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EFFECTS OF PEDESTRIAN PROMPTS ON MOTORIST YIELDING AT CROSSWALKS

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Pedestrian safety is a serious concern at busy intersections and pedestrian campuses across the nation. Although crosswalks and signs inform pedestrians where to cross, there is no standard protocol for pedestrians to signal drivers that they wish to use the crosswalks, except to stand in or at the crosswalk. We examined the effects of two pedestrian prompts, a raised hand and extended arm, on motorist yielding at uncontrolled crosswalks. The two prompts were effective at increasing yielding.

Key words: crosswalks, motorist yielding, pedestrian safety, prompting drivers

Despite the many systems in place to guide and prompt the behavior of motorists who encounter pedestrians in crosswalks, approximately 4,378 pedestrian fatalities and 69,000 pedestrian injuries occurred in 2008 (U.S. Department of Transporation, 2008). Several methods of prompting drivers at crosswalks have proven to be effective in controlling motorist behavior. Van Houten (1988) used advanced stop lines to prompt motorists to yield further back from the crosswalk on a multilane road in Canada. Huybers, Van Houten, and Malenfant (2004) evaluated the combined and separate effects of advance pavement markings and advance signs to prompt motorists to yield further back from crosswalks. Pavement markings alone had a greater effect on increasing yielding distance than signs alone; the signs plus markings were no more effective than the markings. Other studies have used prompts combined with consequences to evaluate effects on pedestrian safety. Van Houten, Malenfant, and Rolider (1985) utilized this type of package to increase motorist yielding to pedestrians at crosswalks in a Canadian city. The public responded positively to the study, and the city implemented the procedure for all crosswalks.

Crosswalks are sites of frequent interactions between automobiles and pedestrians. Although signs and markings may prompt motorists to yield and pedestrians to cross within crosswalks, there is not yet an effective or established prompt that the pedestrian can use to increase the chance of a driver yielding once the pedestrian has entered the crosswalk. Pedestrian use of a signal to cross is an assertive yet low-effort behavior that alerts the motorist that the pedestrian would like to cross the street. Signaling also promotes courtesy between pedestrians and motorists. Extending an arm into the crosswalk was part of the treatment package in Van Houten et al. (1985). However, no analysis was performed to determine

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whether this component contributed to the increase in yielding. The purpose of this study was to determine whether an extended arm and a similar topography, a raised hand, were effective in prompting motorist yielding at uncontrolled crosswalks.

METHOD

Participants and Settings

Research assistants served as pedestrians throughout the study. Participants were motorists using city roads. The settings were 10 uncontrolled marked crosswalks (without traffic signals or stop signs), six in the Chicago metropolitan area and four in smaller cities in western Michigan.

Materials

A walking wheel was used to determine dilemma zones (see below) in advance of the crosswalks. Colored chalk or lawn flags marked each dilemma zone.

Measures

Observers recorded on data sheets the number of vehicles that yielded or failed to yield for each crossing to generate the percentage of motorists yielding and not yielding to the pedestrians who crossed. Yielding was defined as the motorist stopping or slowing to allow a pedestrian to cross. Not yielding was scored as the motorist passing in front of the pedestrian even though the vehicle would have been able to stop safely when the pedestrian was in the crosswalk. A maximum of two cars could yield for each crossing on a two-lane road, and a maximum of four cars could yield for each crossing on a four-lane road. An unlimited number of cars could fail to yield on each crossing. A signal-timing formula, as described by Van Houten and Malenfant (2004), was used to determine whether a driver could have stopped safely for the pedestrian. A dilemma zone was calculated and marked for each site using this formula. If the motorist was at or before the dilemma zone when the pedestrian entered the crosswalk, the motorist had sufficient time to yield.

Procedure

This study compared two ways in which pedestrians could inform drivers of their intention to cross the street. In all conditions, the pedestrian placed one foot inside the crosswalk. In the baseline condition, the pedestrian used no arm gestures. During the extended arm condition, the pedestrian extended the right arm into the crosswalk at 90 degrees, with the palm facing the driver while entering the crosswalk. During the raised hand condition, the pedestrian held the left hand up at chest height in front of the body with the elbow bent, palm facing the driver. The pedestrians maintained eye contact with each motorist in all conditions and always followed a safe crossing protocol (Van Houten & Malenfant, 2004) designed to minimize conflicts with motorists.

One research assistant served as the pedestrian while the other scored driver behavior. The pedestrian approached the crosswalk as a vehicle approached the dilemma zone (marked by colored chalk or lawn flags) and then followed the baseline or one of the two prompting procedures once while entering the first lane. If the vehicle yielded, the researcher crossed the street. If the first vehicle did not yield, subsequent vehicles were scored until a vehicle yielded or a gap occurred in traffic allowing the pedestrian to cross. In other words, more than one vehicle could fail to yield in a given crossing. If another vehicle was in the opposite lane, yielding was recorded for that motorist as well (the independent variable was displayed only for the first approaching vehicle in the first lane). The second motorist's behavior was differentiated on the observation sheet. If the first vehicle failed to yield, the pedestrian waited until another vehicle yielded or a gap in traffic occurred and then crossed the street; this was to ensure there was ample room for a safe crossing and to preserve a naturalistic scene.

Research assistants scored yielding several days per week at each of the crosswalks. Data were not collected in the case of rain because stopping distances changed for wet pavement. Observation sessions lasted approximately 80 min, and at least two sessions were conducted on most days. If an observation session was cut short, it was finished on the next available data collection day. The order of each crossing method was randomized during each observation session yielding a multielement design. Thus, each session consisted of three observation blocks, one block for each experimental condition. Each block consisted of 20 staged pedestrian crossings. Thus, each session included 20 crossings for the baseline condition, 20 crossings for the extended arm condition, and 20 crossings for the raised hand condition.

Interobserver Agreement and Integrity of the Independent Variable

Interobserver agreement was assessed for 40% of the observations sessions, except for one location (Marshall, Michigan) where agreement was assessed for 20% of sessions due to a lost data sheet. The data records for the two observers were compared on a crossing-by-crossing basis. An agreement for an occurrence of yielding was scored when both observers recorded the same number of cars yielding for that particular crossing. An agreement for the nonoccurrence of yielding was scored when the same number cars was marked as not yielding for that particular crossing. Interobserver agreement was calculated by dividing the agreements by the sum of the agreements plus disagreements and then multiplying by 100%. Mean agreement was 97%, with a range of 60% to 100%.

Integrity of the independent variable also was assessed by videotaping 10 crossings during each condition at each site. An agreement was scored when both observers scored the pedestrian's behavior as conforming to the behavior required for that condition (e.g., both observers scored the pedestrian as raising a hand when the raised hand condition was in effect). Integrity of the independent variable, calculated by dividing the number of times it was used correctly by the number of times it was used correctly and incorrectly, was 100% at each site.

RESULTS AND DISCUSSION

Figure 1 (top) shows the mean percentage of motorists who yielded to pedestrians during each of the three conditions, separated by site. The data are arranged by ascending baseline level so that the relation of baseline yielding to the other conditions can be easily discerned. At each site, the raised hand generated the greatest percentage of yielding, followed by the extended arm. The baseline condition produced the lowest yielding levels at all 10 sites. Figure 1 (bottom) shows the mean percentage of motorists who yielded to pedestrians across all sites during each condition for each observation session. These data show that the extended arm increased yielding over baseline, and the raised hand produced more yielding than the extended arm.

Yielding levels seemed to depend on characteristics of the roadway and surrounding environment. Table 1 shows the roadway characteristics for each site, along with the level of yielding during each condition. The lowest yielding occurred at the site with the highest speed and the two sites with one-way traffic. For example, WM-1 and Chi-5 were two sites with poor yielding overall. WM-1 had a speed limit of 48.2 kph (30 mph), but vehicles appeared to be traveling much faster. Chi-5 was a three-lane one-way road where vehicles traveled between 40.2 and 64.3 kph (25 and 40 mph). It is possible that drivers who were traveling faster were less likely to yield because of the greater effort to come to a stop. Multiple-lane one-way streets may influence yielding because vehicles in other lanes screen the view of pedestrians.

The raised hand may have produced better results than the extended arm because it mimics a ubiquitous hand gesture for the behavior of

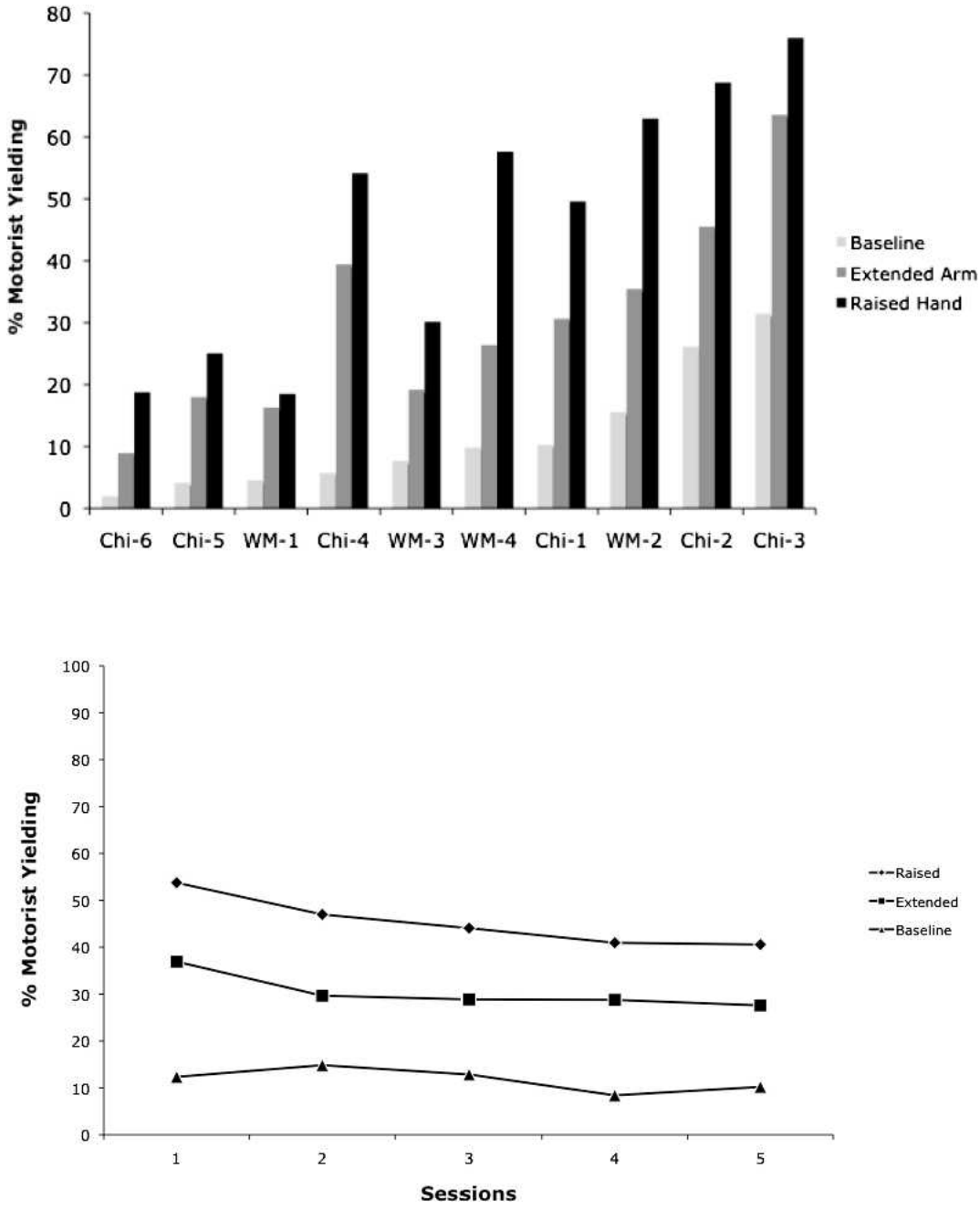

Figure 1. Percentage of motorists yielding by site, organized by ascending baseline levels (top). Chi = Chicago, WM = western Michigan. Mean percentage of motorists yielding across sites by session (bottom).

halting. Police officers use a more aggressive topography when directing traffic. Skinner (1957) referred to the verbal yet nonvocal mand of the police officer using a hand to communicate to motorists. The raised hand can also be easily transitioned into a thank you wave, which may reinforce the motorist's yielding.

Table 1
Roadway Characteristics by Site Including Dependent Variable Measures

Site	Speed	Number of lanes	Traffic direction	Avg daily vehicle count	Traffic signals	Roadway characteristics	Baseline yielding (%)	Extended arm yielding (%)	Raised hand yielding (%)
Chi-1	30	4	two-way	15,026	in street "yield to pedestrian"	near elevated train station	10.3	30.7	49.6
Chi-2	30	2	two-way	10,515	in street "yield to pedestrian"	connects two hospital buildings	26.1	45.5	68.8
Chi-3	30	2	two-way	6,748	no sign	connects hospital to parking area and bus stop	31.5	63.6	76
Chi-4	30	2	two-way	3,762	no sign	connects residential community to a park	5.7	39.4	45.2
Chi-5	30	2	one-way	3,762	no sign	connects residential community to a park	4.2	18	25.1
Chi-6	30	3	one-way	6,562	no sign	connects police station to businesses	1.9	9	18.8
WM-1	35	2	two-way	no data	overhead flashing amber	bicycle path crossing	4.6	16.3	18.5
WM-2	25	2	two-way	no data	no sign	connects residential buildings to library	15.6	35.5	63
WM-3	25	4	two-way	no data	no sign	connects businesses to town hall	7.2	19.2	30.2
WM-4	25	2	two-way	no data	no sign	connects business districts	9.8	26.4	57.6

A few of the Chicago sites were located outside of hospitals with high pedestrian traffic. On one occasion, the hospital security vehicles were used to stop traffic in both directions so that a patient on a stretcher could be transferred to an adjacent hospital. The first author also witnessed a hospital employee using an aggressive form of the raised hand technique at the same site, and it was very effective. Whether the employee acquired this behavior from watching the research team or from some other source is unknown. The first author and research assistants encountered support for the study at nearly every site. Inevitably, pedestrians and local business owners noticed our repeated crossing and inquired about the study, telling us how poor yielding was at their street.

Sessions were conducted at random times and days, but time of day was not related to differences in yielding. Several sessions were completed consecutively, so motorists who used the same road repeatedly during that time may have been exposed to more than one condition. Thus, sequence or carryover effects could have influenced results for those motorists. However, the design involved presenting the three conditions in random blocks, which likely diminished these factors. The consistency of the results across sites suggests that the treatment was responsible for the observed effects.

In conclusion, raising a hand and extending an arm are both effective means of increasing yielding. When pedestrians signal that they are about to cross, motorists are more likely to yield to them. The results of these procedures might be enhanced by combining them with other interventions such as enforcement or engineering changes (e.g. signs, lights), which have also been shown to raise baseline yielding levels. A logical next step would be to prompt actual pedestrians to use these techniques. To do this, some possible interventions include adding pedestrian behavior training to driver education courses, teaching crossing guards to prompt and reinforce children's signaling, prompting pedestrians to signal through signs or painted markings at crosswalks, and implementing community education programs.

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