

CAN VIRTUAL REALITY TEACH PEDESTRIAN SAFETY?

Efficiently teaching adults with ASD in a VR environment to safely navigate pedestrian street crossing

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One of the most important and influential activities of daily living for assimilating into the community is the ability to safely navigate as a pedestrian in a variety of settings. Individuals with autism spectrum disorders (ASD) typically have difficulty with this (Goldsmith, 2009), and in particular street safety is a major concern and may have severe consequences such as injury and possible death (Feeley et al, 2015). Pedestrian navigation and street crossing training are recognized as an integral life skills and are fundamental steps in the development of independence, increasing safety awareness, mobility, and safely integrating into society. The goal of this project was to develop and pilot test a pedestrian skills program using a mixed reality Virtual Reality (VR) program that focused on street crossings in a number of different situations for persons on the autism spectrum. The program assessed the skill acquisition through traditional classroom style instructional design followed by a mixed reality Virtual Reality instruction using the single subject research design.

Background

The ADA spurred the redesign of pedestrian infrastructure and the focus was to remove physical barriers to persons with disabilities. Changes included curb cuts that enable movement for those using mobility devices as well as truncated domes available in an array of colors and textures to assist those with visual impairments. However, very little is understood in regards to the cognitive processes involved with pedestrian infrastructure and street crossings for individuals with ASD.

Independent road crossing and pedestrian skills are needed for community integration and full societal inclusion. Most safe street crossing programs were developed for teaching neuro-typical children. However these programs do not provide a method to determine if the level of comprehension for an autistic individual regarding safe road crossing instruction. Due to the complexity of skills involved just with pedestrian travel, such as the instructions “look both ways twice” or “look left, right, left” before crossing the street does not mean the individual understands that they need to scan for oncoming vehicles while calculating if the distance and speed of any vehicles in which to determine and provide them the time to cross. Through identifying the required skills and tasks needed for a variety of pedestrian infrastructure designs in addition to a variety of street intersections, a more conducive and comprehensive street crossing teaching strategy, that has been empirically tested, can be implemented.

Support for this project is needed since research indicates that the majority of individuals on the autism spectrum have difficulty as pedestrians independently crossing the street. Additionally walking is a mode that many adults on the autism spectrum are unable to currently perform safely and/or independently. Inability to do so greatly impacts one's quality of life by limiting the ability to access life sustaining and enhancing activities in one's residential community such as employment, shopping, healthcare, continuing education opportunities, recreational activities, and access to public transportation services. Data from a Rutgers study indicates that, according to the 703 adult respondents on the spectrum and their family members, 53.5% of these adults with ASD do not know how to safely cross a road without assistance from others. In addition, Table 1 excerpted from the 2015 report demonstrates the difficulties that adults with ASD have with pedestrian skills (Feeley et al, 2015).

Table 1. Difficulty with Different Aspects of Walking

Difficult Aspects of Walking	Responses	Percent of Responses	Percent of Respondents
Crossing a street	290	16.7	41.3
Judging the distance and/or speed of cars	318	18.3	45.2
Walking in areas without sidewalks (on grass or in streets)	193	11.1	27.5
Dealing with distractions while walking	282	16.2	40.1
Too many people on the sidewalk	64	3.7	9.1
Too many cars or too much traffic	257	14.8	36.6
Difficulty determining directions/route	247	14.2	35.1
Other barriers	86	5.0	12.2

Literature Review

Individuals with ASD often lack this essential skill for independent living due to their heightened distractibility, lack of awareness to stimuli, environmental cues, and weak problem solving in unfamiliar settings (Goldsmith, 2009; Josman et al, 2008; Feeley et al, 2015). Incorrectly crossing the street may have severe consequences such as grave injury and possible death. A survey created by Agran and Krupp (2010) interviewed 121 parents of individuals with developmental disabilities, reported that 93% of parents believed that specific safety skills training was very important for their children. Nearly 20% of those concerned parents argued that safety skills training was never incorporated into their children's Individualized Education Plans (IEP).

Pedestrian skills training is recognized as a basic integral life skills for individuals with ASD, considered by many as significant as teaching social, communicative, or motor skills (Collins, et al, 1991). Thus, this skill is vital to master because it is a fundamental step in the development of independence, increasing safety awareness, mobility, and lastly safely integrating into society.

The autism stakeholder community recognizes that more robust education and instructional programs are needed for both pedestrian skills and street crossing skills to support persons on the spectrum for diverse reasons including personal injury prevention and as a means to support independence and community integration success (Dixon et al, 2010; Feeley et al, 2015; Batu et

al, 2014; Josman et al, 2008). Further, these critical skills are often not taught in school, even during the transition period (Dixon et al, 2010).

Several studies were identified that demonstrated success in students on the spectrums' capability to generalize their knowledge gain post intervention when video technology was used as an instructional strategy (Steinborn and Knapp, 1982; Haring et al, 1987).

While available literature discusses numerous strategies for consideration in teaching mobility and travel skills to persons with disability, simulated versus in vivo (i.e. real life situation) training is the most frequently cited. Therefore, the positives associated with training in an analogue or simulated setting mentioned will be included for convenience and instructional customization ability (Dixon et al, 2010; Strickland et al, 1996). In contrast, potential obstacles inherent in using simulated teaching focus on concerns related to ensuring students' ability to generalize instructions to a real setting (Dixon et al, 2010). The literature documents successful pedestrian training using each of these approaches. Marchetti et al. (1983) found their instruction of 18 persons with intellectual disability in city traffic was more effective in teaching pedestrian skills than their simulated instruction efforts. Another study determined that teaching pedestrian skills in a natural environment resulted in the participant successfully acquiring, generalizing, and maintaining the skills post training (Pattavina, 1992).

Regarding success in combining simulated and in vivo training in street crossing instruction and travel and mobility for persons with disability, a 1993 study found that teaching first in simulation did not either assist or inhibit later instruction conducted in vivo (Collins et al). Notably, however, a 2006 study that explored job skill training for supported workers with autism found that participants who received both jobsite and simulation training acquired a higher level of skill more rapidly compared to their peers who received only jobsite training (Lattimore et al).

Available literature discusses numerous strategies for consideration in teaching travel and mobility skills to persons with disability, with simulated versus in vivo (i.e. real-life situation) training the most frequently cited (Dixon et al, 2010; Strickland et al, 1996; Marchetti et al, 1983; Pattavina 1992; Collins et al, 1993). Several studies were identified that demonstrated success in students on the spectrums' capability to generalize their knowledge gain post intervention when video and media technology was used as an instructional strategy (Steinborn and Knapp, 1982; Haring et al, 1987; Settineri et al, 2018; Nair et al, 2018).

Methodology

The study assessed the skill acquisition through traditional classroom style instructional design followed by a mixed reality Virtual Reality instruction including through Behavioral Skills Training (BST). It is considered mixed reality since the individual has to physically and actively cross the virtual street in the VR headset while in reality they walked across a very large room. The educational training and the mixed reality VR were conducted in a private and secure room locations in the Rutgers Center for Adult Autism Services building on the Douglass Campus in New Brunswick, NJ. The probes were conducted on a University owned campus road also on the Douglass Campus. The study utilized a mixed reality VR procedure to facilitate training in a

safe, controlled environment to acquire the necessary skills to independently cross the street. Along with VR, BST was used to examine whether skills would generalize in a natural setting. The testing was conducted and the data was analyzed through single subject research design methods.

The evaluation was on the virtual reality program used to facilitate training in a safe and controlled environment permitting a gradual increase in the difficulty of five various street crossing conditions. The purpose of this study was to evaluate whether five adults with autism spectrum disorder are able to acquire the necessary skills to cross the street safely via a computerized virtual street crossing reality headset where they still were required to do the physical activity of crossing the street. Along with VR, BST was used to examine whether learned skills would generalize in a natural setting. Data was taken following a safe pedestrian crossing checklist. All of the probe and the virtual reality street crossing sessions were digitally recorded.

The research team used the HTC Vive Pro Eye VR headset which allowed an individual to experience the physical and psychological aspects of pedestrian environments and street crossings under a multitude of factors and conditions.

Every crossing was observed by two to four trained observers who observed and scored each of the individual crossings for all of the crossings in the full study. In addition to the observers present, there was support staff present at the testing and trainings to work with the participants as well as to ensure the participants' safety. The results from the interobserver agreements are displayed in Table 2.

Table 2. Interobserver Agreement for Street Crossings.

	Lowest	Highest	Range	Mean	% Intervals w/IOA	Total # of Crossings
Participant 1	37.00%	100%	63.00%	75.50%	66.00%	14
Participant 2	62.00%	100%	38.00%	83.90%	62.50%	15
Participant 3	50.00%	100%	50.00%	82.80%	61.00%	11
Participant 4	37.00%	100%	63.00%	86.83%	93.90%	31
Participant 5	62.00%	100%	38.00%	89.90%	60.60%	20

The participants were tested on 5 different intersection types. These were represented in the probe as well as the educational model and the VR programs. The five types of street crossings that were evaluated were 1) an unmarked street crossing, 2) a street crossing designated only pavement markings (Standard Crosswalk consisting of 2 parallel lines), 3) a street crossing with designated pavement markings and a stop sign, 4) street crossing with designated pavement markings and traffic signal, and 5) a crossing with designated pavement markings and a traffic signal with a walk/don't walk signal. The probe site is displayed in Figure 1.



Figure 1. Conditions for Probe Tests

Results

As noted, the aim of the research was to demonstrate that the mixed reality VR training experience can reliably teach safe pedestrian navigation and street crossing skills. The project included enhancing the skills using a series of customized VR programs to provide simulated street crossing experiences otherwise extremely hard to implement in real physical environments. The research team tracked each individual's progress using single subject research design observing and collecting data for all of the crossings.

The project used the aid of a relatively inexpensive virtual reality equipment and a Unity developed program that simulated real-world location-based experiences. The study included the initial probe of the participants, followed by a community based evaluation, a traditional instruction program based on The Kennedy Center's A Chance to Ride program and called contrived intersections, another probe called VR baseline, the active mixed reality Virtual Reality that included walking and other physical moving in VR in an empty indoor real world space with a Behavior Skills Training experience, followed by the final probe. The research team worked with five individuals from the Rutgers Center for Adult Autism Services who met the inclusion criteria.

One of the participants was not able to functionally use the VR equipment during the period of the study and those results are shown in Figure 2.

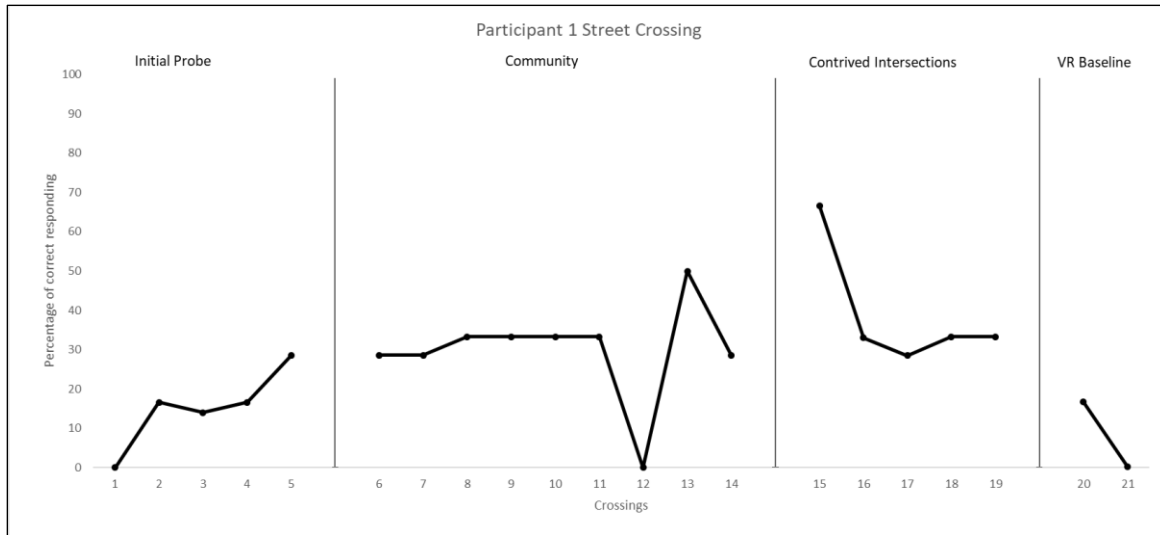


Figure 2. Participant 1 Street Crossing Results – Negative Response to VR

A second participant mastered the skills after the traditional educational program and therefore did not require the VR and BST training. This participants results can be found in Figure 3.

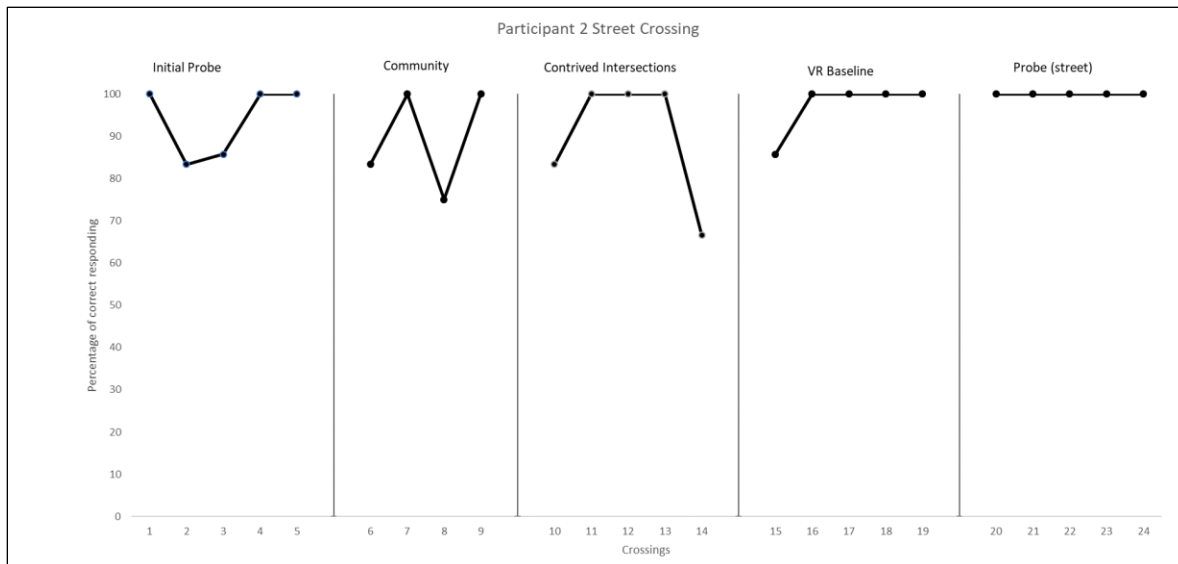


Figure 3. Participant 2 Street Crossing – Mastered Task Prior to VR

A third participant had to take an undisclosed hiatus from the study and was not able to complete the study during the study period. (Note – the participant has since indicated they will complete the study.) The results for this participants are shown in Figure 4.

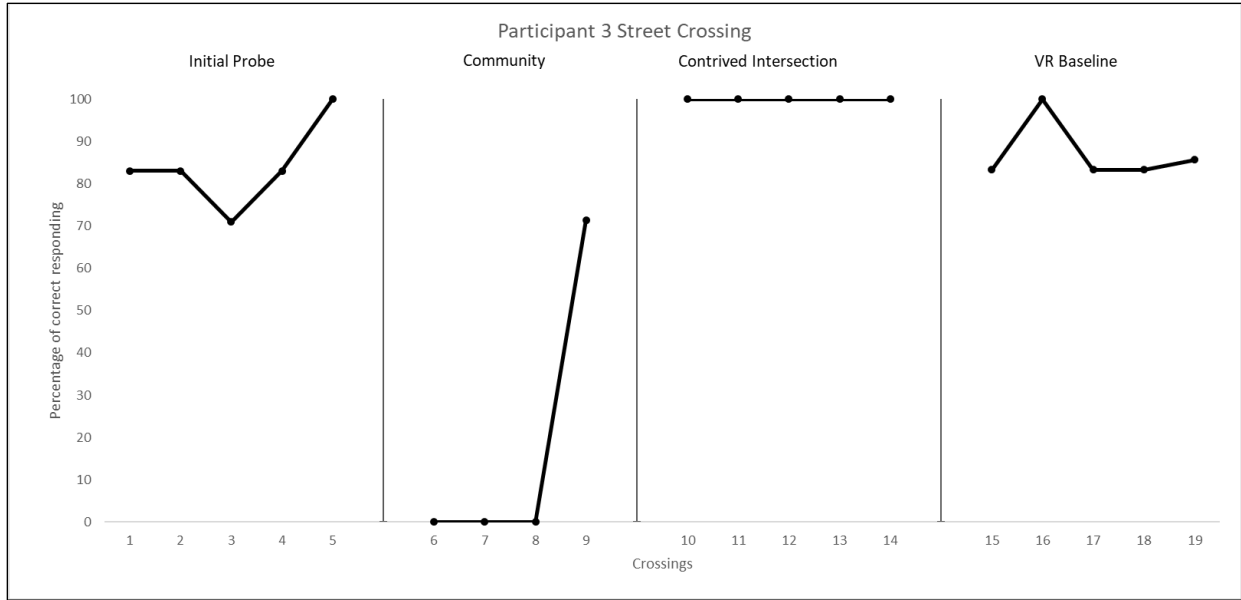


Figure 4. Participant 3 Street Crossing – Study Hiatus

At the end of the study only two participants were able to participate through the full study and partake in all of the study protocols. For the two participants that were able to complete the full study as intended the results for participant 4 can be found in Figure 5.

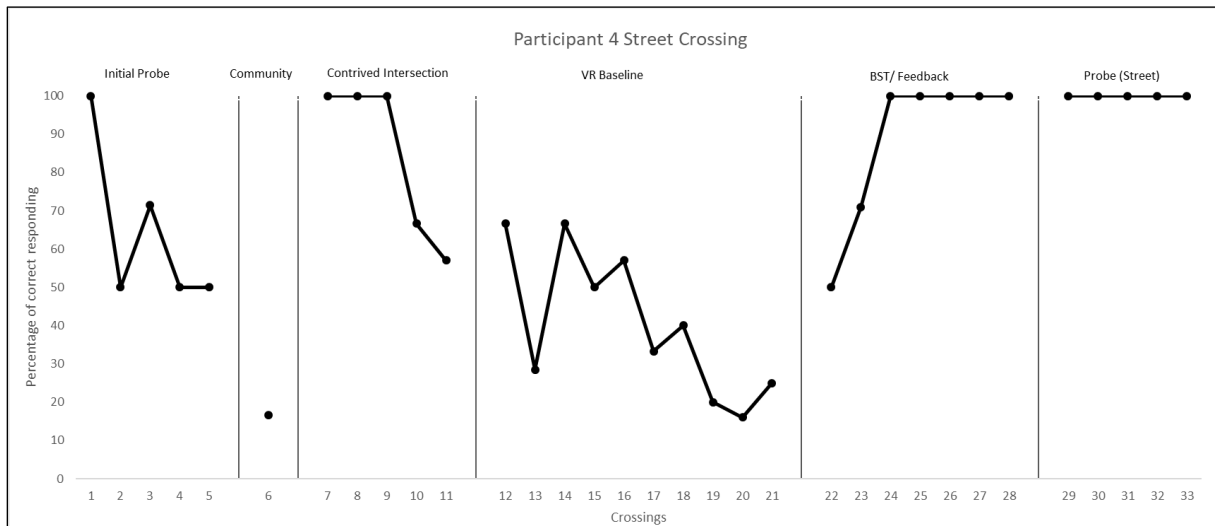


Figure 5. Participant 4 Street Crossing – Completed Full Study

The results for participant 5 are shown in Figure 6.

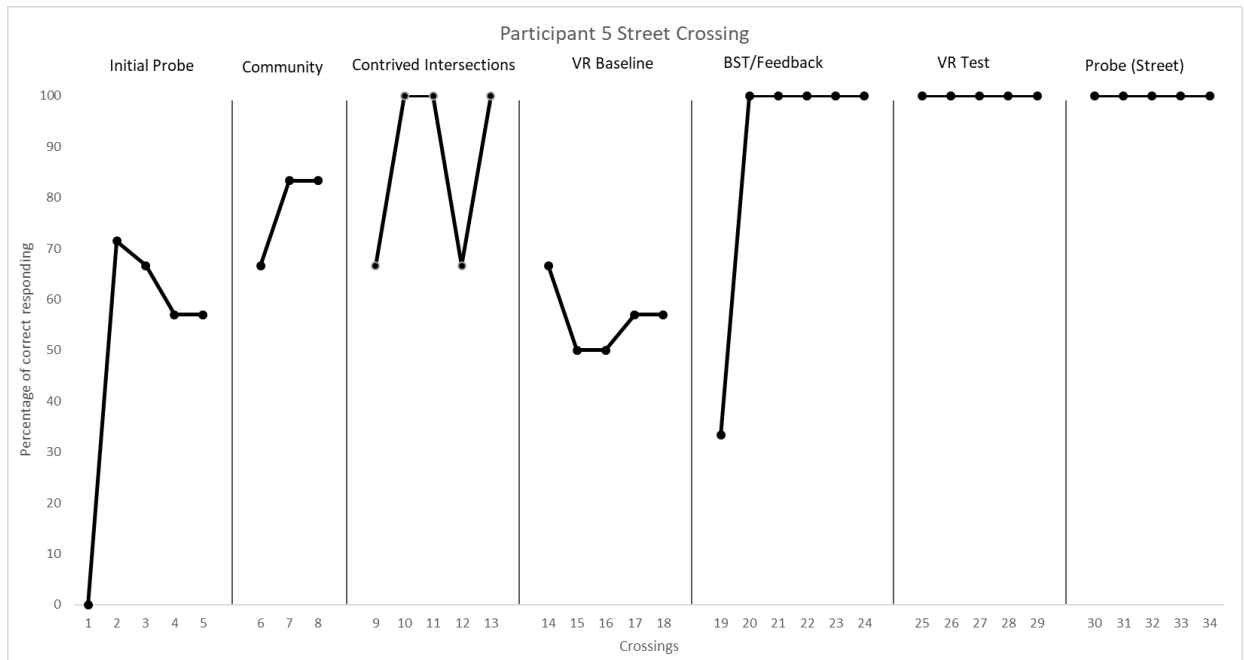


Figure 6 – Participant 5 Street Crossing – Completed Full Study

The Figures 5 and 6 show the mastering of the skills needed for the five street crossing intersection types after completing the full training program. Additionally, the results showed that two out of five of the participants mastered VR street crossing conditions and successfully generalized the skills into real life street crossing when tested in a natural street probe condition. As previously noted, Participant 2 mastered the skills after the educational program labeled as contrived intersection in the Figures 2-6. Results indicate that VR should be used when teaching pedestrian street crossing skills due to its safety and resemblance to natural settings.

Discussion

This research provides preliminary evidence that mixed reality VR can have positive outcomes in pedestrian navigation and street crossing skills. Results showed three of five participants mastered VR conditions and generalized skills in a natural setting. The study provides a model for efficiently and safely teaching pedestrian street crossing to adults with ASD. This starting the study with the foundation of a traditional educational street crossing program that provided limited results with only one of the five participants mastering the skills. But by compounding the traditional education model with the mixed reality VR as well as the BST instruction, the program produced results of 60% of all the participants in the pilot model mastering the skill acquisition and 100% of the participants that completed the full study protocol having acquired skills relatively quickly.

The research also illustrated while using VR can be extremely beneficial in skill acquisition for many there are some that have negative reactions to the technology. As one out of the five participants did not have a positive experience and therefore it did not complete the study protocols and did not acquire the necessary skill acquisition to safely navigate the community. For the segment of the population where VR is not an option, new and novel approaches to the

traditional educational model still need to be developed. It is recommended that VR averse individuals try using the virtual cave model as opposed to the headset VR model.

This project addressed the needs of the autistic community so that the mobility needs of this emerging adolescent and adult population can be more holistically addressing moving forward. This research can offer many individuals on the spectrum much needed support mechanisms to travel in their communities safely and independently, thus contributing positively to both their physical and behavioral health, as well as quality of life. It also allows for the transition to a new community through familiarization of the built and natural environment.

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