# EVALUATION OF THE IMPACT OF TWO COUNTDOWN PEDESTRIAN SIGNAL DISPLAYS ON PEDESTRIAN BEHAVIOR IN AN URBAN AREA

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## ABSTRACT

The Manual on Uniform Traffic Control Devices (MUTCD) prescribes that Countdown Pedestrian Signals (CPS) shall only be displayed during the clearance interval (FLASHING DON'T WALK - FDW) of pedestrian signals. The primary purpose of this CPS display is to inform pedestrians of the remaining time for crossing a road controlled by the signal, to discourage them from starting, and to inform those who are already on the way of the remaining time before the beginning of the DON'T WALK (DW) interval. The general literature on CPS is conclusive that CPS is better understood than the conventional pedestrian signals. In the District of Columbia the CPS display starts at the onset of the Steady WALK (SW) interval and continues through the FDW interval. It is not certain whether this CPS display has any advantage over the standard display as prescribed by the MUTCD. In this research, a comparative field study of both types of countdown displays at twenty-five (25) intersections in the District of Columbia was conducted. In addition, an attitudinal survey was conducted to gauge the public's preference and perception of both displays. The results of the evaluation showed that at the majority of the intersections studied, there were no statistically significant differences in pedestrian crossing behaviors (using 5% significance level) due to the type of CPS display. The attitudinal survey results showed that the majority of pedestrians (~86%) and drivers (~83%) prefer CPS display which starts at the onset of the SW.

**Keywords:** pedestrian safety, countdown pedestrian signals,

# 1 INTRODUCTION

One of the significant developments in traffic control in the United States in recent years has been the accelerated use of Countdown Pedestrians Signals (CPS) at signalized intersections. A considerable number of signalized urban and sub-urban intersections in the United States are now equipped with CPS. The use of intersections by pedestrians and vehicles pose a potential conflict in the movement of the two traffic modes. Consequently, a pedestrian signal is used to allocate the right–of–way for the safe passage of pedestrians at signalized intersections.

Generally, *"a pedestrian signal provides a dedicated phase during which the pedestrian can enter the intersection during the steady WALK interval, and complete crossing the street during the FLASHING DON'T WALK (FDW) or STEADY DON'T WALK intervals"* (Federal Highway Administration, MUTCD, 2009). A CPS flashes continuously while displaying the number of seconds remaining during the pedestrian change interval, counting down to zero. The time displayed by the CPS serves as a risk mitigation mechanism used by pedestrians in resolving the crossing challenge. While the time information displayed by the signals has unanimously been accepted as a useful aid in enhancing pedestrian safety at crosswalks of signalized intersections, the type of CPS display has differed among some jurisdictions in the United States. Some jurisdictions activate their countdown display during the "STEADY WALK" (SW) interval, while others prefer to begin the countdown display during the FDW interval. The national standard on the use of CPS is provided in Section 4E-07 of the Manual on Uniform Traffic Control Devices (MUTCD). The MUTCD prescribes that the CPS display should begin at the onset of the FDW interval. The District of Columbia CPS display studied in this research starts at the onset of the SW interval and continues through the FDW interval.

The primary purpose of CPS is to inform pedestrians of the remaining time for crossing a signalized intersection, to discourage them from starting, and to inform those already in the crossing process of the number of seconds remaining before the beginning of the DON'T WALK (DW) interval. The general literature on CPS is conclusive that CPS is well understood by pedestrians and motorists and has a significant advantage over conventional pedestrian signals (Farraher, 2000; Botha, 2002). In the District of Columbia, the CPS display starts at the onset of the SW interval and continues through the FDW interval. This is contrary to the prescribed standard in the MUTCD. The District elected to use this type of display on an experimental basis for fixed-time traffic signals prior to the 2009 MUTCD guideline. An earlier research study conducted in the District of Columbia found that the SW-FDW countdown is well-understood by pedestrians (Arhin, 2006). However, it is not certain whether the SW-FWD countdown display has any advantage over the standard CPS display as prescribed by the MUTCD. This research is aimed at investigating whether the CPS display at fixed-time control intersection in the District of Columbia has any advantage over the standard display prescribed by the MUTCD. The study also includes an opinion survey of pedestrians and drivers regarding their perception of the CPS display options.

## 2 LITERATURE REVIEW

Pedestrian signals approved by the MUTCD consist of the illuminated words WALK (or a symbol of a person) and "DON'T WALK" (DW) (or a symbolic hand). The meanings of the indications are follows:

- The Steady WALK (SW), signified by a white silhouette of a person, "means that a pedestrian facing the signal indication is permitted to start to cross the roadway in the direction of the signal indication, possibly in conflict with turning vehicles."
- The Flashing DON'T WALK (FDW), signified by a Portland orange flashing upraised hand, means that a pedestrian shall not start to cross in the direction of the indication, but a pedestrian who has already started, shall proceed out of the crosswalk.
- The Steady DON'T WALK (SDW), signified by a Portland orange steady upraised Hand, means that a pedestrian shall not enter the crosswalk in the direction of the indication.

The duration of each interval, depends on the geometric characteristics and the vehicular traffic at a signalized intersection. According to the 2009 edition of the MUTCD (Section 4E.07), the CPS shall display the number of seconds remaining until the termination of the pedestrian change interval. The MUTCD also states that the countdown display shall neither be used during the walk interval nor during the yellow change interval of a concurrent vehicular phase. In practice, the choice of the interval to start the countdown display is largely dependent on the jurisdictional preferences. For example, in Montgomery County, MD, Minneapolis, St. Paul, MN, Las Vegas, NV, and San Jose, CA, the countdown display starts with the FDW. However, in the District of Columbia, Cambridge and Boston, MA, the countdown involves the total time for the SW and the FDW intervals.

Many evaluation studies on the effectiveness of the CPS have been conducted across the United States. However, studies that focused primarily on the comparison of CPS displays are rare. Most of the studies have shown that pedestrians prefer either of the countdown displays over the conventional pedestrian signals. The findings of selected research efforts for evaluating countdown signals are discussed below.

Eccles (2003) conducted a pedestrian study at locations with CPS in Montgomery County, MD to determine the effect of CPS at five intersections The County applied the countdown only to the FDW interval. Comparisons were made between behavioral changes of pedestrians at the same location during daylight hours and in good weather. A total of 107 pedestrians were interviewed to determine their perception of CPS. Observations of pedestrian compliance with the signal and pedestrian-vehicle conflicts were also made. A student's t-test was used to analyze the data. At 3 of the 5 intersections evaluated, there were statistically significant decreases in the number of pedestrians remaining in the crosswalk when conflicting traffic received the green indication. The majority of the pedestrians surveyed correctly explained what the countdown signal phases meant. There was also a significant reduction in the frequency of pedestrian-vehicle conflicts as a result of the installation of the CPS.

Petraglia (2004) conducted a study on CPS that was installed at three intersections in Boston, Massachusetts. The countdown display was active for the entire "WALK" and FDW intervals, similar to the practice in the District of Columbia. A "before" and "after" study was conducted.

The measures of effectiveness investigated were the number of pedestrians starting on WALK, the number of pedestrians starting on FDW, the number of pedestrians finishing during the DW, the number of pedestrians running or aborting, and the number of pedestrian-vehicle conflicts. The research concluded that countdown signals did not cause any significant improvement in the mentioned variables and in some instances actually degraded pedestrian safety.

Botha (2002), of the San Jose State University the City of San Jose, conducted a study which consisted of a “before” (installation of the countdown signals) and “after” evaluation California installed CPS at 5 intersections. The countdown started at the same time as the FDW. Among the variables studied were the proportions of pedestrians who arrived during the FDW and waited for the “WALK” before crossing, the proportion of pedestrians that entered during the “WALK”, FDW and DW intervals, as well as those who run, baulk or hesitated. A concurrent survey was conducted to determine how well pedestrians interpreted the meaning of the FDW indication. From the results, 59% of pedestrians gave the wrong interpretation of the FDW signals. Simple frequency analyses of the data was conducted which showed that the differences between the “before” and “after” results were not significant. Although the number of motorist-pedestrian conflicts decreased, the study did not conclude that there was discernable effect due to the CPS.

In 1997, a CPS was installed and studied at the intersection of Florida State Route 535 and Hotel Plaza Boulevard in Orlando, Florida (Chester, 1998). The purpose of that study was to evaluate pedestrian understanding of the CPS through field interviews. Surveys were conducted at random among local citizens and visitors. The selected crosswalk traversed eight lanes and measures about 140 feet in length. The countdown was applied to the entire WALK and FDW intervals. A total of 50 pedestrians were surveyed and the results indicated that 88% understood the functions of new countdown signals. The results of the survey of local citizens and visitors show high CPS comprehension levels of 91% and 81%, respectively.

Pulugurtha (2004) of the Transportation Research Center of University of Nevada evaluated of the effectiveness of CPS deployed at 14 intersections in the City of Las Vegas’ downtown area. The research methodology was one of a “treatment” and “control” type. Among the 14 intersections, 10 were treated with CPS and the remaining 4 “control” sites operated with the conventional pedestrian signals. The countdown display was applied to the FDW phase. The key variables investigated included pedestrian compliance with pedestrian signals, pedestrian–vehicle conflicts, and pedestrians who ran out of time and thus were trapped in the crosswalk. Data collection was conducted with a video recorder. The results indicated that the CPS improved pedestrian compliance with the SW, FDW and the SDW indications by 29%, 75% and 11%, respectively. There was also a substantial reduction in pedestrian-vehicle conflicts, in comparison to the “control” intersections. Field interviews were conducted to receive feedback from pedestrians with regards to their understanding of the countdown signals and the FDW symbol. The results indicated that over 90% understood the general functions of the CPS and the FDW phase. The researchers believed that the CPS had a positive effect on pedestrian crossing behavior, and by inference, countdown signals could mitigate pedestrian crashes.

In 1999, the Minnesota Department of Transportation conducted a before-and-after survey of pedestrians at six intersections equipped with CPS in the metropolitan area of Minneapolis and St. Paul (Cook Research and Consulting, 1999). Pedestrians were interviewed before and after the countdown signals were installed. Field observations of pedestrian behavior were also made during the two periods. The countdown display was applied during the FDW interval. Overall, 78% of the respondents felt that the CPS was easier to understand than the conventional signal, while only 6% felt that it was more difficult to understand. The research showed that the numerical countdown, displayed during the FDW interval, was intuitively understood and used successfully by pedestrians. However, the study recommended that CPS should not become a standard signal component since the need is not always present. Situations recommended for CPS include long pedestrian crossing distances, crossing to medians, and intersections predominantly used by pedestrians with disabilities and elderly individuals.

Huang and Zegeer (2000) conducted an observational study of CPS effectiveness in Lake Buena Vista, Florida. Five intersections were observed: two with CPS and three control sites without CPS. The countdown at the two treatment sites began with the "WALK" interval. Since data was not collected at the intersections before the CPS installation, potential differences between individual sites were not fully accounted for. At each intersection, a single crosswalk was observed for the study. It was found from the analysis that significantly fewer pedestrians began crossing during the WALK signal at CPS locations (47%) than at those with the conventional signal locations (59%). Thus, pedestrians were more likely to begin crossing during the pedestrian change interval rather than wait for the next WALK indication. In addition, contrary to expectations, slightly more pedestrians who could not complete crossing the intersection before the SDW were found at the intersections with CPS (10.5%) than at those with the conventional signals (7.7%). The report also reported fewer instances of pedestrians running at locations with CPS (3.4%) than at locations with conventional pedestrian signals (10.4%).

At least 2 studies conducted by DKS Associates (2001) on pedestrian satisfaction with traffic control devices indicated pedestrians overwhelmingly approved of the CPS and typically prefer them to the pedestrian conventional signal. For example in San Francisco 78% of the pedestrians surveyed reported that CPS are "very helpful," and 34% favor conventional pedestrian signal. In that same study, 92% of the pedestrians expressed a preference for the CPS.

A study was conducted by Mahach, et al., (2002) to compare pedestrian signal preference among a set of seven signals which included a conventional pedestrian signal and a CPS with the countdown starting at the beginning of the steady "WALK" interval *(12)*. Nearly 60% of the participants selected the CPS as their favorite.

Markowitz et al. (2006) conducted an extensive pilot study in the City of San Francisco, CA at 14 intersections that evaluated the potential impact of CPS reducing pedestrian injuries as well as changing pedestrian crossing behaviors. The study also analyzed the potential impact of the CPS on any maintenance and installation issues, as well as driver behavior. The CPS display evaluated also had the countdown starting at the onset of the FDW interval. The authors reported that "*starting the countdown on the pedestrian clearance does not to reduce effectiveness substantially or trigger public complaints*" (Markowitz et al., 2006) They also indicated that there was an initial notion of receiving complaints about insufficient crossing time and lack of usefulness with the countdown starting from the onset of the FWD interval. They found that not to be the case.

In summary, the literature suggests that the CPS provide pedestrians with additional information that help them to cross intersections more safely. The literature also suggests that pedestrians prefer CPS to conventional signals. However, none of the studies reviewed in this research compared the SW-FDW CPS display with the FDW CPS display. This study is aimed at determining whether the SW-FDW CPS has any safety advantage over the FWD CPS.

## 3 RESEARCH METHODOLOGY

A "before" and "after" study was performed to compare the two types of CPS displays. See Figure 1. The "before" scenario is the SW-FDW CPS in which the countdown starts at the beginning of the SW interval and continues through the FDW interval, while in the "after" scenario the countdown coincides with the FDW interval.

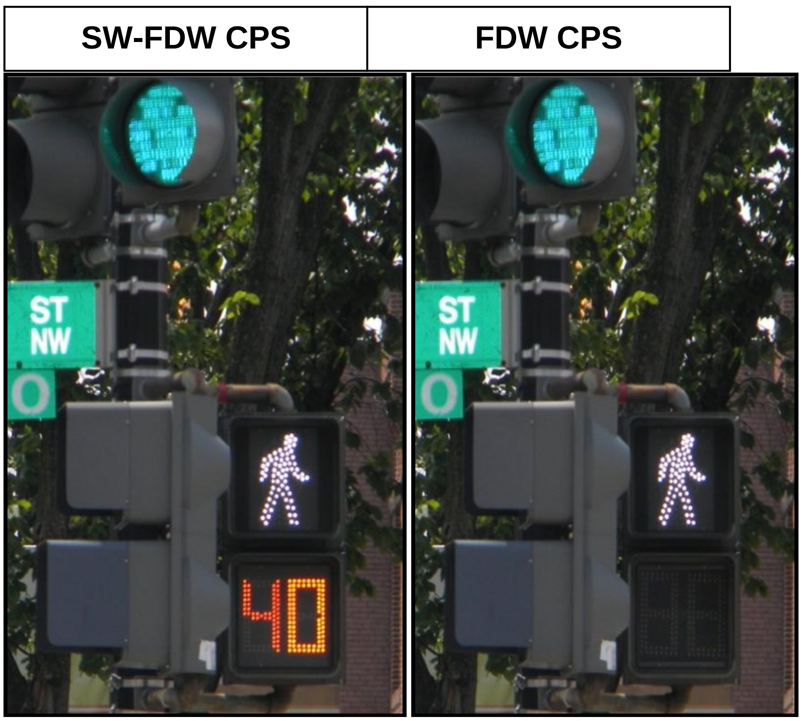


**Figure 1: The Two CPS Displays**

From playback of video recordings of traffic of both morning and evening peak periods, pedestrian and driver behaviors were observed at 25 crosswalks located at 25 selected intersections in the District of Columbia. The same observations were made at each crosswalk during the "before" and "after" scenarios. The data collected for the two scenarios were analyzed for statistical significance using a 95% confidence interval. In addition, a pedestrian and driver survey was conducted to evaluate their understanding and preferences for each of the two CPS displays. The following sections outlines the variables analyzed the description of the study intersections, the data collection process and the research hypotheses.

### 3.1 Selection of variables

The following variables were analyzed for the comparative study of SW-FDW CPS and FDW CPS displays:

- Pedestrians completing crossing during the FDW interval: this occurs when a pedestrian completes crossing during the FDW interval.
- Pedestrians beginning to cross during FDW - this occurs when a pedestrian starts crossing during the FDW interval. Pedestrians are not supposed to start crossing during that interval.
- Pedestrian-vehicle conflicts - A conflict occurs when either a pedestrian (or group of pedestrians) with a right of way takes an evasive action to avoid collision with a vehicle. This study considered only conflicts that occurred between a pedestrian with a right of way in a crosswalk and a vehicle making a right-turn to/from the crosswalk.

### 3.2 Description of Study Intersections

Twenty-five intersections, with fixed time control and located across the District of Columbia were selected for this study. The primary criteria for selecting the intersections were intersections with high pedestrian volumes, especially those in close proximity to bus stops and metro stations. Pedestrian behavior video data were collected at the twenty-five intersections during the “before” and “after” scenarios.

The pavement conditions at the intersections were all clearly marked with stop bars and crosswalks. The lanes widths ranged between 11 to 12 feet. Pedestrian activities were usually high during the morning peak period (7:30 A.M through 9:30 A.M.) and evening peak period (4:30 P.M. through 6:30 P.M.) at the selected intersections. Pedestrian traffic generators in close proximity to the intersections included subway stations, bus stops, restaurants, office buildings, and educational institutions. All the intersections involved in this study had asphalt pavement, sidewalks on all quadrants and were equipped with handicap ramps.

### 3.3 Data Collection and Reduction

At each intersection, a crosswalk was selected for a 2-hour videotaping of pedestrian crossing behavior during the morning and evening peak periods. The videotaping was made for both the “before” and “after” scenarios of CPS displays. The camera was positioned strategically in order to capture the pedestrian signal display as well as the pedestrian behaviors at the crosswalk. The video recordings were done between 7:30 A.M. and 9:30 A.M. for the morning peak period, and between 4:30 P.M. and 6:30 P.M. for the evening peak period. The video recordings were reviewed, and the pedestrian behavior variables were extracted. For each intersection, the total pedestrian counts, as well as the frequencies of the following variables were extracted for the morning and evening peak hours for the “before” and “after” scenarios:

Variable 1: Pedestrians completing crossing during the FDW interval
Variable 2: Pedestrians beginning to cross during FDW
Variable 3: Pedestrians-vehicle conflicts

### 3.4 Attitudinal Survey

Pedestrian survey was conducted at six of the study intersections. The intersections were chosen because of high pedestrian volumes and pedestrian activities within their vicinity. The survey was conducted over seven weekdays between 9:00 A.M. and 2:00 P.M. under good weather conditions. The driver survey was conducted at the offices of District Department of Motor Vehicles in the District of Columbia over a 3-day period. The location was chosen due to easy access to drivers. A total of 744 pedestrians and 243 drivers were surveyed. The survey questions were posed to willing pedestrians and drivers at the respective locations. The interviewers used both animated displays of the CPS on laptops as well as laminated snapshots of the two types of CPS displays (as shown in Figure 1) for illustration. Most of the interviewees who were shown the laminated snapshots of the two types of CPS displays were also shown the dynamic displays on the laptop. Some of the survey questions that were posed presented here are as follows:

For pedestrians:

1. Which display provides you with more information?
2. Which display do you prefer for crossing signalized intersections?

For drivers:

1. Does the number in the CPS display help you make intersection driving decisions?
2. Which of the displays do you prefer?

## 4 Analysis

### 4.1 Statistical Assumptions

The three variables defined in this study were analyzed using the test statistic of proportions. It was assumed that the samples collected at each intersection during the "before" and the "after" scenarios were independent and random. It is assumed that the sample proportions were obtained. Applying the normal approximation to the binomial to each population, the estimators of each proportion can be assumed to approximate to the normal distribution. Since the sample sizes used in this study were large (N≥30; see Table 1), the sampling distribution of the difference in proportions was also assumed to be normally distributed.

### 4.2 Hypothesis

The null hypothesis ($H_0$) and the alternative hypothesis ($H_1$) were as follows:

$$\begin{cases} H_0 : P_b = P_a \\ H_1 : P_b \neq P_a \end{cases} \quad \text{or} \quad \begin{cases} H_0 : P_b - P_a = 0 \\ H_1 : P_b - P_a \neq 0 \end{cases} \qquad [1]$$

where

$P_b$ = the proportion of the variable of interest for the SW-FDW CPS

$P_a$ = the proportion of the variable of interest for FDW CPS

Table 1 Number of Pedestrian Crossings Observed (Sample Size)

| No. | Intersection | AM | | PM | |
|---|---|---|---|---|---|
| | | *$N_b$ | *$N_a$ | *$N_b$ | *$N_a$ |
| 1 | 23rd Street & H Street, NW | 1662 | 1657 | 2013 | 1759 |
| 2 | 13th Street & U Street, NW | 922 | 1215 | 1498 | 1190 |
| 3 | 12th Street & G Street, NW | 541 | 699 | 713 | 1020 |
| 4 | Wisconsin Ave & N Street, NW | 357 | 346 | 586 | 612 |
| 5 | 7th Street & H Street, NW | 1502 | 1468 | 2607 | 2421 |
| 6 | 7th Street & Constitution Ave, NW | 206 | 273 | 789 | 868 |
| 7 | 12th Street & Pennsylvania Ave, NW | 431 | 596 | 864 | 831 |
| 8 | 14th Street & U Street, NW | 727 | 776 | 826 | 1074 |
| 9 | 14th Street & K Street, NW | 1186 | 1012 | 1169 | 1012 |
| 10 | 7th Street, Mount Vernon Square, & New York Ave, NW | 232 | 143 | 500 | 313 |
| 11 | 21st Street & K Street, NW | 444 | 390 | 597 | 475 |
| 12 | Connecticut Ave & Woodly Road, NW | 196 | 241 | 294 | 356 |
| 13 | Connecticut Ave & Nebraska Ave, NW | 74 | 66 | 84 | 58 |
| 14 | Connecticut Ave & Van Ness Street, NW | 94 | 109 | 222 | 146 |
| 15 | North Capitol & H Street | 643 | 597 | 490 | 432 |
| 16 | Benning Road & East Capitol Street | 411 | 404 | 556 | 626 |
| 17 | Benning Road & Minnesota Ave, NE | 306 | 358 | 534 | 646 |
| 18 | New Jersey Ave & M Street, SE | 1437 | 1551 | 864 | 1155 |
| 19 | Florida Ave & North Capitol Street | 355 | 383 | 290 | 271 |
| 20 | New York Ave & Florida Ave, NE | 377 | 390 | 389 | 368 |
| 21 | 14th Street & Constitution Ave, NW | 186 | 203 | 606 | 541 |
| 22 | Independence Ave & 7th Street | 180 | 209 | 335 | 622 |
| 23 | Martin L. King Jr. Ave, Howard Road, & Sheridan Road, SE | 223 | 248 | 139 | 127 |
| 24 | Wisconsin Ave, Western Ave, & Military Road, NW | 268 | 244 | 718 | 722 |
| 25 | 20th Street & M Street, NW | 780 | 905 | 999 | 1167 |

*$N_b$ = the number of pedestrian crossings observed in the SW-FDW CPS
*$N_a$ = the number of pedestrian crossings observed in the FDW CPS

The null hypothesis ($H_o$) states that there is no difference (that is, $P_b$ - $P_a$ = 0) between the observed variable for the two scenarios. Using a two-tailed test at 5% level of significance, ($H_1$) would be rejected if the absolute value of z-statistic is greater than the critical value (1.645).

### 4.3 Test Statistic

The z-statistic was calculated from the following formula:

$$z = \frac{P_b - P_a}{\sqrt{pq\left(\frac{1}{N_b} + \frac{1}{N_a}\right)}} \qquad [2]$$

where:

$$p = \frac{N_b P_b + N_a P_a}{N_b + N_a} \quad \text{and} \quad q = 1 - p\,, \qquad [3]$$

$N_b$ = the sample size (Total number of pedestrians) for SW-FDW CPS
$N_a$ = the sample size (Total number of pedestrians) for FDW CPS.
$p$ = proportion of variable of interest

$q$ = 1 - $p$

### 4.4 Analysis of Attitudinal Survey

A survey was conducted to obtain the opinions of pedestrians and drivers in the District of Columbia regarding their preference of the CPS displays. The opinions were tallied and tabulated from which the summaries were obtained.

## 5 Results

### 5.1 Hypothesis Testing

The proportion for each variable was calculated by dividing the frequency of the outcome by the sample size. The sample size is the total number of pedestrians. The analyses of the difference in proportions for the “before” and “after” scenarios were conducted for morning and evening peak periods at 5% level of significance.

#### 5.1.1 Pedestrians completing crossing during the FDW interval

The proportion of pedestrians completing crossing during the FDW interval were computed. The results of the analysis of this variable are presented in Tables 2 and 3 for the A.M. and P.M. peak period, respectively.

Table 2 Results for "Pedestrian Completing Crossing during the FDW Interval"-A.M. Peak Period

| **No.** | **Intersection** | **SW-FDW** | **FDW** | **z-statistic** | **p-value** | **Significant?** |
|---|---|---|---|---|---|---|
| | | **$P_b$** | **$P_a$** | | | |
| 1 | 23rd Street & H Street, NW | 0.040 | 0.031 | 1.296 | 0.195 | **No** |
| 2 | 13th Street & U Street, NW | 0.112 | 0.062 | 4.142 | 0.000 | **Yes** |
| 3 | 12th Street & G Street, NW | 0.235 | 0.064 | 8.608 | 0.000 | **Yes** |
| 4 | Wisconsin Ave & N Street, NW | 0.115 | 0.095 | 0.841 | 0.400 | **No** |
| 5 | 7th Street & H Street, NW | 0.052 | 0.048 | 0.532 | 0.595 | **No** |
| 6 | 7th Street & Constitution Ave, NW | 0.160 | 0.150 | 0.300 | 0.764 | **No** |
| 7 | 12th Street & Pennsylvania Ave, NW | 0.090 | 0.082 | 0.467 | 0.640 | **No** |
| 8 | 14th Street & U Street, NW | 0.083 | 0.055 | 2.080 | 0.038 | **Yes** |
| 9 | 14th Street & K Street, NW | 0.030 | 0.042 | -1.639 | 0.101 | **No** |
| 10 | 7th Street, Mount Vernon Square, & New York Ave, NW | 0.030 | 0.084 | -2.305 | 0.021 | **Yes** |
| 11 | 21st Street & K Street, NW | 0.264 | 0.097 | 6.152 | 0.000 | **Yes** |
| 12 | Connecticut Ave & Woodly Road, NW | 0.041 | 0.025 | 0.940 | 0.347 | **No** |
| 13 | Connecticut Ave & Nebraska Ave, NW | 0.014 | 0.030 | -0.685 | 0.493 | **No** |
| 14 | Connecticut Ave & Van Ness Street, NW | 0.021 | 0.128 | -2.825 | 0.005 | **Yes** |
| 15 | North Capitol & H Street | 0.011 | 0.069 | -5.271 | 0.000 | **Yes** |
| 16 | Benning Road & East Capitol Street | 0.049 | 0.040 | 0.629 | 0.529 | **No** |
| 17 | Benning Road & Minnesota Ave, NE | 0.190 | 0.061 | 3.574 | 0.000 | **Yes** |
| 18 | New Jersey Ave & M Street, SE | 0.055 | 0.077 | -2.388 | 0.017 | **Yes** |
| 19 | Florida Ave & North Capitol Street | 0.023 | 0.018 | 0.410 | 0.682 | **No** |
| 20 | New York Ave & Florida Ave, NE | 0.119 | 0.138 | -0.789 | 0.430 | **No** |
| 21 | 14th Street & Constitution Ave, NW | 0.043 | 0.049 | -0.293 | 0.769 | **No** |
| 22 | Independence Ave & 7th Street | 0.022 | 0.043 | -1.140 | 0.254 | **No** |
| 23 | Martin L. King Jr. Ave, Howard Road, & Sheridan Road, SE | 0.094 | 0.105 | -0.386 | 0.700 | **No** |
| 24 | Wisconsin Ave, Western Ave, & Military Road, NW | 0.071 | 0.045 | 1.242 | 0.214 | **No** |
| 25 | 20th Street & M Street, NW | 0.010 | 0.012 | -0.368 | 0.713 | **No** |

Table 3 Results for "Pedestrian Completing Crossing during the FDW Interval" –P.M. Peak Period

| **No.** | **Intersection** | **SW-FDW** | **FDW** | **z-statistic** | ***p*-value** | **Significant?** |
|---|---|---|---|---|---|---|
| | | **$P_b$** | **$P_a$** | | | |
| 1 | 23rd Street & H Street, NW | 0.030 | 0.024 | 1.096 | 0.273 | **No** |
| 2 | 13th Street & U Street, NW | 0.089 | 0.072 | 1.141 | 0.254 | **No** |
| 3 | 12th Street & G Street, NW | 0.181 | 0.030 | 10.653 | 0.000 | **Yes** |
| 4 | Wisconsin Ave & N Street, NW | 0.014 | 0.026 | -1.091 | 0.275 | **No** |
| 5 | 7th Street & H Street, NW | 0.013 | 0.011 | 0.730 | 0.466 | **No** |
| 6 | 7th Street & Constitution Ave, NW | 0.133 | 0.111 | 1.400 | 0.162 | **No** |
| 7 | 12th Street & Pennsylvania Ave, NW | 0.065 | 0.128 | -4.392 | 0.000 | **Yes** |
| 8 | 14th Street & U Street, NW | 0.068 | 0.043 | 1.692 | 0.091 | **No** |
| 9 | 14th Street & K Street, NW | 0.076 | 0.042 | 3.286 | 0.001 | **Yes** |
| 10 | 7th Street, Mount Vernon Square, & New York Ave, NW | 0.046 | 0.042 | 0.301 | 0.763 | **No** |
| 11 | 21st Street & K Street, NW | 0.132 | 0.082 | 2.610 | 0.009 | **Yes** |
| 12 | Connecticut Ave & Woodly Road, NW | 0.010 | 0.101 | -4.858 | 0.000 | **Yes** |
| 13 | Connecticut Ave & Nebraska Ave, NW | 0.048 | 0.000 | 1.686 | 0.092 | **No** |
| 14 | Connecticut Ave & Van Ness Street, NW | 0.072 | 0.082 | -0.253 | 0.800 | **No** |
| 15 | North Capitol & H Street | 0.008 | 0.088 | -5.799 | 0.000 | **Yes** |
| 16 | Benning Road & East Capitol Street | 0.047 | 0.032 | 0.929 | 0.353 | **No** |
| 17 | Benning Road & Minnesota Ave, NE | 0.067 | 0.101 | -2.029 | 0.042 | **Yes** |
| 18 | New Jersey Ave & M Street, SE | 0.038 | 0.037 | 0.113 | 0.910 | **No** |
| 19 | Florida Ave & North Capitol Street | 0.069 | 0.063 | 0.297 | 0.766 | **No** |
| 20 | New York Ave & Florida Ave, NE | 0.126 | 0.220 | -3.433 | 0.001 | **Yes** |
| 21 | 14th Street & Constitution Ave, NW | 0.033 | 0.048 | -1.297 | 0.195 | **No** |
| 22 | Independence Ave & 7th Street | 0.027 | 0.023 | 0.420 | 0.675 | **No** |
| 23 | Martin L. King Jr. Ave, Howard Road, & Sheridan Road, SE | 0.245 | 0.079 | 3.637 | 0.000 | **Yes** |
| 24 | Wisconsin Ave, Western Ave, & Military Road, NW | 0.047 | 0.069 | -1.254 | 0.210 | **No** |
| 25 | 20th Street & M Street, NW | 0.014 | 0.019 | -0.878 | 0.380 | **No** |

For the A.M. peak period, the proportions of pedestrians completing crossing during the FDW interval decreased at 14 intersections and increased at the remaining 11 intersections. The reductions were statistically significant at five (of the 14) intersections, and the increases were significant at four (of the 11) intersections during the A.M. peak period. In the PM peak period, 15 of the intersections experienced reductions in the proportions of pedestrians completing the crossing in the FDW interval, while 10 intersections showed an increase in proportion. The reductions in proportions were statistically significant at four (of the 15) intersections, and the increases in proportions were found to be statistically significant at five (of the 10) intersections. Overall, in the A.M. peak periods, the alternate hypothesis $H_1$, that there is a difference in proportions, would be rejected at the nine intersections that produced statistically significant changes in proportions of pedestrians completing crossing during the FDW interval. For the P.M. peak hours, the hypothesis $H_1$ would be rejected at nine intersections.

In summary, as shown in Table 4, the results of the hypothesis test for this variable at 5% level of significance indicate in general that there is no discernable behavioral change in pedestrian behavior due to the type of CPS display. The majority of the intersections in both the morning and evening peak periods recorded no statistically significant difference in pedestrian behavior due to the CPS displays.

Table 4 Summary Results for "Pedestrian Completing Crossing during the FDW Interval"

| **Peak Period** | **Percentage of intersections showing statistically significant results** | |
|---|---|---|
| | *No difference in proportions* | *Difference in proportions* |
| ***Morning*** | 64% | 36% |
| ***Evening*** | 64% | 36% |

5.1.2 Pedestrian starting to cross during FDW

The same analytical process was used for this variable. The number of pedestrians that started crossing during the FDW was observed for the “before” and “after” scenarios. Table 5 presents the summary results of the hypothesis tests for pedestrian beginning to cross at the onset of FDW. Overall, there is no discernable behavioral change in this pedestrian behavior due to the type of CPS display, at 5% level of significance.

Table 5 Summary Results for "Pedestrian Starting to Cross during FDW"

| **Peak Period** | **Percentage of intersections showing statistically significant results** | |
|---|---|---|
| | No difference in proportions | Difference in proportions |
| ***Morning*** | 52% | 48% |
| ***Evening*** | 64% | 36% |

5.1.3 Pedestrian-vehicle conflicts

The results for the evaluation of pedestrian-vehicle conflicts, using the same procedure, are presented in Table 7. In summary, as shown in Table 6, the results of the hypothesis tests for this variable indicate in general that there is no discernable behavioral change in pedestrian-vehicle conflicts due to the type of CPS display.

Table 6 Summary Results for "Pedestrian-Vehicle Conflicts"

| **Peak Period** | **Percentage of intersections showing statistically significant results** | |
|---|---|---|
| | *No difference in percentage* | *Difference in percentage* |
| ***Morning*** | 72% | 28% |
| ***Evening*** | 68% | 32% |

## 5.2 Pedestrian Survey

A survey, designed to gather information from pedestrians regarding their understanding and preference for the two types of CPS, was conducted at six intersections where SW-FDW countdown display was changed to FDW countdown display. Pedestrians were selected at random from those who were waiting at the curb to cross at the intersections. The total number of respondents was 744. This survey was conducted independent of the driver survey.

### 5.2.1 Results for Question 1

The summary of the responses to the question *"As a pedestrian, which display provides you with more information?"* is presented in Figure 2.

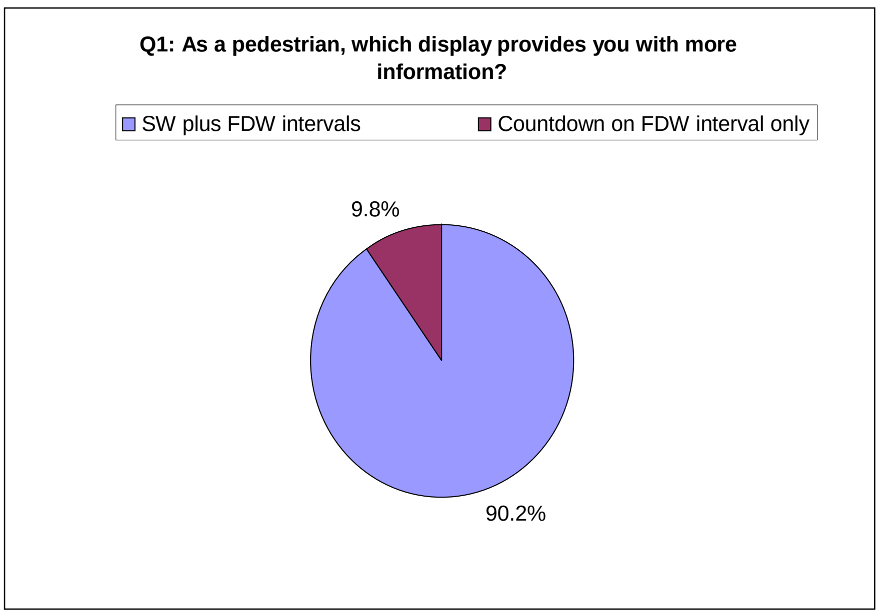


Figure 2 Responses to Question 1 of Pedestrian Survey

The results indicate that approximately 90% of the pedestrians surveyed chose the SW-FDW countdown which corresponds to the "before" scenario. The responses suggest that pedestrians believe that displaying the time during the SW interval help them make more educated crossing decisions.

5.2.2 Results for Question 2

Finally, pedestrian were asked to indicate which of the two types of CPS displays they would prefer for signalized intersections in the City. The summary of the responses to that question is presented in Figure 3. Approximately 86% of the respondents said that they would prefer the SW-FDW countdown display to be used at signalized intersection in the City.

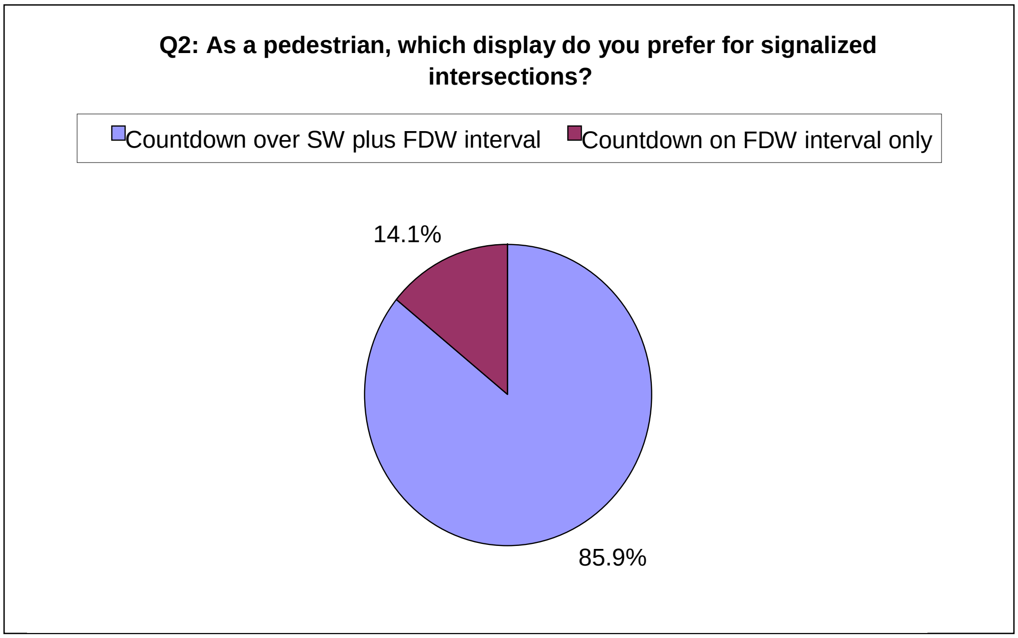


Figure 3: Responses to Question 2 of Pedestrian Survey

Some of the pedestrians surveyed made a number of comments about the FDW countdown display. The WALK interval for FDW display is usually exhibited with a SW symbol without the countdown time. Some respondents contended that when there is no countdown time below the SW, it appears to them that the pedestrian signal is malfunctioning, until the FDW interval is displayed with the countdown seconds before proceeding to cross.

### 5.3 Driver Survey

A survey was conducted to assess driver's opinions about the countdown displays. A total of 243 drivers were surveyed. The following questions were posed:

1. Does the number in the CPS display help you make intersection driving decisions?
2. Which of the displays do you prefer?

Figures 4 and 5 show the results of the survey. Nearly all drivers that admitted paying attention to the countdown also agreed that the CPS help them make driving decisions. In addition, the majority (83%) of drivers surveyed prefer SW-FDW display because it gives them more information than the FDW display.

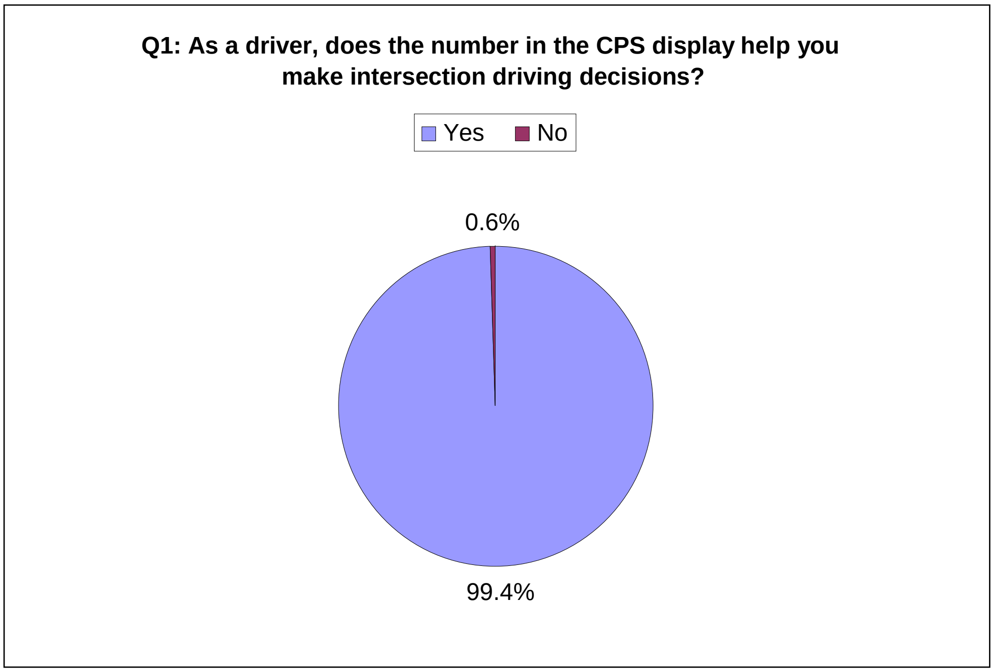

Figure 4 Responses to Question 1 of Driver Survey

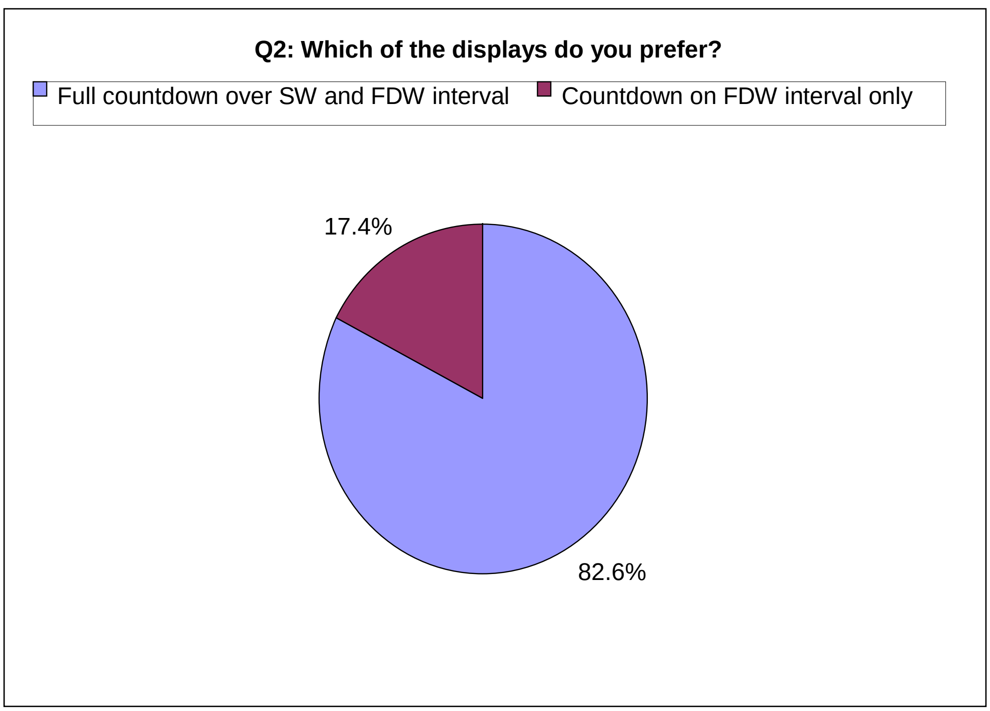

Figure 5 Responses to Question 2 of Driver Survey

## 6. Conclusions

From the results, 36% of the intersections showed statistically significant changes in proportions (reductions or increases) of pedestrians who completed their crossing during the FWD interval in the A.M. peak period. In the P.M. peak period, 36% of the intersections recorded statistically significant changes in proportions. Overall, there is no discernable behavioral change in this pedestrian behavior due to the type of CPS display.

The evaluation of pedestrians beginning to cross during FDW showed statistically significant difference in proportions at 48% of the intersections during the A.M. peak period. The P.M. peak period showed 36% of the intersections had a statistically significant increase or decrease in proportion. These results suggest that there is no behavioral change in this pedestrian behavior due to the type of CPS display.

The results indicate that 28% of the intersections recorded statistically significant difference in proportions of pedestrians who had conflicts with vehicles in the A.M. peak period. During the P.M. peak period, intersections that had significant changes in proportions related to this behavior represented 32%. Overall, only one intersection showed a decrease in proportions for both A.M. and P.M. peak periods. The increases in proportions were constantly significant at two of the 25 intersections. In summary, there is no clear pattern of change in pedestrian-vehicle conflicts due to the type of CPS display.

The pedestrian survey showed that the majority of respondents prefer the full countdown display (SW-FDW CPS) over the FDW CPS (as prescribed in the MUTCD). These results imply that pedestrian believe that the time displayed during the WALK interval of the SW-FDW CPS help them make better crossing decisions. The driver survey results indicate that most of the drivers paid attention to CPS displays and use the countdown to make driving decisions at intersections (99%). The majority of the surveyed drivers indicated that they prefer SW-FDW CPS since the displayed time helps them in making driving decisions at signalized intersections.

The results of the analyses only apply to signalized intersections with fixed time control and show that the differences in pedestrian crossing behavior due to the two types of CPS displays are minimal. With pedestrians' and drivers' overwhelming preference for the CPS display which starts at the beginning of the SW interval, coupled with the fact that there is no clear advantage of using one display over the other, there is the need for an expanded study to cover intersections in several jurisdictions in order to obtain a broad consensus on the preferred countdown display. The expanded research could also include additional pedestrian crossing behavior variables, a broader survey of survey of pedestrians and drivers, a diverse selection of intersection and traffic control.

## 7 Acknowledgement

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## 8 References

Arhin S., Noel E. *Evaluation of Countdown Pedestrian Signals in the District of Columbia*. Washington DC, 2006

Botha, J.L., Zabyshny, A.A., Day, J.E., Northouse, R.L., Rodriguez, J.O., & Nix, T.L. (2002). *Pedestrian Countdown Signals: An Experimental Evaluation – Volume 1.* Retrieved October 16, 2003 from City of San Jose, California Web site: www.ci.san-jose.ca.us/dot/forms/ report_pedcountdown.pdf

Chester, D.C., Hammond, M. *Evaluation of Pedestrian Understanding of Pedestrian Countdown Signals*. 68th Annual Meeting of Institute of Transportation Engineers, 1998.

Cook Research & Consulting, Inc. (1999). *Countdown Pedestrian Indication Market Research.* Minneapolis, MN: Mn/DOT's Metropolitan Division Traffic Engineering Section City of Chicago Department of Transportation (2002).

DKS Associates. *San Francisco Pedestrian Countdown Signals: Preliminary Evaluation Summary.* San Francisco, CA: San Francisco Dept. of Parking and Traffic, 2001.

Eccles, K.A. (2003). *Evaluation of Pedestrian Countdown Signals.* Silver Spring, MD: Prepared by BMI-SG for Montgomery County Maryland and Maryland State Highway Administration.

Farraher, B.E.B. (2000). *Pedestrian Countdown Indication – Market Research and Evaluation.* Minnesota Department of Transportation: http://www.dot.state.mn.us/metro/trafficeng/signals/files/compendium.pdf

Federal Highway Administration (2009). *Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition.* Washington, DC.

Huang, H., & Zegeer, C. (2000). *The effects of pedestrian countdown signals in Lake Buena Vista*. Retrieved October 16, 2009 from Florida Department of Transportation: www11.myflorida.com/safety/ped_bike/handbooks_and_research/research/CNTREPT.pdf

Mahach, K., Nedzesky, A.J., Atwater, L., & Saunders, R. *A comparison of Pedestrian signal heads*. ITE Annual Meeting Compendium, 2002

Markowitz, F., Sciortino, S., Fleck, J.L., and Yee, B.M. *Pedestrian Countdown Signals: Experience with an Extensive Pilot Installation*. Institute of Transportation Engineers (ITE) Journal, January 2006 Issue, p. 43-48.

Petraglia Ken. *An Evaluation of Countdown Pedestrian Signals.* New England Chronicle. May 2004.

Pulugurtha, S. S. and S. S. Nambisan. *Effectiveness of Pedestrian Countdown Timers to Enhance Safety in Las Vegas.* Institute of Transportation Engineers District 6 Annual Meeting, Sacramento, CA. June 2004.