**TITLE:** Evaluation of Pedestrian Extended Arm Signal to Improve Communication between Pedestrians and Drivers at Marked and Unmarked Crosswalks

**SCOPE OF WORK:**

**OVERVIEW:** Because over two thirds of pedestrian crashes occur at non-intersection sites it is important that we indentify effective methods for pedestrians to communicate their intention to cross to drivers (DOT, 2005). Most state laws require the pedestrian to be in the crosswalk before drivers are required to yield. Because it is imprudent to step in front of the path of moving vehicles pedestrians need to place at least one foot in the crosswalk when standing at the curb, or step into the gutter pan to indicate their intention to cross. It is critical to identify simple ways that pedestrians can further communicate their intention to cross to drivers to increase yielding and reduce ambiguity. In order to obtain data that would have broad generality data will be collected on the efficacy of various arm signals to better communicate with drivers at crosswalks on a variety of different types of roadway in a number of communities. During this five-month project data will be collected at un-signalized marked crosswalks.

**DETAILED METHOD**

**UNCONTROLLED CROSSWALKS**

**General Procedural Issues**

*Staged crossing procedure for uncontrolled crosswalks:* The pedestrian protocols used in pedestrian decoy operations will be consistently followed to ensure a standard and safe crossing procedure at un-signalized and signalized crosswalks. These protocols have been selected to provide a standard way of crossing that is compliance with the uniform vehicle code and ensure the safety of the pedestrian crossing the street. The following protocol will be employed at uncontrolled crosswalks (marked crosswalks that are not controlled by a traffic signals or stop sign).

1. Step with one foot into the crosswalk when an approaching vehicle is just beyond the marked dilemma zone (the dilemma zone is the measured distance for the vehicle speed limit and road grade, which ensures a safe stopping distance for vehicles traveling at the posted speed). If there is on street parking or a bicycle lane it is necessary to walk to and stop at the lane line to view approaching traffic and so drivers of approaching vehicles can see the pedestrian. Pedestrians shall not cross into the travel lane until the driver significantly slows or stops his or her vehicle to allow the pedestrian to safely cross.

2. If the vehicle makes no attempt to stop, do not proceed to cross and score the vehicle as not yielding. Also, score subsequent vehicles that do not stop as not yielding.
3. On multilane roads, if the vehicle clearly begins to yield and the next lane is free, begin crossing. **Always stop at the lane line for the second travel lane and make sure the next lane is clear before proceeding.** Score the vehicle that slowed or stopped as yielding.

4. If a vehicle in the second lane makes no attempt to slow and stop, let it pass and score it as not yielding.

5. If the vehicle yields, proceed to the centerline or median.

6. If a vehicle that is inside the marked dilemma zone, score the driver as yielding, but if they do not yield, do not score them at all.

7. If a large gap appears finish crossing.

8. For four-lane roads, follow the same procedure for the second half of the crossing. All vehicles that are beyond the marked dilemma zone when you are halfway across the 2nd travel lanes that do not slow or stop to allow you to cross should be scored as not yielding.

**Note:** This protocol has been employed in other studies where we have measured motor vehicle pedestrian conflicts (a crash surrogate measure) and has not associated with conflicts. This study will also be submitted to the University HSIRB for approval.

**Calculation of the Dilemma Zone.** Calculating the distance beyond which a motorist can safely stop for a pedestrian is essentially the same problem as calculating the distance in advance of a traffic signal that a motorist driving the speed limit can stop if the traffic signal changes to red. Traffic engineers use the signal-timing formula (Institute of Transportation Engineers, 1985), which takes into account driver reaction time, safe deceleration rate, the posted speed, and the grade of the road to calculate this interval for the amber indication. This formula will be used to measure the distance beyond which a driver could easily stop for a pedestrian by multiplying the time by the speed limit, and a landmark will be placed at this distance on each side of each crosswalk by marking the curb with colored sprinkler flags, colored tape or a traffic cone. Anyone inside the calculated distance may not have sufficient distance to safely stop for a pedestrian in the crosswalk and therefore is not scored as not yielding. Anyone beyond the calculated distance is assumed to have sufficient distance to safely stop before the crosswalk. The formula for the calculating the dilemma zone is \( Y = t + \frac{V}{2a+2Ag} \).

**Measures**

*Driver yielding to pedestrians.* Observers will score the percentage of motorists yielding and not yielding to pedestrians. A motorist will be scored as yielding if he or she stops or slows to allow the pedestrian to cross. A motorist will be scored, as not yielding if he or she passes in front of the pedestrian but would have been able to stop when the
pedestrian arrived at the crosswalk. We will use the formula used by traffic engineers to determine whether a driver could have safely stopped at a traffic signal that was presented under the calculation of dilemma zone to determine whether the driver could have stopped for a pedestrian. Motorists who have passed this landmark when a pedestrian enters the crosswalk can be scored as yielding to pedestrians but not as failing to yield, because they have passed a point in which there was sufficient time to yield. Motorists beyond the landmark when the pedestrian entered the crosswalk can be scored as yielding or not yielding because they have sufficient distance to safely stop. When the pedestrian first starts to cross, only drivers in the first half of the roadway will be scored for yielding. Once the pedestrian approaches within a half lane of the median, the yielding behaviors of motorists in the remaining lane(s) will be scored. This procedure will be followed because it conforms to the obligation of motorists specified in the Michigan and Illinois statutes. A sample data sheet is shown in Appendix 1.

Motorists waving to signal the pedestrian to cross. This behavior will be scored when the motorist makes a beckoning motion with their hand or hand and arm signaling the pedestrian to cross. This behavior usually consists of the motorists using their right hand and motioning the hand back and forth in the direction of the crosswalk. Two variations are common with one using the whole arm in a waving motion and the other using mostly the hand and fingers to lead the pedestrian across.

Conflicts between motorists and pedestrians. A conflict between a motorist and a pedestrian will be scored whenever a motorist suddenly stops or swerves to avoid striking a pedestrian or whenever a pedestrian jumps, runs, or suddenly steps or lunges backward to avoid being struck by a vehicle. Because pedestrians will be following the safe crossing protocol these types of incidents should be rare events.

Pedestrian trapped in the roadway. A pedestrian was scored as trapped at the center whenever he or she had to wait at the centerline while one or more vehicles pass in front of him or her.

Driver passed or attempted to pass stopped vehicle. A driver was recorded as passing a stopped vehicle if they passed a vehicle that was yielding to the pedestrian. A driver was recorded as attempting to pass a stopped vehicle if they did not yield until after they were along side, or past, a yielding vehicle and hence then seeing the pedestrian, or if the driver behind a yielding vehicle changed lanes to go around but then yielded.

Car behind yielding car performs rapid deceleration. A car was recorded as performing rapid deceleration if they were behind a yielding car and the front-end of the car was observed taking a sudden movement to the ground.

Inter-observer agreement

Video tape recording of sessions. Sessions will be videotaped for calculation of inter-observer agreement and procedural integrity A measure of inter-observer agreement will be computed by dividing the number of times both observers agreed on the
occurrence of each driver behavior by the number of times they agreed plus the number of times they disagreed on its occurrence. Inter-observer agreement will also be computed for the treatment integrity measure described below. A measure of inter-observer agreement will be computed at least twice during each condition at each site.

**Treatment integrity**

A measure of treatment integrity in regard to whether the staged pedestrian followed the crossing protocol will be calculated at least twice during each condition at each site. The percentage of time the participant followed the protocol correctly will be reported along with the frequency of each type of error.

**RESEARCH DESIGN**

A multi-element research design will be employed in this research. Data will be collected on crossing with and without two methods of extending the arm each day at each site. Participants will alternate crossing with an extended arm, the raised hand and standing at crosswalk baseline procedure. This will allow for the collection of sets of data under all three conditions each session. This design controls for any confounding weather that may vary from day to day such as, lighting, traffic volume, etc. Data will be collected on a minimum of 200 pedestrian crossings using each of the three aforementioned procedures. Because the person that is crossing has to wait between trials so potential drivers did not see the last crossing, it typically takes 70 to 90 minutes to collect data for 60 crossings (one full data sheet). The procedure also requires between two and three assistants to collect data; one assistant to cross; one assistant to score driver behavior; and on assistant to conduct inter-observer agreement data and to collect data on treatment integrity. Observers will also need to travel between sites and measure distances and place flags or colored tape markings to record yielding distances.

**DESCRIPTION OF ROADWAY SETTINGS**

Each crosswalk setting will be described in terms of average traffic rate and pedestrian usage. The number of lanes, width of lanes, and other surrounding factors such as parked cars and bus stops will be noted. Any significant landmarks surrounding the crosswalk will also be recorded.
PEDESTRIAN BEHAVIORS

Standing at crosswalk: Standing at crosswalk is defined as the pedestrian standing perpendicular to the roadway with one foot in the gutter pan or crosswalk, depending on the situation of the roadway. The pedestrian’s head is turned looking towards traffic so that eye contact can be made with the motorist. Below is a picture of “standing at crosswalk” position.

Extended Arm to cross: Extended arm describes the same body position as standing at crosswalk except the right arm is extended at a 90 degree angle from the torso into the crosswalk. The palm of the extended arm is open and facing the oncoming traffic. An example of the “extended arm” is depicted below.
Raising hand to cross: Raising the hand to cross consists of basically the same position as “standing on curb” except that the left arm is raised, bent, in front of the chest. The palm is facing the oncoming traffic. This is a more relaxed position than the “extended arm” yet serves the same function. A depiction of “raising hand to cross” is shown below.
During all crosswalk positions the pedestrians will refrain from wearing bright colored clothing, such as orange or red, which have similar properties to pervasive road signs. The sex of the pedestrian will also be noted to determine if gender plays a role in yielding to pedestrians at crosswalks.

SOCIAL VALIDITY

A random selection of pedestrians will be surveyed as a focus group to determine which of the pedestrian behaviors described above feels most comfortable, natural, and which of the behaviors they are more inclined to try when crossing crosswalks.

STATISTICAL ANALYSIS
Data will be compared using an analysis of variance between the extended arm, the raised hand, and standing alone. We predict that the treatment will lead to increased driver yielding behavior, a reduction of passing stopped vehicles and a reduction in the percentage of pedestrian’s trapped in the middle of the road. The dependent measures will be the proportion of drivers yielding to pedestrians and the independent variable will be the method or absence of signaling the intention to cross.

SITE SELECTION

Ten sites will be selected in total. Four sites will be collected in Chicago, Illinois at crosswalks with one lane in each direction and two lanes in each direction and the remaining data will be collected in medium size cities in Western Michigan. Three sites will be selected in Kalamazoo and the remaining three will be split between Battle Creek and Marshall. Data will also be collected on roads with a low, median and high speed limit (25 mph, 35 mph, 40 mph). We anticipate that speed and ADT will be correlated but to will also have a minimum ADT criteria of between 7000 and 9000 for low sites, between 10,000 and 13,000 for moderate sites and over 17,000 for high sites. We anticipate that we will examine a total of 10 uncontrolled sites. For each site the contractor will provide information on the number of lanes to be crossed, the width of the roadway, the presence or absence of bicycle lanes, the speed limit of the road to be crossed, and the geometry of the intersection, if an intersection is present.

GANTT CHART

A Gantt chart showing the study timeline is shown in Appendix 2.

DELIVERABLES

A final report in a format that could be submitted as a paper to TRB will be the primary deliverable for this study. A research note will also be prepared.

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         49008
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Appendix 1

Sample Data Sheet for Marked Uncontrolled Crosswalks

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<th>Location</th>
<th>Weather</th>
<th>Reliability</th>
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<table>
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<tr>
<th>BASELINE</th>
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<tbody>
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<td>Yielding</td>
<td>Not Yielding</td>
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Appendix 2

Gantt chart.

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<td>Identify sites in each community.</td>
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References

NHTSA: Washington, D.C. (NTIS No. PB2006-107224)