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Conditions that Influence Drivers' Yielding Behavior at Uncontrolled Crossings and Intersections with Traffic Signal Controls

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16. Abstract
There is a dearth of studies on how pedestrian who are blind might positively influence driver yielding in different travel situations. This project assessed common pedestrian behaviors (head turning, holding a cane, taking a step, holding up a hand, exaggerated cane movement, standing without a cane) on yielding rate for right turning traffic at lighted intersections as well as at entry and exit lanes at roundabouts. Data replicated previous findings on yielding rates for displaying a cane (about 60%), holding up a hand (65% to 80%), or taking one step into the roadway (80% to 100%) and also showed that head and gaze related behaviors do not increase yielding. In some cases, adding a head turn or gaze behavior decreases yielding rates. At the roundabout, yielding rates at exit lanes were always lower than at the entry lanes or the light controlled intersection. The outcomes have implications for O&M instruction. O&M students who benefit from a forward-facing head position to align at a crossing, or to remain aligned during a crossing, do not need to be concerned that a lack of head movement and face gaze will cause drivers to yield less often. Other students who must turn their heads to visually monitor potential threats from turning vehicles, likewise, need not be apprehensive that their head movements or gazing will likely reduce the drivers' yielding.

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Introduction to the problem

Traditional techniques used by pedestrians who are visually impaired and blind to cross streets have not generally been found effective for crossing roadways at roundabouts. Pedestrians typically monitor traffic movements visually and/or auditorily to determine a time to cross when the risk is acceptable. At traffic signal-controlled intersections this has usually been at the onset of a near-lane parallel vehicular surge, and at roundabouts when a crossable gap is detected or if and when driver(s)' yields are detectable. However, Orientation and Mobility (O&M) specialists have identified many problems with pedestrians who are blind accurately detecting and identifying appropriate times to cross the street, even in the presence of robust traffic cues.

At roundabouts, there are recognized and substantial information limitations for crossing performance of pedestrians who are blind (Guth & Rieser, 1997). Roundabouts do not have rectilinear traffic movements and the geometry can create an unfamiliar acoustical environment which presents sounds from unfamiliar places at unexpected times. Ashmead, Guth, Wall, Long, and Ponchillia (2005) indicated that pedestrian behaviors related to safety at these sites were not well understood.

To address some of these challenges, some O&M specialists have examined drivers' and pedestrians' behaviors at roundabouts. Considering the documented difficulties of detecting crossable gaps (Ashmead, Guth, Wall, Long, & Ponchillia, 2005; Geruschat, Fujiwara, & Wall Emerson, 2011; Guth, Ashmead, Long, Wall, & Ponchillia, 2005), increased yielding on behalf of drivers can represent a substantial decreased level of risk. O&M specialists and engineers have also looked at road treatments and signalization to reduce risks at roundabout crosswalks (Inman, Davis, & Sauerburger, 2006; Schroeder, et al., 2011). None of these enquiries, with the possible exception of adding traffic signals at roundabout entrances and exits, have identified tools or strategies that are widely effective and applicable at roundabout crosswalks.

We have previously investigated different ways that pedestrian behaviors might been shown to improve yielding in other settings (Bourquin, Wall Emerson, & Sauerburger, 2011; Bourquin, Wall Emerson, Sauerburger & Barlow, 2014). This project replicates some of the previous findings by repeating certain more promising pedestrian behaviors involving movement at a lighted intersection, extending this work to see whether some of these behaviors would be effective at roundabouts, and assessing a new area of pedestrian behaviors: pedestrian gaze.

It has been suggested that eye gaze, eye contact, and head turning may be useful to pedestrians wishing to cross a street by communicating that intention to approaching or waiting drivers. A 2014 website headline of the Colorado Department of Transportation stated, "CDOT Reminds Pedestrians and Drivers to Lock Eyes and Keep Heads Up at Crosswalks" ("Believe it or not," 2014), and claimed that, "The simple act of making eye contact at intersections and crosswalks could reverse this growing problem [preventable pedestrian-related crashes], in turn saving lives" (para. 3). However, it is unknown whether these strategies are applicable and a benefit to pedestrians who are blind or severely visually impaired (hereafter referred to together as blind in this article).

Literature review

Yielding and pedestrian behaviors

Recent articles written by Orientation and Mobility specialists presented empirical findings on how pedestrians who are blind might influence drivers' yielding behavior. Bourquin, Wall Emerson, and Sauerburger (2011) found that at uncontrolled crossings, the prominent use of a long white cane while moving into the street caused significantly higher rates of yielding compared to moving without the cane, and higher than waving cane display, a bright flag, or wearing an orange reflective vest. Bourquin, Wall Emerson, Sauerburger, and Barlow (2014) found that "flagging" a cane while taking one reversible step into the street, or holding up an open palm toward drivers, caused high rates of yielding for drivers waiting to turn right at the onset of a circular green signal.

In 2005, the field of Orientation and Mobility began to examine drivers' yielding behaviors through empirical research, when the potential proliferation of roundabouts presented situations where traffic controls were predominantly absent and pedestrians who were blind were often faced with crosswalks where they could not easily use traffic sounds to make crossing decisions at acceptable levels of risk. At these roundabout crosswalks, drivers' yielding was proposed by traffic engineers as the strategy pedestrians who use a white cane could rely on, but researchers mostly found very low yielding rates, especially at roundabout exits and at multilane crossings (Ashmead, Guth, Wall, Long & Ponchillia, 2005; Long, Guth, Ashmead, Wall Emerson & Ponchillia, 2005; Schroeder, et al, 2011). Ashmead, Guth, Wall, Long, and Ponchillia (2005) noted that drivers' yielding was more frequent at entrances than exits, and that compared to their sighted peers, attempts to cross by participants who were blind required more safety interventions and rarely took advantage of drivers' yielding. The researchers pointed out the information limitations for auditory-only traffic monitoring, and further, that drivers' yielding was often not useful for pedestrians who are blind. Geruschat and Hassan (2005), in a study at two roundabouts, found that yielding increased from 52% to 63% when a pedestrian held a mobility cane, and that an increase in yielding was greater at locations where yielding was unlikely. And Guth, Ashmead, Long, Wall, and Ponchillia (2005) published an article where results indicated that the use of a mobility device increased drivers' yielding, stating "[a]t the roundabout's exit lane, for example, yielding increased from 4% with no dog or cane to 21 % and 29% for the dog and cane conditions, respectively" (p. 327). This low level of yielding was not considered sufficient to make a substantial difference to pedestrians who are blind.

Traffic gap detection by blind pedestrians for crossing at roundabouts has been the subject of concern and inquiry. Geruschat, Fujiwara, and Wall Emerson's findings (2011) indicated that pedestrians with vision loss identified gaps more slowly and pedestrian with central vision loss had reduced safety margins. Guth, Ashmead, Long, Wall, and Ponchillia (2005) found in an experiment at a roundabout that blind participants were two-and-a-half times less likely to make correct judgments about when to cross at a roundabout compared to sighted peers. These results seem to confirm concerns and promulgate efforts to increase the safety of blind pedestrians at roundabouts.

Efforts at providing pedestrian information about when to cross have met with some success. The National Cooperative Highway Research Program (Schroeder, et al., 2011) evaluated two treatments at two roundabouts: pedestrian hybrid beacons (also known as a HAWK signal) and a raised crosswalk. Although there were some positive results in terms of reduced pedestrian delay and risk at lower traffic volumes, pedestrians who were blind were still unaware on many crossings of the serious risks and near-crashes that occurred. Likewise, a Federal Highway Administration study (Inman, Davis, & Sauerburger, 2006) looked at driver information treatments at roundabouts. They studied rumble strip-like devices placed in the roadway to provide blind and visually impaired pedestrians information about approaching and yielding vehicles. The experiments did not appear promising, at least not at double-lane roundabouts.

Human gazing

In a research review, Kleinke (1986) delineated the terms and definitions used by psychologists to describe eye gaze, eye contact, and head turning. Looking and gazing are the general terms for visually attending in the direction of another. More specifically, face-gaze is the "direction of one person's gaze at another's face"; eye-gaze is the "direction of one's gaze at another's eyes"; mutual gaze is "two people gazing at each other's faces"; and eye contact refers to "two people gazing at each other's eyes" (p. 78). In general, gaze has a broad range of influences in human interactions, including "liking and attraction, attentiveness, competence, social skills and mental health, credibility, and dominance" (p. 80). According to cognitive psychologists, gazing between humans is thought to cause an automatic response, refocusing attention toward the one who gazes (Greene, Mooshagian, Kaplan, Zaidel, & Iacoboni, 2009). Gaze shifts can change attention automatically and rapidly to particular places (Frischen & Tipper, 2006). These psychological phenomena may be the reason why many traffic managers and safety advocates encourage pedestrians to look toward drivers when attempting to cross streets.

In 1975, Katz, Zaidel, and Elgrishi conducted an experiment wherein trained pedestrians crossed midblock at marked and unmarked crosswalks. They collected a total of 960 observations, measuring the speed of approaching drivers using (among other sets of variables) two conditions: looking and non-looking. In the former, pedestrians who were sighted "continuously looked at the oncoming car seeking to make eye contact with the driver"; in the latter the pedestrians "started crossing after being ostensibly occupied with a wallet or a paper. While walking he looked straight ahead to the other side of the road" (p. 519). The researchers concluded that "[l]ower crossing velocities can be expected when . . . pedestrians do not look at the approaching vehicle" (p. 525); pedestrian behavior was statistically significant at one site and in the same direction at the other.

In a 2015 study of pedestrian behaviors and drivers' responses, Guéguen, Meineri, and Eyssartier examined positive eye contact between pedestrians and drivers. The researchers observed 2,560 drivers at four pedestrian crosswalks. They found that 55.1% of drivers stopped for pedestrians who did not stare at them (eye contact), compared to 67.7% when pedestrians did stare. While considering other variables including male-female gender dyads, the researchers suggested that effects of eye contact might be explained by social theories of dominance, desire for a positive interaction, or positive impressions. They recommended that pedestrians could use "appropriate nonverbal signals toward drivers" to increase safety (p. 87).

Procedures

The participant in the studies was of one of the male experimenters who acted as the pedestrian and implemented all of the conditions at all of the intersections. Data were collected at the single lane entry and two lane exit legs of a roundabout and at two signal-controlled intersections in Kalamazoo, Michigan. Approval for the study was obtained from the Institutional Review Board of Western Michigan University.

The intersections and the experimental conditions used were chosen in order to advance previous work in three ways: to replicate previous results, to generalize previous results to crossing at a roundabout, and to expand previous yielding results to include gaze behavior by a pedestrian. The signal-controlled intersections each had one leg that had a high number of vehicles turning right from a dedicated right turn lane, with cross traffic or signal phases that tended to hold right turning traffic until a circular green signal was displayed for the right turning traffic. At both signal-controlled intersections, when the green signal was displayed, the visual WALK signal was also displayed. The roundabout had moderate traffic volume when data were being collected. The experimental entry and exit crosswalks had the majority of the traffic going through the roundabout.

In all situations, the experimenter participant stood on the sidewalk where people would stand if they were intending to cross the street. The experimenter participant wore dark clothing and glasses and looked forward unless the condition for a given trial required him to do otherwise. The experimenter participant did not actually cross the street, but did the prescribed behavior at the proscribed time and held the position for at least 10 seconds. Here, the general term *gaze* will be used to refer to blind pedestrians' behaviors that indicate an attentional shift, by head and face orientation, toward the driver and vehicle waiting at a crosswalk to turn.

Study 1procedures - traffic signal-controlled intersections

The behaviors assessed at the signalized intersections included:

CANE DISPLAY: The pedestrian held a long white cane so that it was visible to drivers. MONITORING: The pedestrian turned his head back toward a potentially turning vehicle, then forward toward the crosswalk and pedestrian signal head, repeating the movement three times for about 3 seconds for each interval. The monitoring movement was begun when the perpendicular traffic's pedestrian signal head displayed a flashing orange hand. This gave approximately 15 to 20 seconds of monitoring before the waiting parallel traffic (with the right turning vehicle) received their green signal and the pedestrian received the visual WALK signal. HEAD TURN GAZE: When the perpendicular traffic's pedestrian signal head showed a flashing orange hand, the pedestrian turned his head toward the potentially turning vehicle and held his gaze at the vehicle. HEAD TURN AT SIGNAL ONSET: the pedestrian turned his head toward the potentially turning vehicle at the onset of the visual WALK signal. He then kept his head facing the vehicle throughout the rest of the trial.

Data were also collected for some trials where no pedestrian was present and with two other conditions as reported in previous work (Bourquin, Wall Emerson, Sauerburger & Barlow, 2014): hand-up and reversible step. These trials were used as a reference for calculating yields in the results section. The pedestrian pushbutton was pressed before every trial (including the "no pedestrian" trials) in order to receive the walk indication and achieve the same pedestrian signal phase lengths for each trial.

Data collected included a judgment of whether the right-turning vehicle yielded for the pedestrian; the time from the onset of the green signal and WALK signal to when the vehicle started to move (start time); and the time from the onset of the green signal to when the vehicle reached the middle of the crosswalk in front of the pedestrian (crosswalk time). Finally, qualitative data were collected throughout the trials, with raters make notations of their observations and impressions of the drivers' behaviors.

Study 2 procedures - roundabout entrance and exit

At the roundabout, the pedestrian started each trial by standing less than a foot from the edge of the street. The behaviors assessed there included:

PEDESTRIAN ONLY: The pedestrian stood on the sidewalk, looking forward.

CANE DISPLAY: The pedestrian held a long white cane at the curb (not extended) so that it was visible to drivers.

HAND UP: While displaying a long white cane, the pedestrian held a hand up with the palm facing an approaching vehicle.

REVERSIBLE STEP: The pedestrian took a single step off the sidewalk into the gutter of the street while flagging the cane, swinging it from side to side twice to waist level.

HEAD TURN GAZE: While displaying a long white cane, the pedestrian turned his head toward the potentially turning vehicle and held his gaze at the vehicle.

HAND UP PLUS GAZE: While displaying a long white cane, the pedestrian combined the hand up with the head turn gaze.

REVERSIBLE STEP PLUS GAZE: Using a long white cane, the pedestrian combined the reversible step with the head turn gaze.

The pedestrian behaviors involved a gaze toward the driver, and on some trials the hand up, or reversible step. The combined conditions were all initiated when an approaching vehicle on the entry or the exit lane was approximately 130 feet away from the crosswalk. The collaborating pedestrian could nearly always hear the approaching vehicles at this distance, however, for consistency, another researcher verbally cued the experimenter when a car was at the proscribed distance. Trials were begun when there were no vehicles approaching the roundabout whose drivers could see the pedestrian approach the crossing. The entry crossing was a single lane while the exit lane crossing was two lanes.

At the roundabout, data collected included a judgment of whether the approaching vehicle yielded for the pedestrian, as has been done in other research on yielding to pedestrians who are blind at roundabout crossings. Judgments of yields were made by three experimenters to allow for reliability of coding to be calculated. All three experimenters were experienced orientation and mobility specialists and based their judgments on observation of the drivers' behaviors, the speed and deceleration of the vehicles, and what else was happening in the environment. Quantitative and qualitative data were collected.

One experimenter coded all trials while the other two coders were used for reliability checking. Each of the secondary yield coders coded 85% of all of the trials. The principal yield coder agreed with the first secondary coder on 90.7% of the trials and agreed with the second secondary coder on 91.9% of the trials. Due to the high level of agreement, yields coded by the principal yield coder were primarily used in the analyses. However, comparison analyses were also conducted that coded a trial as having a yield if any of the three coders indicated a yield on that trial. Table 4 shows the numbers of yields coded by the principal yield coder, broken down by experimental condition, for entry and exits lanes at the roundabout. As with study 1, raters collected qualitative data about their observations and impressions.

The three experimenters also coded yields as either a hard or soft yield. Hard yields were defined as instances where the driver was yielding for the pedestrian and the vehicle's wheels stopped turning (e.g., the vehicle came to a full stop). Soft yields (also known as rolling yields) were defined as instances where the driver was yielding for the pedestrian (e.g., vehicle slowed appreciably, and/or driver motioned for pedestrian to cross) but the wheels of the vehicle never stopped turning.

Results

Study 1 results

Means and standard deviations for each outcome measure (time for vehicle to start moving and time for vehicle to reach the crosswalk) for each pedestrian behavior condition are shown in Table 1-1. The results for the four conditions tested are presented in Figure 1-1.

Table 1-1

Mean, standard deviation, and median values for vehicle start time and vehicle crosswalk time by condition

	Mean start time (sec)	Median start time (sec)	Mean time crosswalk (sec)	Median time crosswalk (sec)
No pedestrian	1.71 (.58)	1.55	5.11 (.94)	5.05
Cane display	3.09 (2.71)	2.47	8.32 (3.30)	7.60
Monitor	2.70 (1.99)	1.94	7.41 (2.12)	7.21
Long gaze	2.32 (1.53)	1.71	7.71 (2.90)	6.89
Gaze at green signal onset	2.49 (1.49)	1.86	7.97 (2.26)	7.42

Mean and standard deviation of vehicle timing in the absence of a pedestrian was used to calculate yields in the other conditions in the following manner: in trials with the pedestrian, a driver who took longer to start moving or to reach the crosswalk than two standard deviations beyond the mean for drivers with no pedestrian present was considered to have yielded.

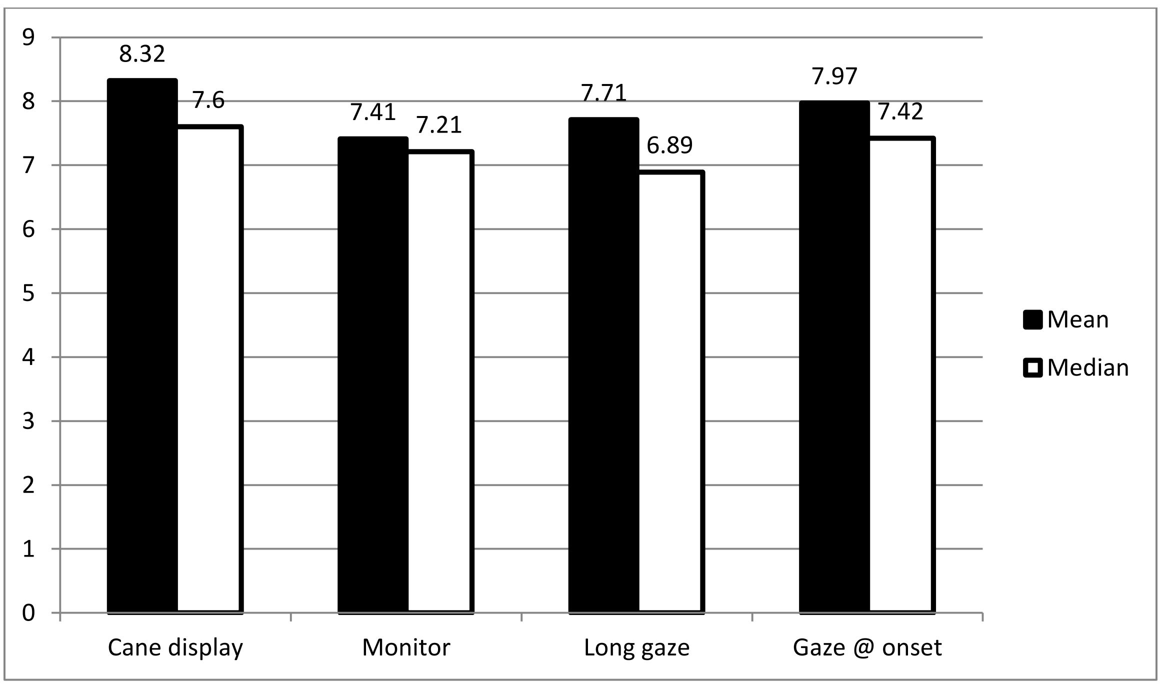

Figure 1-1. The mean and median seconds for vehicles to reach the crosswalk for each condition at traffic signal-controlled intersections.

Yields were also coded by an experimenter and the two types of yield measurements were compared. Table 1-2 shows the yields coded by each of the three identification modes. Each of the conditions had 20 trials. Data from the two signal-controlled intersections were combined because identical patterns of results were seen in the data at the two sites.

Table 1-2

Yield percentages for three yield identification modes

	Coded by experimenter	2 SD beyond mean of vehicle start time in no ped condition	2 SD beyond mean of vehicle crosswalk time in no ped condition
Cane display	60%	40%	65%
Monitor	65%	20%	55%
Long gaze	40%	30%	50%
Gaze at green signal onset	55%	30%	60%

When the experimenter's judgments were compared to the two other ways of identifying yields, the experimenter's judgments agreed with yields based on vehicle start times on 70% of the trials and agreed with yields based on vehicle crosswalk times on 86.25% of the trials. The yield data showed no significant differences across the pedestrian behavior conditions, no matter which yield identification mode was used in the analysis. Using the vehicle start time as a basis for identifying yields gave uniformly lower yielding rates than relying on the crosswalk timing or the experimenter's judgment. The authors also combined all the crosswalk timing data where the pedestrian exhibited some sort of gaze behavior and compared the combined data to the cane display condition and found no statistical difference in yielding behavior.

We wanted to see if the results from the current study were congruent with previous similar research. Bourquin, Wall Emerson, Sauerburger, and Barlow in 2014 published a study, with significantly more data points, related to pedestrian behaviors' influence on drivers' yielding. In general, while there was some increase in the magnitude of delay and yielding for drivers, on all common metrics the changes in results were in identical directions (Table 1-3), suggesting the positive reliability of the current results.

Table 1-3

Comparisons of drivers' yielding statistics with previous research (2014) at signal-controlled crosswalks.

	Median start (2014)	Median start (current)	Median crosswalk (2014)	Median to crosswalk (current)	Percent yields (2014)	Percent yields (current)	Overall crosswalk mean (2014)	Overall crosswalk mean (current)
No ped	0.77	1.55						
Display	1.00	2.47						
No ped			5.68	5.05				
Display			6.13	7.60				
No ped					1.9	5.0		
Display					44.3	60.0		
No ped							3.92(1.51)	5.11(0.94)

The variability in drivers' behaviors was evident in the qualitative data. Raters noted the location where drivers waited at the red signal, often substantially behind or forward of the painted stop line. With the monitoring and the head turn at signal onset, the drivers tended to delay their surge long enough to be a useable yield, but not with the head turn gaze. Also notable was that drivers who were apparently attending to their mobile devices tended not to yield.

Study 2 results

One experimenter coded all trials while the other two coders were used for reliability checking. Each of the secondary yield coders coded 85% of all of the trials. The principal yield coder agreed with the first secondary coder on 90.7% of the trials and agreed with the second secondary coder on 91.9% of the trials. Due to the high level of agreement, yields coded by the principal yield coder were primarily used in the analyses. However, comparison analyses were also conducted that coded a trial as having a yield if any of the three coders indicated a yield on that trial. Table 2-1 shows the numbers of yields coded by the principal yield coder, as well as yield percentages, broken down by experimental condition, for entry and exit lanes at the roundabout.

Table 2-1

Yields and yield percentages by condition

		Hard yields	Soft yields	No yields	Yield % (any yield, primary coder)	Yield % (any yield, any coder)
Entry lane						
	Ped only	1	5	14	30	40
	Cane display	1	6	13	35	55
	Hand up	15	6	0	100	100
	Rev step	16	4	0	100	100
	Gaze	2	4	15	28.6	28.6
Exit lane						
	Ped only	1	0	19	5	5
	Cane display	0	2	18	10	10
	Hand up	8	4	8	60	60
	Rev step	10	9	1	95	95
	Gaze	1	1	18	10	10

There were significant differences across the conditions in the yielding percentages at the entry lane for both the primary coder ($\chi^2(4) = 48.18$, $p < .0001$) and a yield coded by any experimenter ($\chi^2(4) = 40.54$, $p < .0001$) as well as at the exit lane for both the primary coder ($\chi^2(4) = 55.30$, $p < .0001$) and a yield coded by any experimenter ($\chi^2(4) = 55.30$, $p < .0001$). At the entry lane, the hand up and reversible step conditions received significantly higher yield percentages than pedestrian only ($\chi^2(1) = 14.86$, $p < .0001$), cane display ($\chi^2(1) = 12.32$, $p < .0001$), or gaze ($\chi^2(1) = 16.04$, $p < .0001$). At the exit lanes, the hand up condition received a significantly higher yield percentage than pedestrian only ($\chi^2(1) = 31.05$, $p < .0001$), cane display ($\chi^2(1) = 27.31$, $p < .0001$), or gaze ($\chi^2(1) = 27.31$, $p < .0001$). The reversible step condition also received a significantly higher yield percentage than pedestrian only ($\chi^2(1) = 51.34$, $p < .0001$), cane display ($\chi^2(1) = 47.18$, $p < .0001$), or gaze ($\chi^2(1) = 47.18$, $p < .0001$). In a difference from the entry lanes, at the exit lanes, the reversible step condition received a significantly higher yield percentage than the hand up condition ($\chi^2(1) = 14.71$, $p < .0001$).

When hard yields are compared to soft yields at the entry lane, there was a significant difference across conditions ($\chi^2(4) = 16.48$, $p = .002$). Table 2-1 shows that the hand up and reversible step conditions had 71.4% and 80% hard yields, respectively (an no trials with no yield) while the other conditions had either 5% or 9.5% hard yields (with a high percentage of trials with no yield). This pattern of results indicates that the hand up and reversible step conditions not only garnered more yields but a higher percentage of hard yields. A similar pattern of differences in hard and soft yields across conditions was observed at the exit lane crossing but due to the high number of trials with no yield, several conditions had so few trials with any yield that the Kruskal Wallis test was non-significant ($\chi^2(4) = 3.88$, $p = .42$). The pedestrian only, cane display, and gaze conditions had only 1 or 2 trials each with any yield at all, so patterns of soft versus hard yields were not possible to evaluate reliably. The hand up and reversible step conditions had slightly lower percentages of hard yields as seen at the entry lane crossing (40% for hand up and 50% for reversible step).

In order to further investigate the impact of the gaze condition, we then collected data at the exit lane crossing where we replicated the hand up condition and then paired the gaze condition with hand up and also paired it with the reversible step. The intention was to see whether the hand up behavior replicated a lower yield rate (60%) than at the entry lane crossing and to see whether adding the gaze behavior could increase yielding for either of the more promising yield getting behaviors (hand up and reversible step). Table 2-2 shows the yielding percentages for these three conditions at the exit lane crossing.

Table 2-2

Yielding percentages at the exit lane crossing

Condition	Hard yield	Soft yield	No yield	Yield percentage (any yield, primary coder)
Hand up	10	3	7	65
Hand up plus gaze	13	3	4	80
Reversible step plus gaze	12	4	4	80

There was no significant difference among these three conditions ($\chi^2(2) = 1.60$, $p = .45$) and the hand up only did not change appreciably (60% to 65%) between the two collection sets. Adding the gaze did improve the hand up condition performance to 80% from 60% the day before but it decreased the performance of the reversible step to 80% from 95% the day before. The rate of hard yields for the hand up condition went from 40% to 50% between the two data collection days and adding the gaze increased the rate of hard yields to 65% for the hand up and 60% for the reversible step.

Finally, in order to verify the reliability of this study, we compared results with similar previously conducted research (Bourquin, Wall Emerson, & Sauerburger, 2011; Bourquin, Wall Emerson, Sauerburger, & Barlow, 2014). Looking at the patterns of results from these studies with larger numbers of trials, the outcomes for all common measures moved in the same direction, indicating a positive consistency and external reliability. Internal reliability is indicated by the high inter-rater agreement.

At both the entry lane and exit lanes, there was no significant difference between yielding percentages for cane display versus a pedestrian without a cane (entry $\chi^2(1) = 0.11$, $p = .74$; exit $\chi^2(1) = 0.36$, $p = .55$), cane display with a gaze versus a pedestrian without a cane (entry $\chi^2(1) = 0.10$, $p = .92$; exit $\chi^2(1) = 0.36$, $p = .55$), or between cane display and cane display with a gaze (entry $\chi^2(1) = 0.20$, $p = .66$; exit $\chi^2(1) = 0.00$, $p = 1.00$).

In order to further investigate the impact of the gaze condition, we collected data at the exit lane crossing using the most promising yield-getting behaviors, the hand up and reversible step conditions. We then paired trials of these conditions with a gaze toward the vehicle. The intention was to see whether adding the gaze behavior could change (increase or decrease) yielding. Table 2-3 shows the yielding percentages for these four conditions at the exit lane crossing.

Table 2-3

Yielding percentages at the exit lane crossing

Condition	Yield percentage (primary coder)
Hand up	65
Reversible step	100
Hand up plus gaze	80
Reversible step plus gaze	80

There was no significant difference among these conditions ($\chi^2(2) = 1.60$, $p = .45$). Adding the gaze did increase the hand up condition performance to 80% but it decreased the performance of the reversible step to 80%; these were no statistically significant differences.

Our results for Study 2 are congruent with previous research results at roundabouts, where yielding when a pedestrian displayed a cane was always higher than without a visible cane (Geruschat & Hassan, 2005; Guth, et al., 2005; Inman, Davis, & Sauerburger, 2006). For example, Geruschat and Hassan reported that when a cane was displayed "drivers yielded 63% of the time, whereas, when the long cane was not present, they yielded 52% of the time" (p. 295). Also evident in Study 2 was the tendency for drivers to yield far less at exit lane crossings than at entry lane crossings.

A review of the qualitative data indicated that at the roundabout entrance drivers approached and yielded or not, while at exits they frequently hesitated and moved on, sometime accelerating, without actually yielding. At the exit, if drivers did yield, they also sometimes stopped sooner and further from the pedestrian than at the entrance.

Discussion and Conclusions

The current studies introduced three conditions in order to understand how gaze and head movement would impact drivers' yielding behaviors: monitoring a vehicle at a red signal with multiple head turns and gaze, maintaining a longer gaze towards a vehicle at a red signal while the perpendicular traffic moved, and a shorter turn and gaze at the onset of the green signal. These studies did not find any statistical or practical differences in drivers' responses to the display of a long cane alone from when a displayed cane was paired with each of these three types of pedestrian gazing behaviors. This was true when crossing at traffic signal-controlled intersections or at the entry or exit crossings of a roundabout. It was also true when gaze was used with a reversible step or hand-up technique at a roundabout.

There was a high degree of variability in how drivers responded and no definitive pattern in the yielding results. Each of the gaze conditions, individually, or when combined, produced less delay and fewer yields than just a cane display. The variability in drivers' behaviors was evident in the quantitative data and qualitative. While results were not significant, O&M specialists may infer from this pattern that pedestrian gazing at drivers at crosswalks may have a mild diminishing impact on yielding.

We conclude that these types of pedestrian behaviors do not substantially influence drivers' yielding rates for pedestrians who are blind, and that any minor effect on drivers is unpredictable. This may be interpreted by some O&M specialists as the loss of an effective option that they have used, in one fashion or another, with their students who are learning to cross streets. However, findings showing no influence on drivers may have useful practical effects for specialists and O&M instruction. Pedestrians who are blind or visually impaired and who benefit from a forward-facing head position to align at a crossing, or to remain aligned during a crossing, do not need to be concerned that a lack of head movement and face gaze will cause drivers to yield less often. Pedestrians who must turn their heads to visually monitor potential threats from turning vehicles, likewise, need not be apprehensive that their head movements or gazing will likely reduce the drivers' yielding.

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