AN ASSESSMENT OF THE EFFECTIVENESS OF ROADSIDE INSTRUCTION IN

TEACHING CHILDREN WITH VISUAL IMPAIRMENTS STREET CROSSINGS

By

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CHAPTER I

INTRODUCTION

Orientation and mobility (O&M) is the label given to the area of instruction which focuses on teaching individuals who are blind and visually impaired to orient mentally and physically travel within their environments (Hill & Ponder, 1976). Frequently this instructional time involves teaching individuals who are blind or visually impaired to use tools such as a cane or optical devices. It also involves teaching individuals who are blind and visually impaired how to travel in a variety of settings such as the home, school or workplace, residential neighborhoods, and commercial settings. One of the skills this involves is street crossings (Blasch, Wiener, & Welch, 1997; Hill & Ponder, 1976; Jacobson, 1993).

The ability to cross streets safely provides more opportunities for individuals to function independently within their communities (Horner, Jones, & Williams, 1985; Mowafy & Pollack, 1995). This includes socializing; using public transportation to travel to work, activities, and services (Bart, Katz, Weiss, & Josman, 2008). The ability to travel and cross streets for business and pleasure increases individuals' functional independence (Katz et al., 2005; Naveh, Katz, & Weiss, 2000).

Street crossing is a common, but dangerous activity. In 2007, approximately 70,000 pedestrians sustained injuries due to motor vehicles (National Highway Traffic Safety Administration, 2008a). The majority of the injured pedestrians were children (National Highway Traffic Safety Administration, 2008b). This is likely because children are not as skilled at making decisions about traffic (Pitcairn & Edlmann, 2000). A broad body of research, however, has investigated the effectiveness of teaching high risk populations, children and individuals with disabilities, about street crossing.

As of 2009, 17 experimental studies were identified which pertained to teaching children street crossing, and 8 experimental studies were identified which pertained to teaching individuals with disabilities street crossing. These studies used a variety of methods to teach individuals about street crossing which included virtual reality (Bart et al., 2008; Goldsmith, 2008; McComas, MacKay, & Pivik, 2002; Thomson et al., 2005; Tolmie, Thomson, & Foot, 2002; Tolmie et al., 2005), classroom based instruction (Batu, Egenekon, Erbas, & Akmanoglu, 2004; Miller & Davis, 1984; Padgett, 1975; Page, Iwata, & Neef, 1976; Singh, 1979), roadside instruction (Blew, Schwarts, & Luce, 1985; Horner et al., 1985; Rothengatter, 1984; Thomson & Whelan, 1997; Yeaton & Bailey, 1978; Yeaton & Bailey, 1983), or a combination of these methods (Collins, Stinson, & Land, 1993; Limbourg & Gerber, 1981; Marchetti, McCartney, Drain, Hooper, & Dix, 1983; Matson, 1980; Miller, Austin, & Rohn, 2004; Thomson et al., 1992; Thomson et al., 1998; Van Schagen & Rothengatter, 1997). It is difficult, based on these studies, to discern if a specific method of instruction is more effective than another. This is primarily because the bulk of the studies compared a type of intervention to no intervention. However, based on the current literature, one could make an argument for any of these types of intervention because they all found instruction improved performance compared to no instruction. However, some evidence exists in the literature suggesting roadside instruction may be more effective than classroom-based instruction.

The three studies that only used classroom-based instruction, did find improvements over the control group. However, two of these studies measured improvement using only a written test of the participants' knowledge which indicated the participants' level of knowledge about street crossing improved but not their actual performance in crossing streets (Miller & Davis, 1984; Singh, 1979). The third study only used a classroom-based instruction and used a measure of actual street crossing ability in addition to the written assessment, but found students did not improve on the street crossing measure (Padgett, 1975). One study which used classroom-based instruction as a baseline and then implemented roadside instruction found a significant increase at the time the roadside instruction was introduced (Miller et al., 2004). Furthermore, four studies which compared roadside instruction against classroom based instruction found roadside instruction was more effective when participants were assessed with actual crossings (Collins et al., 1993; Limbourg & Gerber, 1981; Marchetti et al., 1983; Matson, 1980). Although, the majority of street crossing training with individuals who are visually impaired takes place roadside (which is supported by the above research), currently, no experimental studies were identified which examined teaching street crossing to individuals with visual impairments.

Street crossing is a chained skill with observable behaviors which are generally agreed upon to define successful street crossing. These behaviors include: stopping at the curb, looking left and right, walking at a reasonable rate across the intersection, and continuing to check for traffic while crossing. When a crosswalk was present, walking within the crosswalk lines was also a commonly required behavior (Batu et al., 2004; Collins et al., 1993; Goldsmith, 2008; Matson, 1980; McComas et al., 2002; Miller et al., 2004; Padgett, 1975; Page et al., 1976; Tolmie et al., 2002; Yeaton & Bailey, 1978; Yeaton & Bailey, 1983). Two skills unique to individuals with severe visual impairments are using auditory cues to align and cross at an appropriate time (e.g., absence of traffic or presence of a traffic gap) (Hill & Ponder, 1976).

Researchers and educators have had success teaching chained behaviors using a graduated guidance approach. Most commonly, this instructional procedure has been used with individuals with autism and other severe disabilities (Bopp, Brown, & Mirenda, 2004). Frequently this approach was used to teach individuals with severe disabilities to use alternative and augmentative communication devices (Bopp et al., 2004; Schepis, Reid, & Behrman, 1996; Wacker et al., 1990). It also has been used to teach daily living skills such as self dressing (Sisson, Kilwein, & Van Hasselt, 1988). Additionally, it has been used to modify behavior such as to promote on task behavior (Bryan & Gast, 2000) or as a consequence for inappropriate behavior (Wacker et al., 1990). Often graduated guidance was paired with positive reinforcement, and instruction traditionally began at the physical prompt level (Bryan & Gast, 2000; Schepis et al., 1996; Wacker et al., 1990).

Since evidence suggests graduated guidance is an effective way to teach chained behaviors to individuals with severe disabilities, graduated guidance with praise and verbal rehearsal was implemented to teach street crossings. However, given the participants in this study had a sensory impairment rather than severe intellectual impairments, verbal prompts were used rather than physical prompts unless the participant was in danger. The level and amount of prompts provided by the teacher was dictated by the behaviors of the student. Graduated guidance involved six steps: (a) identification of the cue for the student to respond, (b) identification of the level of prompt, (c) determination of how prompts would be faded, (d) determination of the consequences which accompanied correct and incorrect responses by the students, (e) determination of how data would be collected, and (f) tailoring the program to the student on the basis of collected data (Wolery, Ault, & Doyle, 1992).

In addition to graduated guidance, the strategy of verbal rehearsal was used. In this study, verbal rehearsal involved stating each of the steps in the chain of behaviors related to street crossing prior to performing the crossing. Some evidence suggests verbal rehearsal benefits both short (Baddeley, 1986; Bjork, 1975; Craik & Watkins, 1973; Horton, Hay, & Smyth, 2008) and long term memory (Horton et al.) as well as maintenance (Baddeley, 1981). Verbal rehearsal has been used to aid individuals in visual recall tasks (Horton et al.,; Logie, Brockmole, & Vandenbrouke, 2009), for children with learning disabilities (Kennedy & Miller, 1976; Kirchner & Klatzky, 1985; Loomes, Rasmussen, Pei, Manji, & Andrew, 2007), and to promote participant success during behavioral studies (Holcombe, Wolery, & Katzenmeyer, 1995).

In the current study, a protocol for teaching the chained behavior of street crossing using graduated guidance with verbal rehearsal prior to each crossing was evaluated. Psychophysical assessments of the ability of participants to detect gaps and align to traffic noise was conducted in an anechoic chamber. The study was then implemented using roadside instruction to determine if graduated guidance paired with verbal rehearsal was effective in teaching children with visual impairments to cross the street. Maintenance and generalization also were assessed roadside. The study attempted to answer the following questions:

Roadside Training

1. Do participants whose sole disability is legal blindness learn to cross streets accurately and safely when taught with graduated guidance and verbal rehearsal?
2. Do participants who learn to cross streets when taught with graduated guidance and verbal rehearsal maintain the skills needed to cross the street accurately and safely at intersections where they have received instruction?
3. Do participants who learn to cross streets when taught with graduated guidance and verbal rehearsal generalize skills to intersections where they have received no instruction?

Psychophysical Tests

4. Do participants improve on the psychophysical activities of alignment and gap detection after instruction compared to performance before instruction?
5. Do participants who perform better on the psychophysical activities of alignment and gap detection before instruction learn more quickly during roadside training? Since participant numbers were not sufficient to truly discern a trend, this question was exploratory in nature.

CHAPTER II

METHOD

Participants

This study involved 4 students as participants. Inclusion criteria were: (a) demonstration of concepts related to travel and street crossing (e.g., left, right, positional concepts); (b) ability to maneuver independently with a long cane (e.g., constant contact or two point touch proficiency); (c) ability to detect surface changes and drop offs, (d) legal blindness, (e) an age of less than 21 years and more than 7 years. Exclusion criteria were (a) additionally diagnosed severe disabilities, (b) prior education in street crossings, and (c) a functional hearing loss. Inclusion and exclusion criteria were measured by the principal investigator (PI), a certified orientation and mobility specialist (COMS), using portions of *TAPS: An Orientation and Mobility Curriculum for Students with Visual Impairments Comprehensive Assessment and Ongoing Evaluation* (TAPS) (Pogrund et al., 2005). Additionally, pertinent medical records, documents, and assessments were reviewed. Further, a COMS at the participants' school was interviewed regarding the potential participants' current abilities. Other demographic information such as gender and time and type of previous intervention by a COMS were recorded for descriptive purposes. None of this information played a role in inclusion or exclusion, in the study, if the participant met the previously defined inclusion and exclusion criteria. The specific measure used for each criterion is listed in Table 1.

Table 1. Inclusion and Exclusion Information: Criteria and Method of Assessment

Criteria	Method of Assessment
Inclusion	
• Demonstration of directional and positional concepts	• COMS report & TAPS
• Ability to maneuver independently (e.g., constant contact, two point touch)	• COMS report & TAPS
• Ability to detect surface changes and drop offs	• COMS report & TAPS
• Legally blind	• Ophthalmologist report
• Cane user	• COMS report
• Less than 21 years of age but more than 7 years of age	• Record review
Exclusion	
• Additional severe disabilities	• Record review
• Prior education in street crossings	• COMS report
• Functional hearing loss	• Record review including hearing screening

For the observable behaviors portion of the inclusion criteria assessment, the participants were assessed individually. Each participant began at his/her classroom on the first floor and was asked to walk to the library on the second floor. After arriving at the library, each participant was then asked to walk to the O&M office on the first floor. Each participant was then seated at a desk and given two objects (e.g., a book and a pencil). Each participant was then asked to complete a variety of tasks which demonstrated directional and positional concepts (e.g., place the pencil above the book; place the pencil (tip to eraser) parallel to the book's spine; point to your left hand; point to my left hand). The participants' performance and responses were recorded using checklists in the *TAPS* book.

The participants' usual O&M instructor was interviewed regarding each participant's (a) demonstration of concepts related to travel and street crossing (e.g., left, right, positional concepts); (b) ability to maneuver independently with a long cane (e.g., constant contact or two point touch proficiency); (c) ability to detect surface changes and drop offs; and (d) an age of less than 21 years and more than 7 years.

The O&M instructor reviewed each participant's medical records and provided information on (a) each participant's acuity, (b) results of a hearing screening for each participant, (c) the absence of additional disabilities, and (d) each participant's date of birth.

A hearing screening was performed with all the participants by an audiologist at Vanderbilt University. As a part of the hearing screening, she performed three tests which included otoscopy, tympanometry, and audiometric hearing thresholds. The otoscopy was a visual examination of the ear which looked for cerumen and visibility of the tympanic membrane. The tympanometry measured pressure of the inner ear canal. Immittance testing was completed. Normal tympanometry was defined as peak compliance of 0.3-1.4 mL and ear canal volume of 0.6-1.5 cc (Margolis & Heller, 1987). Audiometric threshold testing was completed in a double-walled, sound-treated room. Pure tones at seven frequencies ranging from 250-8000 Hz were presented to each ear individually through insert earphones using the modified Hughson-Westlake procedure (Carhart & Jerger, 1959). One participant did not tolerate the insert earphones so TDH-50 headphones were used instead. Participants raised their hands in response to audible tones presented to each ear to determine behavioral auditory thresholds.

Participant 1 was a female aged 16 years and 4 months at the beginning of data collection. She lost vision adventitiously at the age of 14 years due to a brain tumor. Her eye report listed her acuity as light perception (LP) in both eyes (OU). The student had been a cane traveler for two years and had adequate skills to travel independently in the school environment, detect surface changes and drop offs. Likewise, she demonstrated a thorough understanding of directional and positional concepts. When her hearing was assessed, the results of her otoscopy and tympanometry were normal. The audiologist also found Participant 1 had hearing thresholds that were within normal limits for all frequencies tested in both ears. The student had no additional disabilities and no prior, formal education in street crossings since her vision loss.

Participant 2 was a male aged 14 years and 10 months at the beginning of data collection. He was congenitally blind due to retinopathy of prematurity (ROP). His acuity according to the eye report was no light perception (NLP) OU. He has been a cane traveler since 5 years of age and uses the cane to travel independently in the school environment. He detects surface changes and drop offs with ease in the familiar school environment and demonstrated an adequate understanding of directional and positional concepts. When his hearing was assessed, the results of his otoscopy and tympanometry were normal. The audiologist also found Participant 2 had hearing thresholds that were within normal limits for all frequencies tested in the right ear but found a mild hearing loss from 2000 to 4000 Hz in the left ear which the audiologist determined did not meet the definition of functional hearing loss. Thresholds at all other frequencies tested were within normal limits. The student had no additional disabilities and no prior, formal education in street crossings.

Participant 3 was a female aged 20 years and 0 months at the beginning of data collection. She was congenitally blind due to optic nerve hypoplasia. Her acuity according to the eye report was NLP OU. She has been a cane traveler since 12 years of age and uses the cane to travel independently in the school environment. She detects surface changes and drop offs in the familiar school environment and demonstrated an adequate understanding of directional and positional concepts. When her hearing was assessed, the results of her otoscopy and tympanometry were normal. The audiologist also found Participant 3 had hearing thresholds that were within normal limits for all frequencies tested in both ears. The student had no additional disabilities and no prior, formal education in street crossings.

Participant 4, who served as a control and did not receive instruction, was a female aged 13 years and 11 months at the beginning of data collection. She was congenitally blind due to ROP. Her acuity according to the eye report was NLP in the right eye (OD) and LP in the left eye (OS). She has been a cane traveler since 5 years of age and uses the cane to travel independently in the school environment. She detects surface changes and drop offs easily in the familiar school environment and demonstrated an adequate understanding of directional and positional concepts. When her hearing was assessed, the otoscopy exam revealed non-impacting cerumen bilaterally. The tympanic membrane was partially visible in both ears. The tympanometry could not be completed because the participant did not tolerate it. The audiologist also found Participant 4 had a slight hearing loss in the left ear at 250 Hz rising to normal thresholds from 500 to 8000 Hz. It is possible that the slight hearing loss was due to the cerumen in the ear. The audiologist determined this did not meet the definition of a functional hearing loss. In the right ear, the audiologist found normal hearing thresholds from 250-8000 Hz. The student had no additional disabilities and no prior, formal education in street crossings. A summary of the participants appears in Table 2.

Table 2. Description of Participants

	Gender	Age	Acuity OS	Acuity OD	Reason for Loss of Vision	# of Years with Cane
Participant 1	F	16 years 4 months	LP	LP	Brain tumor	2
Participant 2	M	14 years 10 months	NLP	NLP	ROP	9
Participant 3	F	20 years 0 months	NLP	NLP	Optic Nerve Hypoplasia	8
Participant 4	F	13 years 11 months	LP	NLP	ROP	8

Note. Light perception (LP); No light perception (NLP); Retinopathy of prematurity (ROP)

Additionally, the COMS who typically taught the participants in the school setting participated as an interventionist. The bulk of instruction, however, was provided by the PI. Inclusion criteria for interventionists were: certification as an orientation and mobility specialist, access to a student who meets the inclusion criteria for the study, and willingness to participate.

The COMS who typically taught the participants in the school setting was a male with a master's degree and some doctoral work. His current status in his doctoral program is all but dissertation (ABD). He has 41 years of experience teaching O&M to students with visual impairments and is certified by the Academy for Certification of Vision Rehabilitation and Education Professionals (ACVREP).

The PI, who provided the bulk of instruction, is a female doctoral student who is ABD. She likewise obtained certification in O&M at the master's degree level. She has four years of experience teaching O&M to individuals with visual impairments and is certified by ACVREP.

Setting

Assessment for inclusion criteria took place on the students' school grounds within the school building on both the first and second floors. The psychophysical tests took place in the anechoic chamber located in the Vanderbilt University Medical Center. Data collection for probe and instructional sessions took place roadside at three intersections in Nashville, TN.

Intersections. Intersection 1 was a residential, two lane (one lane in each direction), plus-sign intersection with very little traffic. The traffic running parallel to the crossing was controlled by a stop sign. The traffic running perpendicular to the crossing had the right-of-way and did not stop. The participants were taught to cross this intersection when the intersection was “all quiet” (no traffic).

Intersection 2 was a busier, residential and very light commercial two lane (one lane in each direction), plus-sign intersection. The traffic perpendicular to the crossing flowed freely without any control. The traffic parallel to the crossing was controlled by a stop sign. Perpendicular traffic was frequent. Parallel traffic was rare. Ideally participants would have been taught to cross the intersection with the parallel traffic surge. Parallel traffic, however, was unreliable, so this intersection likewise became an instance where the participants were expected to cross when the intersection was all quiet.

Intersection 3 was a residential, two lane (one lane in each direction), plus-sign intersection with light to moderate traffic levels. Parallel and perpendicular traffic were controlled with stop signs (4-way stop).

Materials

A video recording of the PI teaching a sighted but blindfolded adult to cross the street using a cane was used to train the second observer and the interventionist. Sessions were video recorded using a handheld digital video recorder with a built in microphone. Students were allowed to use their personal long canes.

Response Definitions and Measurement

Response definitions. The behaviors measured in verbal rehearsal and street crossing included: finding the curb with the cane, stepping up to it, lining up for the crossing, taking one step back, sweeping the area in front of the feet with the cane, holding the cane in the “ready position” (diagonal), describing the parallel and perpendicular traffic and how each were controlled, identifying a sufficient gap in traffic for the crossing, walking quickly, walking without veering, finding the opposite curb, and stepping out of the street. This list of behaviors was compiled from O&M textbooks (Hill & Ponder, 1976; Jacobson, 1993). See Tables 3 and 4 for operational definitions with examples and nonexamples of each.

Operationalizing street crossing times. To measure accurately the behavior of students crossing the street at a slightly elevated pace, the slightly elevated pace needed to be operationalized. This was done primarily by locating a two lane, stop sign controlled intersection comparable to the ones used for teaching the participants to cross the street during data collection. Fifteen people were timed as they crossed the street. Timing started as soon as the individual's first foot left the curb, and timing ended as soon as the individual's second foot stepped onto the destination curb. The average crossing time for the intersection was 9.58 seconds. The range was 8.03 secs to 11.6 seconds. All of these crossings seemed reasonable and in line with the finding that the average middle school student walks at a rate of about 2.5 ft per second (Schulze, 2006) and the average two lane road is approximately 25 ft (Trailnet, 2009). With this information in mind, the range for an acceptable pace was rounded to 8 to 12 seconds.

Measurement procedures. All roadside sessions were video recorded by an adult who was present in addition to the interventionist and the students. These videos were later coded based on the operationalized definitions, examples, and nonexamples listed in Tables 3 and 4. The videos were coded by watching both the verbal rehearsal and the crossing and marking each behavior listed on the checklist in one of six ways. The step was coded as unprompted correct if the participant performed the behavior independently. The step was coded as prompted correct if a brief, general verbal prompt

Table 3. Responses for Verbal Rehearsal Component

Behavior: What participant should describe	
Examples	Non Examples
Touch curb edge with cane: When exploring with the cane, participant touches tip of cane to the edge of the sidewalk/curb.	
• I find the curb. • I touch the curb with my cane.	• I step over the curb. • I find the curb with my foot.
Move to be one step from curb: After finding the edge of the curb with cane, participant moves toes to the edge of the curb and takes one step back.	
• I stand near the curb. • I find the curb and take one step back.	• I stand with my toes over the curb. • I stand with my toes at the curb.
Sweep edge of curb with cane: Participant moves the cane in a circular or "s-shaped" motion on the ground in front of the curb.	
• I sweep my cane. • I move my cane in front of the curb. • I do a circle with my cane. • I make an "s" with my cane.	• I keep my cane on the curb. • I run my cane along the edge of the curb but not in the street.
Align with crosswalk: Participant makes sure head, shoulders, hips, and feet are facing the opposite curb.	
• I get lined up. • I make sure I'm facing the right way.	• It doesn't matter how I stand. • I make sure my head only is facing the opposite curb.
Cane in ready position: Cane is held at a diagonal across the body, with the tip on the curb in front of feet or in the street up against the curb.	
• I hold my cane in diagonal. • I get my cane ready. • I hold my cane across my body.	• I hold my cane at my side.

Table 3, Continued

Describe traffic: Participant describes the parallel and perpendicular traffic as well as how the intersection in controlled.		
	• There are stop signs. • The parallel traffic keeps moving-no stop sign. • There is no parallel or perpendicular traffic	• Participant says the intersection is lighted. • Participant does not describe parallel and perpendicular traffic. • Participant describes an inaccurate traffic pattern.
Starts to walk in sufficient gap: Participant walks during a gap in traffic that is at least 12 seconds long.		
	• I walk when there aren't cars coming. • I walk when it's safe.	• I walk when I hear a car coming but I think I can walk faster.
Walks without stepping outside of crosswalk/chalk lines: Participant walks in a straight trajectory toward the opposite curb.		
	• I walk without veering. • I walk in a straight line toward the curb.	• I find the diagonal curb. • I walk in a zig zag pattern.
Walks quickly: The time from the moment the first foot leaves the curb to the moment the second foot steps up onto the opposite curb is 8 to 12 seconds.		
	• I walk fast. • I walk quickly but don't run.	• I stroll across the intersection. • I run as fast as I can across the intersection.
Touch target curb with cane: Participant touches cane tip to opposite curb.		
	• I find the opposite curb. • I find the curb with my cane.	• I find the opposite curb with my cane.
Steps out of street: Participant moves both feet from the street up onto the curb, grass, or sidewalk where they will not be in danger of traffic.		
	• I step up. • I get out of the road. • I step onto the opposite curb.	• I stop when I find the curb. • I use my cane to trail along the curb.

Table 4. Responses for Street Crossing

Behavior: Definition	
Examples	Nonexamples
Touch curb edge with cane: When exploring with the cane, participant touches tip of cane to the edge of the sidewalk/curb.	
• Participant explores sidewalk and locates curb edge with cane.	• Participant finds curb edge with foot (and does not move cane back to find it). • Participant steps over curb edge (and does not move back to find it with cane).
Move to be one step from curb: After finding the edge of the curb with cane, participant moves toes to the edge of the curb and takes one step back.	
• Participant moves toes to approximately the edge of curb and takes one step back.	• Participant stands with toes overlapping curb. • Participant stands more than one step from curb. • Participant does not step up to the edge of the curb.
Sweep edge of curb with cane: Participant moves the cane in a circular or “s-shaped” motion on the ground in front of the curb.	
• Participant circles the cane in the street in front of the curb. • Participant makes and “s” with the cane in front of the curb.	• Participant moves the cane on the sidewalk but not the street. • Participant touches street with cane but does not make any searching motion.

Table 4, continued

Align with crosswalk: Participant makes sure head, shoulders, hips, and feet are facing the opposite curb.	• Various body parts in the definition are facing the curb to which the Participant is intending to walk.	• Participant’s feet are facing in a direction other than the opposite curb. • Participant’s head is facing the opposite curb.
Cane in ready position: Cane is held at a diagonal across the body, with the tip on the curb in front of feet or in the street up against the curb.	• Cane covers the participant’s body (from one shoulder to the opposite foot) and the tip is resting in the street up against the curb. • Cane covers the participant’s body (from one shoulder to the opposite foot) and the tip is resting on the sidewalk in front of the participant’s foot.	• Cane is straight up and down, not crossing the participant’s body. • The cane is extended into the street (not with the tip against the curb). • Cane is resting at participant’s side
Describe traffic: Participant describes the parallel and perpendicular traffic as well as how the intersection in controlled.	• There are stop signs. • The parallel traffic keeps moving-no stop sign. • There is no parallel or perpendicular traffic.	• Participant says the intersection is lighted. • Participant does not describe parallel and perpendicular traffic. • Participant describes and inaccurate traffic pattern.

Table 4, continued

Starts to walk in sufficient gap: Participant walks during a gap in traffic that is at least 12 seconds long.	• Participant walks when there are no cars. • Participant walks at a four way stop when the parallel traffic surges from the stop sign and there is no perpendicular traffic moving into the intersection.	• Participant walks when the gap in traffic is less than 12 seconds long. • Participant steps in front of oncoming traffic. • Participant waits when a gap in traffic is longer than 12 seconds.
Walks without stepping outside of crosswalk/chalk lines: Participant walks in a straight trajectory toward the opposite curb.	• Participant walks with both feet in the crosswalk or chalk lines. • Participant walks in a path that leads directly to the opposite curb (in the absence of crosswalk or chalk lines).	• Participant steps one or both feet outside the crosswalk or chalk lines. • Participant walks in a path that leads to a spot on the opposite sidewalk that is not the opposite curb. • Participant crosses intersection to diagonal curb.
Walks quickly: The time from the moment the first foot leaves the curb to the moment the second foot steps up onto the opposite curb is 7 to 12 seconds.	• The time for the participant to leave one curb and arrive at the opposite curb is less than 12 seconds.	• The time for the participant to leave one curb and arrive at the opposite curb is more than 12 seconds.

Table 4, continued

Touch target curb with cane: Participant touches cane tip to opposite curb.		
	• Participant finds opposite curb with cane.	• Participant does not find opposite curb (continues walking down the street). • Participant trips over opposite curb because it was not located with cane.
Steps out of street: Participant moves both feet from the street up onto the curb, grass, or sidewalk where they will not be in danger of traffic.		
	• Participant moves both feet out of the street.	• Participant does not move out of the street. • Participant continues trailing along the curb, sidewalk, or street

was given and the student performed the behavior correctly (e.g., interventionist asks, "What about traffic," and the student describes). The step was coded as unprompted incorrect if the participant performed the step incorrectly but was not given correction. The step was coded as prompted incorrect, if the participant performed the behavior incorrectly and received a prompt (e.g., participant veers to the left; interventionist says, "You're veering to your left"). The step was coded as unprompted no response if the participant did not complete the step and did not receive a prompt. The step was coded as prompted no response if the participant was prompted and still failed to respond (e.g., the interventionist prompts, "Tell me about traffic," and the participant does not respond). Multiple opportunity probes were used so the participant always had the opportunity to complete each step of the chain of behaviors even if an error occurred early in the chain.

Inter-observer agreement (IOA). Observations were performed by the PI, a doctoral student at Vanderbilt University and a COMS, and another doctoral student in special education at Vanderbilt University. After receiving a copy of the protocol and definitions of the desired behaviors with examples and nonexamples, the observers trained using the same video that was used for training the interventionist.

Interobserver agreement (IOA) was measured by comparing recorded frequencies using a point by point approach (Ayres & Gast, 2010). IOA was calculated using the formula agreements / agreements + disagreements x 100. The PI decided that IOA would be collected on a minimum of 25% of the total sessions.

In the first and second probe conditions, IOA was collected for 33.3% of sessions for all four participants. In the third probe condition, IOA was collected for 33.3% of the sessions for Participant 1 and 66.6% of the sessions for the other three participants. Participant 1 did not participate in a fourth probe condition, but IOA was collected for 33.3% of the sessions for the remaining three participants. During instruction at the first intersection, IOA was collected for 28.6% of the sessions for Participant 1 and 2. For Participant 3, IOA was collected for 36.4% of the instructional sessions at the first intersection. Only Participants 1 and 2 received instruction at the second intersection. For participant 1, IOA was collected for 27.3% of the instructional sessions at the second intersection. For Participant 2, IOA was collected during 40% of the instructional sessions at the second intersection. See Table 5 for information on IOA data and ranges.

In the first probe condition, IOA was 92.9% for Participant 1, 95.2% for Participants 2 and 3, and 97.6% for Participant 4. In the second probe condition, IOA was 92.9% for Participant 1, 97.6% for Participant 2, 88.1% for Participant 3, and 90.8% for Participant 4. In the third probe condition, IOA was 90.5% for Participant 1, 96.4% for Participant 2, 97.6% for Participant 3, and 95.2% for Participant 4. A fourth probe condition was not appropriate for Participant 1. In the forth probe condition, IOA was

Table 5. Percentage of IOA by Experimental Condition and Participant

	Probe 1	Instruction 1	Probe 2	Instruction 2	Probe 3	Probe 4
Participant 1 % of agreement Range (% of sessions measured)	92.9 92.9 – 92.9 (33.3)	100 100 - 100 (28.6)	92.9 92.9 – 92.9 (33.3)	100 100 - 100 (27.3)	90.5 90.5 – 90.5 (33.3)	N/A
Participant 2 % of agreement Range (% of sessions measured)	95.2 95.2 – 95.2 (33.3)	100 100 - 100 (28.5)	97.6 95.2 - 100 (50)	100 100 - 100 (40)	96.4 95.2 – 97.6 (66.7)	92.9 95.2 – 95.2 (33.3)
Participant 3 % of agreement Range (% of sessions measured)	95.2 95.2 – 95.2 (33.3)	98.8 92.9 - 100 (36.4)	88.1 88.1 – 88.1 (33.3)	N/A	97.6 95.2 - 100 (66.7)	95.2 95.2 – 95.2 (33.3)
Participant 4 % of agreement Range (% of sessions measured)	97.6 97.6 – 97.6 (33.3)	N/A	90.8 90.8 – 90.8 (33.3)	N/A	95.2 92.9 - 100 (66.7)	95.2 95.2 – 95.2 (33.3)

92.9% for Participant 2, 95.2% for Participants 3 and 4. In the instructional condition at the first intersection, IOA was 100% for Participants 1 and 2 and 98.8% for Participant 3. Participant 4 did not receive instruction at the first intersection. In the instructional condition at the second intersection, IOA for Participants 1 and 2 was 100%. Participants

3 and 4 did not receive instruction at the second and third intersections. These data with ranges are shown in Table 5.

Procedural fidelity. Similarly, procedural fidelity was measured using a checklist of behaviors for both verbal rehearsal and the crossing. In both verbal rehearsal and during the crossing, the coder marked if each step was addressed and whether praise or a prompt was delivered because one or the other should have been delivered for each step depending on participant performance. If the student performed the behavior correctly, praise for that step should have been delivered. If it was not, that was considered a procedural error. If the student omitted a step or performed it incorrectly, a prompt should have been given. If it was not, this also was considered a procedural error.

Procedural fidelity was calculated by adding the number of steps addressed and the number of correctly given prompts and praise and then divided by the total number of steps which should have been addressed using either prompts or praise. This resulted in a percentage of interventionist behaviors implemented with fidelity. When total procedural fidelity fell below 90% for any tier, the study was halted and the interventionist was retrained using video recordings. Procedural fidelity was collected on a minimum of 33% of the total sessions. IOA was not measured for procedural fidelity data collection.

Procedural fidelity data were collected for a minimum of 33.3% of each probe condition for each of the four participants. Participant 1 did not participate in a fourth probe condition, but procedural fidelity data were collected for 33.3% of the sessions for the remaining three participants. During instruction at the first intersection, procedural fidelity data were collected for 42.9% of the sessions for Participant 1 and 2. For Participant 3, procedural fidelity data were collected for 45.5% of the instructional sessions at intersection 1. Only Participants 1 and 2 received instruction at the second intersection. For Participant 1, procedural fidelity data were collected for 36.4% of the instructional sessions at the second intersection. For Participant 2, procedural fidelity data were collected during 40% of the instructional sessions at the second intersection. See Table 6 for information on procedural fidelity data and ranges.

In the first and second probe conditions, correct implementation occurred at 100% for all participants. In the third probe condition, procedural fidelity was 98.2% for Participant 2, and 100% for Participants 1, 3, and 4. A fourth probe condition was not appropriate for Participant 1 because she only participated in one probe condition before beginning instruction at the first intersection. Participants 2 and 3 participated respectively in two and three probe conditions before beginning instruction at the first intersection. In the fourth probe condition, procedural fidelity was 100% for Participants 2, 3, and 4.

In the instructional condition at the first intersection with Participant 1, procedural fidelity was 87.7% for verbal rehearsal and 92.6% for the crossing. In the instructional condition at the second intersection, procedural fidelity for Participant 1 was 73.2% during verbal rehearsal and 78.7% during the crossing. At the first intersection with Participant 2, procedural fidelity was 61.1% for verbal rehearsal and 69.1% for the crossing. In the instructional condition at the second intersection, procedural fidelity for Participant 2 was 98.8% during verbal rehearsal and 100% during the crossing. During instruction at the first intersection with Participant 3, procedural fidelity was 98.5% during verbal rehearsal and 100% during the crossing. Participant 3 did not receive

Table 6. Procedural Fidelity: Percentage of Correct Implementation by Condition and Participant

	Probe 1	Instruction 1		Probe 2	Instruction 2		Probe 3	Probe 4
	C	VR	C	C	VR	C	C	C
Participant 1								
% of agreement	100	87.7	92.6	100	73.2	78.7	100	
Range	100-100	74.1-100	88.9-100	100-100	40.7–100	14.8–100	100-100	NA
(% of sessions measured for PF)	(33.3)	(42.9)	(42.9)	(33.3)	(36.4)	(36.4)	(33.3)	
Participant 2								
% of agreement	100	61.1	69.1	100	98.8	100	98.2	100
Range	100-100	0-97.5	14.8-100	100-100	97.5-100	100-100	98.2–98.2	100-100
(% of sessions measured for PF)	(33.3)	(42.9)	(42.9)	(33.3)	(40)	(40)	(33.3)	(33.3)
Participant 3								
% of agreement	100	98.5	100	100			100	100
Range	100-100	92.6-100	100-100	100-100	NA	NA	100-100	100-100
(% of sessions measured for PF)	(33.3)	(45.5)	(45.5)	(33.3)			(33.3)	(33.3)
Participant 4								
% of agreement	100			100			100	100
Range	100-100	NA	NA	100-100	NA	NA	100-100	100-100
(% of sessions measured for PF)	(33.3)			(33.3)			(33.3)	(33.3)

Note. Verbal rehearsal is abbreviated VR. Crossing is abbreviated C. Verbal Rehearsal was not used during probes; therefore, procedural fidelity is not reported.

instruction at the second intersection. Participant 4 did not receive instruction. See Table 6 for procedural fidelity data and ranges.

There were two sessions when the procedural fidelity fell below the minimum of 90% when the PI was providing instruction at the first intersection with Participant 1. When this was noted, the videos were reviewed to double check which portions of the procedure had been violated. In most cases, the problem was a lack of praise after correctly executed behaviors. The protocol was reviewed, and procedural fidelity with the PI returned to acceptable levels. The other COMS only proved instruction on one day. This instruction was with Participant 1 at the second intersection and Participant 2 at the first intersection. Procedural fidelity levels were unacceptably low that day: 40.7% during verbal rehearsal and 14.8% during the crossing for Participant 1 and 0% during verbal rehearsal and 14.8% during the crossing for Participant 2. The instructor provided virtually no praise or prompts during the crossing. The COMS did not provide any further instruction during data collection, so he was not retrained on the protocol. If it had been necessary for him to provide further instruction, he would have been retrained before this was permitted.

Experimental Design

A multiple probe design across participants and replicated across settings (intersections) was used to assess the effectiveness of verbal rehearsal plus a graduated guidance approach to the roadside instruction of intersection crossings. Staggered entry of participants also was employed as a means of retaining experimental control in case participants generalized instruction at the first intersection to the second and third intersections. One of the primary benefits of a multiple probe design is that withdrawal of the intervention is not necessary to establish experimental control (Kennedy, 2005). Street crossing is not generally a readily reversible behavior; once an individual has acquired the behaviors for a specific type of intersection, the individual usually continues to engage in those behaviors. Furthermore, this design allows researchers multiple opportunities to assess if the participant has learned skills necessary for performing each street crossing before it is taught and allows for periodic assessment of maintenance and generalization (Kennedy).

Procedures

Interventionist training. The interventionist was trained in how to use verbal rehearsal and graduated guidance to teach street crossing to participants. First the interventionist was provided with a written description of the protocol and was given two days to read it. After two days had passed, the interventionist met with the PI. At this time, the PI reviewed major points of the protocol with the interventionist and answered questions. The PI read through the vignette with the interventionist and showed video recorded examples of using graduated guidance to teach street crossing, pointing out each step in the chain of the video recorded individual's behaviors as well as verbal rehearsal, prompts, praise, and correction. This required two viewings of the recordings. The first viewing focused on pointing out the behaviors. The second viewing focused on rehearsal, prompting, and praise. The interventionist then had the opportunity to ask questions and express concerns which were addressed by the PI. This meant both the PI and the cooperating interventionist were trained on the protocol; however, the PI provided the majority of instruction.

Psychophysical test procedures. Primarily, this portion of the assessment was used to assess the participants' ability to detect gaps in traffic and to align to traffic using auditory cues in an anechoic chamber. In both tests, the room was arranged so a chair was situated in the middle of the chamber. The participant sat in this chair. Speakers were suspended from the ceiling 360 degrees around the participant.

The participants' ability to detect gaps in traffic using auditory cues was tested by the simulated sounds of two pairs of cars passing in succession. The first two simulated cars passed by the participant. A pause followed the first two simulated cars, then the second pair of simulated cars passed by the participant. The participant then indicated if the gap between the first and second car was larger or if the gap between the third and fourth car was larger. The PI entered the participants' responses using a binary keypad which was recorded by the computer running the simulation program. Half of the sessions were checked for IOA by a second coder who recorded the participants' responses using pencil and paper.

The participants' ability to align to traffic was measured by a simulated car traveling past the participant at a velocity of 10 to 15 mph. The velocity was randomly varied to simulate real traffic situations. The distance the car traveled, however, was equidistant on both sides of the participant. The direction the simulated car traveled varied randomly (left to right or right to left) just as traffic would travel from both directions in a real traffic situation, but the onset point of the vehicles remained the same, as it would in a real traffic situation. The point of onset was retained as constant because it was considered to be an important cue in a real life situation, so it seemed to be a logical cue to retain in the lab setting.

The simulated car sound was emitted so that the participant would have to turn to the left or right to make the car pass in front of him/her. This was meant to simulate the action of the participant if the participant was standing at the curb of an intersection and lining up to face perpendicular traffic directly to make a crossing. In the alignment task, after the participant heard each sound, they were asked to say “right” or “left” or point to indicate the direction they would turn to. None of the participants both stated their answer verbally and pointed, so there was never a discrepancy within the participant’s answer. The PI then entered the participants’ responses using a binary keypad which was recorded by the computer running the simulation program. Half of the sessions were checked for IOA by a second coder who recorded the participants’ responses using pencil and paper.

A set number of trials was not used for these tasks. The simulation program was designed using a “two-up, one-down” model. Each time the participant responded correctly to two consecutive trials, the task got more difficult. In the case of the gap detection task, the disparity in the gaps was decreased so it was more difficult to discern which gap was longer. In the case of the alignment task, the degree of deviation from perpendicular to the participant was made smaller which made it more difficult to discern which direction the participant should turn to align to the traffic. Each time the participant responded incorrectly to one trial, the task became easier. In the case of the gap detection task, the disparity in the gaps was increased so it was easier to discern which gap was longer. In the case of the alignment task, the degree of deviation from perpendicular to the participant was made larger which made it less difficult to discern which direction the participant should turn to align to the traffic. Using this model, a threshold, or a geometric mean, was determined for each participant based on the number of reversals. A maximum and minimum length of gap in which each participant could accurately choose the proper gap for crossing was determined. A maximum and minimum deviation from parallel in which each participant could accurately align so the passing traffic would be perpendicular was determined.

Probe procedures. In this study, participants were assessed on all three intersections before and after each phase of instruction. The probe procedures were similar to the instructional procedures except no verbal rehearsal or graduated guidance occurred. The interventionist guided the student to the intersection and asked the participant to cross the street. The interventionist did not provide any orientation to the intersection, instruction, or feedback before, during, or after the crossing. The only time the interventionist intervened was in cases when the participant made a decision which was considered unsafe (e.g., stepping in front of a car, veering so that the target curb was missed and subsequently walking in the middle of a parallel street). Unless the crossing became unsafe, the participant was assessed using multiple opportunity probes rather than single opportunity probes. The participant was allowed to complete the entire crossing even if an error was made early in the chain of the behavior. When the crossing was complete, the interventionist thanked the participant. During the probe condition, all three intersections were assessed in a single day with one trial per intersection. This continued for a minimum of three sessions.

Intervention procedures. Each session began with verbal rehearsal of the steps involved in safe, successful street crossing. In the initial session at the first intersection, the interventionist described each step to the participant. A description of the steps is found in Table 3. In subsequent sessions, the interventionist asked the participant to describe each step he/she was going to perform before beginning the crossing. Each time the participant stated the correct step in a logical order, the interventionist praised the student (e.g., "good," "correct"). If the participant made an error, the interventionist corrected the student by stopping the student and providing a verbal prompt as necessary. (e.g., "What information are you going to tell me about the traffic?"). Verbal rehearsal was conducted before each crossing.

After verbally rehearsing the steps of successful street crossing, the interventionist indicated the participant could begin the crossing by saying something to the effect of, "Let me see you do everything you just told me." The initial session at the first intersection was taught using full verbal prompting by the interventionist. The interventionist verbally guided the student through each step of the crossing by, for example saying, "Find the curb with your cane. Good. Now step up to it. Good." After the initial session at the first intersection in which each step was prompted, the interventionist told the participant to begin the crossing and allowed the participant to perform the crossing. As long as the participant performed the behaviors correctly and in the correct sequence, the interventionist delivered brief verbal praise (e.g., "good," "nice job," "correct") and allowed the participant to continue. If the participant made an error (e.g., forgot to describe the traffic), the interventionist immediately intervened by verbally correcting the student (e.g., "Be sure to tell me about traffic"). All prompts began as verbal prompts; however, physical prompts were used if the participant did not successfully complete the behavior with only a verbal prompt (e.g., did not understand how to sweep the cane correctly) or if the participant was in danger. After the initial session, prompts were only given if the participant paused or made an error. Three trials, crossings, were completed during each session.

To teach street crossing, the interventionists used the behavioral technique, graduated guidance, which uses a system of most to least prompts to encourage the participants to acquire the ability to perform the behaviors independently. Graduated guidance has often been used to teach chained behaviors, however, the primary method of prompting in these studies has been physical prompting (Bryan & Gast, 2000; Schepis et al., 1996; Wacker et al., 1990). The primary prompting level for this study was verbal prompting with physical prompts used only if the student did not understand the required behavior with a verbal prompt or if the participant made an unsafe choice and needed to be physically restrained (e.g., physically stopped from moving into the street when a car was coming).

Changing phases. In the probe conditions, the interventionist assessed each participant's ability at each of three intersections. Each of the three intersections were assessed, and at least three data points were required with minimal celeration or a counter therapeutic trend before instruction could begin on the first intersection. This was done to document the participants did not perform the behaviors required to cross the intersections independently prior to instruction. When at least three data points had been gathered for all three intersections, intervention began at the first intersection with Participant 1.

The intervention phase continued with Participant 1 until criterion level performance was established. Criterion performance was completing each step of the chained skill with 100% accuracy during three trials per session in three consecutive sessions. When the participant achieved criterion at the first intersection, a probe condition of all three intersections with all participants was repeated. In the second probe condition, at least three data points were required at each of the three intersections for all participants. Intervention then began on the second intersection for Participant 1, and instruction began at the first intersection for Participant 2. When criterion was reached during instruction at the first and second participants' respective intersections, a third probe condition was conducted with all participants at all intersections. A minimum of three probe sessions were conducted at each intersection for each participant. The third intersection was only used to assess generalization, so after the third probe condition, Participant 1 was exited from the study. Participant 2 began instruction at the second intersection; and Participant 3 began instruction at the first intersection. When criterion was reached during instruction at the first three participants' respective intersections, a fourth probe condition was conducted with Participants 2, 3, and 4 at all intersections. Participant 2 was exited from the study when he completed instruction at the first two intersections and was measured for generalization at the third intersection. Due to school closure because of severe flooding during the data collection, no time existed for Participant 3 to receive instruction at the second intersection or for Participant 4 to receive instruction on any of the intersections. For this reason, the fourth participant served as a control in the experiment; she will receive instruction on street crossing from her school's COMS at a later time.

CHAPTER III

RESULTS

Acquisition of First Intersection

Although this study was a multiple probe design across participants and replicated across settings (intersections), staggered entry of participants was used to demonstrate experimental control. Experimental control is demonstrated at the first intersection by the student behaviors during the baseline and instructional phases. The chained behavior of street crossing was broken down into 14 steps. The percentage of steps completed correctly during each crossing at the first intersection is shown in Figure 1.

In baseline, Participant 1's correct performance was low (mean of 40.5%) and stable (range of 35.7 to 42.9%). During the instructional phase at the first intersection, the mean abruptly increased to 91.2% (range of 76.2 to 100%). She first performed all the steps of the chain correctly without prompts during the fifth session and met criterion during the seventh session.

Participant 2's performance prior to instruction was likewise low (mean of 29.8%) and stable (range of 21.4 to 35.7%). During instruction at the first intersection, the mean increased dramatically to 95.2% (range of 88.1 to 100%). He first performed 100% of the steps of the chain correctly without prompts during the fifth session and met criterion during the seventh session of instruction.

In baseline, the mean percentage of steps completed correctly by Participant 3 at the first intersection was also low (25.4%) and relatively stable (range of 7.1 to 35.7%).

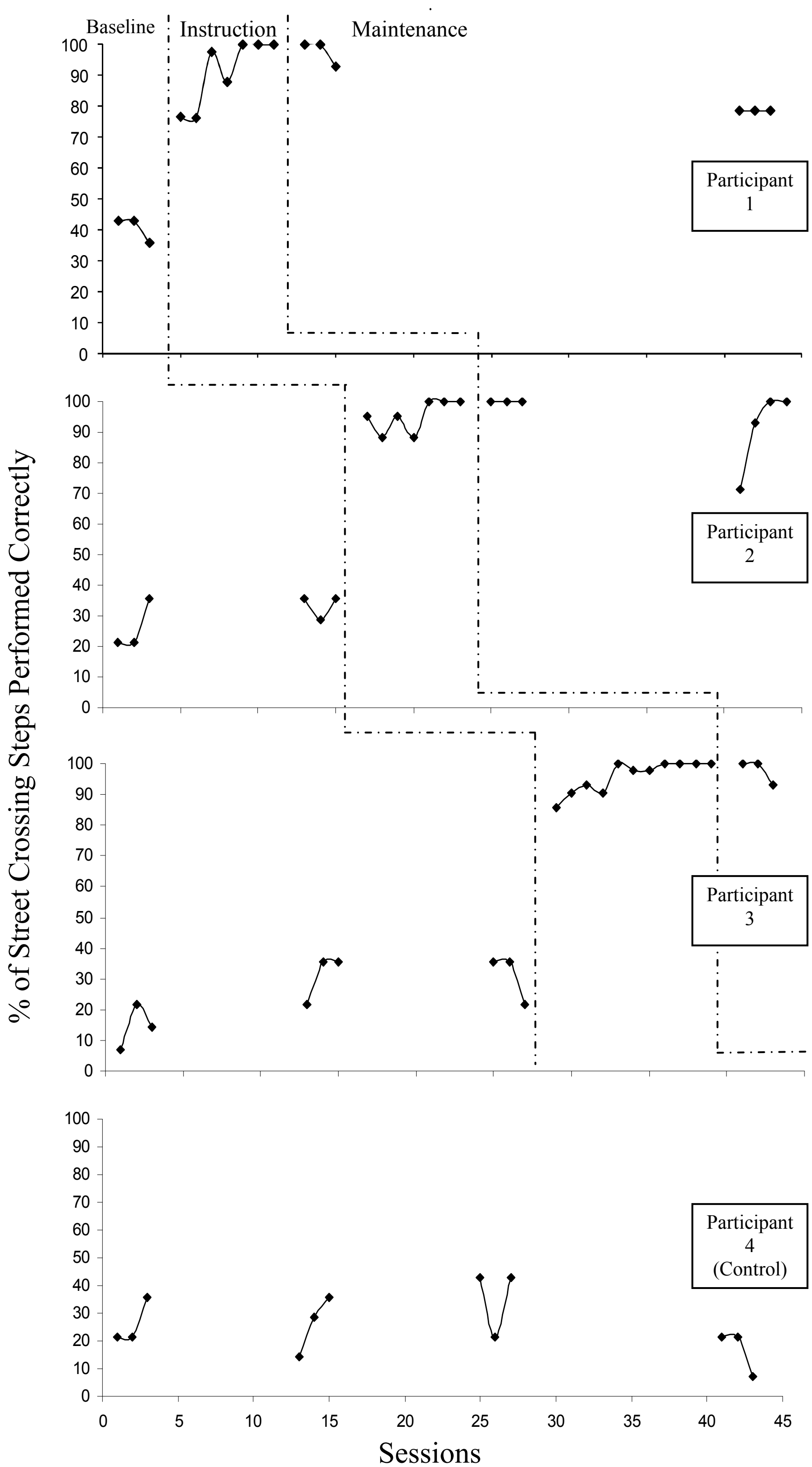


Figure 1. Experimental Control: Intersection 1

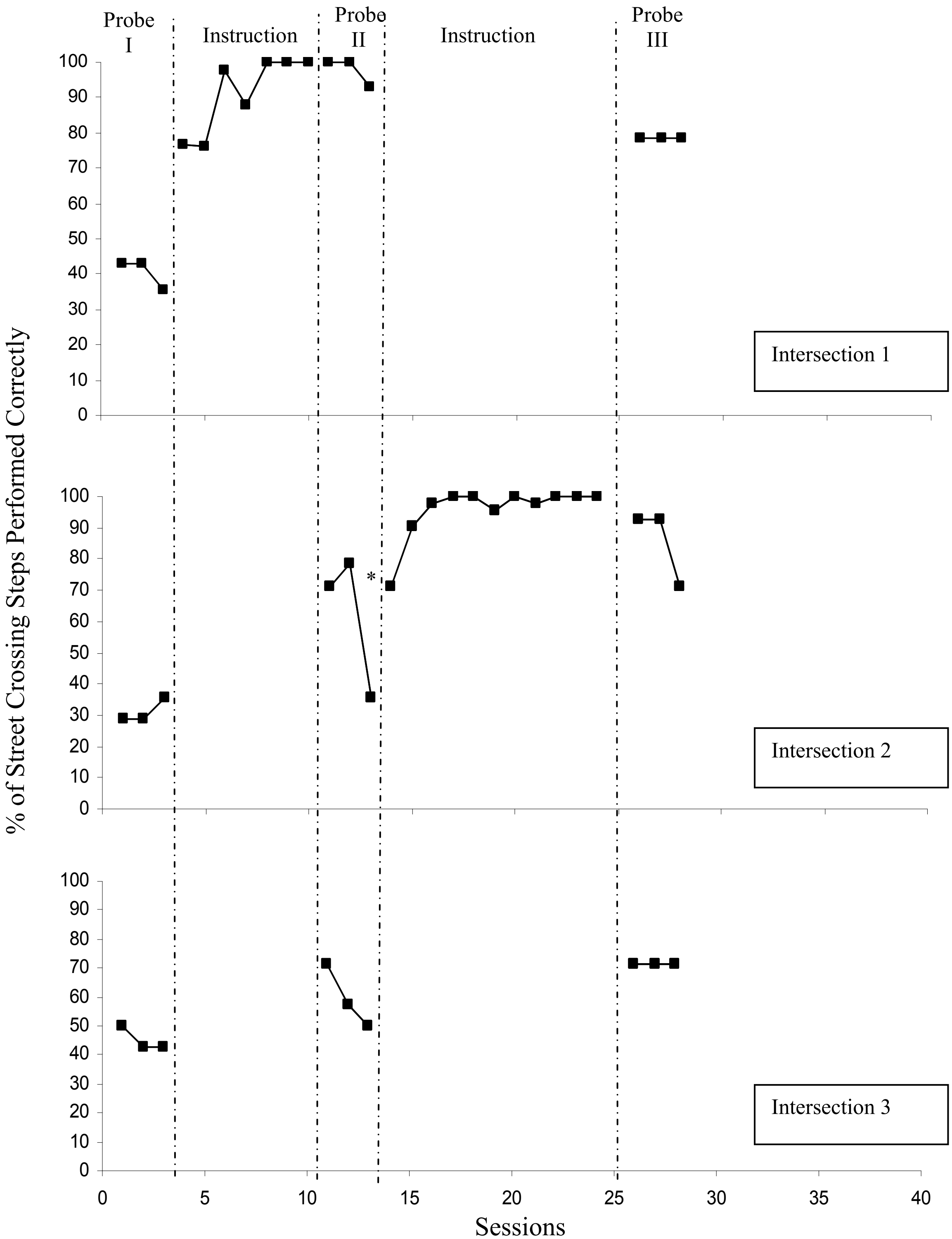
Once instruction at the first intersection began, Participant 3's mean abruptly increased to 95.9% (range of 85.7 to 100%). She first performed the steps of the chain 100% correctly without prompts in the fifth session. After meeting criterion the first time, however, she had two sessions which involved errors. Therefore, Participant 3 did not reach criterion until the tenth session.

Participant 4 participated as a control and remained in baseline throughout the study. At the first intersection her mean percentage of correctly completed steps involved in the crossing was low (26.2%). There was some inconsistency, but performance never neared the other participants' performance levels during instruction (range of 7.1 to 42.9%).

The percentage of nonoverlapping data (PND) from baseline to instruction was 100% across all participants who experienced instruction. Given the noticeable increase as each participant moved from baseline to instruction, the lack of noticeable increase for Participant 4, and the lack of overlapping data, it is highly likely the increase in the percentage of correctly completed steps during intervention occurred because of the instruction rather than happening by chance, due to exposure, or due to maturation or a history event.

Performance at Subsequent Intersections

Time to acquire. Figure 2 provides a graphical depiction of Participant 1's performance. Similar to the patterns described at the first intersection, Participants 1 showed marked improvement after instruction at the second intersection. During the first probe at the second intersection, prior to any instruction, Participant 1's performance was low and steady (mean = 31%; range of 28.6 to35.7%). During the second probe at the



Note. * indicates low procedural fidelity for the data point to the right of the asterisk.

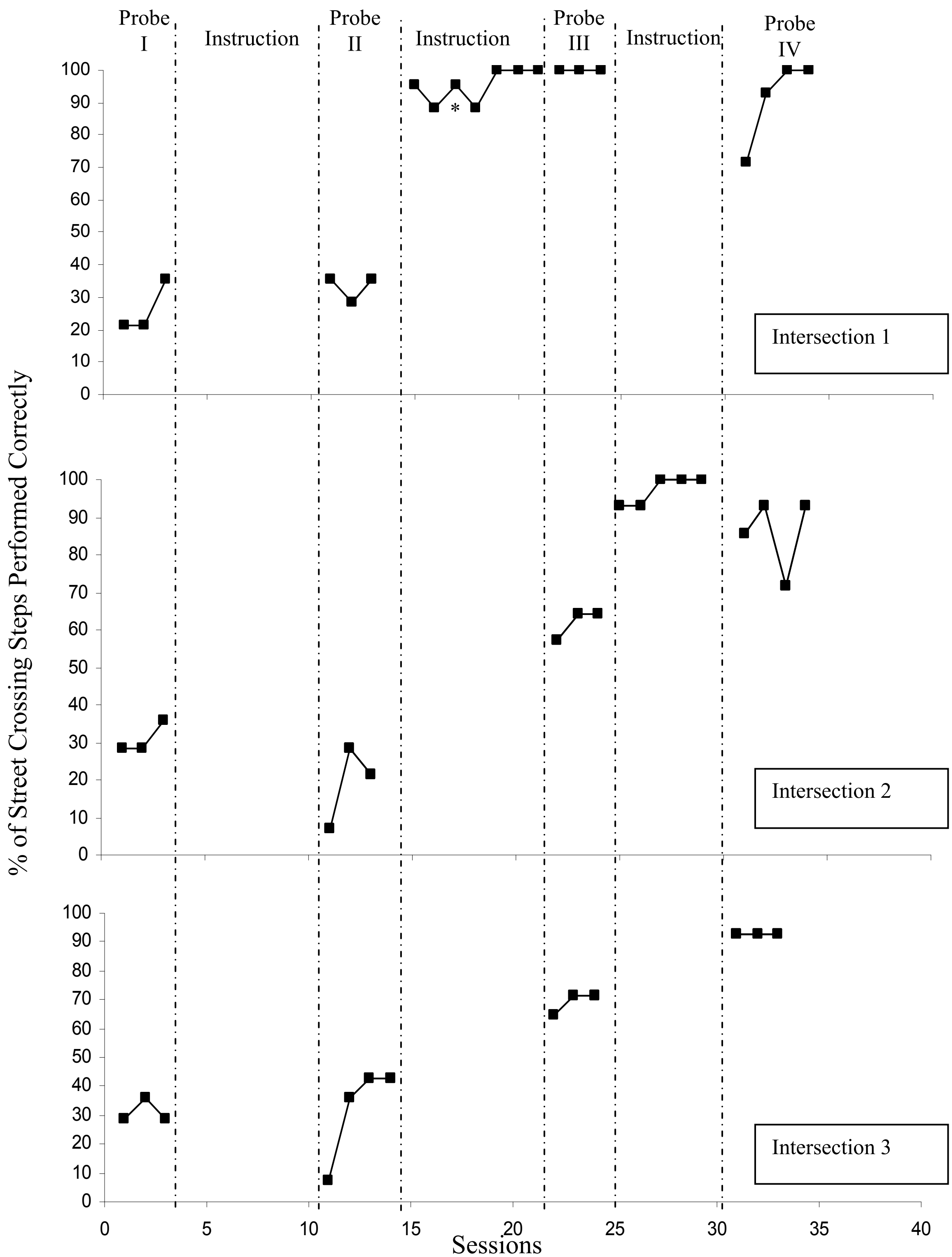
Figure 2. Participant 1

second intersection, after instruction at the first intersection, generalization of skills caused her performance to rise substantially (mean = 61.9% ; range of 35.7 to78.6%) though her final data point during that probe condition did demonstrate a counter therapeutic trend. Once instruction began on the second intersection, her performance increased dramatically during the first three sessions and then became relatively stable around criterion. During instruction, her mean performance was 95.7% (range of 71.4 to 100%). During instruction Participant 1 completed 100% of the steps accurately for 3 trials during her fourth and fifth sessions, but she made an error in the sixth session which meant it took her a total of 11 sessions to reach criterion at the second intersection.

Figure 3 provides a graphical depiction of Participant 2's performance. In the initial baseline condition, the first and second probes, Participant 2's performance was likewise low (mean of 25%) and relatively stable (range of 7.14 to 35.71%), failing to show a therapeutic trend. During the third probe condition at the second intersection, after instruction at the first intersection, Participant 2's performance was substantially higher (mean = 61.9%; range of 57.1 to 64.3%). Once instruction began at the second intersection, Participant 2's performance jumped appreciably (mean = 97.1%; range of 92.9 to 100%) and increased to criterion levels after two sessions. At the second intersection, Participant 2 met criterion most rapidly, requiring only 5 sessions. Participant 3 only received instruction at the first intersection, so her progress on the second intersection is described in the maintenance and generalization sections.

Types of Errors

Types of errors in baseline. Before any instruction, Participant 1 made a total of 76 errors at the three intersections used for the study. The majority of these errors 48.7%



Note. * indicates low procedural fidelity for the data point to the right of the asterisk.

Figure 3. Participant 2

had to do with setting up for the crossing: finding the curb, aligning for the crossing, moving to be one step from the curb, sweeping with the cane, and holding the cane in the ready position. However, the student did find the curb independently 77.8% of the time during these crossing, indicating that of the steps involved in preparing for a crossing, this step might be the most intuitive. Of Participant 1's total errors, 47.4% were due to not describing the traffic. Participant 1 failed to describe the traffic 100% of the time during the crossings before instruction. The participant's remaining errors had to do with veering during the crossing. Prior to instruction, Participant 1 veered 100% of the time when crossing the second intersection, the broadest crossing required of the students.

Prior to any instruction, Participant 2 made a total of 184 errors across intersections. Of these errors, 41.3% had to do with setting up for the crossing. Like Participant 1, of the steps involved in setting up for the crossing, Participant 2 most frequently found the curb independently. He found the curb independently 57.9% of the time before any instruction occurred. Participant 2 failed to describe the traffic or failed to describe the traffic correctly 100% of the time. Additionally, Participant 2 often crossed the intersections slower thus had errors of proper speed, which accounted for 6.5% of his errors, and veering, which accounted for 5.4% of his errors before any instruction. Participant 2's veering, however, was not usually severe enough to prevent him from locating the opposite sidewalk and stepping out of the street.

Prior to any instruction, Participant 3 made a total of 303 errors across intersections. Of these errors, 38.6% were related to setting up for the crossing, though she did independently locate the curb 51.9% of the time. Like Participants 1 and 2, Participant 3 failed to describe traffic 100% of the time prior to instruction. Like

Participant 2, Participant 3 had errors related to crossing at an appropriate speed, which accounted for 4.0% of her errors, and veering, which accounted for 7.6% of her errors before any instruction. Participant 3's veering was significant enough that she rarely was able to step out of the street onto the opposite curb.

Participant 4 never received instruction and made a total of 418 errors across intersections. Of the errors, 15.6% were related to setting up for the crossing though she did independently locate the curb starting 33.3% of the time. She failed to describe the traffic 100% of the time. Participant 4 also had difficulty crossing the street at an appropriate speed, which accounted for 6.0% of her errors, and veered severely, which accounted for 6.2% of her errors. Her veering was severe enough that often she was unable to locate the opposite curb and step out of the street. Additionally, Participant 4 was the only participant who had notable difficulty with trying to cross during and insufficient gap. Trying to cross during an insufficient gap only accounted for 2.2% of her total errors, but this was error occurred during 25% of her crossings. This is noteworthy, because it is potentially the most important step in the chain related to participant safety. The percentages of mistakes for each step of the chain during baseline, maintenance, and generalization are displayed in Table 7.

Errors during instruction. Participant 1 made a total of 18 errors during instruction at the first intersection. She consistently veered, which accounted for 27.8% of her total errors during instruction. Describing the traffic accounted for 50% of her total errors during instruction at the first intersection.

Participant 2 made a total of 12 errors during instruction at the first intersection. Alignment accounted for 25% of his errors. Failure to describe traffic or failure to

Table 7. Frequency of Errors (Reported as Percentages of Errors)

			Baseline			Maintenance		*Generalization*	
			Intersection Number			Intersection Number		*Intersection Number*	
			1	*2*	*3*	1	2	*2*	*3*
Touch curb edge		1	33.3	0	0	0	0	0	0
with cane	Participant #	2	66.7	16.7	28.6	0	0	0	0
		3	22.2	66.7	44.4	0	NA	0	0
		4	58.3	66.7	75	NA	NA	NA	NA
Move to be one step		1	100	100	66.7	0	0	0	0
from curb	Participant #	2	100	100	100	0	0	0	0
		3	100	100	100	0	NA	0	0
		4	91.7	100	91.7	NA	NA	NA	NA
Sweep edge of curb		1	100	100	100	0	0	0	0
with cane	Participant #	2	100	100	100	0	0	0	0
		3	100	100	100	0	NA	0	0
		4	100	100	100	NA	NA	NA	NA
Align with		1	100	100	100	0	0	100	0
crosswalk	Participant #	2	83.3	66.7	100	0	0	33.3	0
		3	77.8	88.9	88.9	0	NA	0	0
		4	100	100	91.7	NA	NA	NA	NA
Cane in ready		1	100	100	100	0	0	0	0
position	Participant #	2	100	100	100	0	0	0	0
		3	100	100	100	0	NA	0	0
		4	100	100	100	NA	NA	NA	NA
Describe Traffic		1	100	100	100	*66.7 **100	66.7	66.7	*100 **100
	Participant #	2	100	100	100	*0 **50	100	66.7	*100 **100
		3	100	100	100	33.3	NA	33.3	100

Table 7, Continued

		4	100	100	100	NA	NA	NA	NA	
Starts to walk in sufficient gap		**1**	**0**	**100**	**0**	**0**	**0**	**33.3**	***33.3**	****0**
	Participant #	2	0	0	0	0	0	33.3	0	
		3	**11.1**	**77.8**	**0**	**0**	**NA**	**0**	**0**	
		4	8.3	41.7	8.3	NA	NA	NA	NA	
Walks without stepping outside of crosswalk/chalk lines		**1**	**0**	**0**	**0**	**0**	**33.3**	**100**	***100**	****0**
	Participant #	2	50	83.3	42.9	0	50	100	*16.7	**0
		3	**77.8**	**88.9**	**100**	**0**	**NA**	**0**	**25**	
		4	58.3	91.7	83.3	NA	NA	NA	NA	
Walk Quickly		**1**	**0**	**0**	**0**	**0**	**0**	**66.7**	***33.3**	****0**
	Participant #	2	33.3	100	57.1	0	0	100	0	
		3	**22.2**	**77.8**	**44.4**	**0**	**NA**	**33.3**	**0**	
		4	41.7	75	83.3	NA	NA	NA	NA	
Touches target curb with cane		**1**	**0**	**0**	**0**	**0**	**0**	**33.3**	***100**	****0**
	Participant #	2	16.7	33.3	14.3	0	25	100	0	
		3	**44.4**	**77.8**	**100**	**0**	**NA**	**0**	**25**	
		4	58.3	50	83.3	NA	NA	NA	NA	
Steps out of street		**1**	**0**	**0**	**0**	**0**	**0**	**33.3**	***100**	***0**
	Participant #	2	33.3	33.3	28.6	0	25	100	0	
		3	**100**	**88.9**	**88.9**	**0**	**NA**	**0**	**25**	
		4	33.3	50	83.3	NA	NA	NA	NA	

Note. Participant 3 did not receive instruction on the second intersection so maintenance at the second intersection could not be assessed. Participant 4 did not receive instruction so maintenance and generalization could not be assessed. * indicates performance after instruction at the first intersection. ** indicates performance after instruction at the second intersection.

describe traffic accurately accounted for 16.7% of his errors. Veering accounted for another 16.7% of his errors during instruction at the first intersection.

Participant 3 made a total of 19 errors during instruction at the first intersection. The majority of these were related to describing traffic accurately, which accounted for 36.8% of her errors during instruction at the first intersection. Alignment accounted for 21.2% of her errors; veering accounted for 15.8% of her errors; and sweeping with cane accounted for 10.5% of her errors during instruction at the first intersection.

During instruction at the second intersection, Participant 1 made 16 errors. Of these errors, 75.0% were related to failing to describe traffic or failing to describe traffic correctly. Veering and attempting to cross during an insufficient gap each accounted for 12.5% of the errors during instruction at the second intersection. Participant 2 made four errors during instruction at the second intersection. Alignment, attempting to cross during and insufficient gap, veering, and failure to locate the opposite curb with the cane each accounted for 25% of the errors.

Maintenance

As shown in Figures 2 – 5, maintenance was high for participants once they mastered an intersection. During the first probe condition after instruction and meeting criterion at the first intersection, Participant 1 maintained at a mean of 97.6% (range of 92.8 to 100%). During the second probe after instruction at the first intersection, she maintained at a mean of 78.5%. At the second intersection, Participant 1 maintained at a mean of 85.7% (range of 71.4 to 92.9%). Participant 1's progress during probes and instruction on all three intersections is shown in Figure 2.

During the first probe at the first intersection after instruction and meeting criterion, Participant 2 maintained at 100% during all three sessions. In the second probe after instruction at the first intersection he maintained at a mean of 91.1% (range of 71.4 to 100%). At the second intersection he maintained at a mean of 85.7% (range of 71.4 to 92.9%). The majority of his errors were related to describing traffic; however, during one probe where his percentage of steps performed correctly was 71.4%, he veered during the crossing which made the last two steps in the chain, finding the curb and stepping out of the street, impossible which lowered the mean of his maintenance. Participant 2's progress during probes and instruction on all three intersections is shown in Figure 3.

During the probe after instruction at the first intersection, Participant 3 maintained at a mean of 97.6% (range of 92.8 to 100%). Maintenance at the second intersection was not assessed for Participant 3 because they did not receive instruction at the second intersection. Participant 4 did not receive instruction so maintenance was not assessed. Progress during probes and instruction on all three intersections for Participants 3 and 4 is shown in Figures 4 and 5.

Types of errors. The percentages of mistakes for each step of the chain during baseline, maintenance, and generalization are displayed in Table 7. During maintenance checks at intersection 1, after instruction at the first intersection, Participant 1 only made two errors. In both cases, she failed to describe the perpendicular traffic. During the maintenance check of the first intersection after instruction at the second intersection, Participant 1 made 9 errors. All errors were related to describing the traffic pattern. During the maintenance check of the first intersection after instruction at the second intersection, Participant 2 made 5 errors. All errors were related to describing the traffic

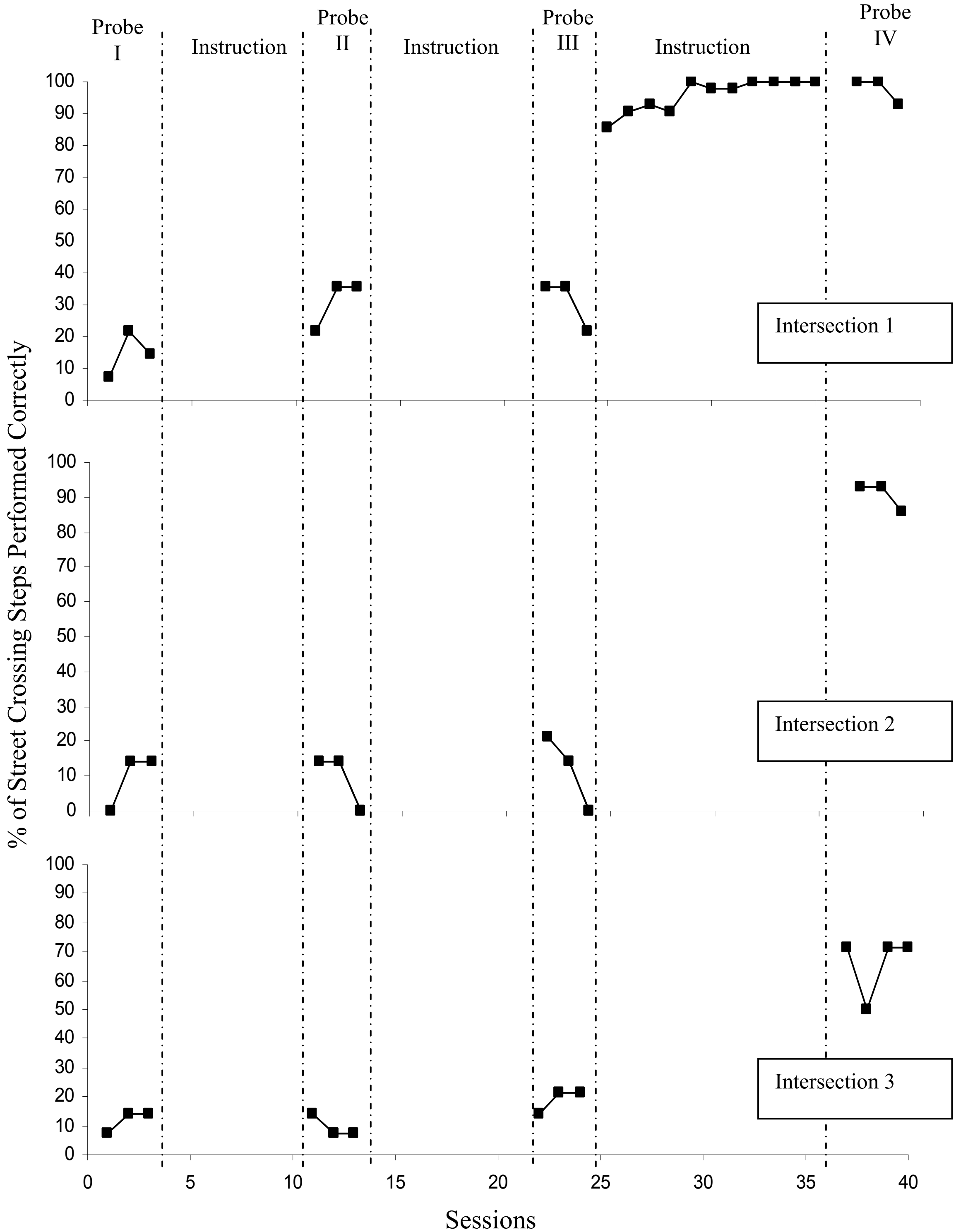


Figure 4. Participant 3

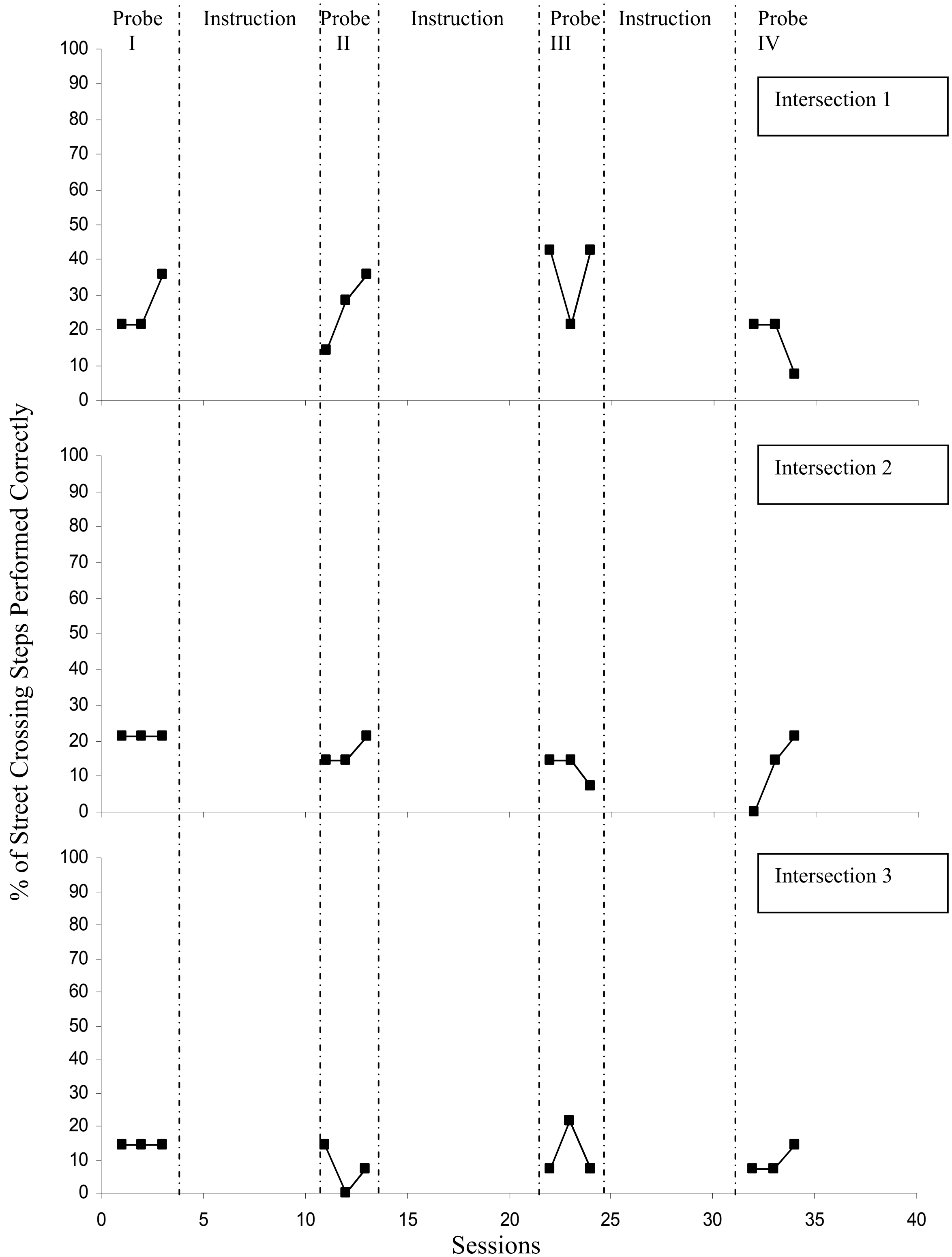


Figure 5. Participant 4: The Control Participant

pattern. During the maintenance check of the first intersection after instruction at the first intersection, Participant 3 made 1 error which was related to describing the traffic pattern.

During maintenance checks at intersection 2 after instruction at the second intersection Participant 1 made 6 errors, all of which were related to describing the traffic pattern. Participant 2 made one crossing where he veered severely enough to fail to locate the opposite curb and step out of the street. Otherwise, he made 4 errors, all of which were related to describing the traffic pattern.

Generalization

After instruction at the first intersection, Participants 1, 2, and 3 were assessed for generalization at the second and third intersections. Although the participants did not generalize completely, a notable improvement was seen. This is illustrated in Figures 2 – 5. Prior to instruction at the first intersection, the mean for Participant 1 at the second intersection was 31% (range of 28.6 to 35.7%) and at the third intersection was 45.2% (range of 42.9 to 50%). After instruction at the first intersection, the mean for Participant 1 at the second intersection increased to 61.9% (range of 35.7 to 71.4%) and at the third intersection increased to 59.5% (range of 50.0 to 71.4%). The means and ranges during the generalization probes were not as high as they were during the instructional phases, but were higher than during the initial probe condition. No substantial improvement on the third intersection occurred after Participant 1 received instruction on the second intersection.

Participant 2's progress during probes and instruction on all three intersections is shown in Figure 3. Prior to instruction at the first intersection, the mean for Participant 2 at the second intersection was 25.0% (range of 7.1 to 35.7%), and the third intersection was 31.6% (range of 7.1 to 42.9%). After instruction at the first intersection, the mean for Participant 2 at the second intersection increased to 61.9% (range of 57.1 to 64.2%) and at the third intersection increased to 69.2% (range of 64.8 to 71.4%). Unlike Participant 1, an increase in the number of correctly performed steps was noted at the third intersection after instruction at the second intersection. After instruction at the second intersection, Participant 2's performance at the third intersection increased to 92.9% during all three sessions from a mean of 69.2% after instruction at the first intersection. Like Participant 1, the means and ranges during the generalization probes were not as high as they were during the instructional phases, but were higher than they were during baseline.

Participant 3's progress during probes and instruction on all three intersections is shown in Figure 4. Participant 3 only received instruction on the first intersection. Prior to instruction at the first intersection, her mean at the second intersection was 10.32% with a range of 0 to 21.4% and her mean at the third intersection was 13.5% with a range of 7.1% to 21.4%. After instruction at the first intersection, her mean at the second intersection increased to 90.5% with a range of 85.7 to 92.9%. After instruction at the first intersection, her mean at the third intersection increased to 66.1% with a range of 50.0 to 71.5%.

Types of errors. After instruction at the first intersection, Intersections 2 and 3 were probed for generalization. At the second intersection, Participant 1 made 18 errors. Of these errors, failure to describe traffic accurately accounted for 44.4%; veering accounted for 22.2%; alignment accounted for 16.7%; walking too slowly accounted for 11.1%; attempting to walk during an insufficient gap accounted for 5.6% of the errors in generalization to the second intersection. At the second intersection, Participant 2 made 15 errors. Although failure to align only accounted for 6.7% of these errors, veering and subsequently failure to find the opposite curb and step out of the street each accounted for 20% of the errors. Walking too slowly also accounted for 20% of the errors. Failure to describe traffic correctly accounted for 1.3% of the errors. After instruction at the first intersection, Participant 3 only made 3 mistakes at the second intersection. Of these errors, 66.7% were related to describing traffic incorrectly. One error (33.3%) was related to her speed of crossing.

After instruction at the first intersection, when generalization was probed at the third intersection, Participant 1 made 17 errors. Of these errors, failure to accurately describe traffic accounted for 35.3% of these errors, veering and subsequently failing to locate the opposite curb and step out of the road each accounted for 17.6% of the errors. Walking at an insufficient speed and attempting to walk during an insufficient gap each accounted for 5.9% of the errors. At the third intersection, Participant 2 made 12 errors. 91.7% of these errors were related to incorrectly describing the traffic pattern. Only one of the errors (8.3%) was related to veering. The veering, however, was not severe enough to impeded locating the opposite sidewalk and stepping out of the street. Participant 3 made 12 errors when generalization was probed at the third intersection after receiving instruction at the first intersection, all errors were related to describing traffic.

After instruction at the second intersection, generalization was assessed at the third intersection. Participant 1 made 12 errors, and participant 2 made 3 errors. All the errors were related to describing the traffic pattern.

Another, potentially more important way to look at the generalization data, however, is to look at the skills which generalized rather than the mistakes participants continued to make. Once participants met criterion at the first intersection, four of the behaviors (touch curb edge with cane, move to be one step from curb, sweep edge of cub with cane) generalized at 100% at both the second and third intersections. One additional behavior, walks quickly, generalized at 100% to both the second and third intersections for two of the participants. Participant 1 did make one error after meeting criteria at the first intersection, but generalized at 100% on the third intersection after meeting criterion at the second intersection. All the other steps of the chain exhibited substantial generalization with the exception of describing traffic. Participants 1, 2, and 3 generalized the skill of describing traffic somewhat at the second intersection, but no real difference was noted at the third intersection. The percentages of mistakes for each step of the chain during baseline, maintenance, and generalization are displayed in Table 7.

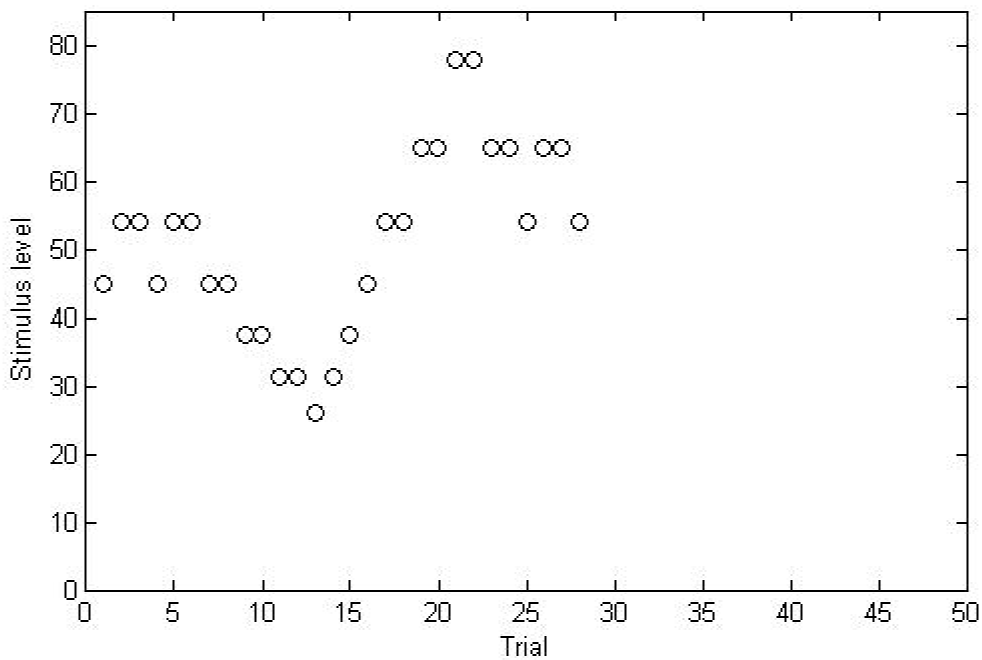
Psychophysical Tests

Two psychophysical tests were conducted in a lab setting, a gap detection test and an alignment test. Based on the two-down, one-up model, these tests generated a geometric mean and a graph which visually depicts the participant's thresholds. In the gap detection test, the mean represents the number of seconds which are necessary between the car for the participant to reliably discern which gap was longer. The mean for Participants 1, 3, and 4 before and after instruction was 9.1 which was the maximum gap allowed by the program. A threshold could not be determined for Participant 2 before or after instruction within a reasonable number of trials. Therefore, no improvement was noted. All participants did as poorly as the program would allow them to do.

In the alignment test, the mean represented the minimum degree of misalignment with which the participant could consistently determine which way he/she needed to turn to be perpendicular to the simulated car sound. On the alignment task, the most notable difference in performance before instruction and performance after instruction was by Participant 2. Before instruction, his geometric mean was 61.9. After instruction, his geometric mean improved to 5.3. The graphs of his performance before and after instruction are shown in Figure 6. The only other notable change on the alignment task was Participant 1 who performed slightly worse after instruction with a geometric mean of 21.7 than before instruction when she had a geometric mean of 13.1. The graphs of Participant 1's performance before and after instruction are shown in Figure 7. Participants 3 and 4 both made modest improvements on the alignment task after instruction compared to performance before instruction. The means for each participant in before and after instruction are shown in Table 8. Figures are not shown for the participants whose performance did not change substantially after instruction when compared to performance before instruction, but their means are included in Table 8.

Alignment Before Instruction

Geometric Mean = 61.9



Alignment After Instruction

Geometric Mean = 5.3

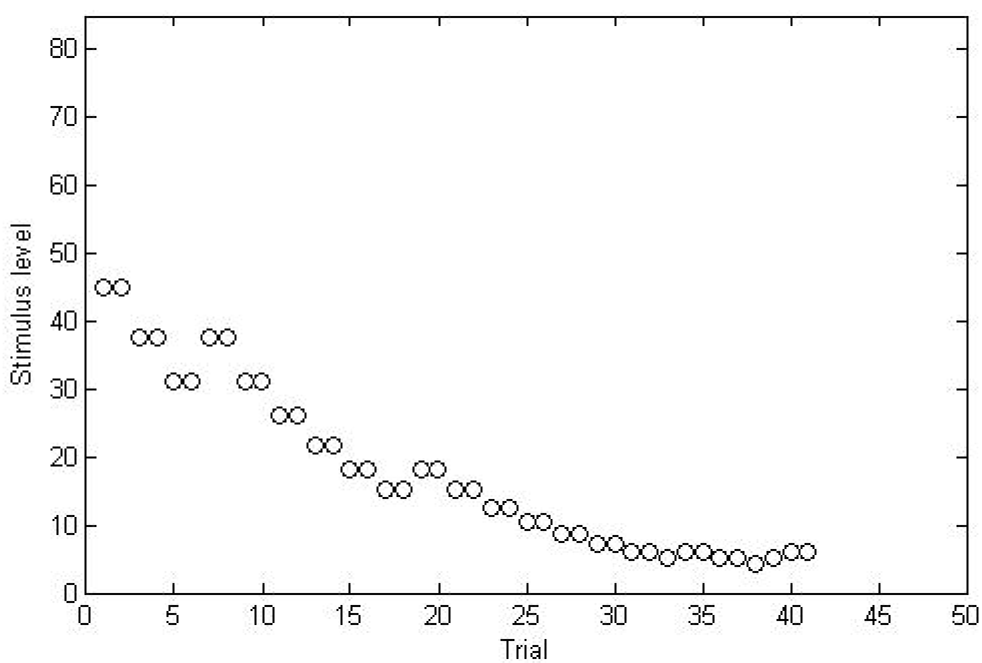
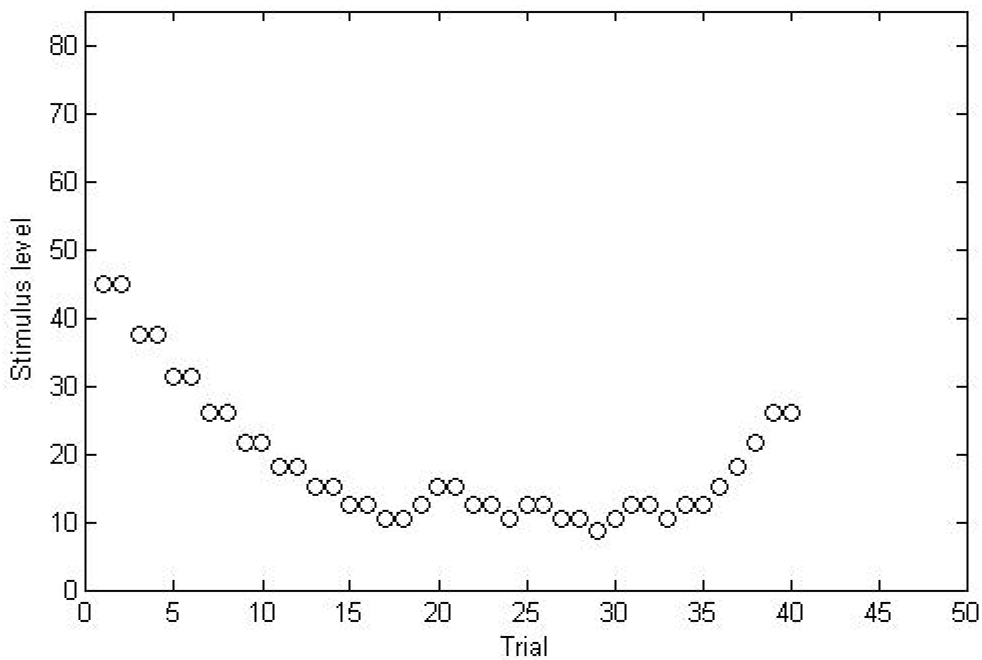


Figure 6. Alignment Performance for Participant 2

Alignment Before Instruction

Geometric Mean = 13.1



Alignment After Instruction

Geometric Mean = 21.7

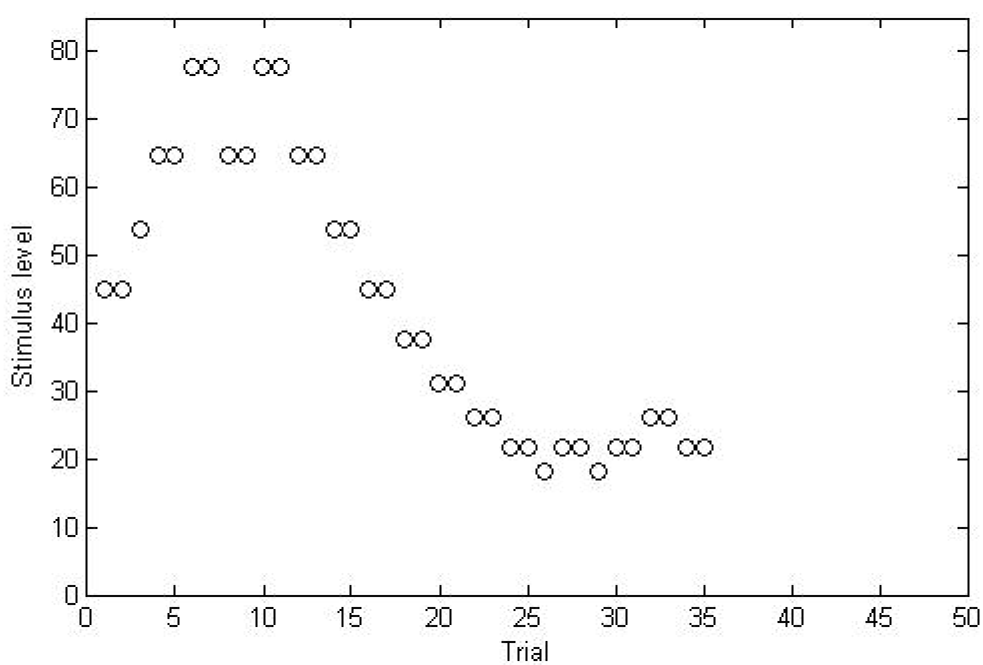


Figure 7. Alignment Performance for Participant 1

Table 8. Psychophysical Test Results

	Before Instruction Gap Detection	After Instruction Gap Detection	Before Instruction Alignment	After Instruction Alignment
Participant 1	9.1	9.1	13.1	21.7
Participant 2	N/A	N/A	61.9	5.3
Participant 3	9.1	9.1	73.0	68.3
Participant 4	9.1	9.1	73.0	63.7

CHAPTER IV

DISCUSSION

The primary purpose of this study was to evaluate the effectiveness of using verbal rehearsal paired with graduated guidance to teach participants with LP or less to cross the street safely. Maintenance and generalization of the steps involved in the chained behavior of street crossing were also measured. From the acquisition, maintenance, and generalization data, clear patterns developed, revealing the errors participants made most frequently. Furthermore, abilities of the participants to detect gaps and align to traffic were measured in an anechoic chamber before and after roadside assessment and instruction.

Success of the Teaching Techniques

Instruction. The method of verbal rehearsal paired with graduated guidance appeared to be an effective method of instruction for the students as is supported by the literature involving using these methods for teaching other behavioral tasks (Holcombe et al., 1995; Sisson et al., 1988). When questioned, Participant 1 indicated that the praise for steps completed correctly was the most helpful aspect of the instruction. After the participant completed instruction at the first intersection and moved to the probe condition, she expressed frustration. She stated she made mistakes at the second and third intersections. In a discussion with the participant, she said it was frustrating because she wanted feedback and correction on what she was doing wrong. Perhaps, the prompts and praise associated with graduated guidance were useful to the participant's learning.

Verbal rehearsal was added at the beginning of each trial during the instructional phase. When questioned about the use of verbal rehearsal, Participant 1 conceded verbal rehearsal became redundant as she mastered the skills for crossing the street; however, she said it was “necessary” for her in the beginning “to get the steps in her head.” Participant 3 spontaneously volunteered, during instruction at the first intersection that talking through the steps before crossing made her “feel better.”

Procedural Fidelity. Procedural fidelity data were measured for both verbal rehearsal and the crossings. The second and third sessions during which procedural fidelity were collected had noticeably lower levels of fidelity than the majority of instruction. This was largely because of errors in consistently providing prompts and praise after each step. At one point, the prompt/praise level dropped to 74.1% during verbal rehearsal and 88.9% during the crossing when the PI was providing instruction. During the other interventionist’s only attempt to provide instruction, the procedural fidelity levels were as low as 0% for verbal rehearsal and 14.8% during the crossing. This was primarily due to a lack of praise for each individual step stated or performed correctly. During verbal rehearsal and the crossing, the behaviors happened in quick succession. During the sessions with low procedural fidelity, the interventionist tended to provide general praise at the end of verbal rehearsal or the crossing rather than praising each step. When the PI provided instruction, this did not appear to affect the pattern of the data profoundly during instruction for Participant 1 at the first intersection which is displayed in Figure 2 though the breach in procedural fidelity may have slowed acquisition somewhat. The first participant frequently veered during the crossing, and during the initial instructional sessions, the interventionist failed to prompt the participant when the veer began. Once the interventionist began providing a verbal prompt at the beginning of a veer, the participant's errors related to veering decreased. If not for the failure to prompt the participant at the beginning of a veer, the participant may have stopped veering and met criterion in fewer sessions. The breech in procedural fidelity by the other interventionist did have a substantial negative impact on the participants' performance as noted by the asterisks in Figures 2 and 3. The effect on the participants' performance is most visible for Participant 1 (Figure 2). Her performance during that session is lower than her performance during any other instructional session during the study; however, it was still higher than baseline performance. This is possibly because the levels of procedural fidelity for the other interventionist were much lower than any levels demonstrated by the PI.

To address the breaches in procedural fidelity, the interventionist reviewed the videos and noted the mistakes related to praise and prompting. Additionally, the interventionist used a note card with the steps listed to avoid skipping steps. After approximately four sessions, procedural fidelity improved and the use of the note card was removed. After procedural fidelity consistently reached acceptable levels, the interventionist reported it was difficult to refrain from providing praise during subsequent probe conditions. Withholding prompts was much less difficult than withholding praise.

Acquisition, Maintenance, and Generalization

All students who were taught effectively learned to cross the street and met the criterion of performing each of the steps of the chained behavior with 100% accuracy in three consecutive sessions with three trials per session within a maximum of 11 sessions. After instruction at the first intersection, none of the participants generalized at criterion to the other two intersections, but all participants improved over the initial baseline condition. After instruction, Participant 1's generalized mean at the second intersection increased by 30.9%. Her generalized mean at the third intersection increased by 14.3%. Participant 2's, generalized mean increased by 36.9% at the second intersection and 37.6% at the third intersection. Participant 3's generalized mean increased by 75.38% at the second intersection and 52.6% at the third intersection after instruction at the first intersection. Learning was maintained at mean levels which ranged from 78.5% to 100%.

In additional to the information about these participants generalizing to the second and third intersections after receiving instruction, the successful acquisition of the skills suggests this intervention could be generalized to others participants with similar characteristics, entry level abilities, and experiences. Given the 100% success rate for acquisition, it is reasonable that other individuals in their early to late teen years who are severely visually impaired and have no additional severe disabilities could learn to cross streets using verbal rehearsal and graduated guidance. Though the techniques might be applicable to other groups, further research would need to be conducted to confirm the effectiveness of the intervention.

Types of Errors

Setting up for the crossing. Prior to instruction, errors in these steps accounted for the majority of the participant errors. It is highly likely this is because the participants had limited exposure to preparing to cross the street prior to instruction, especially preparing to cross independently, and therefore, had learned very little through exposure. After instruction at the first intersection, errors on these steps decreased to minimal levels. Generalization for these steps was high.

Description of traffic. Prior to instruction, none of the participants described the traffic, so the error rate for these steps in the street crossing process was 100% across participants before any instruction. This is not to say participants never noted the traffic. In fact, rates of trying to cross during an inadequate gap were relatively low, indicating participants were aware of traffic. The frequency of this error prior to instruction may have been because it is somewhat artificial to describe the traffic at an intersection aloud. Participants were only required to describe the traffic aloud because it was a method of measuring participants' understanding and awareness of traffic patterns. The frequency of these errors; however, was not due simply to it being somewhat artificial to describe the traffic aloud. When the participants described the traffic, they did not always describe it correctly. Once participants received instruction at the first intersection and began describing the traffic, the skills were maintained at high levels. After instruction at the first intersection, when generalization was assessed at the second intersection, levels of generalization were relatively high. However, the traffic pattern at the second intersection was the same as it was at the first intersection: parallel traffic was controlled by stop signs, and perpendicular traffic was not controlled. Therefore, when participants remembered to describe the traffic, they generally did so accurately. Generalization of describing the traffic pattern at the third intersection was low. The traffic pattern at the third intersection differed from the first two intersections. The third intersection was a four-way stop. While two of the participants described portions of the intersection correctly, none of the participants described traffic at the intersection with 100% accuracy. The traffic was not consistent at the intersection which would have made it difficult to determine the traffic pattern at times, but each participant did have crossing opportunities with both parallel and perpendicular traffic which provided the necessary auditory information to indicate the intersection was controlled by stop signs in all directions. These were the steps which all participants generalized the least and accounted for the majority of errors after instruction.

This suggests that while individuals who become adept at crossing a particular intersection can generalize knowledge to unfamiliar intersections. Individuals who are novice at crossing streets might fail to make correct discriminations. This is one area where concept building related to intersections with a tactile map or model prior to instruction could be studied. Additionally, in vivo instruction at different intersections with participants describing traffic could be useful.

Alignment and veering. Before the study began, based on prior experience with teaching students who were blind to cross streets and the literature, the author intended to teach the task of aligning at an intersection using auditory cues since the participants had no usable vision to orient for the crossings. However, participants made errors and required prompts on this step. The participants did not use the auditory cues to line up satisfactorily. The results of the alignment task in the anechoic chamber before instruction further confirmed the participants did not align consistently solely on the basis of auditory cues as does the research literature related to aligning on the basis of auditory cues (Ashmead, Wall Emerson, & Grantham, 2010; Guth, Hill, & Rieser, 1989). Furthermore, traffic was often light and inconsistent. For these reasons the tactile cue of the cane against the curb became a more important stimulus for helping the participants align for crossings. The tactile cue of finding the straight part of the curb was an effective strategy and once participants learned to find the “straight part of the curb,” the number of errors related to alignment and veering decreased. For this strategy to be effective, the curb has to have a straight edge. If there had been no straight edge to the curb for lining up errors of alignment and veering may have remained high. There was some evidence of this at the second intersection which was rounded at the curb. Participant 1 consistently veered at the second intersection until she compensated by moving a couple of steps to the left of the intersection where the sidewalk was straighter and provided a better tactile cue. If the curb had no straight edge and the traffic was inconsistent, the participants would have had minimal reliable cues to prevent errors of alignment and veering.

Time to cross the street and veering. Participants 2, 3, and 4 tended to cross at a slow speed prior to instruction. These participants frequently crossed the intersection at a diagonal rather than moving straight across the intersection which affected the time it took to cross the street. Participants would often miss the target curb and continue walking down an adjacent street until they were stopped. Participant 3 even found the target curb with her cane several times, startled, and changed direction to walk down the intersecting street rather than stepping up on the opposite curb. None of these students ever commented on the excessively long time to reach the opposite curb. Participant 2, did comment (after veering and walking down and intersecting street) that he noticed he had made an error by not finding the opposite curb and stepping out of the street after the interventionist prompted him to end the crossing, but he only made this comment once, and it was after instruction at the first intersection. This seemed to indicate the participants had very little concept of how long it should take them to cross the street or even that there should be a target curb to step onto. Although all of these participants did arrive at the target curb at some point during the probes, they did not seem to transfer the information of how long the crossing took to subsequent probes.

Participant 1 never made these errors during the probe condition. After instruction, however, during her first trial in the second probe condition, she veered enough to miss the target curb at the third intersection. Just as she passed where the target curb would be, she expressed frustration (e.g., "Oh snap!") and indicated she thought she had been walking too long. It is impossible to know if she was aware of the time it should take her to cross the street because of instruction or prior knowledge because she did not make this error in the first probe condition. It is noteworthy that this could have been related to prior knowledge since Participant 1 lost vision adventitiously, approximately two years prior to the study, whereas all the other participants were congenitally blind.

Similarly, Participants 2, 3, and 4, who were congenitally blind, did not express concerns associated with lingering in the road. Participants 2, 3, and 4 were observed to stop occasionally mid crossing and stand in the street when they heard something that confused them rather than observing the unfamiliar sound as a threat and moving out of the street as quickly as possible. These participants may not have had an understanding of where they were in space related to cars, curbs, and adjoining streets. Perhaps introducing the participants to the concept of the intersection by walking with guide or using a model prior to probing and instruction could have aided in them not lingering in the intersection. Errors related to not walking quickly enough were much higher for these participants than for Participant 1. Before instruction, Participant 2 consistently exceeded the amount of time considered acceptable for crossing a two lane, residential road (12 seconds). Prior to instruction, Participant 3 never previewed the curb before commencing the crossing which contributed to the length of time it took her to cross the street. She waited for complete silence, then found the edge of the curb with her feet, paused for 2 to 4 seconds as she moved from the curb to the street, then began crossing.

For Participant 3, the speed of crossing actually accounted for a larger percentage of her errors at the second intersection after instruction at the first intersection. Perhaps, this is because initially she was nervous and uncomfortable, so she rushed, often making mistakes. After instruction at the first intersection, she relaxed and walked more slowly. While this was not optimal, she did make fewer mistakes once she moved more slowly.

Crossing during a sufficient gap. Of all the steps assessed, this was the step with which the participants consistently had the fewest errors. This is likely because the participants were never really crossing during a gap. Due to the intermittent traffic patterns, all intersections had to be treated as times when the participants should in the absence of traffic. This is different than crossing between gaps in moderate to heavy flows of traffic. This is a limitation of the study and might explain why all participants did poorly on the gap detection assessment before and after instruction but had few errors when choosing a time to cross roadside.

Psychophysical Tests

Because of the small number of participants, the initial questions related to the alignment and gap detection tasks measured before and after instruction could not be answered concretely; however, a couple of interesting trends were noted. As has been stated, all participants performed as poorly as the program would allow on the gap detection task before and after instruction. This is not surprising because the participants did not practice crossing during gaps in traffic. The participants, largely due to inconsistent traffic patterns, treated each of the three instructional intersections as instances where they should cross in the absence of traffic.

The other psychophysical task measured the participant's abilities to align to simulated traffic sounds. Before instruction, Participant 1 performed the best on the alignment task with a geometric mean of 13.1. Participant 2 performed the second best on the alignment task with a geometric mean of 61.9. Participants 3 and 4 both performed poorly with a geometric mean of 73.0 each. During roadside probes and instruction, all participants tended to veer, but Participant 2 veered the least. At posttest, Participant 2's performance on the alignment task improved noticeably with his geometric mean after instruction decreasing to 5.3 from 61.9 before instruction. Participant 1 performed slightly worse after instruction than before instruction with her geometric mean increasing to 21.7 from 13.1. Participants 3 and 4 both made improvements after instruction compared to performance before instruction on the alignment task which were modest. Since Participant 2 is the only participant who made a significant increase from after instruction compared to performance before instruction on the alignment task, it is possible that this is related to him veering little during roadside probes and instruction. This, however, is only a suggested interpretation of the data. More research is needed with larger pools of participants to reach conclusions adequately.

Limitations

This study represents a first attempt to better understand how to teach street crossings to individuals with severe visual impairments, and many questions remain unanswered. Since it is the first instructional intervention study related to teaching street crossings to individuals with visual impairments, it is far from comprehensive. An intersection which is ideal for pedestrians with visual impairments to cross the street might have features which include a sidewalk; a clean, identifiable curb line; an opposite curb positioned directly across from the beginning curb; and consistent traffic to serve as auditory cues. Keeping this ideal description in mind, selecting intersections was challenging. Sidewalks were not prevalent, and finding a four-way stop near the participants' school was quite difficult. Suitable intersections were located, but the traffic at these intersections was not reliable. Since the flow of traffic was not steady, it may have contributed to the participants' difficulties in identifying traffic patterns. It also necessitated all crossings to be performed in the absence of traffic rather than teaching participants to travel with the parallel surge since the parallel surge was not consistent. The curb at the second intersection was rounded with a small amount of damage to the pavement at the curb, so participants had to step just to the left of the curb to find a straight tactile cue and avoid stepping on uneven pavement. The target curb at the second intersection was also slightly offset. Additionally, the third intersection did not have sidewalks, so the participants had to stand in the grass.

Additionally, the video recording of all sessions was beneficial for a variety of reasons. The videos made coding and calculating IOA more reliable than coding events as they happened because the recording could be watched multiple times. Also, recording the events rather than coding them in real time allowed additional attention to be focused on participant safety. However, there were times when the video recordings did not capture the entire scene. Since the camera was aimed at the participant, some events, such as the actions of cars passing by were not recorded on the video. It was sometimes difficult to hear the participants during verbal rehearsal as well as when they were describing traffic. To mitigate these concerns to the extent possible, coding was done daily so anything noteworthy would be fresh in the primary coder's mind.

Related to the measurement of the behaviors, the baseline performance might have been somewhat deflated due to the definition of successful street crossing. Although the 14 steps which defined successful street crossing in this study were based on orientation and mobility texts, and adequately defined the chain of behaviors involved in street crossing for the purposes of this study, the steps are of equal importance. Some of the steps might not always be required to successfully cross the street. In other words, some of the steps might be considered somewhat arbitrary. Since they were included as part of the measurement, this could have made the performance in baseline appear worse than other measures which could have been applied.

Another limitation was related to the psychophysical tasks. Ideally, the participants would have participated in several trials of each task. However, since this occurred during the school day, the participants only completed one trial of each psychophysical task at before and after instruction. This limitation may have affected Participant 1 the most. Participant 1 performed slightly worse on after instruction compared to her performance before instruction according to her geometric mean; however, when Figure 7 is examined, the ending point is approximately the same. The increase in geometric mean might have been due to an error or two early on in the process which can be seen around trials 5 to 10 in the posttest portion of Figure 7. If she had participated in more than one trial, the disparity between her performance before and after instruction might have been smaller. However, the participants still may have not performed well. Typically, experienced travelers have difficulty aligning when the degree of deviation is less than 8 to 15% (Ashmead et al., 2010; Guth et al., 1989). Future studies might determine this is a skill which can only be improved with task specific instruction.

Additionally, related to the psychophysical tasks, another potential limitation has to do with the sensitivity of the gap detection task. Since no prior research has been done using the program, it is possible that the task was not sensitive enough to truly capture participant abilities. It is possible that the task could have been altered so there was a greater disparity between the gaps making the task easier and increasing participant performance.

Future Directions

Since this was the initial instructional intervention study with individuals with visual impairments and street crossing, there are many directions for future research. For instance, do participants who are oriented to an intersection using a map or model prior to direct roadside instruction learn to cross the street more quickly and exhibit better conceptual understanding than participants who only receive direct instruction? Several studies in the literature with children without disabilities and individuals with disabilities other than visual impairments found maps and models to be effective when teaching participants to cross streets (Batu et al., 2004; Page et al., 1976). Furthermore, studies involving participants with visual impairments found spatial awareness and cognitive mapping abilities were improved when tactile maps and models (Sapp, 2003; Ungar, Blades, & Spencer, 1996; Ungar, Blades, Spencer, & Morsley, 1994). Perhaps incorporating tactile maps or models prior to roadside instruction using verbal rehearsal and graduated guidance would add conceptual understanding for students with visual impairments. This might reduce the number of errors the participants made related to the traffic and traffic patterns. While the most common error of all participants dealt with describing traffic inaccurately, Participant 2 kept describing parallel traffic as being controlled by “stop lights or stop signs.” Perhaps instruction with a map or model to build concepts prior to crossing would have helped him to understand that he needed to choose whether the intersection was controlled by a stop light or a stop sign. Additionally, during baseline, Participants 2, 3, and 4 frequently veered and failed to find the opposite curb and proceeded to walk down a parallel street until the adult intervened; however, the participants never seemed to notice they had been walking too long. Perhaps initial instruction with a tactile map or model would have given them the expectation that after a certain distance, they should encounter a curb; otherwise, they had made an error in crossing. Similarly, the errors where participants failed to notice they had been walking much longer than necessary for crossing a two-lane street might be alleviated by crossing the street with the student using human guide technique and counting the number of seconds required for the crossing prior to instruction. This technique would be less abstract than using a map or model, but the goal of orienting the participant to the intersection prior to direct instruction in crossing would be the same. Would orientation to the intersection using human guide techniques prior to direct instruction using verbal rehearsal and graduated guidance reduce the number of sessions required for students to reach criterion at an intersection compared to direct instruction alone?

Another direction for future research is related to one-on-one instruction versus small group instruction. Currently, most O&M instruction is provided one-on-one.

However, with children without disabilities, teaching a triad of students has proven more successful than one-on-one instruction (Tolmie et al., 2005). The authors theorized this was because the students worked together to solve the problems through small group consensus building, proposing ideas, and debating solutions. The authors proposed that this approach encouraged the participants to problem solve rather than to simply follow instructions from an adult. This may have provided the participants with a deeper understanding of why certain steps were important. Teaching street crossings with small groups of individuals with visual impairments might be effective for the same reason. Similarly, peer tutoring was proven an effective method of teaching children with autism to cross the street (Blew et al., 1985). The authors theorized peer modeling might have been useful because the participant and the peer tutor were rewarded with a snack at the end of a successful crossing. If the participant made an error, the peer tutor was still given the opportunity to complete the chain and earn a reward. The participant who made an error was not rewarded, but witnessed the peer tutor receiving the reward which might have been motivating. However, the authors also emphasized that this technique of peer tutoring had benefits related to exposure to the community and the social interaction with the peer. Perhaps peer tutoring could be an effective teaching strategy for individuals with visual impairments as well as a positive social experience. A direction for future research could be to study if participants with visual impairments learn to cross streets more quickly when receiving one-on-one instruction from a COMS or when taught in small groups of peers with or without vision.

The participants in this study performed more poorly on auditory tasks than expected. All participants performed poorly in the lab setting on the gap detection task before and after instruction. Participants 3 and 4 performed poorly in the lab setting on the alignment task before and after instruction. When the participants were assessed and received instruction roadside, the most common error was related to describing traffic patterns. Also, the participants primarily aligned for the crossing using tactile cues rather than auditory cues. Perhaps individuals with severe visual impairments are not as accurate in their use of auditory information for isolating traffic and crossing streets as is sometimes assumed. Further research on these abilities before and after instruction might provide more information about which skills should be taught using auditory cues and which skills are too difficult to consistently rely on auditory cues. Furthermore, if individuals with visual impairments have as much difficulty aligning to traffic using auditory cues as this and other studies suggest (Ashmead et al., 2010; Guth et al., 1989), can participants with visual impairments improve their ability to use auditory cues more effectively for tasks like alignment and gap detection? If so, how can these skills effectively be taught?

In this study, experimental control was shown as all participants who received instruction using verbal rehearsal and graduated guidance mastered the intersections at which they received instruction relatively quickly. The participant who did not receive instruction did not improve appreciably. Furthermore, substantial though not perfect levels of maintenance and generalization were observed in all participants who received instruction. This would indicate that verbal rehearsal and graduated guidance are effective methods of teaching adolescents with visual impairments and no additional severe disabilities to cross streets when instruction is delivered roadside. This, however, was the first experimental study to examine how to teach individuals with visual impairments to cross streets. Given the high risk nature of the activity and the value of street crossing related to safety and independence, future studies should follow to ensure individuals with severe visual impairments are taught to cross streets in the most effective and efficient way possible.

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