and changing the height of the avatar from tall to short. The third setting that was changed was adding or removing "bumpers". In the simulation, having bumpers activated provided an invisible barrier that did not allow participants to walk off the crosswalk. When the bumpers were not activated, a trial was automatically failed if the avatar stepped off the crosswalk. The intended setting was to keep bumpers on, as the glancing behaviours often caused some left to right movement if the participants were continuing to walk while glancing. Turning off the bumpers did have a direct impact on outcomes of certain trials, P2 failed 2 trials in baseline, and 6 trials during intervention, and P1 failed 4 trials during the first baseline session.

A final limitation of the study is the lack of a generalization component. Although it appears as though P2, and to a lesser extent P1, did learn some pedestrian safety skills in the VE, a question remains whether any of these skills translate to real world situations.

In terms of future research, it would be useful to extend the current findings by evaluating the extent with which learned skills in a VE transfer to more realistic environments. Such findings could provide insight for software or hardware developers in order to design products that provide experiences that more closely resemble reality.

Another area for future research is developing methods that promote the accurate implementation of an intervention where a secondary party is remotely trained to facilitate sessions. Although the current study trained parents to facilitate sessions, and procedural reliability was quite high overall, effective teaching is most likely to occur when the direct instructors follow all the specified procedures.

Perhaps the most promising area for future research is on how to make the VE itself do the teaching. A VE has an endless possibility of variables for a programmer to manipulate, and much might be learned about how these variables influence both the consumers experience and rate of learning. For example, the program might provide within-stimulus prompts (e.g., environmental features could flash or change in size) dependent upon the input that the student provides. These prompts could be algorithmically faded as the learner achieves greater success.

Conclusion

The results from the current study add to our body of knowledge on how to implement BST in VEs to promote pedestrian safety skills. This information has important implications given the potential real-world benefits of using virtual software to teach pedestrian safety skills to individuals with ASD. The current study demonstrated that BST and can be implemented with a high degree of procedural reliability by remotely trained secondary teachers in a VE. Further, that the task analysis used was effective in teaching safe street crossing behaviours in three virtual environments (e.g., crosswalk, stop sign, street lights).

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Table 1. Data Summary for Participant 1

Session	Date	Number of Trials	Procedural Reliability
Pre-Baseline	23-Jul-21		58.3%
1 - Baseline	12-Aug-21	5	85.0%
2	6-Sep-21	4	68.8%
3	18-Sep-21	4	87.5%
4	20-Sep-21	3	91.7%
5	3-Oct-21	3	66.7%
6	10-Oct-21	2	75.0%
7 - Intervention	14-Nov-21	3	83.3%
8	28-Nov-21	1	100.0%
9	13-Dec-21	3	100.0%
10	16-Dec-21	2	100.0%
11	12-Jan-22	2	87.5%
Average		3	86.7%

Table 2. Data Summary for Participant 2

Session	Date	Number of Trials	Number of trials - Crosswalk	Number of trials - stop sign	Number of trials - traffic lights	Procedural Reliability
Pre-Baseline	4-Aug-21	-	-	-	-	75.0%
1 - Baseline	24-Aug-21	20	20	0	0	100.0%
2	8-Sep-21	11	3	3	5	96.4%
3	27-Sep-21	Data not available	-	-	-	-
4	2-Nov-21	15	6	5	4	100.0%
5	16-Nov-21	14	6	3	5	100.0%
6	21-Nov-21	12	5	4	3	100.0%
7 - Intervention	14-Dec-22	11	3	3	5	94.5%
8	9-Jan-22	12	3	3	6	93.3%
9	18-Jan-22	12	3	3	6	98.3%
10	27-Jan-22	11	3	3	5	98.2%
11	6-Feb-22	12	5	3	4	95.0%
12	15-Feb-22	13	3	7	3	100.0%
13	8-Mar-22	15	3	8	4	98.7%
14	17-Mar-22	11	3	5	3	96.4%
15	24-Mar-22	12	3	5	4	98.3%
16	18-May-22	13	4	5	4	95.4%
Averages		13	5	4	4	97.9%

Table 3. Questionnaires Answered by Parents

Satisfaction Questionnaire - Caregivers

GOALS	P1	P2
I think it is important to evaluate the use of computer simulations as a teaching tool.	5	4
I think it is important for my child to learn how to cross the street safely and independently.	5	5
I understood the goals of the research.	5	4
I have observed a positive behaviour change in my child's ability to cross the street safely	4	5
METHODS		
The procedures used to train me, such as virtual meetings, were easy to understand.	5	3
The technology used in this project, such as the simulation, recording devices, and data sharing software, were easy to use.	5	3
The procedures used, such as virtual simulations and behaviour skills training, were acceptable.	5	5
The procedures used required an acceptable amount of time and effort.	5	4
PERSONEL		
I am satisfied with the personnel that conducted the research.	5	5

1 = Strongly Disagree
2 = Disagree
3 = Neither Agree or Disagree
4 = Agree
5 = Strongly Agree

Child Street-Crossing Behaviours Questionnaire - Caregivers

	P1	P2
Does your child identify where to cross the street when he/she is outside in the streets?	3	4
Does your child wait at the curb when it is not safe to cross?	4	5
Does your child look left and right for oncoming traffic while waiting at the curb?	4	5
Does your child identify when it is safe to cross the street?	4	4
Does your child cross the street safely by themselves?	4	4

1 = Never
2 = Rarely
3 = Occasionally
4 = Often
5 = Always

Figure 1. Screen shot of the “crosswalk” simulation. (*BehaviorMe©, 2019).*

Figure 2. Screen shot of the "street lights" simulation. (*BehaviorMe*©*, 2019).*

Figure 3. Screen shot of the “stop sign” simulation. (*BehaviorMe©, 2019.*

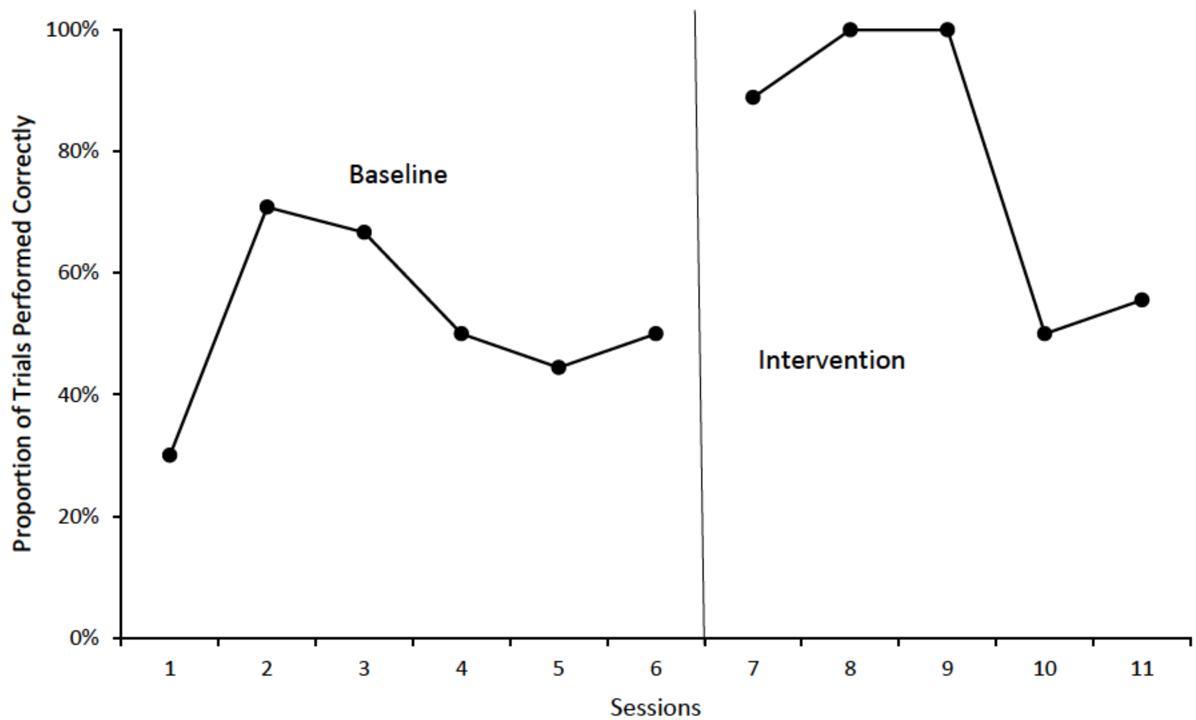

Figure 4. Participant 1's sessional means of the percentages of task components completed correctly on each trial.

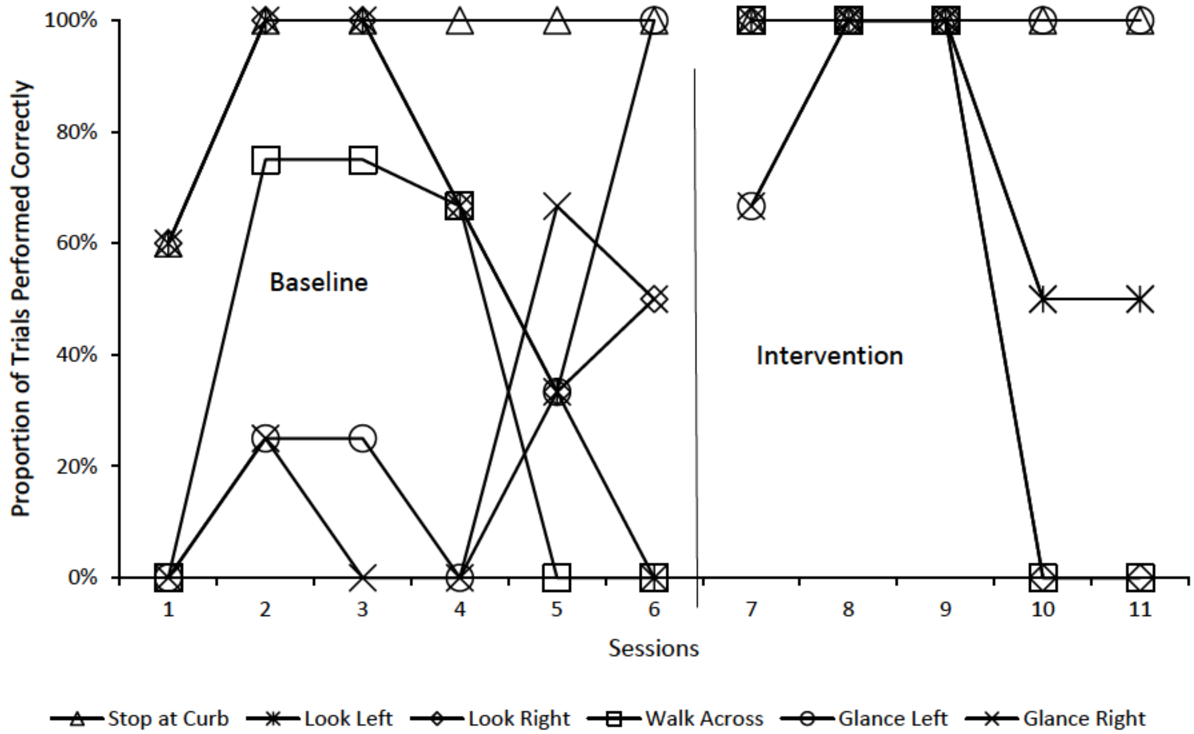

Figure 5. Participant 1's proportions of trials per session in which a given task component was performed correctly.

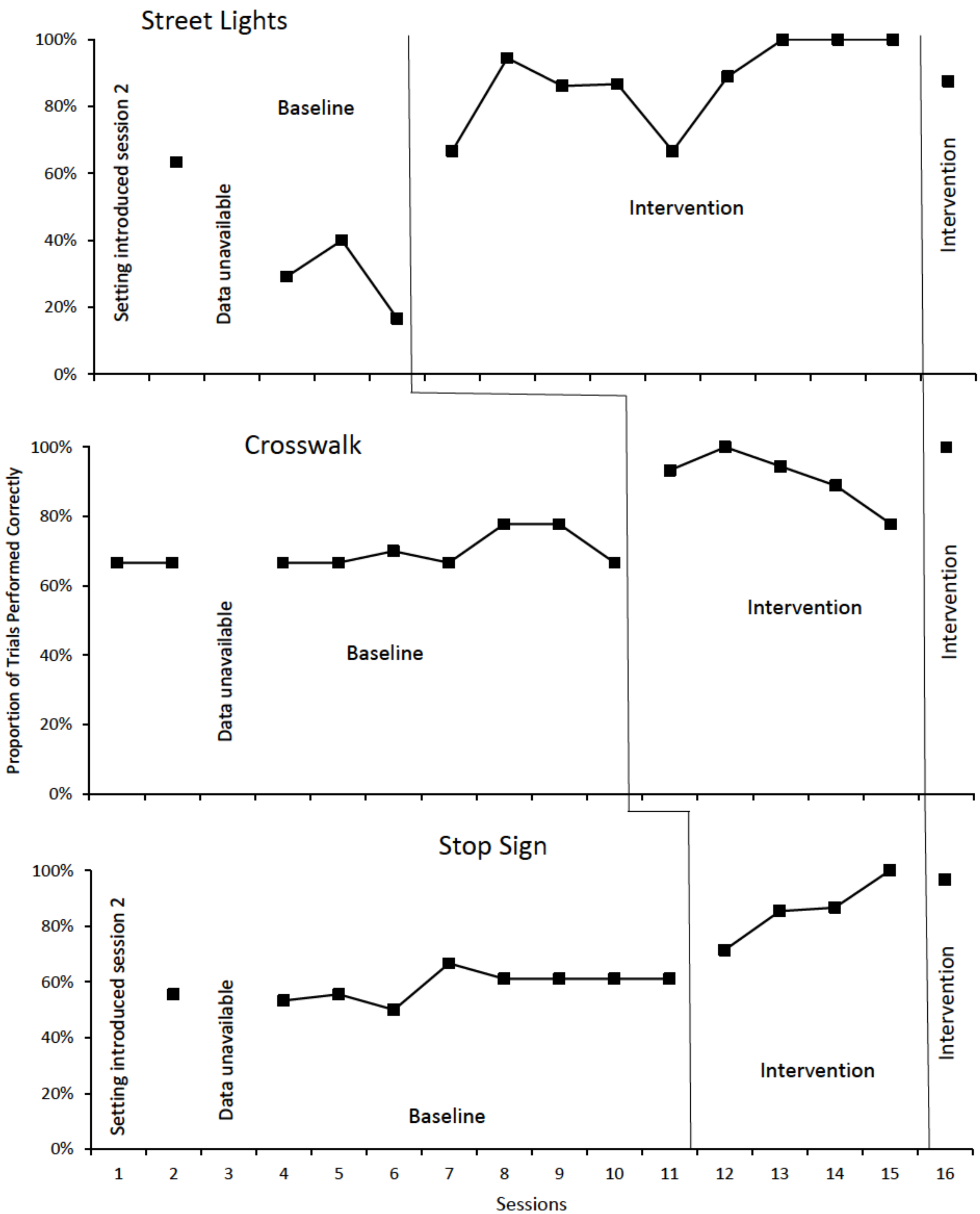

Figure 6. Participant 2's sessional means of the percentages of task components completed correctly on each trial, by setting.

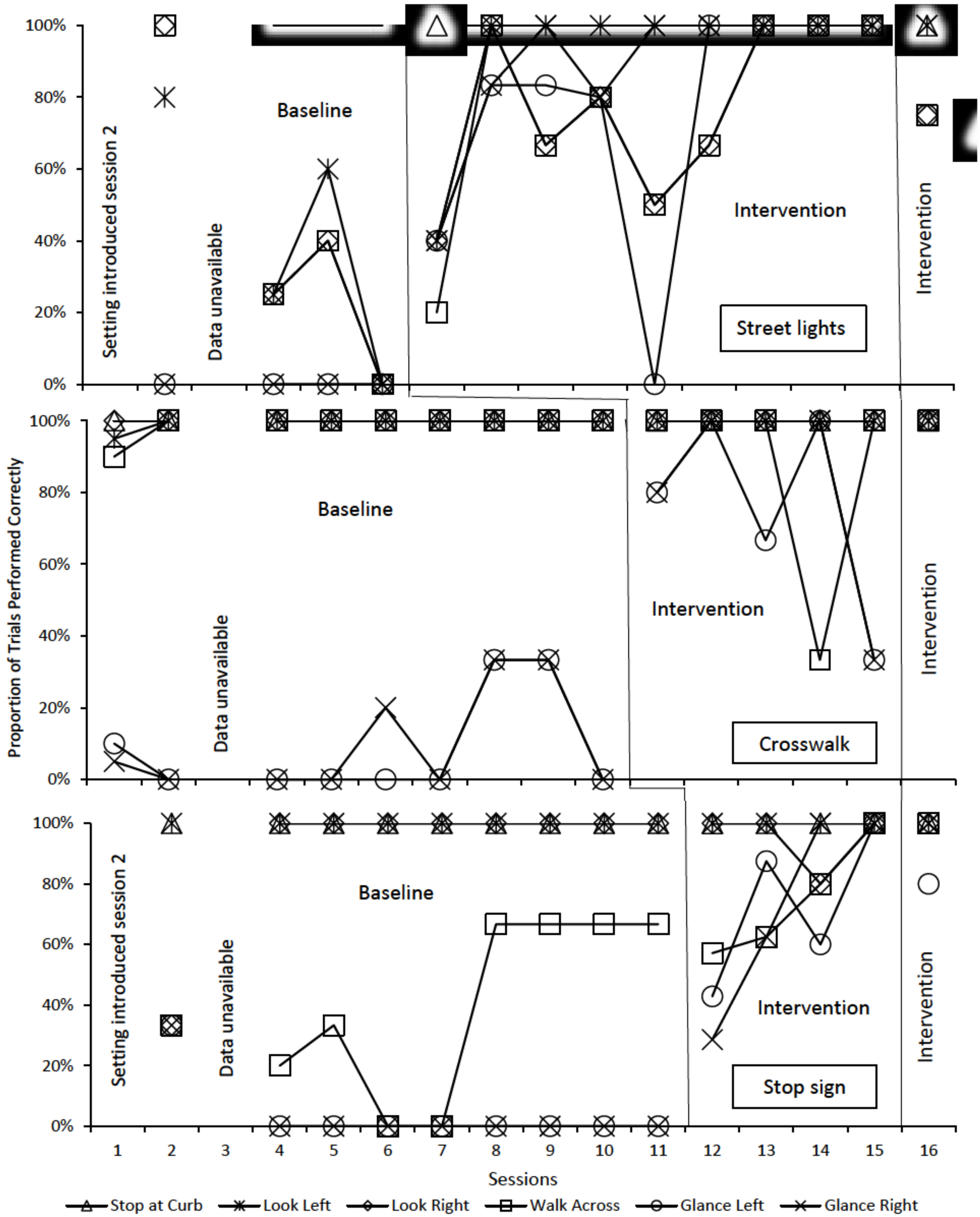

Figure 7. Participant 2's proportions of trials per session in which a given task component was performed correctly.

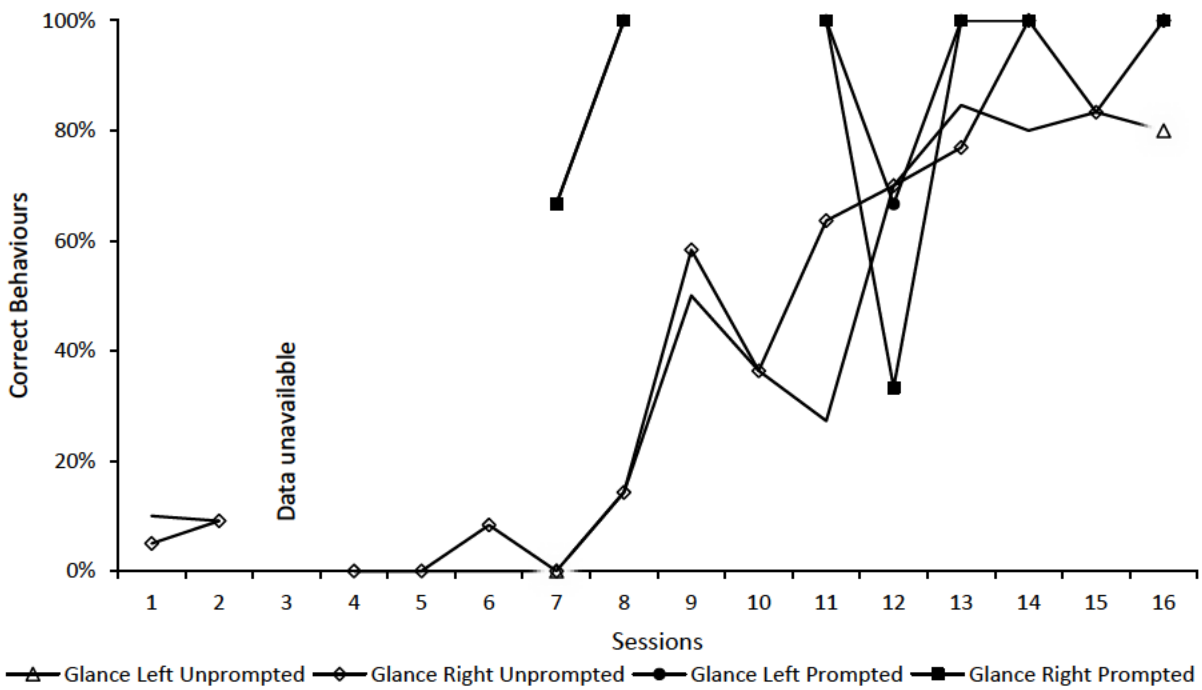

Figure 8. Participant 2's average scores for "glance left" and "glance right" behaviours, separated by prompted versus unprompted trials for each session. Scores for prompted trials begin when prompts began to be delivered during intervention phase. Intervention was introduced in the street lights setting on session 7, in the crosswalk setting on session 11, and in the stop sign setting on session 12. Sessions without data points for prompted trials are because no prompts were delivered during that session.

Appendix A
Advertisement

PARTICIPANTS NEEDED FOR RESEARCH

Researchers at the University of Manitoba are conducting a research project investigating the use of Virtual Reality to teach individuals approximately 7-16 years old with Autism Spectrum Disorder street crossing skills.

Participants will practice crossing the street using only **SAFE** and simulated environments in a computer game.

Expected time commitment: approximately 1-2 sessions each week (30-40 minutes) for 2 months.

To learn more, contact Daniel Foidart at [redacted]

Appendix B
Project Description & Consent Form

Study Name: Behavioural Skills Training to Teach Children with Autism Spectrum Disorder Street-Crossing in a Virtual Environment

Principal Researcher: Daniel Foidart, graduate student, Psychology

204-256-4301 x 3463; dfoidart@stamant.ca

Research Supervisor: Dr. Toby Martin, Professor, Psychology

204-256-4301 x 5481; Toby.Martin@umanitoba.ca

Affiliations: University of Manitoba and St.Amant Research Centre

Sponsor: None

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve.

What is the purpose of the study?

The purpose of this study is to evaluate a virtual reality training program delivered by parents for teaching street-crossing to children with autism.

What will you and your child do in the study, and how long will the study take?

You will teach your child street crossing skills in a virtual environment. You will receive ongoing training from the experimenter on how to implement the different phases of the study. Each person learns at a different rate and the number of sessions needed may vary. You and your child can anticipate participating in 1-2 sessions each week, lasting about 30-40 minutes. The study includes four phases.

Pre-baseline.

During this phase, you will be asked to complete an initial questionnaire to gather some background information. You will work with your child to teach them how to use the keyboard and mouse to move around in the computer simulation. You will give your child tokens for appropriate behaviours and allow an exchange of tokens for a reward.

Baseline.

During the baseline phase, you will sit next to your child at a computer and ask them to try to cross the street safely within the simulation. You will ask them to do this several times, but you will not provide them with any type of assistance to help them succeed.

Intervention.

During the intervention phase, you will ask your child again to try to cross the street safely within the simulation. However, you will now help them cross safely and successfully. You will use demonstrations, verbal instructions, gestural cues, and feedback to assist them. Your child will be able to earn tokens that he/she can exchange for items or activities that they enjoy. If your child begins to cross successfully with your support, you will give them opportunities to try by themselves.

Generalization.

Once the intervention phase has finished, your child will be asked to watch video recordings of different street crossing settings that they did not practice in the training. They will be asked to tell you when they think it would be safe to cross the street. You will be asked to fill out a questionnaire about your child's street crossing behaviours.

Lastly, you and your child will complete a final questionnaire about the teaching techniques that were used in this study.

Will any recording devices be used?

Each session will be video recorded on an Ipod that will remain with you for the duration of the study, which will include video/audio of both you and your child sitting at the computer and engaging with the program. You will also record the screen on your computer during each session. A screen recording is like a video of what appears on the computer display as the program runs. These videos will not include your child's image, their voice, or any other identifying information. Both the video recordings and the screen recordings will automatically be uploaded to a secure iCloud folder that only the primary researcher will have access to. The files will be accessible on the primary researchers' personal computer that will remain secure in their home. Access to the videos will be restricted to only members of the research team. The videos will be deleted and unrecoverable following completion of data analysis.

What are the risks and benefits in taking part in the study?

The procedures of this project present no risk since the street crossing skill is practiced on a computer, providing a virtual learning experience. A potential risk is one that extends outside the practice sessions. Your child may attempt street crossing in the natural setting after practicing this skill in a virtual environment. If this skill is not yet mastered, there is a safety risk for them. While this project does aim to teach safe street crossing skills, the primary focus is for research. You should not assume that your child will now be safe to cross the street alone, and you should continue to monitor them appropriately.

Your child may benefit by learning valuable safety skills which might allow them to navigate more safely and independently in their natural environment.

Will personal information about you be kept confidential?

Yes. All information will be handled in compliance with Section 24 of the Personal Health Information Act (PHIA). All information will be kept confidential and stored in the primary researchers home. Only the research staff will have access to the information. The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way. In any documentation such as data sheets, and databases, you will be identified by a code only – no identifying information will appear on data sheets or in databases. A password-protected document ("key") containing participants' codes that are linked to their names and other identifying information will be stored on a password-protected computer network in the primary researchers home and will only be accessible to the researcher. The key will be destroyed after the data is analysed. Videos will be deleted and unrecoverable following completion of data analysis. Any presentations, reports, or publications about the project will not contain any identifying information. Anonymous data may be kept indefinitely.

Is there payment or cost for participating?

There is no cost or payment for participating in this study.

Is participation voluntary?

Yes. Participation is voluntary and whether you give consent to participate or not will in no way affect your employment/or volunteer position or any services you may be receiving now or in the future from St.Amant, the University of Manitoba, or any other service agency. Moreover, even after you give consent, you can stop at any time and for any reason by simply calling or emailing the principal researcher listed at the beginning of this form. Again, your decision to withdrawal from this study will not affect your employment/or volunteer position.

Will I receive the results of the study?

If you would like to receive the results of the study, please check YES in the appropriate box below and provide either your email address or mailing address, whichever method you would prefer to receive the results. We will send you a brief 1-page summary of the findings within approximately a month after completion of the study (by approximately April 2021).

Please check YES or NO for the following items:	**YES**	**NO**
Would like to receive the results of this project?		
If you responded Yes to the previous question, please write your email address or mailing address here:		

How and to whom will research results be shared?

Summary (anonymous) results will be disseminated in scientific journals and at conferences. Summary results will be shared (in the form of written reports, workshops, or presentations) with the software developers (BehaviorMe©), and possibly other service providers in Manitoba, and other public forums so that others may learn from this project. Results will be shared for the purpose of disseminating potentially useful information that improves training of direct care staff. Any presentations, reports, or publications about the project will not contain any identifying information.

Signing the Consent Form

In signing this document I freely agree to participate in this research study titled, *Behaviour Skills Training to Teach Children with Autism Spectrum Disorder Street-Crossing in a Virtual Environment,* in which video recordings containing identifying information may be distributed only to members of the research team (principal researcher, research supervisor and research assistants), and will only be used in the context of data collection and analysis for this research project. I authorize the use of such data and recordings only for the scientific and educational purposes specified above. I have been told that my name will not appear in any report or publication resulting from this study.

I have read this consent form. I have had the opportunity to discuss this research study with the research staff. I have had all my questions answered by them in language I understand. The risks and benefits have been explained to me. I believe that I have not been unduly influenced by any study team member to participate in the research study by any statements or implied statements.

Any relationship (such as employer, supervisor or family member) I may have with the study team has not affected my decision to participate and that I may choose to withdraw my consent and decline to be recorded and to participate in any activity related to this study at any time, without penalty, prejudice or consequence. I understand that I will be given a copy of this consent form after signing it. I authorize the inspection of any of my records that relate to this study by the University of Manitoba.

By signing this consent form, I have not waived any of the legal rights that I have as a participant in a research study and I have not released the researchers, sponsors, or involved institutions from their legal and professional responsibilities.

____________________________________ __________________
Participant's Signature Date

____
Participant's Printed Name

__________________________ _____________________________
Phone Number Email address

__________________________ __________________
Researcher and/or Delegate's Signature Date

____
Researcher or Delegate's Printed Name

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way. This research has been approved by the Psychology/Sociology Research Ethics Board. If you have any concerns or complaints about this project you may contact any of the above named persons or the Human Ethics Coordinator (HEC) at 204-474-7122. A copy of this consent form has been given to you to keep for your records and reference.

Appendix C

Background Information

Participant ID Number: ________ Date Completed: ________

Child's Age: _______ Child's Gender: Male / Female

Child's Diagnosis:

____
____

Other Disabilities or Special Needs (e.g., hearing, vision, mobility):

____
____

Current grade and educational placement (regular education, special education, etc.)

____
____

Has your child received any previous training or education for street safety skills? **Y / N**
If yes, please describe the training and whether or not it was successful.

____
____
____
____

Does your child have a history of any dangerous roadside behaviours (running away)? **Y / N**
If yes, please describe:

____
____
____
____

Please describe your child's level of experience with technology, such as the use of video games, computers (keyboard and mouse), television, etc.

____
____
____
____

Reinforcement Information

During the experiment, your child will be provided with tokens and will have the opportunity to exchange them for things they like. For each section below, please list or describe items or activities that may bring the person joy, satisfaction, or pleasurable feelings.

Food:

____
____
____
____

Toys/entertainment:

____
____
____
____

Social/interactions:

____
____
____
____

Other:

____
____
____
____

Appendix D

Parent Training

- Introduction:
    - Purpose of the study is to:
        - Evaluate if a virtual environment is effective way to teach safe street crossing to individuals with ASD
        - Evaluate if remote parent training is effective training method for carrying out teaching sessions to their children
    - Explain the purpose for each phase
- General:
    - Set up: two chairs, computer, recording equipment
    - Minimize distractions during sessions
- Equipment:
    - Camera/tripod
- Software:
    - Simulation training
        - Headquarters
        - Crosswalk
    - Screen recording program
    - File transfer program (e.g., Firefox Send, Dropbox)
- Pre-baseline:
    - Explain purpose for phase
    - Caregiver reads Task Analysis for Pre-baseline and reviews with experimenter
    - Using tokens and exchanging for reinforcers
    - Modelling and prompting
    - Wrap-up: closing simulation, sending files
    - Caregiver runs pre-baseline session with confederate
    - Caregiver runs session with child
- Baseline:
    - Explain purpose for phase
    - Caregiver reads Task Analysis for Baseline and reviews with experimenter
    - Tokens and reinforcers
    - Instructions for sessions/trials
    - Contingencies for ending a trial
    - Datasheet and data recording
    - Wrap-up: closing simulation, sending/storing data/files
    - Caregiver runs baseline session with confederate
    - Caregiver runs session with child
- Intervention:
    - Explain purpose for phase
    - Caregiver reads Task Analysis for Intervention and reviews with experimenter
    - Tokens and reinforcers

- Prompt training:
  - Verbal prompts
  - Gestural prompts
  - Modelling
  - Feedback
  - When to prompt/when to give opportunity for independent trial
  - Mastery criteria
- Contingencies for ending a trial
- Datasheet and data recording
- Wrap-up: closing simulation, sending/storing data/files
- Caregiver runs intervention session with confederate
- Caregiver runs session with child

Appendix E

<u>Task Analysis for **Pre-Baseline**</u>

This tool is a step-by-step guide designed to help parents implement a **PRE-BASELINE** session of the street-crossing simulation experiment

Preparation:

- Caregiver turns on computer and starts up the simulation using the headquarters **tutorial**
- Caregiver skips through the prompts from the simulation before inviting child over to the computer
- Caregiver turns on camera and **<u>ensures it is recording</u>**
- Caregiver turns on screen recording program and **<u>ensures it is recording</u>**
- One chair is positioned for the child in front and one for the parent next to their child
- Distractions are minimized (e.g., door closed, other electronics turned off, notify other members in the household that a session is underway and not to be disturbed)
- Caregiver tells child that they will practice moving around in the computer game and that they will show them how it works
- Caregiver shows child the token board, and tells child that they can earn tokens to exchange them for a reward
- Caregiver presents at least 2 options as reinforcer and prompts child to pick one
- Caregiver asks child to sit next to them at the computer

Teaching the movements by modelling:

Before your child can begin baseline, they must be able to move in all directions and look at various objects within the simulation when specified by the caregiver.

Caregiver sits at the computer and models the following actions while providing explanations on how to do so.

- First, show your child how to move forward and backward. Say to your child: “In this game, you use the up arrow (W) to move forward and the down arrow (S) to move backward” (press the up and down arrow to show your child how the avatar moves forward and backward).
- Next, show your child how to move left and right. Say: “You use the left arrow (A) to move left and the right arrow (D) to move right” (continue modelling).
- Finally, show your child how to look around. Say: “You use your mouse to look around” (model looking around using the mouse).”

Prompting your child:

- Caregiver restarts the simulation (to restart the simulation, press “P” then click “Restart Tutorial”) and switches places with child and tells child it’s their turn to try.
- Caregiver provides verbal and gestural prompts to guide their child through the tutorial.

- Caregiver provides tokens to the child for correct responses and places them on the token board.
- Once the tutorial is complete, caregiver continues to tell the child to look at or move towards objects in the simulation and provides prompting as needed
- Caregiver continues above step until child has earned enough tokens to fill the token board
    - Once the token board is full, caregiver praises child for getting all their tokens and provides them with the reward
- Caregiver continues to prompt child as needed and provides tokens until caregiver thinks their child understands the controls

Opportunity for independent response:

- Caregiver restarts the simulation (to restart the simulation, press “P” then click “Restart Tutorial”) and tells child that now they can try by themselves.
- Caregiver allows child to follow the tutorial without providing any prompts
- If child performs the actions prompted by the tutorial correctly, they are ready for baseline!
- If child makes any errors, repeat the prompting section as needed

If your child requires some additional prompting to understand how to use the keyboard and mouse to move in the simulation, see the “Additional prompting” section below.

Additional prompting:

Keyboard

- Caregiver shows the child the up arrow by pointing and says “this is how you move forward”. The caregiver then presses the up arrow to show that the avatar moves forward.
    - Caregiver then says “now you try”, and provides prompts as needed so that child presses the up arrow.
- Caregiver shows the child the down arrow by pointing and says “this is how you move backward”. The caregiver then presses the down arrow to show that the avatar moves backward.
    - Caregiver then says “now you try”, and provides prompts as needed so that child presses the down arrow.
- Caregiver shows the child the left arrow by pointing and says “this is how you move left”. The caregiver then presses the left arrow to show that the avatar moves left.
    - Caregiver then says “now you try”, and provides prompts as needed so that child presses the left arrow.
- Caregiver shows the child the right arrow by pointing and says “this is how you move right”. The caregiver then presses the right arrow to show that the avatar moves right.
    - Caregiver then says “now you try”, and provides prompts as needed so that child presses the right arrow.

Mouse

- Caregiver shows the child the mouse by pointing to it and says, “you use the mouse to look around”. The caregiver then says “this is how you look left” and moves the mouse to the left to show that the avatar looks left.
  - Caregiver then says “now you try”, and provides prompts as needed so that child moves the mouse to the left.
- The caregiver then says “this is how you look right” and moves the mouse to the right to show that the avatar looks right.
  - Caregiver then says “now you try”, and provides prompts as needed so that child moves the mouse to the right.
- The caregiver then says “this is how you look up” and moves the mouse to the forward to show that the avatar looks up.
  - Caregiver then says “now you try”, and provides prompts as needed so that child moves the mouse forward.
- The caregiver then says “this is how you look down” and moves the mouse to the backward to show that the avatar looks down.
  - Caregiver then says “now you try”, and provides prompts as needed so that child moves the mouse backward.

Note: These steps can be repeated as many times as necessary.

If you have any questions or if you require immediate assistance, email umfoidad@myumanitoba.ca or call xxx-xxx-xxxx to speak with Daniel.

Appendix F

Task Analysis for **Baseline**

This tool is a step-by-step guide designed to help caregivers implement a **BASELINE** session of the street-crossing simulation experiment

Preparing the environment and materials:

- Parent turns on computer and starts up the simulation using the **crosswalk simulation**
- One chair is positioned for the child in front and one for the parent next to their child
- Distractions are minimized (e.g., door closed, other electronics turned off, notify other members in the household that a session is underway and not to be disturbed)
- The following material are present: token board and tokens, reinforcer choices (e.g., edibles), datasheet, pen or pencil
- Parent turns on camera and **ensures it is recording**
- Parent turns on screen recording program and **ensures it is recording**

Choosing reward:

- Give child a brief warning that you are about to begin a street crossing game on the computer with them
- Tell child that if they cooperate, they will earn tokens that can be exchanged for rewards
- Have the child choose their reward by providing at least 2 choices
- Have your child sit at the computer and sit next to them

Trials:

1. Say to your child: "This looks like a game, but in this program, you are supposed to try to cross the street safely. Try to walk to the glowing blue light on the other side without getting hit by a car. Click the "Go!" button when you are ready to begin."
2. Once a trial begins, do not say anything further to your child.
3. A trial ends when:
    a. They have made it across safely
    b. They have not made it across safely (the simulation will end the trial automatically)
    c. 2 minutes has elapsed - There is a timer built into the simulation, keep your eyes on it. If 2 minutes has elapsed say: "time is up" and end the trial by pressing "P" and selecting "Back to Options"
4. Provide a token ONLY IF your child made it across safely
5. Record the point of data for the trial that has just occurred
6. Allow for a brief pause (e.g., 15-30 seconds) then repeat the above steps but simply saying "try again, click the Go! button when you're ready" for subsequent trials
7. Once x number of tokens have been collected, praise your child for their hard work and provide them with the reward they selected

8. Once 20 trials have been completed, the session is over. Thank your child for participating

Wrap up:

- Stop the camera and the screen recording program from recording and save the files
- You can now close down the simulation program
- Scan the datasheet
- Send the datasheet to umfoidad@myumanitoba.ca

If you have any questions or if you require immediate assistance, email umfoidad@myumanitoba.ca or call xxx-xxx-xxxx to speak with Daniel.

Appendix G

Task Analysis for **Intervention**

This tool is a step-by-step guide designed to help caregivers implement an **INTERVENTION** session of the street-crossing simulation experiment

Preparing the environment and materials:

- Parent turns on computer and starts up the simulation using the **crosswalk simulation**
- One chair is positioned for the child in front and one for the parent next to their child
- Distractions are minimized (e.g., door closed, other electronics turned off, notify other members in the household that a session is underway and not to be disturbed)
- The following material are present: token board and tokens, reinforcer choices (e.g., edibles), datasheet, pen or pencil
- Parent turns on camera and **ensures it is recording**
- Parent turns on screen recording program and **ensures it is recording**

Choosing reward:

- Give your child a brief warning that you are about to begin a street crossing game on the computer with them
- Tell your child that if they cooperate, they will earn tokens that can be exchanged for rewards
- Have your child choose their reward by providing at least 2 choices (e.g., candy, chips)
- Have your child sit at the computer and sit next to them

Trials:

1. Say to your child: “This looks like a game, but in this program, you are supposed to try to cross the street safely. Try to walk to the glowing blue light on the other side without getting hit by a car. Click the “Go!” button when you are ready to begin.”
2. The first trial is unprompted, do not say anything further to your child.
3. A trial ends when:
    a. They have made it across safely
    b. They have not made it across safely (the simulation will end the trial automatically)
    c. 2 minutes has elapsed - There is a timer built into the simulation, keep your eyes on it. If 2 minutes has elapsed say: “time is up” and end the trial by pressing “P” and selecting “Back to Options”
4. Provide a token ONLY IF your child made it across safely
5. Record the point of data for the trial that has just occurred
6. Allow for a brief pause (e.g., 15-30 seconds) then repeat following trials by simply saying “try again, click the start button when you’re ready” for subsequent trials
    a. If your child made it across safely on the previous trial, allow an opportunity for an independent response on the next trial

   b. If your child did not make it across safely on the previous trial or 2 minutes elapsed, provide prompts on the next trial
7. Once x number of tokens have been collected, praise your child for their hard work and provide them with the reward they selected
8. Once 20 trials have been completed, the session is over. Thank your child for participating

Wrap up:

- Stop the camera and the screen recording program from recording and save the files
- You can now close down the simulation program
- Scan the datasheet
- Send the datasheet to umfoidad@myumanitoba.ca

Appendix H

List of Task Steps With Verbal and Gestural Prompts

1. Stop/wait at the curb: *Correct response:* Advance no further than the curb. *Verbal prompt:* "Stop before the street." *Gestural prompt:* Stop motion with hand.
2. Look left: *Correct response:* Look left, toward oncoming traffic in the near lane. *Verbal Prompt:* "Look to the left and watch for cars." *Gestural prompt:* Point and sweep with finger.
3. Look right: *Correct response:* Look right, toward oncoming traffic in the far lane. *Verbal prompt:* "Look to the right and watch for cars." *Gestural prompt:* Point and sweep with finger.
4. Begin walking across the street: *Correct response:* Walk directly towards the goal. *Verbal prompt*: "All clear—go!" *Gestural prompt*: Point to the target.
5. Continue walking and glance left: *Correct response:* Glance left while continuing to walk across. *Verbal prompt:* "Keep walking and check left for cars." *Gestural prompt:* Point and sweep with finger.
6. Continue walking and glance right: *Correct response:* Glance right while continuing to walk across. *Verbal prompt:* "Keep walking and check right for cars." *Gestural prompt:* Point and sweep with finger.

Appendix I

Scoring Instructions

1. Stop/wait at the curb: *Correct response:* Advance no further than the curb.
    a. Point awarded if avatar did not drop off the curb to the street.
2. Look left: *Correct response:* Look left, toward oncoming traffic in the near lane.
    a. Point awarded if the camera angle panned to the left to a predetermined point for each VE.
3. Look right: *Correct response:* Look right, toward oncoming traffic in the far lane.
    a. Point awarded if the camera angle panned to the right to a predetermined point for each VE.
4. Begin walking across the street: *Correct response:* Walk directly towards the goal.
    a. Point lost if looked left/right, seen a car at a close proximity and began crossing (scorers used their judgement to assess if a car was too close).
    b. Point lost if didn't look a certain way and began to cross.
    c. Point lost if hit by a car.
    d. Point lost if did not walk directly towards the goal.
5. Continue walking and glance left: *Correct response:* Glance left while continuing to walk across.
    a. Point awarded if the camera angle panned to the left to a predetermined point for each VE.
    b. Point lost if stopped for extended period to glance (scorers used their judgement).
6. Continue walking and glance right: *Correct response:* Glance right while continuing to walk across.

a. Point awarded if the camera angle panned to the right to a predetermined point for each VE.

b. Point lost if stopped for extended period to glance (scorers used their judgement).

Appendix J

Satisfaction Questionnaire - Caregivers

For each of the questions below, circle the response that best characterizes how you feel about the statement: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree, and N/A = Not Applicable

Goals

1. I think it is important to evaluate the use of computer simulations as a teaching tool.

   1 2 3 4 5 N/A
2. I think it is important for my child to learn how to cross the street safely and independently.

   1 2 3 4 5 N/A
3. I understood the goals of the research.

   1 2 3 4 5 N/A
4. I have observed a positive behaviour change in my child's ability to cross the street safely

   1 2 3 4 5 N/A

Methods

5. The procedures used to train me, such as virtual meetings, were easy to understand.

   1 2 3 4 5 N/A
6. The technology used in this project, such as the simulation, recording devices, and data sharing software, were easy to use.

   1 2 3 4 5 N/A
7. The procedures used, such as virtual simulations and behaviour skills training, were acceptable.

   1 2 3 4 5 N/A
8. The procedures used required an acceptable amount of time and effort.

   1 2 3 4 5 N/A

Personnel

9. I am satisfied with the personnel that conducted the research.

   1 2 3 4 5 N/A

What about virtual reality do you think is the most valuable for teaching your child?

____

____

What, if anything, do you think is the most challenging or least acceptable about virtual reality?

____

____

Appendix K

Satisfaction Questionnaire – Participants

For each of the questions below, please circle either “Yes” or “No”.

1.	Was the program easy to use?	Yes	No
2.	Were the simulations fun?	Yes	No
3.	Would you like to use the program again?	Yes	No
4.	Do you feel like you can cross the street by yourself safely in real life?	Yes	No

Appendix L

Child Street-Crossing Behaviours Questionnaire - Caregivers

For each of the questions below, rate how reliably your child displays the relevant behaviour: 1 = Never, 2 = Rarely, 3 = Occasionally, 4 = Often, 5 = Present, and N/A = Not Applicable

1. Does your child identify where to cross the street when he/she is outside in the streets?

   1 2 3 4 5 N/A

2. Does your child wait at the curb when it is not safe to cross?

   1 2 3 4 5 N/A

3. Does your child look left and right for oncoming traffic while waiting at the curb?

   1 2 3 4 5 N/A

4. Does your child identify when it is safe to cross the street?

   1 2 3 4 5 N/A

5. Does your child cross the street safely by themselves?

   1 2 3 4 5 N/A

Have you observed your child perform any other street-crossing behaviours not mentioned above? Please describe.

____
____
____
____
____

Appendix M
Datasheet

Participant code (experimenter only):____ Datasheet Date:_____________

Instructions: Write today's date. For each trial, circle you provided prompts or if your child attempted crossing independently. For each trial, circle the outcome of the trial (safe crossing or time limit reached). If enough tokens are earned to trade for a reward on a particular trial, indicate the reward that was given in the space provided.

Trial	Prompting		Crossed safely			Reward
1	Prompts provided	Independent trial	Yes	No	Time Limit	
2	Prompts provided	Independent trial	Yes	No	Time Limit	
3	Prompts provided	Independent trial	Yes	No	Time Limit	
4	Prompts provided	Independent trial	Yes	No	Time Limit	
5	Prompts provided	Independent trial	Yes	No	Time Limit	
6	Prompts provided	Independent trial	Yes	No	Time Limit	
7	Prompts provided	Independent trial	Yes	No	Time Limit	
8	Prompts provided	Independent trial	Yes	No	Time Limit	
9	Prompts provided	Independent trial	Yes	No	Time Limit	
10	Prompts provided	Independent trial	Yes	No	Time Limit	
11	Prompts provided	Independent trial	Yes	No	Time Limit	
12	Prompts provided	Independent trial	Yes	No	Time Limit	
13	Prompts provided	Independent trial	Yes	No	Time Limit	
14	Prompts provided	Independent trial	Yes	No	Time Limit	
15	Prompts provided	Independent trial	Yes	No	Time Limit	
16	Prompts provided	Independent trial	Yes	No	Time Limit	
17	Prompts provided	Independent trial	Yes	No	Time Limit	
18	Prompts provided	Independent trial	Yes	No	Time Limit	
19	Prompts provided	Independent trial	Yes	No	Time Limit	
20	Prompts provided	Independent trial	Yes	No	Time Limit	

Appendix N

Procedural Reliability Checklist – Pre-Baseline

Date:______________ Participant:______________ Observer:______________
Experimenter:______________

Session elements:	Y / N / NA
Caregiver does the following steps in preparation	
1. Uses the headquarters **tutorial** simulation	
2. Distractions are minimized	
3. Skips through the prompts from the simulation before inviting child over to the computer	
4. Tells child that they will practice moving around in the computer game and that they will show them how it works	
5. Shows child the token board, and tells child that they can earn tokens to exchange them for a reward	
6. Presents at least 2 options as reinforcer and prompts child to pick one	
Caregiver teaches the movements	
1. Models the movements (up, down, right, left) and explains which keys to press for them	
2. Models looking around with the mouse and explains how to do it	
Caregiver prompts the child	
1. Restarts the simulation and prompts child to sit at the computer	
2. Provides verbal and gestural prompts to guide the child through the tutorial	
3. Provides tokens for correct response and places tokens on token board	
4. Provides reward once the token board is full	
Caregiver provides child an opportunity for independent responses	
1. Restarts the simulation and tells child that they can try by themselves	
2. Child progresses through the tutorial without any prompts by caregiver	

3. Caregiver repeats prompting sequence as needed	
4. Session is terminated once child performs actions prompted by the tutorial correctly	

Appendix O

Procedural Reliability Checklist - Baseline

Date:______________ Participant:______________ Observer:______________
Experimenter:______________

Session elements:	Y / N / NA
Caregiver does the following steps in preparation	
1. Uses the **crosswalk** simulation (P1) /minimum 3 trials per setting (P2)	
2. Distractions are minimized	

Trials	1	2	3	4	5	6	7	8	9	10
1. Correct instruction										
2. No further prompts given										
3. Correct consequence										
4. Trial ends appropriately										
5. Appropriate use of tokens/reinforcers										
Trials	11	12	13	14	15	16	17	18	19	20
1. Correct instruction										
2. No further prompts given										
3. Correct consequence										
4. Trial ends appropriately										
5. Appropriate use of tokens/reinforcers										

* *Correct instruction for 1st trial: “This looks like a game, but in this program, you are supposed to try to cross the street safely. Try to walk to the other side without getting hit by a car. Click the “Go!” button when you are ready to begin.”
*Correct instruction for all subsequent trials: “try again, click the Go! button when you’re ready”.
*No further prompts given: No prompts given to help cross the street safely - can give prompts to help with controls (e.g., left hand on keyboard and right hand on mouse).
*Trial consequence = No feedback given about the components of performance.
*Trial ending: Childs makes it across, child does not make it across, or **2 minutes elapses – caregiver must end the trial manually.**
***Tokens/reinforcer: Provides a reinforcer (e.g., candy) **after 2 successful trials.**

Appendix P

Procedural Reliability Checklist - Intervention

Date:______________ Participant:______________ Observer:______________
Experimenter:______________

Session elements:	Y / N / NA
Caregiver does the following steps in preparation	
1. Uses the **crosswalk** simulation/minimum 3 trials per setting	
2. Distractions are minimized	

Trials	1	2	3	4	5	6	7	8	9	10
1. Correct instruction										
2. Appropriate prompts given										
3. Correct consequence										
4. Trial ends appropriately										
5. Appropriate use of tokens/reinforcers										
Trials	11	12	13	14	15	16	17	18	19	20
1. Correct instruction										
2. Appropriate prompts given										
3. Correct consequence										
4. Trial ends appropriately										
5. Appropriate use of tokens/reinforcers										

* *Correct instruction for 1st trial: “This looks like a game, but in this program, you are supposed to try to cross the street safely. Try to walk to the other side without getting hit by a car. Click the “Go!” button when you are ready to begin.”
*Correct prompting: 1st trial always unprompted. If **<u>no errors</u>** on previous trial, no prompting. If **<u>errors</u>** on previous trials, provide prompts.
*Trial consequence = No feedback given about the components of performance if **<u>no errors</u>** on previous trial. Feedback permitted if **<u>errors</u>** on previous trial.
*Trial ending: Childs makes it across, child does not make it across, or **2 minutes elapses – caregiver must end the trial manually.**
*****Tokens/reinforcer: Provides the reinforcer **at the end of the session.**