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MUTCD Experimentation with Countdown Pedestrian Signals and Change Intervals

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Final Report

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The countdown pedestrian signal (CPS) provides additional information to pedestrians when compared to the older displays which only use the Walking Person – Flashing Hand – Upraised Hand signal. Prior studies of the CPS have generally concluded that the device provides information to a pedestrian that helps them make better informed decisions regarding street crossing, and leads to improved pedestrian safety. However, the MUTCD provides differing guidance for terminating the pedestrian change interval (flashing hand) representing the end of the safe crossing period between countdown and non-countdown signals (MUTCD 2003).This study was done to evaluate if there is a safety concern in allowing the pedestrian change interval to terminate at the end of the concurrent vehicular yellow interval using countdown pedestrian indications, as is allowed for non-countdown pedestrian indications. Part of the concern is that the "early" termination of the pedestrian change interval is providing too long of a buffer between the designated time when a pedestrian is notified that they should be out of harm's way, and the actual time when conflicting vehicles will be given a green indication. The hypothesis is that by "lying" to the pedestrian, we are actually breeding contempt for the pedestrian signal indications.

A proposal was made to FHWA for a test to first measure pedestrian behavior at designated CPS crosswalks which currently are in accordance with the 2003 MUTCD, terminating the pedestrian change interval and counting down to zero at the beginning of the concurrent vehicular yellow phase. Then, these selected locations would have their timings adjusted so that the countdown would be zero at the beginning of the red phase, the same synchronization that is currently used for non- CPS signals and pedestrian behavior would be measured again. These before and after behaviors would be compared to determine if the pedestrian safety had or had not been impacted. FHWA approved this waiver to the MUTCD standards for the specific sites included in this experiment. The proposal to FHWA and approved waiver are included in Appendix A.

A before and after methodology was employed at sixteen different intersections in Newark, Delaware. The data collected included the number of pedestrians using the crosswalk during the observation interval, the number who crossed in compliance with the signal, the number who entered the crosswalk after the start of the flashing hand signal (referred to as late starts), those who exited the crosswalk after the beginning of the solid upraised hand signal (referred to as late arrivals), the number of those late starts who existed the crosswalk before (referred to as late start – early arrival) and after the beginning of the solid upraised hand phase (referred to as late start – late arrival). Jaywalking at the crosswalk was also noted and was defined to be any crossing at or near the crosswalk in violation of the pedestrian signal. Also, any occurrences of

vehicle and pedestrian interference were also noted. Two of the listed observed behaviors were considered to be significant for pedestrian safety, late arrival and late departures / late arrivals. The number of vehicle/pedestrian conflicts would be important as well, except that so few occurrences were observed that any results are not statistically significant. The analysis results showed no increase in risk to pedestrians from the change to the synchronization. The details of the data analysis are provided later in this paper.

Background & Review of Literature

According to the Manual on Uniform Traffic Control Devices (Federal Highway Administration, 2009), pedestrian signals generally use three indications:

- **WALK** – represented by a white silhouette in the form of a person that tells a pedestrian facing the signal indication is permitted to start to cross the roadway in the direction of the signal indication.
- **Flashing DON'T WALK (FDW)** –represented by a orange flashing upraised hand that informs pedestrians not to start to cross the roadway in the direction of the signal indication, but that any pedestrian who has already started to cross on a steady WALKING PERSON (symbolizing WALK) signal indication shall proceed to the far side of the traveled way. This is defined as the Pedestrian Change Interval.
- **Steady DON'T WALK (SDW)** –represented by a orange steady upraised hand which indicates that a pedestrian shall not enter the roadway in the direction of the signal indication.

Studies regarding pedestrian understanding and compliance of the signals have consistently concluded that the FDW is the most ambiguous of the indications. The 2004 final report of the Traffic Control Devices Pooled Fund Study reported that comprehension rates of the FDW indication can be 50% or lower (Singer and Lerner, 2004). This lack of understanding of the indication may be partially to blame for pedestrians' unsafe crossing behaviors and failure to comply with the FDW. The countdown pedestrian signal was adopted with the intent of providing a solution which would enhance comprehensibility of the pedestrian signal indications.

A review of literature has revealed that quite a number of studies have investigated the effectiveness of the countdown pedestrian signals. Results from these studies have generally concluded that the device is effective and helpful to pedestrian safety. However, owing to experimentation by different municipalities, there has been some variation in the design and phasing of CPS systems. Some jurisdictions allow the countdown to begin during the WALK phase while others permit the countdown display to begin during pedestrian change interval and in either case the countdown is designed to reach zero at the end of the pedestrian change interval.

Observational studies of both motorists and pedestrians have been the traditional means used to determine the effectiveness of CPS systems. Signal compliance and crossing success are the two measures most often investigated in observational studies of the CPS effectiveness. Compliance studies simply investigate the proportion of pedestrians arriving at the crossing during the pedestrian change interval and waiting until the next WALK phase before they begin to cross. Crossing success on the other hand refers to the proportion of pedestrians who begin to cross during the WALK or pedestrian change interval, and complete crossing before the SDW phase. Empirically, it has been shown by some studies that pedestrians were more likely to begin crossing during the FDW with countdown displays are installed, the timer giving them greater confidence in the existence of a "safe" interval to successfully cross. All of these studies are reported on in the final report of the Traffic Control Devices Pooled Fund Study (Singer and Lerner, 2004). . The duration of the pedestrian change interval is specifically based on an assumed walking speed of 3.5 feet per second. This implies that pedestrians have ample time to complete crossing successfully even if they begin at the exact start of the FDW indication. Although poor signal comprehension, willful disregard of the signal and poor judgment may still lead to unsafe crossing behaviors, it is obvious that the CPS provide pedestrians with the necessary information they need to make wise decisions about whether it is safe to cross or not.

It is however important to note that even though the CPS systems seem to have lots of advantages over the classical pedestrian signals, there are limits to their effectiveness. For instance, while CPS systems seem to improve comprehension of the pedestrian change interval , misunderstandings still occur frequently. The 2004 final report of the Traffic Control Devices Pooled Fund Study (Singer and Lerner, 2004) reported that 80% of pedestrians believe that it is legal to enter a crosswalk during the pedestrian change interval if they complete the crossing before the countdown reaches zero.

Federal MUTCD and Delaware Practice

The 2003 Federal MUTCD gave local agencies discretion with respect to the termination of the pedestrian change interval for non-countdown pedestrian signals. Standard practice in Delaware was to allow the pedestrian change interval to terminate at the end of the concurrent vehicular yellow interval. The 2003 MUTCD was explicit that, if countdown pedestrian indications were used, the pedestrian change interval was to terminate no later than the end of the concurrent vehicular green phase. The Delaware Department of Transportation (DelDOT) began installing countdown indications at signals throughout Delaware in 2008, and all installations were consistent with these requirements.

The inconsistency in the difference in the termination of the pedestrian change interval between non-countdown and countdown locations in Delaware, as well as debate of this issue at the national level such as at the National Committee on Traffic Control Devices (NCUTCD), led to DelDOT's proposed experimentation in 2009. The experimentation was approved on September 22, 2009 by FHWA. Prior to the experiment starting, but after experimental approval was obtained, FHWA published the new Federal MUTCD in December 2009. The new 2009 MUTCD removes the inconsistent treatment between non-countdown and countdown signals related to the termination of the pedestrian change interval. Regardless of the type of pedestrian indication used, the 2009 MUTCD requires a 3-second buffer between the termination of the pedestrian change interval and the release of any conflicting vehicular traffic.

Standard DelDOT practice is to use a 2-second all-red interval. Longer all-red intervals are implemented on a case by case basis as needed. Note that all sites used for this experiment used 2-second all-red intervals for all phases. Therefore, the experimental approval is only off by one second compared to what is specifically allowed in the 2009 MUTCD. Despite the new MUTCD and very minor difference between the allowable pedestrian timings and experimental approval, it was decided to conduct the experiment for several reasons. First, this topic has not been well evaluated by other research. Second, the three-second buffer included in the MUTCD is based on the joint engineering judgment of the NCUTCD and FHWA MUTCD Team, and is not based on documented research. Third, linking the pedestrian change interval to other phases already used in the signal controller (such as the concurrent vehicular yellow phase) can be done with a simple controller setting. Having a separate pedestrian change termination point would be difficult/impossible given DelDOT's current control equipment, and would likely lead to DelDOT terminating the pedestrian change interval with the concurrent vehicular green interval.

Research Objective

This research basically investigates the effects on pedestrian safety of extending the end of the countdown signal timing to synchronize with the beginning of red of vehicle signals. As indicated before, the countdown timer appears to provide pedestrians with useful information that enable them make informed crossing decisions. The key question for this research is to find out if there is a difference in pedestrian safety by synchronizing the CPS to the start of the red phase, as compared to the start of the yellow phase.

If successful, our hope is that FHWA will consider one of two options for the next version of the MUTCD: either to allow the pedestrian change interval to extend through the concurrent vehicular yellow phase, or to reduce the required "buffer" time from three seconds to two.

Project Overview

The study conducted consisted of a before-and-after investigation to determine the effects of replacing the standard CPS synchronization with an approved alternate that allowed the end of the countdown timer to synchronize to the beginning of the red phase. The field observational study approach was employed to determine the effects of the normal and alternative synchronizations on pedestrian behavior. Data was collected during the two observation periods for crossing success, pedestrian compliance, general behavior (e.g. late departures, jaywalking), and pedestrian/vehicle conflict. These behaviors are defined later in this report.

Site Descriptions & Data Collection

Originally, twenty intersections were proposed to be used for this study. After the study began, two locations were excluded because CPS systems were not installed by DelDOT during the study period. Two others were excluded when it was found that these signals did not synchronize to the yellow phase due to special phasing requirements. Data were collected at remaining sixteen different intersections in Newark, Delaware. The sites were located in both urban and suburban areas. The area is heavily used by pedestrians with most of its intersections controlled by CPS systems. Additionally, five of the intersections are three-way, fully signalized intersections with no discernible grades or curves on vehicular approaches and the remaining eleven are four-way, fully signalized intersections with no discernible grades or curves on the vehicular approaches.

With either MUTCD-compliant countdown timings or experimental timings, there are various signal control schemes that will determine whether the countdown timer will always, sometimes, or never synchronize with the beginning of the concurrent vehicular yellow time (2003 MUTCD-compliant) or all-red time (experimental). Some of the statements below are universal; others apply to DelDOT practice.

1. For pedestrian phases that are concurrent with the main street vehicular phase in a coordinated corridor, the countdown will always sync.
2. For pedestrian phases that are concurrent with side street vehicular phase in a coordinated corridor, the countdown will only sync if the pedestrian split is greater than or equal to the vehicular split. This could vary by time of day.
3. For pedestrian phases at non-coordinated signals, syncing will only occur if the pedestrian split is greater than or equal to the vehicular split, which could vary by time of day.
4. For pedestrian phases at pre-timed signals, the countdown will always sync.
5. The above noted operations may not apply to specific locations due to special signal phasing/programming, out-of-date control equipment, etc.

During the “before” observation period, the behavior of pedestrian roadway crossing was observed with the CPS synchronized in accordance with the MUTCD, the zero synched to the beginning of the yellow phase. For the “after” observational period, pedestrian roadway crossing behaviors were again observed but with the countdown signal synchronizing to the beginning of the red phase Locations where the CPS did not synch to the yellow phase prior to the study were considered as control locations since operations would not change between the two phases of the project.

The following table summarizes locations and the functionality of the countdown signal relative to vehicle signals.

Table 1. Study locations with countdown synchronization status during before & after study

No.	Location	Crosswalk	Countdown Synchronization
1	Delaware Ave. & Library Ave	N-S & E-W	Yes
2	Elkton Rd. & Apple Rd.	N-S & E-W	Yes
3	S. College Ave. & Park Place	N-S E-W	Yes No
4	East Main St. & Pomeroy St	N-S & E-W	Yes
5	S. College Ave. & Kent Way	N-S	Cancelled
6	Cleveland Ave. & N. Chapel St.	N-S & E-W	No
7	Hillside Rd. & Apple Rd.	N-S & E-W	Yes
8	Delaware Ave. & S. College Ave.	N-S & E-W	Yes
9	East Main St. & Academy St.	N-S & E-W	Cancelled
10	S. College Ave. & SR4	N-S & E-W	Yes
11	SR4 & Robscott Manor	N-S E-W	No Yes
12	SR4 & SR72	N-S & E-W	Yes
13	Delaware Ave. & S. Chapel St.	N-S E-W	Yes No
14	Elkton Rd. & Thorn Lane	N-S & E-W	No
15	S. College Ave. & Marvin Dr.	N-S & E-W	Yes
16	S. College Ave. & Amstel Ave.	N-S E-W	No Yes
17	Cleveland Ave. & New London	N-S E-W	No Yes
18	East Main St. & Library Ave.	N-S E-W	Yes No
19	East Main St. & S. College Ave	N-S & E-W	Not Installed
20	S. College Avenue & S. Field House.	N-S & E-W	Not Installed

Data Collection

The method used to collect both the compliant (before) and experimental (after) data for this study was visual observation and manual recording. As DelDOT informed the project team of the installation of a CPS, data was collected for the MUTCD - compliant (before) stage. Data collection was only done on weekdays, between 11 am and 1 pm, while the University of Delaware was in session. Once all project CPS installations were complete and before data was collected, the experimental synchronization was implemented.

Pedestrians Crossing Behaviors Observed:

Behaviors of all pedestrians crossing at study sites were recorded during the data collection periods. Based on the scope of this study, data collection excluded the following categories of pedestrian:

- All children up to the age of 12 who were accompanied by adults such as those being pushed in a stroller, those being carried, those walking hand-in-hand and those walking in close proximity to an adult.
- Disabled pedestrians using wheelchairs either by themselves or with assistance.
- Cyclist, skaters, and jogging pedestrians.

The following crossing behaviors were recorded for all other pedestrians at the study sites:

- Pedestrians who crossed during the entire data collection period (shown in the data tables as Total Arrivals
- Pedestrians who began crossing with the WALK signal, but arrived at the far side of the crosswalk after the countdown reached zero (shown as Late Arrivals). Some pedestrians began crossing when the flashing hand was displayed, in violation of the signal. Some of these still crossed before the timer reached zero (classified as late departure – arrive before zero) and some who completed crossing after the zero countdown (classified as late Departures, arrived after zero). Any pedestrian who crossed in while the Don't Walk signal was displayed were classified as jaywalkers.
    - Pedestrian/Driver conflict existed (when a driver had to stop for a jaywalking pedestrian or pedestrians with the right of way had to stop for turning vehicles that refused to yield.

This study was focused on pedestrian safely. Specifically, would a CPS synchronized to the red signal be less safe than one set in accordance with the MUTCD. Those individuals classified as "late arrivals" and "late departures – arrive after zero" were considered the major performance metrics of interest. Occurrence of jaywalking would occur regardless of the synchronization setting as well as pedestrian – driver conflicts. The before and after behavior as a percentage of all crossings were evaluated to see if a statistically significant difference existed. .

Results

The before and after behavior as a percentage of all crossings were evaluated to see if a statistically significant difference existed. After computing these differences, the results were plotted to see determine how they were distributed. It was determined that the data was not normally distributed. The appropriate test for this before and after data would be the Wilcoxon Signed Rank Test for paired observations. A total of six tests were run using the just the data from the locations that were synchronized to yellow before and to red after. A test was run on the control locations where the CPS did not synchronize to either the yellow during the before phase or to the rad during the after phase. The third test was run using the complete data set. The paired comparison was done one the observed behavior of "late departures – arrive after zero" and "late arrivals" for a total of six tests. The hypothesis being tested in each case was that the difference between the before and after data was zero. In other words, based on all of these before and after comparisons, there was no difference between the compliant vs. experimental timing. Also, it was noted in the results, that there was a statistically significant reduction in jaywalking. However, without additional studies it cannot be said that this change of synchronization of the countdown display was directly attributable to the reduction in jaywalking observed. Additional studies are needed which would isolate this issue from the other variables. The detailed data and analyses are found in Appendix B.

Conclusion

The results of this study indicate that the no increased hazard was introduced by changing the synchronization of the CPS from the start of yellow to the start of red. We recommend that FHWA consider one of two options for the next version of the MUTCD related to the termination of the pedestrian change interval: either to allow the pedestrian change interval to extend through the concurrent vehicular yellow phase, or to reduce the required "buffer" time from three seconds to two.

References

Federal Highway Administration (2003). "*Manual on Uniform Traffic Control Device for Streets and Highways, 2003&2009 Editions.*" Washington, DC: Federal Highway Administration.

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