
Conditions that influence drivers' yielding behaviour: Effects of pedestrian gaze and head movements

Eugene A. Bourquin, Robert Wall Emerson, Dona Sauerburger, and Janet Barlow

These studies examined the effects of various types of pedestrian gazing toward vehicles and drivers at traffic signal-controlled intersections and a roundabout, measuring driver delays (seconds) and yielding behaviours. No statistical or practical differences were found between any of the gaze conditions and no-gaze conditions. These findings might have practical application for orientation and mobility (O&M) specialists and students. Pedestrians who are blind or vision impaired who benefit from a forward-facing head position to align, or who must turn their heads to visually monitor potential threats from turning vehicles, need not be apprehensive that their head movements or gazing will likely reduce the drivers' yielding.

It has been suggested that eye gaze, eye contact, and head turning might 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 vision impaired (hereafter referred to together as blind).

When the paths of a driver in a moving vehicle and a person walking intersect, a conflict is created. The level of risk is greater at typical crosswalks, where accident avoidance is reliant upon regulatory codes and pedestrian and driver decisions (Katz, Zaidel, & Elgrishi, 1975). In these situations, either the driver or the pedestrian must often give way, or yield, to the other for the sake of safety. Many variables that affect drivers' yielding behaviours, such as vehicle speed, intersection geometry, sightlines, expectation of pedestrians, and others, might not be within the control of pedestrians.

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 might be the reason why many traffic managers and safety advocates encourage pedestrians to look toward drivers when attempting to cross streets.

Considering this information in the context of pedestrians who are blind, it is not uncommon for orientation and mobility (O&M) specialists to offer advice and hold opinions that are in contradiction regarding the role of eye contact, eye gaze, and head turning to monitor traffic for their students who are blind. The authors have heard opinions that widely vary on the usefulness of strategies that involve eye and head movement and fixation. A recent inquiry to listservs mostly populated by O&M specialists in the USA resulted in a score of responses. Of those, more than half the respondents advise their students to look straight ahead while waiting to cross a street, and not look at the drivers who might turn. "If they CANNOT see the driver, I teach them to look directly across the street" said one individual expressing the most common opinion (Michelle Antinarelli, personal communication, May 17, 2015). Another respondent, though, stated, "I definitely teach positive body language including looking in the direction of the driver in the near lane of traffic which would be the first line of potential danger. ... The point is to communicate a proactive message of intent to cross the street" (Maurice Peret, personal communication, May 18, 2015). Other respondents admitted that they were unsure what was best, but offered ideas that seemed reasonable based upon their personal experiences.

LITERATURE REVIEW

Research from outside the O&M profession involving pedestrians who are sighted is available to inform the issue. 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 pedestrian “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 [vehicle] crossing velocities can be expected when ... pedestrians do not look at the approaching vehicle” (p. 525); pedestrian behaviour was statistically significant at one site and in the same direction at the other.

In a 2015 study of pedestrian behaviours 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).

Considering these various opinions and findings, no consensus appears to guide the O&M specialist. It is unknown whether the behaviours of pedestrians who are sighted who attempted eye contact can induce similar responses for those pedestrians who are blind and might use face gaze. Virtually all pedestrians who are about to cross a street, including those with vision impairment, need to assess their situation for risk. They might engage in risk-reducing behaviours that make them more visible and show their intent to cross.

When the authors decided to examine the topics of gaze and head-turning behaviours in pedestrians who are blind, we found no clear indications of what, if any, effects these would have on drivers. Common working hypotheses inside our profession and out, whether derived empirically or deductively, appeared to predict differing outcomes. The standard and popular texts in O&M offered a paucity of advice, none based on empirical findings, about the way pedestrians can influence drivers to yield or give way regarding eye gaze, eye contact, or head-turning behaviours. We could not find references to eye contact, eye or face gaze, or head turning in Hill and Ponder (1976), Jacobson (1993, 2013), La Grow and Weessies (1994), Allen, Courtney Barbier, Griffith, Kern, and Shaw (1997) or Willoughby

and Monthei (1998). La Grow and Long (2011) in *Orientation and Mobility: Techniques for independence*, wrote, "Travelers should be aware of the choices that drivers may make [and pedestrians] may make other movements, such as head turning or taking one step, which help drivers to be aware that they intend to cross" (p. 182). The second edition of *TAPS* (Teaching Age-Appropriate Purposeful Skills, 1995) stated, "Ask the student to turn her head toward the traffic to give additional information about her desire to cross the street" (p. 148). In the third edition (2012), this advice is no longer presented, and at many types of crossings the authors advise that the pedestrian "[u]se visual and/or auditory scanning (left/right or lane-by-lane) before and during the crossing to monitor traffic ..." (p. 163).

In 2005, researchers in O&M began to examine drivers' yielding behaviours 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).

At least two research articles directly addressed head turns toward an approaching driver. Researchers contended that head movements contributed to safety and stated that they are "taught to blind pedestrians [and are] familiar to both authors and are taught by the first author, who is a certified orientation and mobility (O&M) instructor with many years of experience teaching pedestrians who are blind" (Geruschat & Hassan, 2005, p. 290). However, Hassan, Geruschat, and Turano (2005) found that pedestrians who are blind are less likely to turn their heads.

Recent articles written by O&M specialists presented empirical findings on the way pedestrians who are blind might influence drivers' yielding behaviour. 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 and then pausing, 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. The studies reported in this paper seek to expand on this 2014 study of conditions that influence driver yielding, using the same or similar procedures, to consider the effect of gaze and head turning on drivers' yielding behaviour.

GENERAL STUDY FRAMEWORK

The participant in the studies was 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 two signal-controlled intersections (study 1) and at the single-lane entry and two-lane exit legs of a roundabout (study 2) 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 generalise previous results to crossing at a roundabout, and to expand previous yielding results to include gaze behaviours 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 participant wore dark clothing and glasses and looked forward unless the condition for a given trial required him to do otherwise. The participant did not actually cross the street, but did the prescribed behaviour at the prescribed time and held the position for at least 10 seconds. Here, the general term *gaze* will be used to refer to the behaviours of pedestrians who are blind that indicate an attentional shift, by head and face orientation, toward the driver and vehicle waiting at a crosswalk to turn.

During each of the two studies selected conditions were tested as described below:

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

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

MONITORING: While displaying a long white cane, 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.

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

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

REVERSIBLE STEP: The pedestrian took a single step off the sidewalk into the gutter of the street while flagging the cane, raising the tip from the ground on one side up to waist level and then swinging it to the other side and touching the ground, and back twice, and then paused.

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

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

GAZE AT SIGNAL ONSET: While displaying a long white cane, the pedestrian faced forward, and, at the onset of the visual WALK signal, turned his head toward the potentially turning vehicle. He then kept his head facing the vehicle throughout the rest of the trial.

STUDY 1 – TRAFFIC SIGNAL-CONTROLLED INTERSECTIONS

Study 1 procedure

The behaviours assessed at the signalised intersections included: CANE DISPLAY, MONITORING, LONG GAZE, GAZE AT SIGNAL ONSET, REVERSIBLE STEP, and HAND UP. Data were also collected as a control for some trials when there was no pedestrian. 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: (1) judgment of whether the right-turning vehicle yielded for the pedestrian; (2) the time from the onset of the green signal and WALK signal to when the vehicle started to move (start time); and (3) 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 making notations of their observations and impressions of the drivers’ behaviours.

Study 1 results

We examined the data in several ways. Means and standard deviations for each outcome measure (time for the vehicle to start moving and time for the vehicle to reach

the crosswalk) for each pedestrian behaviour condition are shown in Table 1. The results for the mean crosswalk time for the four conditions tested (arguably the most ecologically relevant measure of whether a vehicle had yielded) are presented in Figure 1.

Table 1. Mean, standard deviation, and median values for vehicle start time and vehicle crosswalk time by condition.

	<i>n</i> =	Mean start time (sec)	Median start time (sec)	Mean time crosswalk (sec)	Median time crosswalk (sec)
No pedestrian	20	1.71 (.58)	1.55	5.11 (.94)	5.05
Cane display	20	3.09 (2.71)	2.47	8.32 (3.30)	7.60
Monitor	20	2.70 (1.99)	1.94	7.41 (2.12)	7.21
Long gaze	20	2.32 (1.53)	1.71	7.71 (2.90)	6.89
Gaze at (green) signal onset	20	2.49 (1.49)	1.86	7.97 (2.26)	7.42

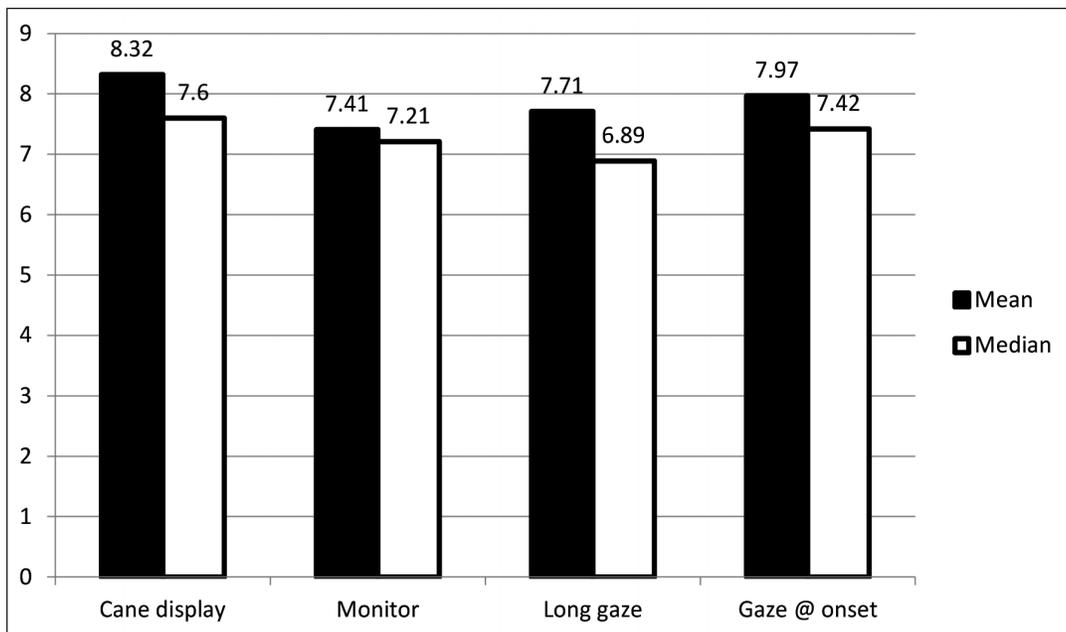


Figure 1. Mean and median times (seconds) when the vehicle reached the middle of the crosswalk for each of the conditions.

The mean and standard deviation of the vehicle timing in the absence of a pedestrian was used to calculate yields in the other conditions in the following manner: in the trials with the pedestrian present, any driver who took longer to start moving or to reach the

crosswalk than two standard deviations beyond the mean for drivers in the no-pedestrian condition was considered to have yielded. Yields were also coded by an experimenter. Table 2 shows the percentage of 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 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 behaviour 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 behaviour and compared the combined data to the cane display condition and found no statistical difference in yielding behaviour.

We wanted to see whether or not the results from the current study were congruent with previous similar research. In 2014, Bourquin, Wall Emerson, Sauerburger, and Barlow published a study, with significantly more data points, related to pedestrian behaviours' influence on drivers' yielding. In each common measurement, that is the time (in seconds) for drivers to begin to move, the time for the driver to reach the centre of the crosswalk, and the percent of yields, the same patterns were noted, suggesting the reliability of the current results.

The variability in drivers' behaviours 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 – ROUNDABOUT ENTRANCE AND EXIT

Study 2 procedure

At the roundabout, the pedestrian started each trial by standing less than a foot from the edge of the street. The behaviours assessed there included: PEDESTRIAN ONLY, CANE DISPLAY, HAND UP, REVERSIBLE STEP, LONG GAZE, HAND UP PLUS GAZE, and REVERSIBLE STEP PLUS GAZE.

The pedestrian behaviours 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 prescribed distance. Trials commenced 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 O&M specialists and based their judgments on observation of the drivers' behaviours, the speed and deceleration of the vehicles, and whatever 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 3 shows the numbers of yields coded by the principal yield coder, divided into experimental condition, for entry and exits lanes at the roundabout.

As with study 1, raters collected qualitative data about their observations and impressions.

Study 2 results

At both the entry lane ($n=102$) and exit lanes ($n=100$), 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 the long 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 $\chi^2(1) = 0.00$, $p = 1.00$).

Table 3. Yields by condition at the roundabout.

		Yield percentage (primary coder)	Yield percentage (any coder)
Entry lane			
	Pedestrian only	30	40
	Cane display	35	55
	Long gaze (with display)	28.6	28.6
Exit lane			
	Pedestrian only	5	5
	Cane display	10	10
	Long gaze (with display)	10	10

In order to further investigate the impact of the gaze condition, data were collected at the exit lane crossing using the most promising yield-getting behaviours ($n=60$), 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 behaviour could change (increase or decrease) yielding. Table 4 shows the yielding percentages for these four conditions at the exit lane crossing.

Table 4. 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 performance of the hand up condition but it decreased the performance of the reversible step, and these differences were not statistically significant.

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 (2005) 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, sometimes 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.

Statistical power for Studies 1 and 2

In the analysis of results, statistical power for the χ^2 tests in Study 1 was .66 for moderate effect sizes and .99 for large effect sizes. In Study 2, statistical power for the χ^2 tests was .48 for moderate effect sizes and .89 for large effect sizes. For χ^2 tests, a moderate effect size was assumed to be $w = .3$ and a large effect size was taken as $w = .5$ (Cohen, 1988). All statistical analyses were conducted with SPSS version 20, except for power analyses which were conducted with G*Power Version 3.1.9.2 (Erdfelder, Faul, & Buchner, 1996). This power analysis indicates that the sample size used in this study is sufficient to find any statistically significant large differences between conditions that we compared.

DISCUSSION AND CONCLUSIONS

The current studies introduced three conditions in order to understand how gaze and head movement would impact the yielding behaviours of drivers turning right at a green light: 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 towards the vehicle 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 behaviours. This was true also at the entry and exit crossings of a

roundabout, and when gaze was used with a reversible step or hand-up technique at a roundabout.

There was a high degree of variability in the way drivers responded (see the SD in Table 2) 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 (Table 1, Figure 1). The variability in drivers' behaviours was evident in the quantitative data and qualitative data.

We conclude that these types of pedestrian behaviours might 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 vision 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.

STRENGTHS AND LIMITATIONS

These studies, although consistent with previous research based on larger sample sizes and more diverse geographic locations, collected relatively small numbers of trials at three locations. Statistical analysis indicates sufficient sampling, however, this limits the generalisability of the results.

Readers should note that the trials were conducted as if the collaborator could not make eye contact with the drivers and measured conditions with gaze; actual eye contact with drivers, when possible, might have a different effect on delay and yielding behaviours.

All trials were completed with a male collaborator; further study is necessary to investigate whether or not there is bias in driver responses related to gender presentation.

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Eugene A. Bourquin, Ph.D., Bourquin Consulting, New York, USA; email: <oandmhc@msn.com>. **Robert Wall Emerson, Ph.D.**, Western Michigan University, Michigan, USA; email: <robert.wall@wmich.edu>. **Dona Sauerburger, M.A.**, COMS, Independent practitioner, USA; email: <dona@sauerburger.org>. **Janet Barlow, M.Ed.**, COMS, Access for the Blind, Inc., Asheville, NC 28806, USA; email: <jmbarlow@accessforblind.org>.