# Countdown Pedestrian Signals (CPS) Legibility and Comprehension without Flashing Hand: Phase I and II Final Report

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# FOREWORD

The objective of the Transportation Pooled Fund Program's Traffic Control Device (TCD) Consortium is to assemble a consortium of regional, State, local entities, appropriate organizations and the Federal Highway Administration (FHWA) to 1) establish a systematic procedure to select, test, and evaluate approaches to novel TCD concepts as well as to incorporate results into the *Manual on Uniform Traffic Control Devices* (MUTCD); 2) select novel TCD approaches to test and evaluate; 3) determine methods of evaluation for novel TCD approaches; 4) initiate and monitor projects intended to evaluate TCDs; and 5) disseminate results.

This report documents an FHWA project examining the comprehension of the countdown pedestrian signal (CPS) with and without the Flashing Don't WALK (FDW) signal, and the effect of removing the FDW on pedestrians (including pedestrians with low vision). The project focused on evaluating the effect that this manipulation had on crossing decisions and crossing times, as well as pedestrian cross behavior at intersections with and without the FDW signal.

This report is of interest to engineers, planners, and other researchers and practitioners who are concerned with the implementation of effective pedestrian signals. Information on the potential effects of these signal modifications may be of interest to local, regional, and State authorities as they evaluate their existing and planned pedestrian management strategies.

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Operations Research and
Development



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| 16. Abstract<br>The purpose of this study was to conduct two human factors field studies examining the utility of the presence of the Flashing Don't WALK (FDW) icon (i.e., the flashing hand) during the countdown pedestrian signal (CPS). Phase I examined pedestrians' comprehension of the CPS with and without the FDW signal, and the effect of removing the FDW on pedestrians with low vision. Three results were found: pedestrians were more likely to consider crossing with the CPS Alone than with the CPS + FDW; healthy, young participants had little difficulty judging the time required to cross for three different distances without changing their speed; and the removal of the FDW from the CPS + FDW signal had no negative impact on low-vision pedestrians' decisions to cross during the CPS.<br>Phase II further evaluated the effect of removing the FDW from the CPS by observing pedestrians' natural behavior at two intersections. Participants were naturally observed pedestrians at two intersections. Following a baseline period, the FDW was removed from the CPS signal. Data were collected immediately after FDW removal and six months later. Regardless of the CPS present, pedestrians were likely to begin crossing during the pedestrian change interval. Finishing times show significantly fewer people in the crosswalk after the cross-traffic was released at three of the four sites during the CPS alone follow-up condition than during the CPS + FDW condition. | | |
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## SI* (MODERN METRIC) CONVERSION FACTORS

### APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| mi | miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yard | 0.836 | square meters | $m^2$ |
| ac | acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | square kilometers | $km^2$ |
| | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57 | milliliters | mL |
| gal | gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | cubic meters | $m^3$ |
| | | NOTE: volumes greater than 1000 L shall be shown in $m^3$ | | |
| | | **MASS** | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams (or "metric ton") | Mg (or "t") |
| | | **TEMPERATURE (exact degrees)** | | |
| $^oF$ | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | $^oC$ |
| | | **ILLUMINATION** | | |
| fc | foot-candles | 10.76 | lux | lx |
| fl | foot-Lamberts | 3.426 | candela/$m^2$ | cd/$m^2$ |
| | | **FORCE and PRESSURE or STRESS** | | |
| lbf | poundforce | 4.45 | newtons | N |
| lbf/$in^2$ | poundforce per square inch | 6.89 | kilopascals | kPa |

### APPROXIMATE CONVERSIONS FROM SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.039 | inches | in |
| m | meters | 3.28 | feet | ft |
| m | meters | 1.09 | yards | yd |
| km | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | square millimeters | 0.0016 | square inches | $in^2$ |
| $m^2$ | square meters | 10.764 | square feet | $ft^2$ |
| $m^2$ | square meters | 1.195 | square yards | $yd^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | cubic meters | 35.314 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.307 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.202 | pounds | lb |
| Mg (or "t") | megagrams (or "metric ton") | 1.103 | short tons (2000 lb) | T |
| | | **TEMPERATURE (exact degrees)** | | |
| $^oC$ | Celsius | 1.8C+32 | Fahrenheit | $^oF$ |
| | | **ILLUMINATION** | | |
| lx | lux | 0.0929 | foot-candles | fc |
| cd/$m^2$ | candela/$m^2$ | 0.2919 | foot-Lamberts | fl |
| | | **FORCE and PRESSURE or STRESS** | | |
| N | newtons | 0.225 | poundforce | lbf |
| kPa | kilopascals | 0.145 | poundforce per square inch | lbf/$in^2$ |

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ADT | Average Daily Traffic |
| CD | Countdown |
| CPS | Countdown Pedestrian Signal |
| DOT | Department of Transportation |
| E-W | East to West |
| FDW | Flashing DON'T WALK |
| FHWA | Federal Highway Administration |
| FW | Flashing WALK |
| ITE | Institute of Transportation Engineers |
| ITS | Intelligent Transportation System |
| LED | Light Emitting Diode |
| MUTCD | *Manual on Uniform Traffic Control Devices* |
| N-S | North to South |
| SDW | Steady DON'T WALK |
| TCD | Traffic Control Device |
| UVC | Uniform Vehicle Code |

# EXECUTIVE SUMMARY

## BACKGROUND

Countdown pedestrian signals (CPS) have been shown to be more intuitive than other crossing signals when communicating the amount of available crossing time at an intersection.

Survey research shows that the traditional flashing DON'T WALK (FDW) signal (i.e., the flashing hand) is poorly understood.[1,2] In contrast, comprehension for CPS tends to be much higher. Between 86 percent[3] and 100 percent of pedestrians understand CPS correctly.[2]

Field research indicates that the traditional FDW signal increases the likelihood of pedestrians initiating a crossing, running out of time while crossing, returning to the starting side of the crossing while crossing, or even stopping in the roadway once the light changes.[4]

Crash data suggest that when countdown timers are added to existing pedestrian signals, crashes decrease by 25 percent.[5] One field study illustrates that pedestrians are more likely to judge whether they have enough time to cross when only the CPS is used.[6] However, little information is available on how well pedestrians calculate the amount of time needed to cross.

The pedestrian change (or clearance) interval is designed to allow pedestrians enough time to finish crossing, after they have initiated a crossing, before the light changes. Before the use of countdown timers, the FDW displayed during the pedestrian change interval, signaled pedestrians to not start crossing and there was no way to tell if there was enough time to finish crossing. It was fine to finish crossing, however, if the pedestrian had started to cross before the FDW appeared.

Since pedestrians cross at different speeds, the timing of the FDW needed to be set at a value that would allow slower pedestrians to safely cross. At the time of this research, the trend toward calculating crossing times based on slower pedestrians meant that faster pedestrians, who arrived at the intersection during the FDW and could have easily crossed before the phase ended, were left trapped on the sidewalk. The addition of the CPS allowed pedestrians to individually determine whether they had enough time to cross the crosswalk.

Technically, at the time of this research (2015), it was a violation of the *Uniform Vehicle Code and Model Traffic Ordinance*—commonly referred to as the UVC[7]—to cross when the FDW was present. Work was underway to revise the UVC, however. One option considered was to remove the rule indicating that pedestrians could not start walking during the FDW and then replace it with a statement that pedestrians that start to cross after the start of the countdown must finish crossing before the appearance of the signal's solid hand. This change would need to be accompanied by a change in the *Manual on Uniform Traffic Control Devices* (MUTCD)[8] and State and local laws that specify allowable pedestrian behaviors—when facing various traffic control device displays.

## PHASE I RESEARCH

The Traffic Control Devices (TCD) Consortium Pooled Fund Study is a continuous effort that focuses on addressing human factors and operations issues in a systematic evaluation of novel TCDs. As part of this effort, the FHWA Human Factors Team is evaluating CPS.

The purpose of this Phase I research was to examine differences in comprehension between signals with or without the flashing hand during the countdown phase. The results of this research provide additional data on the pedestrian comprehension of the CPS Alone compared to pedestrian comprehension of the CPS + FDW. They also provide information on how well pedestrians are able to tell how much time they need to cross during the pedestrian change interval, and they provide data on whether removing the FDW from the pedestrian clearance interval would affect the ability of pedestrians with low vision to determine the pedestrian signal phase and their own safety.

Phase I included three studies. Study 1A examined how well pedestrians understand and react to different pedestrian signals. In this study, 300 people were shown a digital video tablet display of the “WALK” signal, the “DON’T WALK” signal, the CPS + FDW, and the CPS Alone. The results indicated that pedestrians were more likely to consider crossing if they judged that they had enough time with the CPS Alone rather than with the CPS + FDW. This perception concerning the amount of time remaining held for both male and female participants, and also across young adult, adult, and senior age brackets.

Study 1B examined how well pedestrians can tell the amount of time they need to cross. Participants viewed a CPS and were then told to start crossing when they felt that they had just enough time to cross the street. Participants had little difficulty judging the time required for 12 m, 18 m, and 24 m (40 ft, 60 ft, and 80 ft, respectively) crossings. Most pedestrians could tell the amount of time left and then successfully cross without making significant changes to their walking speeds. Another interesting finding was that pedestrians walked faster than usual in most studies when they were timed at the onset of the “WALK” signal. This finding probably resulted from pedestrians walking slower after they knew they had more than enough time to cross.

Study 1C examined how well low-vision pedestrians could determine how to respond and when to cross when comparing the CPS Alone and the CPS + FDW for a 12 m (40 ft) and 30.5 m (100 ft) crossing. The results of this experiment showed that low-vision pedestrians often have difficulty telling what the signal phase is at longer crossings. However, the removal of the FDW from CPS + FDW signal had no negative impact on their decision to cross during the pedestrian clearance phase. At 12 m (40 ft) all participants identified the color and 17 out of 20 identified the shape of the FDW signal, 16 could identify the countdown and 14 could read all or some of the numbers. Only six participants chose to cross. All six participants could identify numbers and based their decision on the numbers that they identified. For the 30.5 m (100 ft) crossing, 13 out of 20 participants identified the color of the CPS + FDW while 15 identified the color of the CPS Alone. However, only one of them could read the numbers. Only four low-vision pedestrians said that they would cross with the CPS + FDW signal without being able to read the numbers. Two of these participants said that they could see that the countdown was present. One said that he would be careful because he did not know how much time he had to cross. Only one person in the CPS Alone condition said that they would cross. That person could see the countdown and based their decision on the amount of time that they had left to cross.

## PHASE II RESEARCH

Phase II was a treatment study designed to examine the short- and long-term impact of removing the FDW signal (flashing hand) from the CPS displayed during the pedestrian change interval. In this naturalistic study pedestrian crossing behavior was observed at two different intersections (four crossings) in Kalamazoo, MI. Pedestrian crossings during three study phases were compared: the baseline phase, in which the standard CPS with FDW was displayed (CPS+FDW); the treatment phase, in which the CPS was displayed without the FDW (CPS Alone); and the follow-up phase, which occurred after the CPS alone signal had been displayed for six months. One of the key dependent variables in this study was, whether pedestrians that arrived at the curb during the pedestrian change interval, began to cross or waited instead for the next "WALK" signal. Regardless of the CPS present, pedestrians were very likely to begin crossing both during the first 5 s (early) of the pedestrian change interval and during the remaining seconds (late) of the pedestrian change interval. The research team also did not find much of a change in the percentage of pedestrians crossing during the pedestrian change interval with the exception of the site with the shortest buffer, which showed an increase during treatment.

Overall, there was a decrease in crossing time, reflecting faster crossing, at three of the four sites during the CPS Alone condition. During the 6-mo follow-up phase, further decreases in crossing times were observed at these three sites, and crossing times also decreased at the fourth site; however, none of these changes were statistically significant. At two of the four sites, there was also an increase in the percentage of pedestrians that ran, during the original CPS Alone phase at any point in the crossing. The increase in the percentage of pedestrians was maintained at these two sites, albeit the increase was not as substantial. However, a third site saw an increase in running during the Follow-up phase as well. Only one change at one site during the CPS Alone condition was statistically significant; however, it was not significantly different from the baseline during the CPS Alone Follow-up condition. The one site that did not show a change in running also did not show a decrease in crossing time.

The study also showed an increase in the percentage of pedestrians crossing during the Steady DON'T WALK (SDW) signal at three of the four sites. The effect was small and was only statistically significant at one site. It is interesting to note that this increase was balanced by a decrease in the percentage crossing during the "WALK" phase at this site.

The starting time distributions were very similar during each condition for all four sites. However, during the CPS Alone Follow-up condition the finishing times show fewer people who had not completed their crossing at the time when the cross-traffic was released at all four sites. This finding is in contrast to what was found during the CPS + FDW condition. The differences were statistically significant at three of the four sites. The one site that did not show a significant change, was also the site with the best pedestrian compliance for all conditions. The site with the poorest compliance was located in an area with social services agencies, while the crosswalk with the most compliance was in a business district. It is interesting that in this study compliance showed the greatest improvement at the crosswalk serving pedestrians utilizing social services.

Very few evasive conflicts were observed between pedestrians and vehicles during this study. One pedestrian crash was observed, but this crash was between a pedestrian that started to cross during the "WALK" signal and a vehicle that was turning. This type of crash should not be related to the type of pedestrian signal used.

# INTRODUCTION

## BACKGROUND

In an increasingly complex pedestrian environment, where pedestrian signal phases may not be concurrent with vehicular green, use of pedestrian signals, such as "WALK" or "DON'T WALK", is necessary. Safely crossing the street requires that pedestrians be able to locate, see, and accurately interpret information provided by pedestrian signals.

Research indicates that countdown pedestrian signals (CPS) are widely desired by pedestrians. In general, CPS are interpreted correctly or at least more accurately than conventional pedestrian signals. They also do not adversely affect crossing safety. Simplifying the design of CPS by replacing the flashing hand indicator with a walking person or steady hand signal may further improve the ability of pedestrians to interpret these signals.

Many questions remain, however, regarding the legibility and interpretability of countdown signals. Size and brightness of CPS have not been investigated. Human factors research is urgently needed to ensure that CPS signals are maximally usable by pedestrians with a full range of vision, and that audible countdown information provided for blind pedestrians does not have adverse consequences.

Estimates derived from the National Health Interview Survey[(9)] found 21.2 million adult Americans who reported trouble seeing, even when they wore glasses or contact lenses, 15.2 million of these Americans were over 65 yr of age. This population of pedestrians with low vision must also be able to utilize the pedestrian signals. The required size of pedestrian signals, in relation to crossing distance, may not be enough to ensure that countdown information is highly legible even for pedestrians who have unimpaired vision.

Technically, at the time of this research (2015) it was a violation of the *Uniform Vehicle Code and Model Traffic Ordinance*—commonly referred to as the UVC[(7)]—to cross when the FDW is present. Work was underway to revise the UVC. One option considered was discontinuing use of the violation indicating that pedestrians could not start walking during the FDW and replace it with a statement that pedestrians that start to cross after the start of the countdown must finish crossing before the solid hand appears. This change would need to be accompanied by a change in the MUTCD [(8)] and State and local laws that specify allowable pedestrian behaviors when facing various traffic control device displays.

The Traffic Control Devices (TCD) Consortium Pooled Fund supports studies focused on a systematic evaluation of novel TCDs. These evaluations examine the human factors and operations issues associated with each novel TCD. As part of this effort, the FHWA Human Factors Team is evaluating CPS. This report summarizes the results of both Phase I and Phase II studies of CPS, examines some of the potential pedestrian comprehension and performance issues associated with these signals, and provides some recommendations for future research.

## OBJECTIVES

### Phase I

The objectives of this study were to determine both the comprehension of the CPS (focusing on the inclusion and elimination of the flashing hand during the countdown) as well as the legibility of the different signals for people making crossing judgments based on visual information.

The main goals of the Phase I study were to test how well pedestrians understood the CPS and how pedestrians would respond to various countdown signal scenarios in the field. Within these broader goals, the following specific goals were part of this Phase I effort:

- Identify previous research in the area and determine current state of the practice.
- Conduct a study to focus on differences in understanding between the inclusion and elimination of the flashing hand of the pedestrian signal during the countdown phase.
- Produce a report describing the study results.

### Phase II

The purpose of the Phase II study was to obtain more data on the effects of CPS with and without the FDW signal. Specifically, this study had the following six objectives:

1. To examine the CPS Alone at wider intersections.
2. To compare the CPS Alone at pedestrian crossings that traverse one-way and two-way streets.
3. To compare the CPS Alone on streets at intersections with longer pedestrian change intervals.
4. To examine the long-term effects of using the CPS Alone at two complete intersections
5. To examine whether the CPS Alone would produce similar results in another region of the country.
6. To determine the effects of using the CPS Alone on a street with a speed limit of 35 mi/h.

### Report Overview

This report provides a description of the methods, results, and conclusions from Phase I and Phase II research. The body of this report contains the following topic sections:

- *Literature and State of the Practice:* A summary of research and findings on CPS use by pedestrians.

- *Signal Information from FHWA Traffic Control Devices (TCD) Consortium Pooled Fund Study States:* Data were collected from members of the FHWA TCD Pooled Fund States to understand the types and sizes of pedestrian heads in use.

- *Study 1A:* An experiment that examined pedestrian comprehension of different pedestrian signals.

- *Study 1B:* An experiment that examined pedestrian performance in determining the amount of time required to cross.

- *Study 1C:* An experiment that examined low-vision pedestrian comprehension of different pedestrian signals.

- *Study 2:* A naturalistic observation study of pedestrians at two intersections in Kalamazoo, MI, under different CPS configurations.

- *Conclusions:* Provides an overview of the research.

- *Appendices:*

    - Appendix A: Question Protocol for Study 1A.
    - Appendix B: Crossing Times for Study 1B.
    - Appendix C: Individual Responses from Study 1C.

# LITERATURE AND STATE OF THE PRACTICE

CPS display the available crossing time in seconds to complement the conventional FDW phase of the pedestrian traffic signal cycle. The MUTCD[8] provides guidance for the use of the CPS and presents it as the standard signal configuration. CPS have been shown to be more intuitive for users in communicating the amount of available crossing time at intersections. Using CPS may also result in better levels of service for pedestrians at signalized intersections. For example, the Florida Department of Transportation conducted a study to determine pedestrians' comprehension of the traditional FDW versus the FDW + CPS. The study showed that the FDW + CPS was more intuitive than the traditional flashing FDW signal. Adding the CPS contributed to pedestrians making better decisions about when to begin crossing and when to wait for the next "WALK" signal. However, when this research was conducted (2015), it was a violation of the UVC[7] to start crossing when the FDW was displayed.

When CPS did not exist, the FDW signaled pedestrians to not start crossing because there was no way for them to determine whether there was adequate time to finish crossing. It was acceptable for a pedestrian to finish crossing, however, if one had already started to cross during the FDW. Because pedestrians cross at different speeds, the timing of the FDW phase needed to be set at a value that would allow slower pedestrians to finish crossing safely. Adding the CPS allowed faster pedestrians to determine whether they had enough time to cross after arriving at the crosswalk.

Survey research has shown that the traditional FDW alone is poorly understood with correct comprehension levels between 31 percent[2] and just below 50 percent[1] while comprehension for the CPS is between 86 percent[3] and 100 percent.[2] Field research has also shown that the traditional FDW signal was associated with pedestrians being more likely to start crossing during the FDW phase, run out of time while crossing, return to the starting side of the crossing, or even stop in the roadway when the light changed.[4] The recent trend toward calculating crossing time based on slower pedestrians has exacerbated this issue because calculating crossing time in that manner traps faster pedestrians on the sidewalk. Those faster pedestrians can cross successfully in the time allotted during the early portion of the crossing signal.

A number of additional studies have documented safety advantages of CPS based on pedestrian behavior.[10,11] The Minnesota Department of Transportation compared the FDW alone and the FDW with CPS by counting the number of pedestrians who successfully crossed an intersection before the FDW phase ended. Their research showed an average 12 percent increase in successful pedestrian crossings with the implementation of CPS.[12] In addition, pedestrians were less likely to cross near the end of a pedestrian "WALK" phase if it appeared that there was insufficient time. Similarly, pedestrians who were crossing during the FDW phase increased their walking speed in an attempt to finish crossing within the amount of time shown on the CPS.[12] A number of other studies have also documented an increase in successful crossings.[13,14]

A summary report of various crash reduction methods and their effectiveness was prepared by the FHWA in 2007; this report included CPS. The evidence summarized in this report suggests that crashes decrease by 25 percent when countdown timers are added to existing pedestrian signals.[5] It is often the case that benefits can vary depending on context and pedestrian and driving culture. Other studies have shown that, relative to traditional FDW signals, the addition of the CPS is associated with reduced crashes.(15,16) A large study examined crashes following the installation of CPS at 362 intersections in the city of Detroit.(17) The results of the analysis showed a 70 percent reduction in pedestrian crashes. These signals were installed in phases with control sites. Crash reductions paralleled the installation schedule and did not occur at any control sites.

Logically, the behavioral and safety changes that took place when the CPS was added to the FDW signal must be a consequence of the addition of the CPS. These results imply that most pedestrians can see and comprehend the meaning of the CPS. This inference is further supported by their regulating crossing speeds as a function of the time remaining to cross.(4)

One study funded by FHWA focused on the issue of whether it would be desirable to delete the FDW icon from the pedestrian change interval.(6) These researchers directly compared the CPS Alone and the CPS + FDW. The authors pointed out that comprehension of the FDW signal is poor and that the legal meaning of the FDW is not well understood. It was speculated that removing the FDW from the CPS might "actually improve pedestrian comprehension and crossing decisions by eliminating the source of confusion."

In the first study, Singer and Lerner investigated pedestrian comprehension of the CPS Alone, the CPS + FDW, and the FDW alone.(6) Forty-five participants were shown pictures of the crossing scenarios. Each scenario was presented three times: once with each of the key pedestrian signal configurations. Pedestrians were asked to describe the correct pedestrian crossing behavior for each scenario. Participants were most likely to believe that they were permitted to start a crossing during the pedestrian change interval when shown the CPS Alone.

A second study examined the field application of the CPS Alone with the CPS + FDW at two sites. The researchers found that pedestrians started crossing later with the CPS Alone but there was no increase in the percentage of pedestrian crossing during the SDW phase although those who finished during the SDW tended to finish somewhat later. However, these shifts toward later starts and finishes did not necessarily indicate an increase in unsafe behavior because of the presence of the five-s buffer time between the start of the SDW and the release of conflicting traffic. There were no pedestrian/vehicle conflicts during the CPS Alone and the CPS + FDW signal.

Singer and Learner also reported a slight but statistically significant decrease in the frequency of pedestrians running in the crossing during the CPS Alone condition. There were several limitations to the Singer and Lerner study. First, the curb-to-curb walking distance on both streets was only 12 m (40 ft). Second, the pedestrian change interval was relatively short, 10 and 11 s respectively. Third, no data were collected on the impact of removing the FDW signal on low-vision pedestrians.

We could not find data on the recognition distance for the countdown signal by low-vision pedestrians. The recent Institute of Traffic Engineers (ITE) performance specification standard recommends only one size (approximately 23 cm, or 9 inches) for the pedestrian countdown signal.(18) The number of individuals experiencing vision loss and other disabilities is expected to grow in coming decades,(19,20,21) in tandem with the anticipated increases in the numbers of older persons in society. Desai, Pratt, Lentzer and Robinson[22] estimate that 14 percent of persons 70-74 yr of age have serious difficulty seeing, even with their glasses, and this percentage increases to 32 percent among persons 85 or older.

Unfortunately, there has been limited research in comparing and examining the effectiveness of different size pedestrian signals and CPS with partially sighted individuals. Available data then suggest that removing the FDW from the CPS may improve decision-making by allowing pedestrians to focus on relevant information without the presence of ambiguous information.

Two studies have examined recognition distance for pedestrians with low vision.[23,24] Williams et al. found that low-vision pedestrians could identify the "WALK" signal at a distance of 33 m (108 ft) with a standard deviation of 12.9 m (42.4 ft) and the SDW at a distance of 28.1 m (92.2 ft) with a standard deviation of 12.9 m (42.3 ft).[23] Van Houten et al. found that low-vision pedestrians could identify the "WALK" signal at 18.6 m (61 ft).[24] In both studies, the man icon and hand icon were 28.4 cm (11.2 inches) high.

In summary, studies show increases in comprehension and crossing success when CPS are added to the FDW signal. A number of studies also report reductions in vehicle-pedestrian conflicts and pedestrian crashes. Data also show that the FDW is still not well understood by pedestrians and limited data from one study even shows that crossing success is somewhat better when the CPS is used without the FDW. However, little is known about how well pedestrians are able to determine how much time they need to cross. For low-vision pedestrians, no data is available concerning whether or not they can recognize the CPS, with or without the FDW.

The purpose of this study is to provide additional data on the possible advantages of using the CPS Alone, how well pedestrians are able to determine how much time they need to cross during the pedestrian change interval, and the effects the CPS has on the ability of low-vision pedestrians to discriminate the pedestrian signal phase.

Previous research on pedestrian comprehension of the CPS with and without the FDW, and field comparisons of their relative efficacy, has only been completed in one part of the country. This study extends the generality of those findings by replicating them elsewhere. This study also increases the generality of those findings by determining how well pedestrians can determine the amount of time needed to cross various widths of roads while also examining the impact that removing the FDW has on people with low vision.

## SIGNAL INFORMATION FROM FHWA TCD POOLED FUND STATES

This section describes data collected from FHWA TCD Pooled Fund States that was conducted in support of studies 1A, 1B, and 1C at the time of this research.

### INTRODUCTION

ITE specifies three sizes for pedestrian signal heads.[25] For crosswalk lengths of less than 18.3 m (60 ft), the walking person and upraised hand icons are 15.2 by 8.9 cm (6 by 3.5 inches), and the countdown display 22.9 by 17.8 cm (9 by 7 inches); for crosswalk lengths of over 18.3 m (60 ft), two dimensions are specified: the walking person and upraised hand icons must be 22.9 by 13.3 cm (9 by 5.25 inches) or 27.9 by 17.8 cm (11 x 7 inches).

In both cases, the countdown display should be 22.9 by 17.8 cm (9 by 7 inches). Each digit in the countdown display in all cases should be 22.9 cm (9 inches) high by 8.23 cm (3.25 inches) wide. The MUTCD specifies that the height of the walking person icon, the upraised hand icon, and the numbers in the countdown display should be 22.9 cm (9 inches) in height for crosswalks where the pedestrian enters the crosswalk more than 30.5 m (100 ft) from the pedestrian signal head indications.[8] A search of vendors on the approved list of several large States indicates that none produce a standard pedestrian countdown display with digits larger than 22.9 cm (9 inches).

To understand how these values are applied at the jurisdictional level, information was requested from States participating in the FHWA TCD Pooled Fund Study. The purpose of this activity was to understand the size of pedestrian heads used for crossing, as well as to gain information on the configuration of the head.

### METHOD

At the time of the research, information was requested from States participating in the TCD Pooled Fund Study. This request asked them to identify the State, provide the size of the pedestrian heads used for crossings less than and greater than 30.5 m (100 ft) inches in length, and provide the size of the digits used in countdown timers for crossings with widths of less than or greater than 30.5 m (100 ft) inches in length.

### RESULTS AND DISCUSSION

We received feedback from the city of Los Angeles, CA, and the following 13 States: Florida, Kansas, Minnesota, Mississippi, Missouri, Nebraska, Nevada, North Carolina, Oregon, Pennsylvania, South Carolina, Texas, and Wisconsin.

Use of the walking person and upraised hand icon signals was common. Thirteen of the fourteen locations (approximately 93 percent) responded that they used the walking person and upraised hand icon signals that were 27.9 by 17.8 cm (11 x 7 inches) on a display that was 40.6 by 45.7 cm (16 by 18 inches) for all crosswalk lengths. Only Nevada used a smaller size for the walking person and upraised hand icons: 22.9 cm by 13.3 cm (9 inches by 5.25 inches) in a housing that was 30.5 by 30.5 cm (12 by 12 inches) for crosswalks less than 30.5 m (100 ft) in length.

Use of the countdown display was also common. Almost all respondents reported using the 22.9- by 17.8-cm (9- by 7-inch) countdown display for crosswalks both under and over 30.5 m (100 ft) in length. Kansas reported using countdown displays with a 15.2-cm (6 inch) height for crosswalks less than 30.5 m (100 ft), and 22.9-cm (9-inch) height for crosswalks more than 30.5 m (100 ft) in length. Los Angeles specified 22.9 cm (9 inches) in height as a minimum but did not specify any other sizes.

The results of this information-gathering exercise suggest the most commonly used configuration is the 40.6- by 45.7-cm (16- by 18-inch) pedestrian signal head housing with the 22.9-cm (9-inch) countdown digit size for all crosswalk lengths. The community appears to have reached a consensus on size of pedestrian signals, and signal vendors are not offering larger sizes for sale. Based on these results, further research was conducted using the 40.6- by 45.7-cm (16- by 18-inch) pedestrian signal housing with the 22.9-cm (9-inch) countdown displays.

## STUDY 1A: PEDESTRIAN COMPREHENSION OF SIGNALS

The purpose of this experiment was to examine comprehension of the CPS Alone and the CPS + FDW to determine whether the removal of the FDW component would improve clarity.

### INTRODUCTION

This experiment examined pedestrian comprehension of various pedestrian countdown scenarios, including the inclusion and exclusion of the flashing hand in the countdown phase. The participant sample was drawn from a diverse population of both genders representing different ages in two geographically distinct locations.

### METHOD

The method for Study 1A is described in the following section.

#### Participants and Experiment Venue

Participants in this study were 100 adults from the Naples, FL, metropolitan area, and 200 adults from the Kalamazoo, MI, metropolitan area, for a total sample size of 300 adults. Data collection in Naples was completed before data collection in Kalamazoo commenced. Testing for this study was conducted between 8:00 a.m. and 4:30 p.m. Potential participants were sampled at mall locations (Naples) or at a downtown location (Kalamazoo). All participants self-reported either corrected or uncorrected visual acuity of 20/40 or better. A summary of participants by location is provided in table 1.

**Table 1. Participant demographics, study 1A.**

| Location | N, Males (All Ages) | N, Young Adult Males | N, Adult Males | N, Seniors Males | N, Females (All Ages) | N, Young Adult Females | N, Adult Females | N, Seniors Females |
|---|---|---|---|---|---|---|---|---|
| Kalamazoo | 111 | 29 | 68 | 14 | 89 | 22 | 53 | 14 |
| Naples | 53 | 10 | 37 | 6 | 47 | 7 | 29 | 11 |
| Total | 164 | 39 | 105 | 20 | 136 | 29 | 82 | 25 |

*N = number.*

#### Apparatus

The research team produced a video for each of the following signal configurations and phases: "WALK", "DON'T WALK", CPS + FDW, CPS Alone, and CPS + Flashing WALK (FW). The research team evaluated the CPS and FW (which had never been tested together) to determine its intuitive meaning. Each video was recorded in clear daylight conditions and had a duration of approximately 10 s. Displays that included the CPS began with the countdown timer displaying 17 s and counted down for 10 s. Videos were displayed to participants on a tablet computer with a 24.6-cm (9.7 inch; diagonally measured) display.

Although the Florida data showed clear differences between the CPS Alone and CPS + FDW display, it was hypothesized that the CPS + FW display would be the most easily understood option. An additional video was included for the later data collection effort in the Michigan location. Participants in Michigan were shown the same videos employed in Florida, plus an additional video that showed the CPS + FW. The videos used for each location are described in table 2.

**Table 2. Videos used in Study 1A.**

| Location | Videos Used |
|---|---|
| Kalamazoo | WALK, DON’T WALK, FDW + CPS, CPS Alone, CPS + FW |
| Naples | WALK, DON’T WALK, FDW + CPS, CPS Alone |

**Procedure**

After providing informed consent, participants were shown each of the videos in a counterbalanced order. Following each video presentation, participants were asked a series of questions (see appendix A for the question protocol) to determine their beliefs as to the display’s meaning, as well as what they should do in response to the display.

For every signal head, people were asked: “Imagine yourself at a crosswalk, about to cross the street, and you see this display.” The participants were then shown the video segment of the relevant video display in a randomized order and asked the following open-ended questions: “What does this display mean? And what should you do if you see this display?” Follow-up questions were then asked when required to ensure clarity. The decision tree followed in asking these questions is described in appendix A. Opened ended questions were asked to avoid leading the pedestrians.

**Analysis**

Similar to the method used by Singer and Lerner,[6] responses were categorized by three possible decisions—"walk”, “make a decision”, or “don’t walk”—for each signal. “Make a decision” includes any response that indicated that participants would need more information about the length of the crossing before deciding whether to cross. Participants that indicated they would “walk” (cross the street) considered 17 s as adequate to cross a typical street walking at a speed of 1.5 or 1.8 m/min (5 or 6 ft/min).

For the “WALK” signal, correct answers included all responses from participants who indicated that they could/would cross, while incorrect answers included all responses from participants who indicated that they could/would not cross. For the solid hand display, correct answers included responses from all participants that indicated that they could/should not cross, while incorrect answers included responses from all participants that indicated that they could/should cross.

For the clearance phase display, responses were coded either as walk when participants replied that there was sufficient time to cross (each video started with 17 s displayed on the countdown) or "make a decision" when participants indicated they needed more information about time and distance to decide.

Responses that indicated that the person should not cross fell into two categories. One response was that they should not cross or start to cross because the hand was present. The second was they should not cross because the hand was counting down the time to the next "WALK". These responses were both coded as don't walk.

Technically, the choice to not start to cross is correct in reference to the UVC. This definition made sense before the CPS was implemented because a pedestrian had no idea how much time was left to cross when the FDW was presented alone. However, after the introduction of CPS, it became possible for pedestrians to determine how much time remained to finish a crossing and then adjust their walking speed if necessary.

## RESULTS

Participant responses, by signal, are presented in table 3 (for Kalamazoo) and table 4 (for Naples). Note that these results illustrate participants' understanding of the signal and do not necessarily represent what they would do. The trends in these data are similar to those obtained in the Singer and Lerner study.[6] The present findings suggest that individuals understand that they can cross during the "WALK" interval and should not cross during the "DON'T WALK" interval when the solid hand is displayed.

**Table 3. Kalamazoo participant responses by signal, Study 1A.**

| Signal | Walk (Percent) | Make a Decision (Percent) | Don't Walk (Percent) |
|---|---|---|---|
| Walk | 200 (100) | 0 (0) | 0 (0) |
| DON'T WALK | 0 (0) | 0 (0) | 200 (100) |
| CPS + FDW | 67 (33.5) | 53 (26.5) | 80 (40) |
| CPS | 88 (44) | 62 (31) | 50 (25) |
| CPS + FW | 133 (66.5) | 47 (23.5) | 20 (10) |

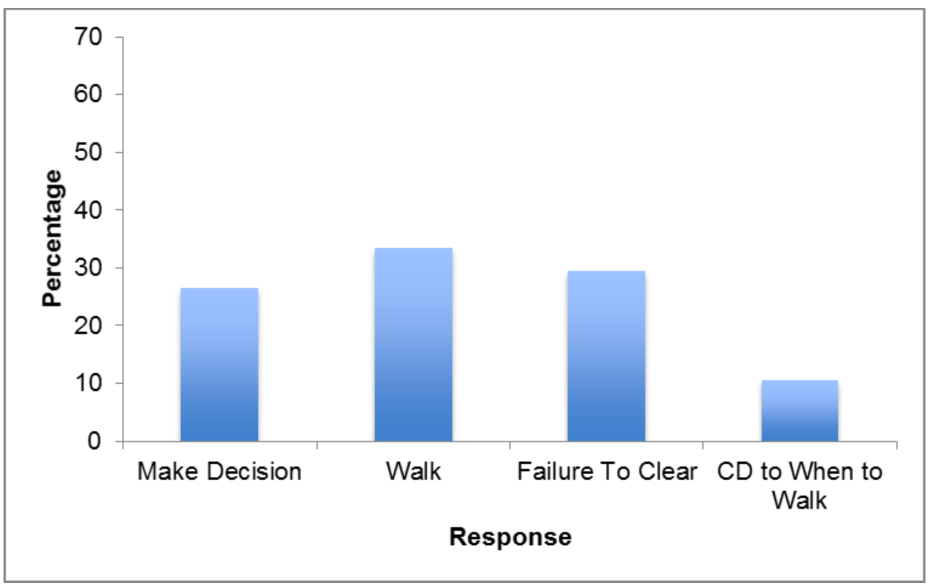
**Table 4. Naples Participant responses and signal, Study 1A.**

| Signal | Walk (Percent) | Make a Decision (Percent) | Don't Walk (Percent) |
|---|---|---|---|
| Walk | 100 (100) | 0 (0) | 0 (0) |
| Don't Walk | 0 (0) | 1 (1) | 99 (99) |
| CPS + FDW | 42 (42) | 16 (16) | 42 (42) |
| CPS | 61 (61) | 23 (23) | 16 (16) |

For the three clearance interval displays (CPS Alone, CPS + FDW, and CPS + FW) tested at the Michigan location, more people understood that they should not start crossing during the clearance interval with the FDW present (40 percent vs. 25 percent for the CPS Alone, and 10 percent for the CPS + FW). However, more participants understood that they could "walk" or "make a decision" with a countdown showing 17 s with the CPS Alone (75 percent), and the most participants thought they could cross or "make a decision" to cross when presented with the CPS + FW (90 percent).

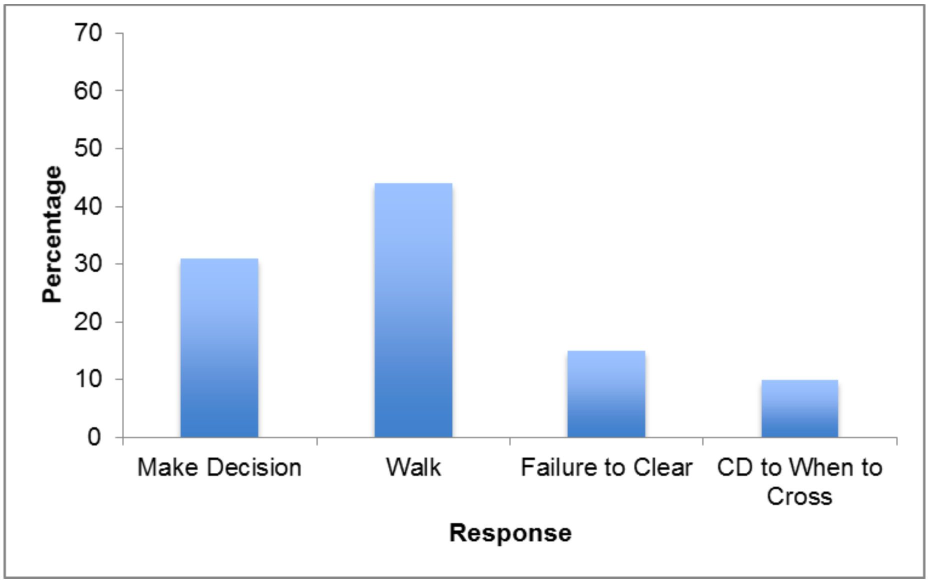
Figure 1, figure 2, and figure 3 display the results for Michigan participant responses to the CPS + FDW, CPS Alone, and the CPS + FW displays, respectively. As shown in the figures, two of the response categories for a decision to cross were "walk" and "make a decision." The CPS Alone has a large effect on pedestrian response to the clearance interval. For the CPS + FDW, only 60 percent of the participants thought that they could "walk" or "make a decision" to begin crossing. However, this percentage increased to 75 percent with the CPS Alone and increased further to 90 percent for the CPS + FW display. This finding indicates a perceived shift in decision-making when the countdown timer is present that places less emphasis on signal compliance and more emphasis on pedestrian choice.

Also shown in the figures are both types of participant responses that were coded as "don't walk": "Failure to clear" and "countdown (CD) displays that show the time until the walk appears." As shown in these figures, approximately 10 percent of participants erroneously thought the CPS + FDW and CPS Alone were timing the amount of time until the WALK signal appeared. This error only occurred in 3 percent of the participants with the CPS and FW display. More participants responded "make a decision" with the CPS Alone than with the CPS + FDW or with CPS + FW.



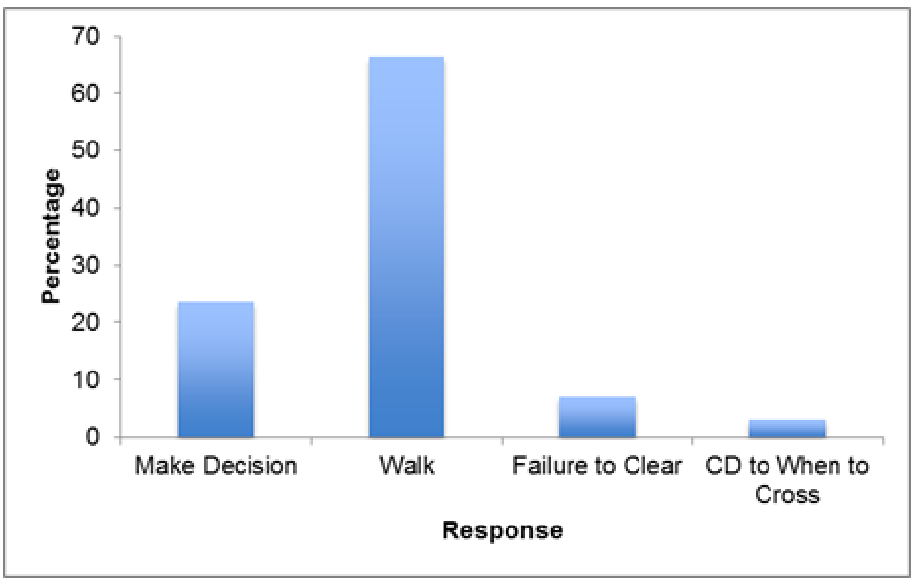

Source: FHWA.
CD = countdown.

**Figure 1. Chart. Percentage of Michigan participant responses to CPS + FDW.**




Source: FHWA.

**Figure 2. Chart. Percentage of Michigan participant responses to CPS Alone.**




Source: FHWA.

**Figure 3. Chart. Percentage of Michigan participant responses to CPS + FW.**

Table 5 shows the pooled data for the Michigan and Florida samples. Those who chose to "walk" or "make a decision" were pooled and a *Z*-score test for dependent groups was used to test for significance. The proportions of the 300 sample who choose to "walk" or "make a decision" was 0.78 for the CPS Alone and 0.59 for the CPS + FDW condition. This difference was significant at the $p = 0.01$ level. These results demonstrate that more people believe they can cross or consider crossing if they are shown a countdown starting at 17 s when the FDW is absent as opposed to when it is present.

**Table 5. Pooled data for Michigan and Florida samples.**

| Signal | Walk (Percent) | Make Decision (Percent) | Don't Walk (Percent) |
|---|---|---|---|
| Walk | 300 (100) | 0 (0) | 0 (0) |
| Don't Walk | 1 (0.3) | 0 (0) | 299 (99.7) |
| CPS + FDW | 109 (36) | 69 (23) | 122 (41) |
| CPS | 150 (50) | 84 (28) | 66 (22) |

Table 6 shows the breakdown by sex and age for the pooled samples. Because the "WALK" alone and "DON'T WALK" alone displays were understood by all but one participant, these signals are not shown in this table.

**Table 6. Responses by demographic category and signal.**

| Category/Signal | Walk (Percent) | Make a Decision (Percent) | Don't Walk (Percent) |
|---|---|---|---|
| Males/CPS + FDW | 58 (35) | 31 (19) | 75 (46) |
| Males/CPS | 79 (48) | 44 (27) | 41 (25) |
| Females/CPS + FDW | 51 (38) | 38 (28) | 47 (35) |
| Females/CPS | 70 (51) | 41 (30) | 25 (18) |
| Young Adults/CPS + FDW | 22 (32) | 15 (22) | 31 (46) |
| Young Adults/CPS | 42 (62) | 10 (15) | 16 (24) |
| Adults/CPS + FDW | 77 (41) | 41 (22) | 69 (37) |
| Adults/CPS | 80 (43) | 62 (33) | 45 (24) |
| Seniors/CPS + FDW | 10 (22) | 13 (29) | 22 (49) |
| Seniors/CPS | 27 (60) | 13 (29) | 5 (11) |

## DISCUSSION

Few differences were observed between the Florida and Michigan data for the walk and don't walk responses. This finding indicates that these signal displays are intuitive and generally understood. Responses to the CPS + FDW and CPS Alone were similar between the Michigan and Florida sites, with more participants responding to cross with the CPS Alone than the CPS + FDW, and fewer choosing not to cross with the CPS + FDW than with the CPS Alone. The percentage choosing "make a decision" was higher with the CPS Alone.

It is also likely the case that many participants choosing to cross did so because they judged the 17 s displayed adequate time to cross. The largest difference between the Michigan and Florida data was the higher proportion of participants choosing to "walk" or "make a decision" to walk for the CPS Alone in the Florida data. If the goal is to allow pedestrians to choose whether to cross based on the time remaining on the CPS display, then the CPS Alone is a better choice than the CPS + FDW display.

Some interesting differences were observed in the clearance interval display data. First, a somewhat higher proportion of males than females indicated that both the CPS+FDW and the CPS Alone signals meant "don't walk", and a higher percentage of females in the CPS + FDW indicated "make a decision". It should be noted that these data do not reflect what each gender would do; instead, the data illustrate what people thought the meaning of the signal was. It is possible that males are more likely to cross when they think that it is not permitted.

Second, in regard to age, relative to adults and seniors, young adults show the largest change in making the decision to walk when the FDW was removed from the display. They also were the only group showing a reduction in choosing to "make a decision" with the CPS. These results are not unexpected considering that the average walking speed should be highest for this group. Most of them thought they could cross with 17 s. The seniors had the highest proportion of choosing to "make a decision" for both the CPS + FDW and CPS Alone.

# STUDY 1B: TIME REQUIRED TO CROSS AN INTERSECTION

The MUTCD[8] specifies that the walking speed used to travel to the other side of the road or to a median of sufficient width to allow a pedestrian to wait should be 1.07 m/s (3.5 ft/s). The manual also specifies that “Where pedestrians who walk slower than [1.07 m/s (3.5 ft/s)], or pedestrians who use wheelchairs, routinely use the crosswalk, a walking speed of less than [1.07 m/s (3.5 ft/s)] should be considered in determining the pedestrian clearance time.”

Clearly, many pedestrians can walk faster than 1.07 m/s (3.5 ft/s) and could safely cross with less time than is provided. The purpose of this experiment was to determine how well pedestrians could estimate how much time they required to cross a crosswalk length of approximately 12 m, 18 m, and 24 m (40 ft, 60 ft, and 80 ft, respectively) at a walking pace.

## INTRODUCTION

Many pedestrians use the CPS to determine whether they have time to cross the intersection when they arrive during the pedestrian clearance interval. Pedestrians who start crossing during the “WALK” display can also monitor their progress during the pedestrian clearance phase and adjust their walking speed, allowing them to finish crossing before the “DON’T WALK” signal appears. Pedestrians with a relatively fast gait use the CPS to determine whether they have enough time to cross, while pedestrians with a slower than average gait use the CPS to adjust their walking speed if needed. Using the CPS to determine whether there is sufficient time to cross allows more pedestrians to cross during each cycle. This study examined how well pedestrians could determine the amount of time required for them to cross the street.

## METHOD

The method for Study 1B is described in the following section.

### Participants and Experiment Venue

Participants in this study were 60 pedestrians drawn from university students and faculty. All pedestrians were capable of walking at a normal or faster than normal walking speed. Testing for this study was conducted between 8:00 a.m. and 4:30 p.m. (daylight hours), with ambient lighting conditions ranging from overcast to bright sunshine. All participants self-reported either corrected or uncorrected visual acuity of 20/40 or better. A summary of participant demographics is provided in table 7.

**Table 7. Participant demographics, study 1B.**

| Gender | N | N, Young Adults | N, Adults | N, Seniors |
|---|---|---|---|---|
| Males | 25 | 21 | 3 | 1 |
| Females | 35 | 33 | 2 | 0 |

**Apparatus**

Researchers created a simulated crosswalk on the campus of a university. The simulated crosswalk was located in an area with no motor vehicle traffic, allowing for participant safety and controlling for the presence of vehicles. The simulated crosswalk was 3-m (10-ft) wide, with a total length of 24 m (80 ft). Distance markings at 3-m (10-ft) intervals were created using red tape.

The pedestrian signal was mounted at the simulated crosswalk 2.4 m (8 ft) above ground level. The signal head had "WALK" and "DON'T WALK" icons that were 22.9 cm (9 inches) high, and countdown numbers that were 15.2 cm (6 inches) high. The following presentation modes were employed: WALK Alone, DON'T WALK Alone, and FDW + CPS.

**Procedure**

Each of the 60 participants was asked to make three crossings, one for each length. Therefore, data were collected for a total of 180 pedestrian crossings. The presentation order for each of the three crosswalk lengths was randomly selected across participants.

Participants were given the following instructions:

> *"Imagine you are at a busy intersection and want to cross the street. The pedestrian signal will begin by showing an orange hand; next it will show a white walking person. When the orange countdown begins, I want you to begin to cross when you think you have just enough time to safely walk, not run, across the street. As you are crossing, try to finish your crossing before the countdown ends. If you see that you might not have enough time to finish crossing, you can adjust your speed, walking faster, jogging, or even running if necessary. If you needed less time than you thought, you can finish crossing before the end of the countdown. You don't have to slow down to finish just at the right time. If you feel you needed to increase your pace but see it is no longer necessary, you can also go back to a normal pace."*

**Analysis**

Participant crossing times were measured for each 3-m (10-ft) segment, for all crosswalk lengths. A trained observer using a stopwatch recorded crossing times. If the participant finished crossing before the countdown was complete, then the number of seconds left was recorded. If the participant finished after the countdown had timed out, then the number of seconds that elapsed after the countdown finished was also recorded.

A second trained observer scored the walking pace for each segment as a walk, a jog, or a run. These three paces were selected due to their ability to be operationally defined. Walking was defined as lifting and setting down each foot in turn, never having both feet off the ground at once. Running was defined as moving so swiftly that both feet leave the ground during each stride. Jogging was distinguished from running by having a wider lateral spacing of foot strikes, creating side to side movement at a lower speed.

The following three measures were collected and evaluated:

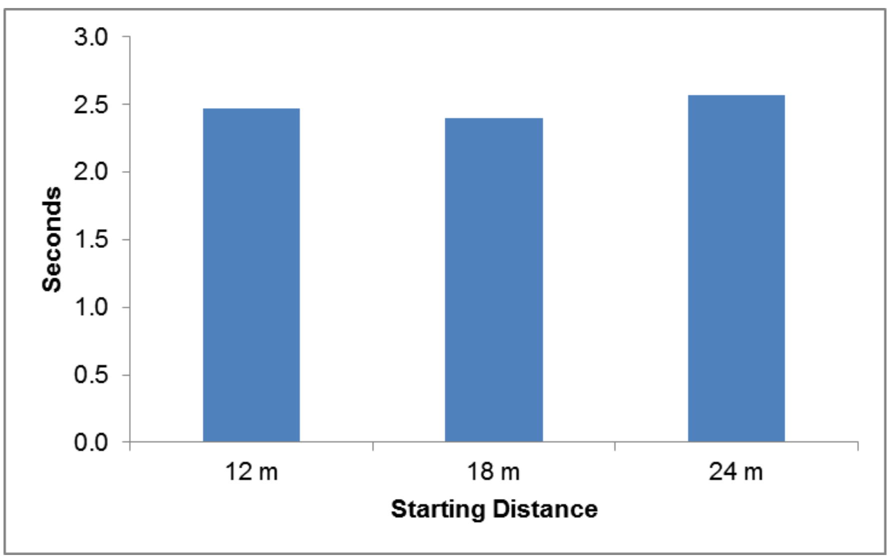
- The time required traversing each consecutive 3-m (10-ft) length of each of the three crosswalk lengths. This measure allowed us to calculate the average walking speed for each consecutive 3-m (10-ft) segment.

- The time remaining before the end of the countdown, or the time elapsed after the end of the countdown, when the participant finished crossing. This measure allowed us to determine the accuracy of participants' estimates.

- Whether participants altered their gait by jogging or running to cross when they thought that they did not have enough time to make it across by walking. This measure acted as a secondary measure of the adequacy of participant's estimates of the time required to cross each length of crosswalk.

## RESULTS

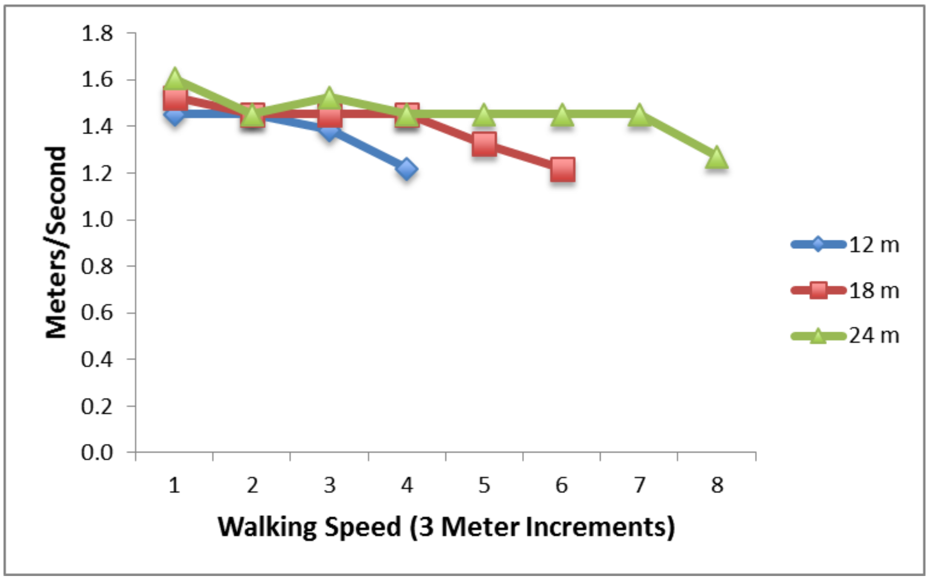
Analysis of crossing times indicated that participants had little or no difficulty telling how much time was needed to cross the approximately 12-, 18-, and 24-m (40-, 60-, and 80-ft, respectively) length crosswalks. For the 12-m (40-ft) crosswalk, only one participant failed to cross the crosswalk in time, and this participant only exceeded the countdown timer by 1 s. Similar results were found for the 18-m (60-ft) crosswalk; only one participant misjudged the 18-m (60-ft) crossing, exceeding the countdown by 1 s. For the 24-m (80-ft) crosswalk, all participants were able to traverse the crosswalk before the countdown timer ended. No order effects were present. As shown in figure 4, the average amount of time on the CPS signal when participants finished crossing was relatively similar between crosswalk lengths.




Source: FHWA.

**Figure 4. Chart. Average time remaining on the countdown when participants finished crossing.**

Analysis of crossing gait indicated that some participants had to shift crossing paces during the crossing period. Eight participants (approximately 13 percent) had to shift from a walk to a jog for at least one 3-m (10-ft) segment. Four participants (approximately 6.7 percent) jogged to cross the last 3-m (10-ft) segment, and four (approximately 6.7 percent) jogged to cross the last two 3-m (10-ft) segments. No participant needed to run. Crossing data for each participant is provided in appendix B. No order effects were present. Most participants were able to judge their ability to cross fairly accurately, with the average participant finishing the crossing with between 2 and 3 s remaining on the countdown timer for each crossing distance. Figure 5 shows the mean participant crossing speed averaged across three-meter segments as a function of crossing distance.




Source: FHWA.

**Figure 5. Chart. Average walking speed for each segment for each crosswalk length.**

## DISCUSSION

The results of this experiment suggest that many people have experience crossing with a CPS and can also estimate how much time is needed to cross. An examination of these data shows a high degree of consistency in crossing speed over the entire crossing. Most participants were able to maintain a steady walking pace, and almost all were able to finish before the end of the countdown display. It is interesting to note that the two pedestrians that did not finish before the end of the countdown would have finished before the end of the yellow signal for the cross-traffic (assuming standard signal timing).

One of the most interesting findings from this experiment was the high walking speeds observed in the study. Most participants walked at a brisk pace and, although most were between the ages of 18 and 24, some participants were over 65 yr of age. It is possible that pedestrians walk slower when they know they have ample time to cross and also walk faster when they know they have less time to cross.

The individual data from Study 1B (shown in appendix B) support this hypothesis, with 35 of the pedestrians decreasing their walking speed during the widest crossing during the last 3 to 6 m (10 to 20 ft). These data suggest that naturalistic crossing speed data collected only on pedestrians starting to cross at the onset of the “WALK” signal may indicate slower speeds than data that could be obtained if pedestrians were aware that they have less time to cross. It is likely that data based on such naturalistic observation may reflect a slower walking speed than people actually need to cross. Further research performed with a random cross-section of adults is needed to examine this issue.

## STUDY 1C: LOW-VISION PEDESTRIAN STUDY

The purpose of this experiment was to determine whether the elimination of the FDW from the CPS display would have an adverse effect on low-vision pedestrians.

### INTRODUCTION

Low-vision individuals often have difficulty discriminating the pedestrian signals, especially at longer crossings. These individuals may utilize the additional information provided by the FDW to help determine whether they can cross. Therefore, the elimination of the FDW may result in these individuals having an increased likelihood of mistaking the display for the "WALK" signal. Some low-vision pedestrians may not be able to see any of the pedestrian signal displays at certain distances; they should not cross if they cannot verify the status of the signal

### METHOD

The method for Study 1C is presented in the following section.

#### Participants and Experiment Venue

Participants in this study had a visual acuity between 20/70 (the criterion for low vision) and 20/200 (the criterion for blindness). Participants ranged in age between 15 and 95 yr of age. To participate in the study, they also needed to be ambulatory and users of crosswalks. For younger participants, parental consent was obtained. Testing for this study was conducted between 8:00 a.m. and 4:30 p.m. (daylight hours), with ambient lighting conditions ranging from overcast to bright sunshine. A summary of participant demographics is provided in table 8.

**Table 8. Participant demographics, study 1C.**

| Gender | N | N, Youth | N, Young Adults | N, Seniors |
|---|---|---|---|---|
| Males | 6 | 1 | 1 | 4 |
| Females | 14 | 1 | 0 | 13 |

#### Apparatus

The apparatus described in Study 1B was employed in this experiment.

#### Procedure

After obtaining informed consent, participants were shown each of the pedestrian signals in a random order from a distance of 4.5 m (15 ft). Participants were asked to describe:

- The color of the signal.
- The shape of the signal.
- The name of the signal.

- Their intended action upon signal.

This procedure was performed to familiarize them with the display and to serve as a participant qualification for the study. A participant who could not see the signals at a distance of 15 ft would be disqualified; no participant failed this test.

Participants were escorted to a distance of either 12 m (40 ft) or 30.5 m (100 ft) from the signal location. Participants were then shown the following five pedestrian display signals: WALK, DON'T WALK, the CPS + FDW, the CPS Alone, and the transition from the DON'T WALK to the WALK display. At the start of each trial, they were instructed to turn around, look at the pedestrian signal, and state whether they see the color of the display, the shape of the display, and (in the case of the presence of the countdown display) the amount of time shown on the display. Participants were also instructed to state what they would do if they wanted to cross the street and saw this display. If the countdown was displayed, they were asked if they could read the numbers and then read them back. The order of trials and the presentation of signals were randomized. The signal options were counterbalanced across participants.

Participant responses were recorded for each of the stimulus conditions. The experimenter recorded whether participants could identify the color of the display, the shape of the display and, if they identified the countdown, they were asked if they could identify the numbers on the display. The experimenter then asked what they would do if they saw this display.

**RESULTS**

The summary percent of participants responding to each question for each of the pedestrian signals tested are presented in table 9 (for 12 m) and table 10 (for 30.5 m). Data from individual participants are presented in appendix C. For the 12 m (40 ft) crossing, results indicated that 95 percent of the participants were able to identify the color and 85 percent were able to identify the shape of the "WALK" signal. All participants who said they could identify the color also said they would choose to cross. One participant (5 percent) could not identify the color or shape and that participant said they would not cross (this participant said they would ask for help in crossing).

Participant responses for the "WALK" signal provided at a 12-m (40-ft) distance are provided in appendix C. For the analysis of the "WALK" signal at the 30.5-m (100-ft) crossing, 60 percent could identify the color and 45 percent could identify the shape of the "WALK" signal. Three participants (15 percent) could only identify the color of the "WALK" signal and not the shape; two of these participants said they would cross, and one said they would not. Eight participants (40 percent) could not identify the color or the shape. All of these participants said that they would not cross and would instead ask for help or observe traffic cycles and then use that information to cross.

All of the participants could identify the color and 85 percent could identify the shape of the "DON'T WALK" signal at the 12-m (40-ft) crossing. All participants said they would not cross. For the 30.5-m (100-ft) crossing, 75 percent of the participants could identify the color and 45 percent said they could identify the shape of the signal. None of the participants said they would cross.

**Table 9. Summary results for each tested signal for 12 m (40 ft), study 1C.**

| Condition | Percent Recognize Color | Percent Recognize Shape(s) | Percent That Could Read Number | Percent Choosing to Cross |
|---|---|---|---|---|
| WALK | 95 | 85 | NA | 95 |
| DON'T WALK | 100 | 85 | NA | 0 |
| DON'T WALK TO WALK | 95 | 80 | NA | 90 |
| CPS + FDW | 100 | FDW 85<br>CPS 80 | 70 | 30 |
| CPS Alone | 100 | 85 | 75 | 35 |

**Table 10. Summary results for each tested signal for 30.5 m (100 ft), study 1C.**

| Condition | Percent Recognize Color | Percent Recognize Shape(s) | Percent That Could Read Number | Percent Choosing to Cross |
|---|---|---|---|---|
| WALK | 60 | 45 | NA | 55 |
| DON'T WALK | 75 | 45 | NA | 0 |
| DON'T WALK TO WALK | 70 | 25 | NA | 65 |
| CPS + FDW | 65 | FDW 30<br>CPS 35 | 0 | 20 |
| CPS Alone | 75 | 40 | 5 | 5 |

Participants who could not identify the color or the shape said that they would ask for help or observe traffic before attempting to cross.

For the 12-m (40-ft) crossing with the transition from "DON'T WALK" to "WALK" signal, 95 percent of the participants identified the color change and 80 percent identified the change in the shape of the signals. Only one participant said they would not cross when they could not identify the color or shape of the signal; this participant said that they would ask for help. For the 30.5-m (100-ft) crossing with the transition from "DON'T WALK" to "WALK" signal, 70 percent were able to identify the color change; all but one of these participants said they would cross. Five of the participants who were able to identify the color change were also able to identify the change in shape. Seven participants (35 percent) said they would not cross. These seven participants said they would ask for help or watch and use other pedestrian traffic to cross.

For the 12-m (40-ft) crossing with CPS + FDW signal, all participants identified the color and 85 percent identified the shape of the flashing "DON'T WALK" display. Sixteen (80 percent) could identify the countdown and 70 percent could read all or some of the numbers. Only six (30 percent) chose to cross; all of these participants could identify numbers and based the decision to cross on the numbers identified. For the 30.5-m (100-ft) crossing with CPS + FDW signal, 65 percent identified the color, 30 percent identified the shape of the FDW, and 35 percent identified the countdown display, but none of them could read the numbers. Four participants (20 percent) said they would cross even though they could not read the numbers. Two of these participants said they could see the countdown was present, and one participant said that he would be careful because he did not know how much time he had to cross.

For the 12-m (40-ft) crossing with the CPS Alone, all participants were able to identify the color and 85 percent could identify that the countdown was present. Moreover, 75 percent of participants could read the numbers. Because sufficient time was left for the crossing, seven participants (35 percent) elected to cross.

For the 30.5-m (100-ft) crossing with the CPS Alone, 75 percent could identify the color of the countdown display, and 40 percent could identify there were numbers; however, only one participant (5 percent) could read the numbers. Only the participant that could read the numbers chose to cross.

## DISCUSSION

The results of this experiment show that persons with low vision typically are cautious when crossing the street. In all but one case the participants would not cross unless they could identify the "WALK" signal or read the numbers on the CPS that displayed sufficient time to cross. The only exceptions were four participants in the CPS + FDW condition who chose to cross even though they could not read the numbers. One participant noted that he had to be careful because he did not know how much time was left. No participants in the CPS Alone condition who could not read the countdown elected to cross. It appears from these data that pedestrians with low vision either wait for the "WALK" signal or are willing to use the CPS if they can read the numbers. The CPS + FDW appeared no more effective than the CPS Alone. Because of the relatively small sample size, it is not possible to conclude that the CPS + FDW was less safe than the CPS Alone. However, these findings also do not suggest that removing the FDW would reduce crossing safety for pedestrians with low vision.

## STUDY 2: NATURALISTIC OBSERVATION OF PEDESTRIANS WITH DIFFERENT SIGNALS

This section provides an overview of the experiment method.

### METHODS

The method for Study 2 (conducted in Phase II) is presented in the following section.

#### Participants and Experimental Venue

Participants in this study were observed by researchers at two separate intersections in downtown Kalamazoo. Both intersections consisted of a one-way street and a two-way street. These intersections were selected due to the high volume of pedestrians.

The first intersection was Rose Street at Michigan Avenue. The two-way street was Rose Street, and the two one-way streets were West Michigan Avenue and Kalamazoo Avenue. The average daily traffic (ADT) for Rose Street was 6,820, the ADT for West Michigan Avenue was 18,900, and the ADT for Kalamazoo Avenue was 25,500.

Rose Street had two lanes in each direction with additional parking lanes on both sides, and a south bound left-turn lane, with a width measuring 19.4 m (63.6 ft). Michigan Avenue at Rose Street consisted of four lanes with additional parking lanes on both sides, with a width measuring 19.1 m (63.6 ft). Typical pedestrian flows averaged 101 pedestrians/hr crossing Rose Street at Michigan Avenue and 145 pedestrians/hr crossing Michigan Avenue at Rose Street.

The second intersection was Rose Street at Kalamazoo Avenue. Rose Street at Kalamazoo Avenue consisted of two lanes in each direction, with additional parking lanes on both sides, with a width measuring 18.4 m (60.5 ft). Kalamazoo Avenue at Rose Street consisted of three lanes with additional parking lanes on both sides, with a width measuring 17.5 m (57.3 ft). Typical pedestrian flows averaged 88 pedestrians/hr crossing Rose Street at Kalamazoo Avenue and 71.5 pedestrians/hr crossing Kalamazoo Avenue at Rose Street.

Land use and general observation showed a marked difference in demographics between the two intersections. The intersection at Michigan Avenue is located in the business district with banks, high-end restaurants, the county courthouse, and a four-star hotel. The intersection at Kalamazoo Avenue is located near the train station, a homeless shelter, and a free clinic. The ratio of males to females was 55:45 at the Michigan Avenue intersection and 60:40 at the Kalamazoo Avenue intersection. A Z-test for proportions was applied to these data and the difference was significant at the .01 confidence level.

#### Apparatus

##### *Baseline*

The baseline apparatus was a standard pedestrian signal consisting of a “WALK” phase, a clearance phase, and a “DON’T WALK” phase. The clearance phase displayed a flashing hand along with the remaining time left before the “DON’T WALK” phase began. The following bullets are the times allotted to each phase at each site:

- Rose Street at Michigan: The “WALK” phase to cross Rose Street at Michigan Avenue lasted 14 s, the clearance phase lasted 15 s, and the “DON’T WALK” phase lasted 41 s.
- Michigan Avenue at Rose Street: The “WALK” phase to cross Michigan Avenue at Rose Street lasted 7 s, the clearance phase lasted 18 s, and the “DON’T WALK” phase lasted 45 s.
- Rose Street at Kalamazoo: The “WALK” phase to cross Rose Street at Kalamazoo Avenue lasted 21 s, the clearance phase lasted 15 s, and the “DON’T WALK” phase lasted 34 s.
- Kalamazoo Avenue at Rose Street: The “WALK” phase to cross Kalamazoo Avenue at Rose Street lasted 7 s, the clearance phase lasted 13 s, and the “DON’T WALK” phase lasted 50 s.

The cycle length was 70 s at both intersections, with West Michigan Avenue and Rose Street having a split of 38 s yellow and red/32 s green and Kalamazoo Avenue and Rose Street having a split of 42 s yellow and red/28 s green. The buffer interval is the time between the end of the countdown and the beginning of the green light for the conflicting traffic. During the buffer interval, a steady upraised hand (i.e., an SDW) is displayed. The buffer interval began at the end of the green light except for the pedestrians at the crossing from north to south (N-S) at Kalamazoo and Rose where the SDW appeared 1.5 s before the yellow light phase. The buffer interval for pedestrians crossing Kalamazoo and Rose from east to west (E-W) was 5.8 s. The buffer interval for pedestrians crossing Michigan and Rose from E-W was 5 s. The buffer interval for pedestrians crossing Kalamazoo and Rose N-S was 7.2 s. The buffer interval for pedestrians crossing Michigan and Rose N-S was 6 s.

### *Treatment*

The treatment apparatus was exactly the same as the baseline apparatus, with one exception: the clearance phase did not include the FDW. Only the countdown numbers were displayed during the clearance phase.

## Experimental Design

An ABB design (Shaddish, Cook, & Campbell, 2002) was employed in this research. During the A (or baseline) phase, the signal functioned in the usual manner with the FDW and CPS presented concurrently during the clearance interval. During the B (or treatment) phase, the FDW was omitted from the pedestrian clearance display. The second B condition was a 6-mo follow-up.

## Procedure

Pedestrians were included as long as they crossed within the crosswalk or within 2 ft of the designated crosswalk area. People who were not walking (e.g., jogging, biking, rollerblading, or in a wheelchair) and children who were accompanied by an adult were excluded from data collection. Testing for this study was conducted between 10:00 a.m. and 5:30 p.m. with ambient lighting conditions ranging from overcast to bright sunshine. Testing was not conducted during poor weather conditions (e.g., rain, extreme cold).

Observers sat at benches on the corners of the two locations to naturally observe the pedestrians without interference. All participants were naturally observed, and therefore interaction between observers and participants was avoided. If an obstacle blocked the line of sight of the pedestrian, the observer then moved to get a better view. When the obstacle was no longer an issue, the observer returned to their original location.

**Measures**

Both direct and derived measures were utilized.

***Direct Measures***

- A tally count was used to measure the number of pedestrians who initiated their crossing during the "WALK" phase and the SDW phase of the pedestrian signal.

- For pedestrians who entered the crosswalk during the countdown phase, the time left on the countdown display when the pedestrian entered the crosswalk (starting time), as well as the time of completion (finishing time), was recorded on the datasheet. Time of completion was measured by either the time remaining on the countdown display, or the time remaining plus the time recorded by a stopwatch that was started after the countdown display reached zero. Additionally, demographic information such as gender, and age group (senior, adult, or child) was recorded by writing a corresponding letter in a designated box on a datasheet.

- If a pedestrian who entered the crosswalk during the countdown phase ran, a corresponding box was checked for running. Running was defined as a change in gait where both feet were off the ground for a portion of each stride.

- If an evasive action by either a vehicle or pedestrian occurred, a corresponding box was checked. Evasive actions by a vehicle were defined as the driver having to break suddenly or swerve to avoid striking a pedestrian. An occurrence of an evasive action by a pedestrian was defined as a pedestrian having to run, jump, or step back to avoid a crash.

- If a pedestrian aborted a crossing, initiated during the clearance phase, a corresponding box was checked. If a pedestrian arrived at the crosswalk during the countdown phase but did not enter the crosswalk, demographic data was collected as well as the time remaining on the countdown display.

***Derived Measures***

From these initial recordings, the following measurements were calculated.

- The crossing time for each individual who entered during the countdown phase was calculated by subtracting the recorded time of completion from the time of initiation.

- The percentage of pedestrians who initiated crossing during each different amount of time remaining on the countdown display was calculated by dividing the total number of pedestrians who initiated crossing at a certain time by the total number of pedestrians who arrived at that time (initiated plus did not enter).

- The percentage of pedestrians leaving during each signal phase was calculated by independently adding up the tally marks for those who initiated their crossing during both the "WALK" and SDW phase, as well as by adding up the number of tally marks for those that initiated their crossing during the countdown phase. The individual sums were then divided by the total number of crossings, to get the percentage of pedestrians leaving during each signal phase.

- A distribution of finishing times was calculated by summing the number of people finishing crossing for each different time, and then dividing it by the total number of crossings initiated during the countdown phase.

- The distribution of starting times was calculated by summing the number of people starting crossing for each different time, and then dividing it by the total number of crossings initiated during the countdown phase.

- The percentage of pedestrians running was calculated by summing the number of occurrences of running by pedestrians that started crossing during the countdown phase with the number of crossings initiated during the countdown phase.

- Statistical data such as means, standard deviations, and p-values were computed for start times, end times, and crossing times. The two-tailed *Z*-test for proportions for independent samples was used to calculate significance levels.

## RESULTS

### Demographics

Table 11 shows the demographic breakdown at each of the four intersections.

**Table 11. Demographic breakdown at each intersection.**

| Intersection | Female (Percent) | Male (Percent) | Adults (Percent) | Children (Percent) | Seniors (Percent) | Total |
|---|---|---|---|---|---|---|
| Kalamazoo and Rose: E-W | 228 (34) | 443 (66) | 653 (97) | 5 (1) | 13 (2) | 671 |
| Michigan and Rose: E-W | 383 (46) | 443 (54) | 809 (98) | 1 (0) | 16 (2) | 826 |
| Kalamazoo and Rose: N-S | 277(46) | 325(54) | 589(98) | 2(0) | 11(2) | 602 |
| Michigan and Rose: N-S | 345(43) | 461(57) | 780(97) | 14(2) | 12(1) | 806 |

At the Kalamazoo Avenue and Rose Street, crossing in the E-W direction, females accounted for 228 (34 percent) of the observations, while males accounted for 443 (66 percent) of the observations. Adults accounted for 653 (97 percent) of the observations, children accounted for 5 (1 percent) of the observations, and seniors accounted for 13 (2 percent) of the observations.

At Michigan Avenue and Rose Street, crossing in the E-W direction, females accounted for 383 (46 percent) of the observations, while males accounted for 443 (54 percent) of the observations. Adults accounted for 809 (98 percent) of the observation, children accounted for 1 (0 percent) of the observations, and seniors accounted for 16 (2 percent) of the observations.

At Kalamazoo Avenue and Rose Street, crossing in the N-S direction, females accounted for 277 (46 percent) of the observations, while males accounted for 325 (54 percent) of the observations. Adults accounted for 589 (98 percent) of the observations, children accounted for 2 (0 percent) of the observations, and seniors accounted for 11 (2 percent) of the observations.

At Michigan Avenue and Rose Street, crossing in the N-S direction, females accounted for 345 (43 percent) of the observations, while males accounted for 461 (57 percent) of the observations. Adults accounted for 780 (97 percent) of the observations, children accounted for 14 (2 percent) of the observations, and seniors accounted for 12 (1 percent) of the observations.

### *Crossing Times*

The crossing time averages for each site are displayed in table 12. These data show the average amount of crossing time for each N-S and E-W leg at each of the two intersections during the CPS + FDW condition, the CPS Alone condition, and the CPS Alone Follow-up condition.

At the Kalamazoo Avenue and Rose Street intersection, crossing in the E-W direction during the CPS + FDW condition, pedestrians averaged 13.9 s crossing the street, with a range of 5 s to 24 s. During the CPS Alone condition, pedestrian crossing times averaged 13.0 s with a range of 4 s to 23 s. During the CPS Alone Follow-up condition, pedestrian crossing times averaged 11.4 s with a range of 3 s to 20 s.

At Michigan Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, pedestrians averaged 12.4 s crossing the street, with a range of 5 s to 18 s. During the CPS Alone condition, pedestrian crossing time averaged 12.1 s, with a range of 6 s to 19 s. During the CPS Alone Follow-up condition, pedestrian crossing times averaged 11.9 s, with a range from 6 s to 17 s.

At Kalamazoo Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, pedestrians averaged 12.0 s with a range of 4 s to 20 s. During the CPS Alone condition pedestrians averaged 11.1 s to cross the street with a range of 4 s to 22 s. During the CPS Alone Follow-up condition, pedestrian crossing times averaged 10.2 s, with a range from 5 s to 17 s.

At Michigan Avenue and Rose Street, crossing in the N-S direction during CPS + FDW condition, pedestrians averaged 12.8 s, with a range of 5 s to 19 s. During the CPS Alone condition pedestrians crossing time averaged 12.9 s with a range of 6 s to 22 s. During the CPS Alone Follow-up condition, pedestrian crossing times averaged 12.3 s with a range from 3 s to 24 s.

**Table 12. Average crossing time during each condition at each site.**

| Phase | Mean Kalamazoo and Rose: East-West | Mean Michigan and Rose: East-West | Mean Kalamazoo and Rose: North-South | Mean Michigan and Rose: North-South |
|---|---|---|---|---|
| CPS + FDW | 13.9 | 12.4 | 12.0 | 12.8 |
| CPS Alone | 13 | 12.1 | 11.1 | 12.9 |
| CPS Alone Follow-up | 11.4 | 11.9 | 10.2 | 12.3 |

Overall, there was a small decrease in average crossing time, which reflects faster crossing, at three of the four sites during the CPS Alone condition. This effect increased somewhat during follow-up measures. However, none of these changes are statistically significant. The remaining site did not display a decrease in average crossing time and showed no change at all.

***Percentage of Pedestrians Leaving by Phase***

The percentages of pedestrians who left during each phase for each site are displayed in table 13. These data show the percentage of pedestrians who began crossing during each phase for each N-S and E-W leg at each of the two intersections during the CPS + FDW condition, the CPS Alone condition, and the CPS Alone Follow-up condition.

At Kalamazoo Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, pedestrians initiated their crossing during the "WALK" phase 65.1 percent of the time, the countdown phase 16.7 percent, and the "DON'T WALK" phase 18.1 percent. During the CPS Alone condition, pedestrians initiated their crossing during the "WALK" phase 64.6 percent of the time, the countdown phase 17 percent, and the "DON'T WALK" phase 18.4 percent. During the CPS Alone Follow-up condition, pedestrians initiated their crossing during the "WALK" phase 64.1 percent of the time, the countdown phase 17.1 percent, and the "DON'T WALK" phase 18.9 percent.

At Michigan Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, pedestrians initiated their crossing during the "WALK" phase 77.1 percent of the time, the countdown phase 12.7 percent, and the "DON'T WALK" phase 10.2 percent. During the CPS Alone condition, pedestrians initiated their crossing during the "WALK" phase 77.1 percent of the time, the countdown phase 14.3 percent, and the "DON'T WALK" phase 8.6 percent. During the CPS Alone Follow-up condition, pedestrians initiated their crossing during the "WALK" phase 74.2 percent of the time, the countdown phase 13.2 percent, and the "DON'T WALK" phase 12.6 percent.

At Kalamazoo Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, pedestrians initiated their crossing during the "WALK" phase 73.7 percent of the time, the countdown phase 16.2 percent, and the "DON'T WALK" phase 10.1 percent. During the CPS Alone condition, pedestrians initiated their crossing during the "WALK" phase 67.4 percent of the time, the countdown phase 18.6 percent, and the "DON'T WALK" phase 14.0 percent. During the CPS Alone Follow-up condition, pedestrians initiated their crossing during the "WALK" phase 69.5 percent of the time, the countdown phase 17.5 percent of the time, and the "DON'T WALK" phase 13.1 percent of the time.

At Michigan Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, pedestrians initiated their crossing during the "WALK" phase 71.9 percent of the time, the countdown phase 23.1 percent, and the "DON'T WALK" phase 5.0 percent. During the CPS Alone condition, pedestrians initiated their crossing during the "WALK" phase 68.8 percent of the time, the countdown phase 21.0 percent, and the "DON'T WALK" phase 9.9 percent. During the CPS Alone Follow-up condition, pedestrians initiated their crossing during the "WALK" phase 63.4 percent of the time, the countdown phase 24 percent of the time, and the "DON'T WALK" phase 13.2 percent of the time.

Overall, there was an increase in the percentage of pedestrians crossing during the "WALK" (SDW) condition at three of the four sites. The effect was small at all but one site. However, there were reductions in the percentage crossing during the "WALK" during CPS Alone, and CPS Alone plus countdown phases at this site. This suggests that more people were arriving during the SDW phase. The increase in the percentage crossing during the SDW reached a significant level at only one of the sites (significant at the .01 level).

**Table 13. Percentage crossing during each signal phase for each condition at each site.**

| Phase | Percentage Crossing Kalamazoo and Rose: East-West | | | Percentage Crossing Michigan and Rose: East-West | | | Percentage Crossing Kalamazoo and Rose: North-South | | | Percentage Crossing Michigan and Rose: North-South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Walk | CD | SDW | Walk | CD | SDW | Walk | CD | SDW | Walk | CD | SDW |
| CPS + FDW | 65.1 | 16.7 | 18.1 | 77.1 | 12.7 | 10.2 | 73.7 | 16.2 | 10.1 | 71.9 | 23.1 | 5.0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CPS Alone | 64.6 | 17.0 | 18.4 | 77.1 | 14.3 | 8.6 | 67.4 | 18.6 | 14.0 | 68.8 | 21.0 | 9.9 |
| CPS Alone Follow-up | 64.1 | 17.1 | 18.9 | 74.2 | 13.2 | 12.6 | 68.5 | 17.5 | 13.1 | 63.4 | 24.0 | 13.2 **.01 |

** = *p*<.01

### *Percentage of Pedestrians Cleared*

The percentages of pedestrians who crossed and arrived during the countdown phase (percentage of pedestrians cleared) are displayed in table 14. These data show the percentages of pedestrians cleared during the countdown phase for each N-S and E-W leg at both of the intersections during the CPS + FDW condition, the CPS Alone condition, and the CPS Alone Follow-up condition.

At Kalamazoo Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, pedestrians cleared during the countdown phase 74.0 percent of the time. During the CPS Alone condition, pedestrians cleared during the countdown phase 78.1 percent of the time. During the CPS Alone Follow-up condition, pedestrians cleared during the countdown phase 83.0 percent of the time.

At Michigan Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, pedestrians cleared during the countdown phase 76.9 percent of the time. During the CPS Alone condition, pedestrians cleared during the countdown phase 72.6 percent of the time. During the CPS Alone Follow-up condition, pedestrians cleared during the countdown phase 78.7 percent of the time.

At Kalamazoo Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, pedestrians cleared during the countdown phase 85.5 percent of the time. During the CPS Alone condition, pedestrians cleared during the countdown phase 85.3 percent of the time. During the CPS Alone Follow-up condition, pedestrians cleared during the countdown phase 86.7 percent of the time.

At Michigan Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, pedestrians cleared during the countdown phase 81.0 percent of the time. During the CPS Alone condition, pedestrians cleared during the countdown phase 81.5 percent of the time. During the CPS Alone Follow-up condition, pedestrians cleared during the countdown phase 83.3 percent of the time.

Overall, there was a small increase in the percentage of pedestrians cleared during the CPS Alone Follow-up condition at all four sites. A standard Z-test was performed to determine if these increases were significant when alpha was set at the .05 level. The increase was only statistically significant at the Kalamazoo and Rose: E-W site.

**Table 14. Percentage of pedestrians that arrived during the countdown phase at each site.**

| Phase | Percentage Crossing Kalamazoo and Rose: East-West | Percentage Crossing Michigan and Rose: East-West | Percentage Crossing Kalamazoo and Rose: North-South | Percentage Crossing Michigan and Rose: North-South |
|---|---|---|---|---|
| CPS + FDW | 74.0 | 76.9 | 85.5 | 81.0 |
| CPS Alone | 78.1 | 72.6 | 85.3 | 81.5 |
| CPS Alone Follow-up | 83.0 *05 | 78.7 | 86.7 | 83.3 |

* = $p<.05$

***Percentage of Pedestrians Running***

The percentages of pedestrians that ran are displayed in table 15. These data show the percentages of pedestrians who initiated their crossing during the countdown phase and started running, ran at some point during their crossing. Data is displayed for the N-S and E-W legs at each of the two intersections during the CPS + FDW condition, the CPS Alone condition, and the CPS Alone Follow-up condition.

At Kalamazoo Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, pedestrians ran 8.9 percent of the time. During the CPS Alone condition, pedestrians ran 8.8 percent of the time. During the CPS Alone Follow-up condition, pedestrians ran 15.5 percent of the time.

At Michigan Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition pedestrians ran 11.5 percent of the time. During the CPS Alone condition, pedestrians ran 22.2 percent of the time. During the CPS Alone Follow-up condition, pedestrians ran 14.2 percent of the time.

At Kalamazoo Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition pedestrians ran 8.1 percent of the time. During the CPS Alone condition, pedestrians ran 13.7 percent of the time. During the CPS Alone Follow-up condition, pedestrians ran 12.5 percent of the time.

At Michigan Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition pedestrians ran 17.2 percent of the time. During the CPS Alone condition, pedestrians ran 15.9 percent of the time. During the CPS Alone Follow-up condition, pedestrians ran 14.2 percent of the time.

Overall, an increase in the percentage of pedestrians running is seen at two of the four sites during the original CPS Alone phase. A standard Z-test was performed to determine if these increases were statistically significant when alpha was set to the .05 and .01 levels. The increase was only statistically significant at the Michigan and Rose: E-W site (.01 level). The percentage running at these two sites saw an increase during the CPS Alone Follow-up condition when compared to the CPS + FDW condition, but these increases were not statistically significant. However, a third site saw an increase in running during the Follow-up phase as well, but this increase was not statistically significant.

**Table 15. Percentage of pedestrians that started crossing during the CPS phase and ran during their crossing.**

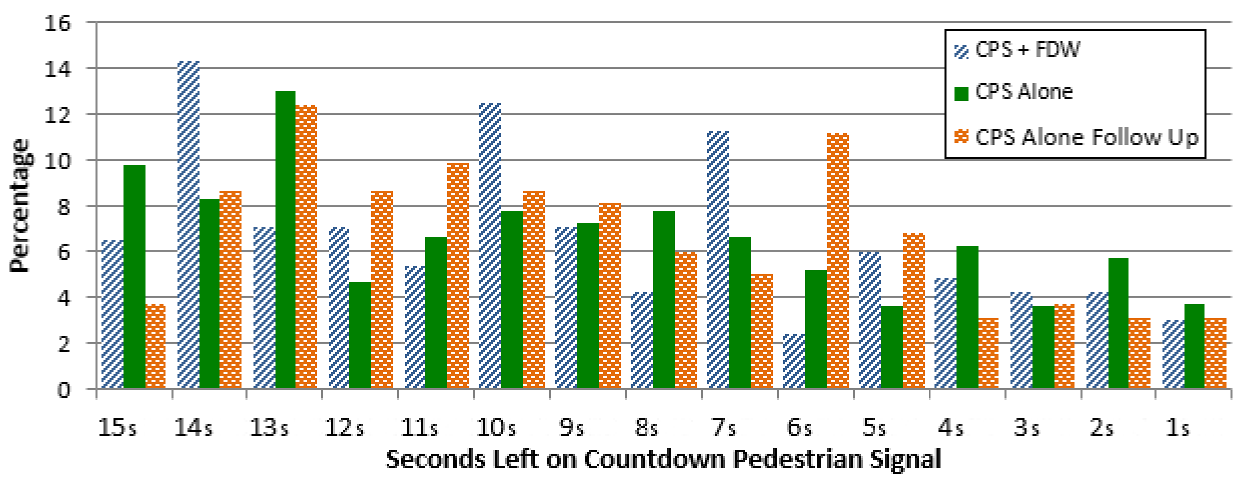
| Phase | Percentage Running Kalamazoo and Rose: East-West | Percentage Running Michigan and Rose: East-West | Percentage Running Kalamazoo and Rose: North-South | Percentage Running Michigan and Rose: North-South |
|---|---|---|---|---|
| CPS + FDW | 8.9 | 11.5 | 8.1 | 17.2 |
| CPS Alone | 8.8 | 22.2<br>** 01 | 13.7 | 15.9 |
| CPS Alone Follow-up | 15.5 | 14.2 | 12.5 | 14.2 |

### *Start Times*

The starting time distributions were calculated by dividing the number of pedestrians who started crossing at that time by the total number of pedestrians who crossed during the countdown phase.

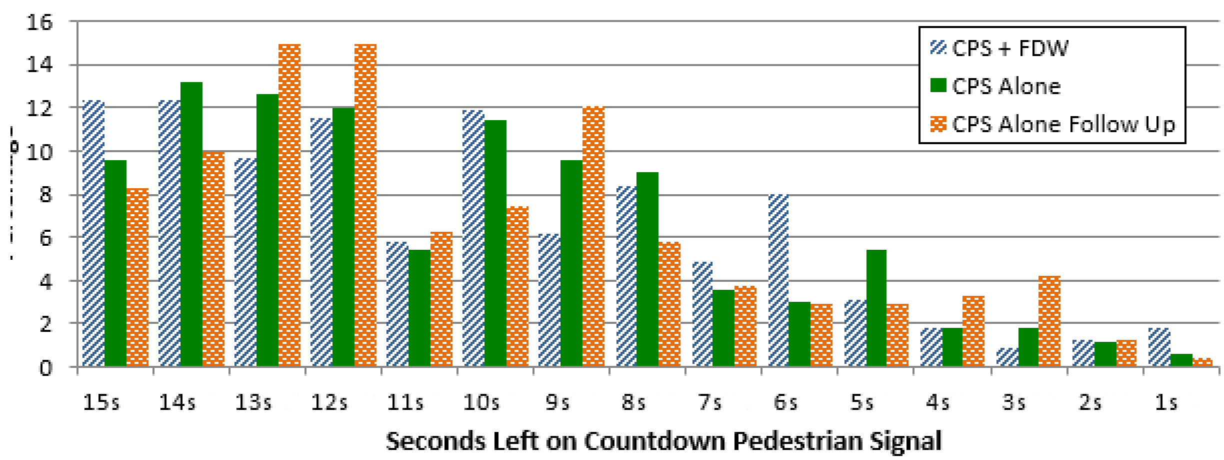
Figure 6 displays the distribution of pedestrian starting times at Kalamazoo Avenue and Rose Street crossing in the E-W direction. During all conditions, starting time ranged between 1 and 15 s left on the countdown display. During the CPS + FDW condition, pedestrians averaged 9.2 s as their starting time. During the CPS Alone condition, pedestrians averaged 9.2 s as their starting time. During the CPS Alone Follow-up condition, pedestrians averaged 9.3 s as their starting time. None of these average differences were statistically significant.

Figure 7 displays the distribution of pedestrian starting times at Michigan Avenue and Rose Street, crossing in the E-W direction. During all conditions, there was a range from 1 s to 15 s left on the countdown display. During the CPS + FDW condition, pedestrians averaged 10.4 s as the starting time. During the CPS Alone condition, pedestrians averaged 12.1 s as the starting time. During the CPS Alone Follow-up condition, pedestrians averaged 10.3 s as the starting time. When comparing the CPS Alone average starting times to both CPS + FDW and CPS Alone Follow-up average starting times, there is a statistically significant increase in start time when alpha is set to the .01 level. There is no statistically significant difference in starting times between the CPS + FDW condition and the CPS Alone Follow-up condition. In fact, the average CPS Follow-up conditions' starting times are slightly less than the CPS+FDW conditions starting time.




Source: FHWA.

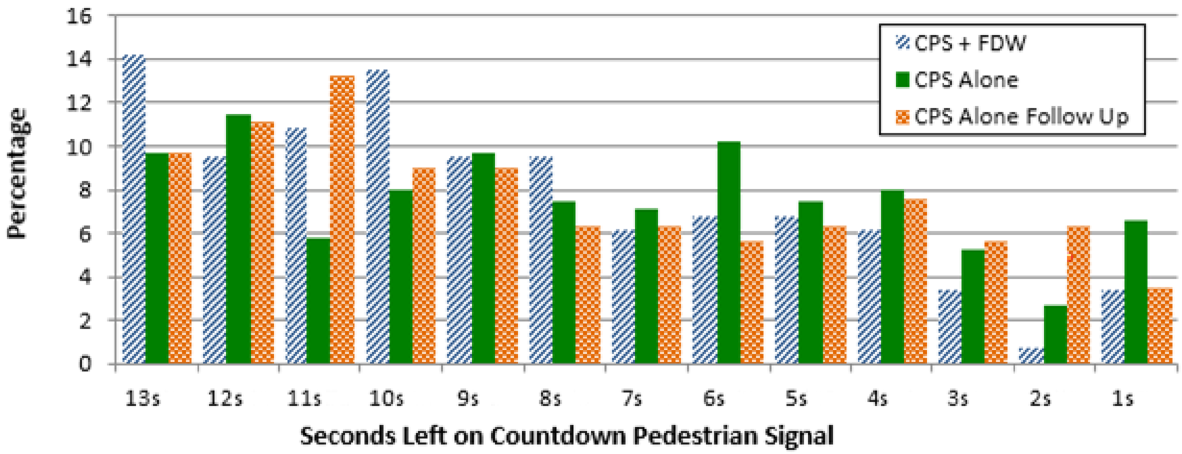
**Figure 6. Graph. CPS starting time distribution for pedestrians crossing Kalamazoo at Rose East-West.**




Source: FHWA.

**Figure 7. Graph. CPS starting time distribution for pedestrians crossing Michigan at Rose East-West.**

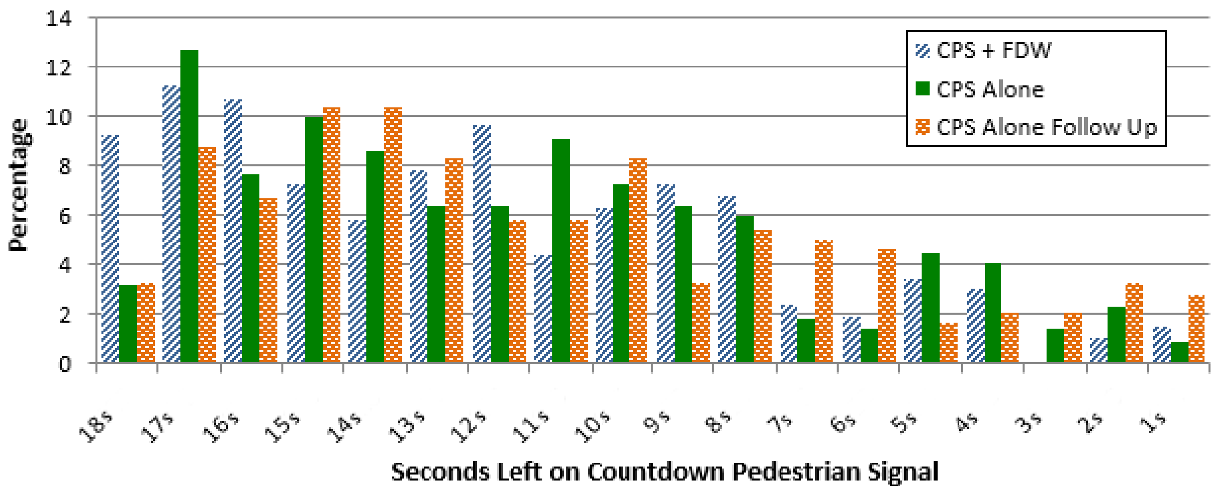
Figure 8 displays the distribution of pedestrian starting times at Kalamazoo Avenue and Rose Street, crossing in the N-S direction. During all conditions, there was a range from 1 s to 13 s. During the CPS + FDW condition, pedestrians averaged 8.7 s as the starting time. During the CPS Alone condition pedestrians averaged 7.6 s as the starting time. During the CPS Alone Follow-up condition, pedestrians averaged 8.0 s as the starting time. There was a statistically significant difference in starting times between the CPS + FDW condition and the CPS Alone condition when alpha was set to the .05 level, but not between the CPS + FDW condition and the CPS Alone Follow-up condition.




Source: FHWA.

**Figure 8. Graph. CPS starting time distribution for pedestrians crossing Kalamazoo at Rose North-South.**

Figure 9 displays the distribution of pedestrian starting times at Michigan Avenue and Rose Street, crossing in the N-S direction. During all conditions, there was a range from 1 s to 18 s. During the CPS + FDW condition, pedestrians averaged 12.4 s as the starting time. During the CPS Alone condition, pedestrians averaged 11.7 s as the starting time. During the CPS Alone Follow-up condition, pedestrians averaged 11.1 s as the starting time. There was not a statistically significant difference in starting times between the CPS + FDW condition and the CPS Alone condition when alpha was set at the .05 level, but there was between the CPS + FDW condition and CPS Alone Follow-up condition.



Source: FHWA.

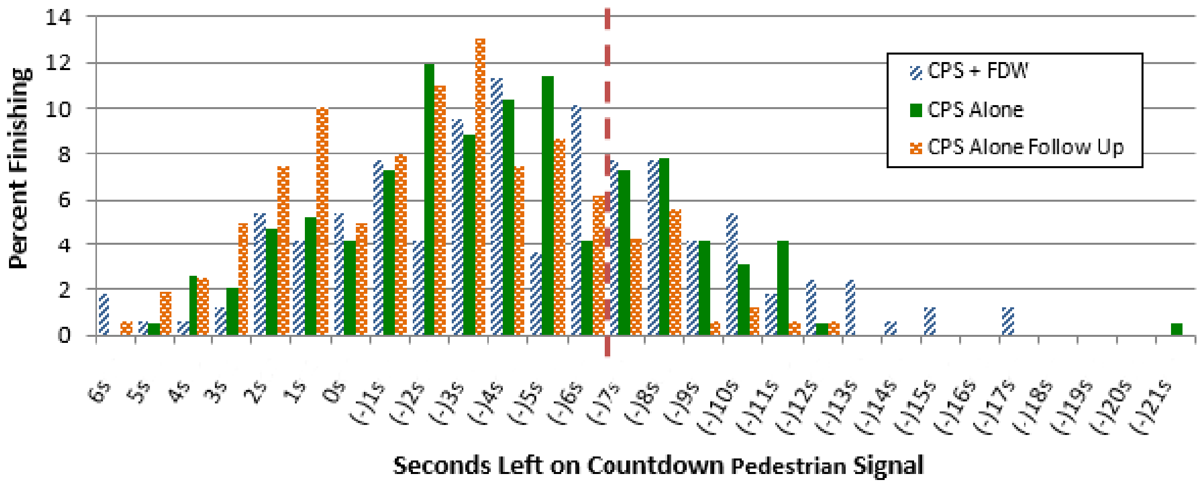
**Figure 9. Graph. CPS starting time distribution for pedestrians crossing Michigan at Rose North-South.**

Each of these graphs shows a similar trend and a great deal of overlap in that more people tend to cross early in the countdown as compared to later in the countdown. Where there were statistical differences, they were not uniform. At one site, the CPS Alone condition resulted in statistically significant earlier starting times. At another, the same CPS Alone condition resulted in statistically significant later starting times. While at another site, they were exactly the same. Therefore, it is difficult to say if these statistically significant results were due to the removal of the flashing hand, or rather the result of some other factor.

***Finishing Times***

The finish time distributions for each site are displayed in figure 10. The distributions were calculated by dividing the number of pedestrians that finished crossing at each time by the total number of pedestrians who crossed during the countdown phase. Included in the graphs are red dashed lines marking the time when cross-traffic was released. All crosswalk lengths include parking lanes on both sides. This design means pedestrians stop being in the traffic lane before they finish crossing the street. The time spent in parking lanes was not considered in our calculations because it was not measured. Therefore, our estimates of those still in the roadway when cross-traffic was released is somewhat conservative.

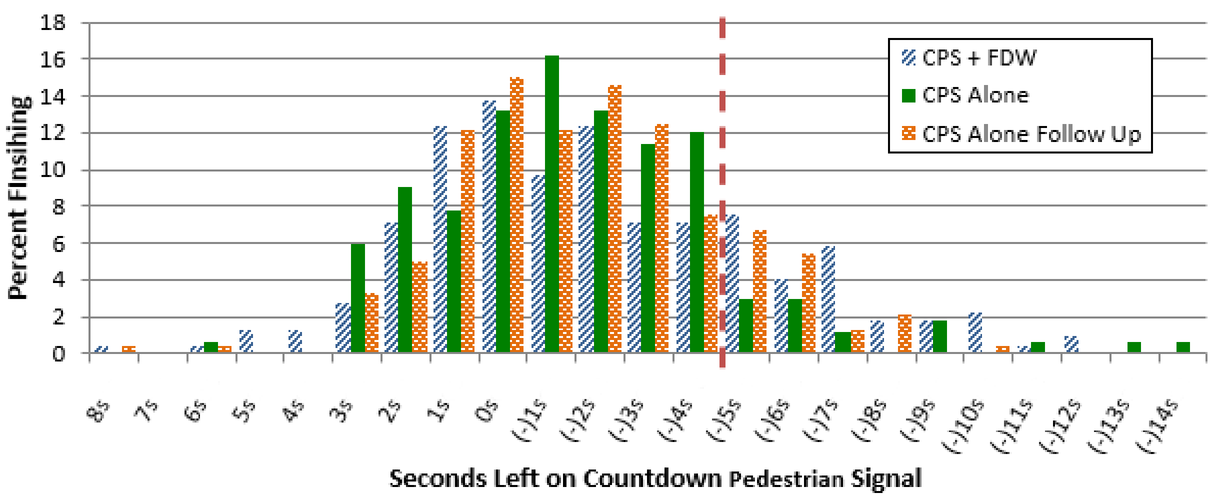
Figure 10 displays the distribution of pedestrian finishing times at Kalamazoo Avenue and Rose Street, crossing in the E-W direction. During the CPS + FDW condition, finishing times ranged from 6 s left on the CPS to 17 s past 0 on the CPS, with a mean finishing time of 4.7 s past 0. During the CPS Alone condition, finishing times ranged from 5 s left on the CPS to 21 s past 0, with a mean of 3.9 s past 0. During the CPS Alone Follow-up condition, finishing times ranged from 8 s left on the CPS to 12 s past 0, with a mean of 2.1 s past 0. The red dashed line signifies the time at which cross-traffic is released, which was 5.8 s after the countdown reached 0 at this site. A trend toward fewer people in the intersection when cross-traffic is released is shown after the flashing hand is removed. The effect became larger during the 6-mo follow-up. At this site a large proportion of the distribution is to the right of the red dashed line.




Source: FHWA.

**Figure 10. Graph. The finishing time distribution for pedestrians crossing Kalamazoo at Rose East-West.**

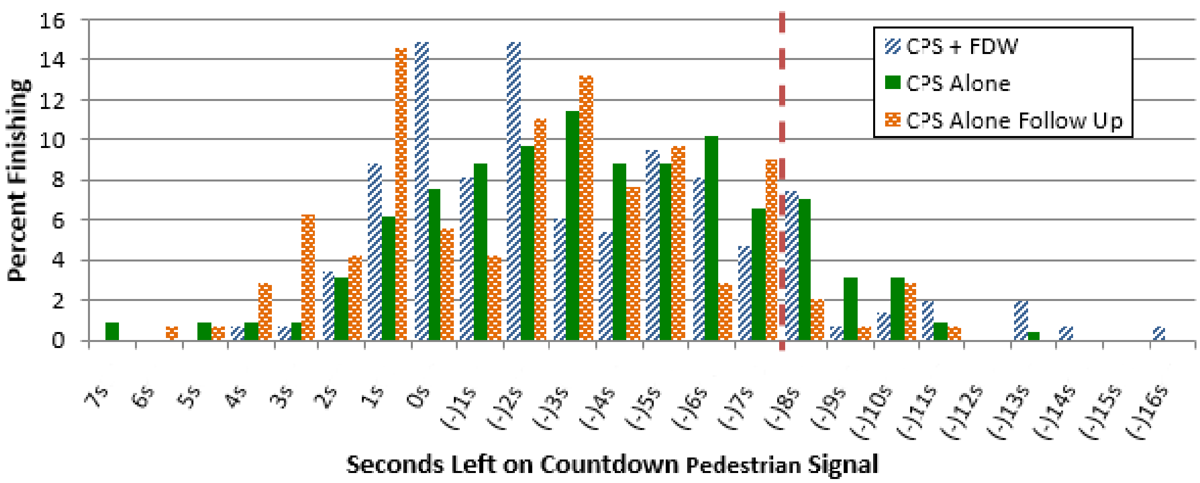
Figure 11 displays the distribution of pedestrian finishing times at Michigan Avenue and Rose Street, crossing in the E-W direction. During the CPS + FDW condition, finishing times ranged from 8 s left on the CPS to 12 s past 0 on the CPS, with a mean of 2.0 s past 0. During the CPS Alone condition, finishing times ranged from 6 s left on the CPS to 14 s past 0, with a mean of 1.6 s past 0. During the CPS Alone Follow-up condition, finishing times ranged from 8 s left on the CPS to 10 s past 0, with a mean of 1.7 s past 0. The red dashed line signifies the time at which cross-traffic is released, which was 5.0 s after the countdown reaches 0 at this site. This site also shows a reduction in the proportion of the people finishing after the cross-traffic is released after the removal of the flashing hand. At this site most of the distribution during both conditions is to the left of the red dashed line. This difference was significant at the .05 level.




Source: FHWA

**Figure 11. Graph. The finishing time distribution for pedestrians crossing Michigan at Rose East-West.**

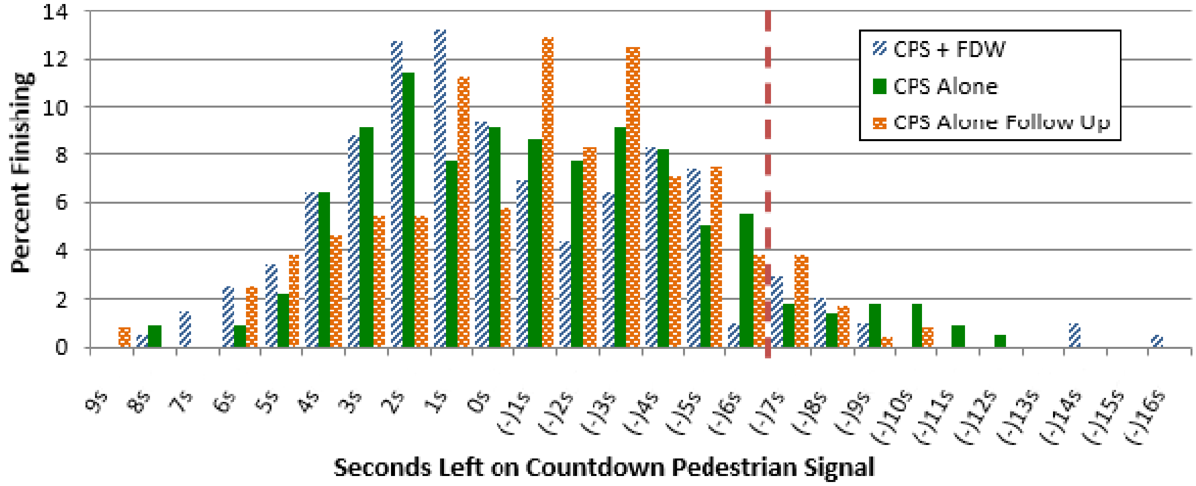
Figure 12 displays the distribution of pedestrian finishing times at Kalamazoo Avenue and Rose Street, crossing in the N-S direction. During the CPS + FDW condition, finishing times ranged from 4 s left on the CPS to 16 s past 0 on the CPS, with a mean of 3.3 s past 0. During the CPS Alone condition, finishing times ranged from 7 s left on the CPS to 13 s past 0 on the CPS, with a mean of 3.5 s past 0. During the CPS Alone Follow-up condition, finishing times ranged from 6 s left on the CPS to 11 s past 0 on the CPS, with a mean of 2.2 s past 0. The red dashed line signifies the time at which cross-traffic is released, which was 7.2 s after the countdown reached 0 at this site. At this site there is a tendency for fewer people to be in the road after the cross-traffic is released during the follow-up condition.




Source: FHWA.

**Figure 12. Graph. The finishing time distribution for pedestrians crossing Kalamazoo at Rose North-South.**

Figure 13 displays the distribution of pedestrian finishing times at Michigan Avenue and Rose Street, crossing in the N-S direction. During the CPS + FDW condition, finishing times ranged from 8 s left on the CPS to 16 s past 0 on the CPS, with a mean of .4 s past 0. During the CPS Alone condition, finishing times ranged from 8 s left on the CPS to 12 s past 0, with a mean of 1.1 s past 0. During the CPS Alone Follow-up condition, finishing times ranged from 9 s left on the CPS to 10 s past 0, with a mean of 1.1 s past 0. The red dashed line signifies the time at which cross-traffic is released, which was 6.0 s after the countdown reaches 0 at this site. At this site most of the distribution is to the left of the red dashed line. There does not appear to be any difference in the proportion to the right of the red dashed line during any of the conditions.



Source: FHWA.

**Figure 13. Graph. The finishing time distribution for pedestrians crossing Michigan at Rose North-South.**

### *Percentage Pedestrians Crossing Before and After Cross-Traffic Released*

Of the pedestrians who started during the CPS, the percentage of pedestrians who finished before and after cross-traffic is released is displayed in table 16.

At Kalamazoo Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, pedestrians finished before cross-traffic was released 65.5 percent of the time and after cross-traffic was released 34.5 percent of the time. During the CPS Alone condition, pedestrians finished before cross-traffic was released 72.7 percent of the time and after cross-traffic was released 27.3 percent of the time. During the CPS Alone Follow-up condition, pedestrians finished before cross-traffic was released 87.3 percent of the time and finished after cross-traffic was released 12.7 percent of the time. Significantly fewer pedestrians finished crossing after the cross-traffic was released during the CPS Alone condition at this site. There was not a statistically significant difference in finishing times before the release of cross-traffic between the CPS + FDW condition and the CPS Alone condition when alpha was set at the .01 level, but there was a significant difference between the CPS + FDW condition and CPS Alone Follow-up condition.

At Michigan Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, pedestrians finished before cross-traffic was released 83.7 percent of the time and finished after cross-traffic was released 15.3 percent of the time. During the CPS Alone condition, pedestrians finished before cross-traffic was released 85.3 percent of the time and finished after cross-traffic was released 14.7 percent of the time. During the CPS Alone Follow-up condition, pedestrians finished before cross-traffic was released 90.7 percent of the time and finished after cross-traffic was released 9.3 percent of the time. Significantly fewer pedestrians finished crossing after cross-traffic was released during the CPS Alone condition. There was not a statistically significant difference in finishing times before the release of cross-traffic between the CPS + FDW condition and the CPS Alone condition when alpha was set at the .05 level, but there was between the CPS + FDW condition and CPS Alone Follow-up condition.

At Kalamazoo Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, pedestrians finished before cross-traffic was released 85.1 percent of the time and finished after cross-traffic was released 14.9 percent of the time. During the CPS Alone condition, pedestrians finished before cross-traffic was released 85.3 percent of the time and finished after cross-traffic was released 14.7 percent of the time. During the CPS Alone Follow-up condition, pedestrians finished before cross-traffic was released 93.7 percent of the time and finished after cross-traffic was released 6.3 percent of the time. There was not a statistically significant difference in finishing times before the release of cross-traffic between the CPS + FDW condition and the CPS Alone condition when alpha was set at the .05 level, but there was between the CPS + FDW condition and CPS Alone Follow-up condition.

At Michigan Avenue and Rose Street crossing, in the N-S direction during the CPS + FDW condition, pedestrians finished before cross-traffic was released 92.7 percent of the time and finished after cross-traffic was released 7.3 percent of the time. During the CPS Alone condition, pedestrians finished before cross-traffic was released 91.7 percent of the time and finished after cross-traffic was released 8.3 percent of the time. During the CPS Alone Follow-up condition, pedestrians finished before cross-traffic was released 93.2 percent of the time and finished after cross-traffic was released 6.8 percent of the time. No effects were significant at this site.

At three of the four sites, we see a statistically significant increase in the percentage of pedestrians finishing before cross-traffic is released during the CPS Alone Follow-up condition.

**Table 16. The percentage of pedestrians that finished crossing at each site before and after the cross-traffic was released.**

| Phase | Kalamazoo and Rose: East-West | | Michigan and Rose: East-West | | Kalamazoo and Rose: North-South | | Michigan and Rose: North-South | |
|---|---|---|---|---|---|---|---|---|
| | **Before** | **After** | **Before** | **After** | **Before** | **After** | **Before** | **After** |
| CPS + FDW | 65.5 | 34.5 | 83.7 | 15.3 | 85.1 | 14.9 | 92.7 | 7.3 |
| CPS Alone | 72.7 | 27.3 | 85.3 | 14.7 | 85.3 | 14.7 | 91.7 | 8.3 |
| CPS Alone Follow-up | 87.3 | 12.7<br>** 01 | 90.7 | 9.3<br>* 05 | 93.7 | 6.3<br>*05 | 93.2. | 6.8 |

***Crossings Finished Before Cross-Traffic Released***

The percentage of male and female pedestrians who started during the CPS, the percentage of pedestrians who finished before and after cross-traffic is released is displayed in table 17. Note that there were an extremely low number of Senior and Adult crossings at some intersections; therefore, these analyses are presented with all age categories combined.

At Kalamazoo Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition 54.8 percent of female pedestrians finished their crossings before cross-traffic was released, while 69.0 percent of male pedestrians finished their crossings before cross-traffic was released. During the CPS Alone condition, 72.7 percent of female pedestrians finished their crossings before cross-traffic was released, while 72.7 percent of male pedestrians finished their crossings before cross-traffic was released. During the CPS Alone Follow-up condition, 86.2 percent of female pedestrians finished their crossings before cross-traffic was released, while 87.9 percent of male pedestrians finished their crossings before cross-traffic was released.

At Michigan Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, 84.7 percent of female pedestrians finished their crossings before cross-traffic was released, while 82.0 percent of male pedestrians finished their crossings before cross-traffic was released. During the CPS Alone condition, 96.0 percent of female pedestrians finished their crossings before cross-traffic was released, while 89.1 percent of male pedestrians finished their crossings before cross-traffic was released. During the CPS Alone Follow-up condition, 92.2 percent of female pedestrians finished their crossings before cross-traffic was released, while 89.6 percent of male pedestrians finished their crossings before cross-traffic was released.

At Kalamazoo Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, 87.1 percent of female pedestrians finished their crossings before cross-traffic was released, while 83.3 percent of male pedestrians finished their crossings before cross-traffic was released. During the CPS Alone condition, 84.4 percent of female pedestrians finished their crossings before cross-traffic was released, while 86.2 percent of male pedestrians finished their crossings before cross-traffic was released. During the CPS Alone Follow-up condition, 94.6 percent of female pedestrians finished their crossings before cross-traffic was released, while 93.1 percent of male pedestrians finished their crossings before cross-traffic was released.

**Table 17. Count and percentage of female and male pedestrians who finished crossing before cross-traffic was released at each site.**

| Phase | Kalamazoo and Rose: East-West | | Michigan and Rose: East-West | | Kalamazoo and Rose: North-South | | Michigan and Rose: North-South | |
|---|---|---|---|---|---|---|---|---|
| | Female (Percent) | Male (Percent) | Female (Percent) | Male (Percent) | Female (Percent) | Male (Percent) | Female (Percent) | Male (Percent) |
| CPS + FDW | 23(54.8) | 87(69.0) | 83(84.7) | 105(82.0) | 61(87.1) | 65(83.3) | 85(92.4) | 105(92.9) |
| CPS Alone | 48(72.7) | 93(72.7) | 72(96.0) | 82(89.1) | 92(84.4) | 100(86.2) | 92(93.9) | 108(90.0) |
| CPS Alone Follow-up | 50(86.2) | 94(87.9) | 95 (92.2) | 120(89.6) | 53(94.6) | 81(93.1) | 82(93.2) | 138(93.2) |

At Michigan Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, 92.4 percent of female pedestrians finished their crossings before cross-traffic was released, while 92.9 percent of male pedestrians finished their crossings before cross-traffic was released.

During the CPS Alone condition, 93.9 percent of female pedestrians finished their crossings before cross-traffic was released, while 90.0 percent of male pedestrians finished their crossings before cross-traffic was released. During the CPS Alone Follow-up condition, 93.2 percent of female pedestrians finished their crossings before cross-traffic was released, while 93.2 percent of male pedestrians finished their crossings before cross-traffic was released.

***Evasive Actions and Aborted Crossings***

Table 18 displays the occurrence of aborted crossings, evasive actions by pedestrians, and evasive actions by vehicles for each N-S and E-W leg at each of the two intersections during the CPS + FDW condition, the CPS Alone condition, and the CPS Alone Follow-up condition.

At Kalamazoo Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, one pedestrian aborted their crossing, zero pedestrians performed an evasive action, and two vehicles performed an evasive action. During the CPS Alone condition, one pedestrian aborted their crossing, zero pedestrians performed an evasive action, and zero vehicles performed an evasive action. During the CPS Alone Follow-up condition, one pedestrian aborted their crossing, zero pedestrians performed an evasive action, and zero vehicles performed an evasive action.

At Michigan Avenue and Rose Street, crossing in the E-W direction during the CPS + FDW condition, zero pedestrians aborted their crossing, zero pedestrians performed an evasive action, and zero vehicles performed an evasive action. During the CPS Alone condition, two pedestrians aborted their crossing, zero pedestrians performed an evasive action, and three vehicles performed an evasive action. During the CPS Alone Follow-up condition, zero pedestrians aborted their crossing, zero pedestrians performed an evasive action, and zero vehicles performed an evasive action.

At Kalamazoo Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, zero pedestrians aborted their crossing, zero pedestrians performed an evasive action, and zero vehicles performed an evasive action. During the CPS Alone condition, zero pedestrians aborted their crossing, zero pedestrians performed an evasive action, and one vehicle performed an evasive action. During the CPS Alone Follow-up condition, zero pedestrians aborted their crossing, zero pedestrians performed an evasive action, and zero vehicles performed an evasive action.

At Michigan Avenue and Rose Street, crossing in the N-S direction during the CPS + FDW condition, one pedestrian aborted their crossing, one pedestrian performed an evasive action, and one vehicle performed an evasive action. During the CPS Alone condition, zero pedestrians aborted their crossing, zero pedestrians performed an evasive action, and two vehicles performed an evasive action. During the CPS Alone Follow-up condition, one pedestrian aborted their crossing, zero pedestrians performed an evasive action, and zero vehicles performed an evasive action.

Overall, these events were very rare during all conditions. Because these events were so rare, no inferential statistical analysis was performed. Despite the lack of a statistical analysis, it was important to look at these events because they are logically closely related to actual pedestrian conflicts (meaning if they were not performed, a conflict would occur). However, there does not appear to be an increase in events following the removal of the FDW, in either the CPS Alone or CPS Alone Follow-up conditions.

**Table 17. Evasive actions and aborted crossings at each site for each condition.**

| Phase | Location | Aborted Crossings | Evasive Pedestrian Actions | Evasive Vehicle Actions |
|---|---|---|---|---|
| CPS + FDW | Kalamazoo and Rose: E-W | 1 | 0 | 2 |
| CPS Alone | Kalamazoo and Rose: E-W | 1 | 0 | 0 |
| CPS Alone Follow-up | Kalamazoo and Rose E-W | 1 | 0 | 0 |
| CPS + FDW | Michigan and Rose: E-W | 0 | 0 | 0 |
| CPS Alone | Michigan and Rose: E-W | 2 | 0 | 3 |
| CPS Alone Follow-up | Michigan and Rose: E-W | 0 | 0 | 0 |
| CPS + FDW | Kalamazoo and Rose: N-S | 0 | 0 | 0 |
| CPS Alone | Kalamazoo and Rose: N-S | 0 | 0 | 1 |
| CPS Alone Follow-up | Kalamazoo and Rose: N-S | 0 | 0 | 0 |
| CPS + FDW | Michigan and Rose: N-S | 1 | 1 | 1 |
| CPS Alone | Michigan and Rose: N-S | 0 | 0 | 2 |
| CPS Alone Follow-up | Michigan and Rose: N-S | 1 | 0 | 0 |

## SUMMARY AND CONCLUSIONS

Information was requested from members of the FHWA TCD Pooled Fund States and a study was conducted to determine the appropriate signal head configuration for testing. The results of this exercise indicated that most States reported the 40.6-by 45.7-cm (16- by 18-inch) pedestrian signal head housing with the 22.9-cm (9-inch) countdown digit size for all crosswalk lengths. Based on these results, we utilized the 40.6-by 45.7-cm (16-by-18 inch) pedestrian signal housing with the 22.9-cm (9-inch) countdown display in our testing.

Study 1A examined pedestrian comprehension of signals. The results indicated that more participants understood that they legally should not start to cross during the clearance interval with the FDW present than when the CPS was displayed alone. However, more participants understood they could cross with a countdown showing a countdown with 17 s when the CPS was presented alone, and most participants thought that they could cross or choose to cross when presented with the CPS + FW.

This finding indicates a perceived shift in decision-making when the countdown timer is present that places less emphasis on signal compliance and more emphasis on pedestrian choice. This result is in agreement with field data showing that more pedestrians cross, but fewer are still in the intersection, after the countdown finishes.(4)

More participants responded "make a decision" with the CPS Alone than with the CPS + FDW or CPS + FW. These results held for males and females and were consistent across age groups. These data are consistent with those reported by Singer and Lerner(6) in the northeast region of the country. Adding data from a midwest and southern State increases the generality of Singer and Lerner's findings. Additionally, these results were statistically significant when alpha was set to the .01 level.

Study 1B examined how well pedestrians could determine how much time they needed to cross a crosswalk of approximately 12 m, 18 m, and 24 m (40 ft, 60 ft, and 80 ft, respectively) in length. A total of 60 participants were instructed to start to cross only when they had sufficient time to finish their crossing. An examination of these data shows a high degree of consistency in crossing speed over the entire crossing. Most pedestrians were able to maintain a steady walking pace, and almost all were able to finish before the end of the countdown display. It is interesting to note that the two pedestrians who did not finish before the end of the countdown would have finished before the end of the yellow signal for the cross-traffic (assuming standard signal timing).

One of the most interesting findings was the high walking speeds observed in this study. Most observational data on walking speeds have based it on pedestrians starting during the WALK signal. It is possible that pedestrians walk slower when they know they have a lot of time to cross and faster when they know they have less time to cross.

An examination of the pedestrian walking speed data (provided in appendix B) shows that most pedestrians did not walk slower when crossing shorter distances. These data support the hypothesis that pedestrians use the CPS time to determine the gait required to cross safely. This hypothesis also implies that pedestrians "trust" the CPS to provide them with accurate information. A study of walking speeds based on the time that pedestrians think they need to cross while facing a countdown timer is needed to better examine this issue. Because these results provide evidence that pedestrians can use the countdown timer to ensure they can clear the crosswalk prior to cross-traffic being released, there appears to be a safety benefit to the CPS. The results of Study 1A also indicate that the countdown used alone would help more pedestrians to cross during each cycle since some pedestrians feel they cannot cross when the FDW is present. Although pedestrian clearance appears to be exclusively a level of service issue, it also impacts safety. Reducing the number of people who would need to wait during the FDW and "DON'T WALK" signal, reduces the number of pedestrians that have an opportunity to violate the SDW signal by attempting to cross during a perceived gap in the cross-traffic. Field data should provide more information on this issue.

Study 1C examined whether eliminating the FDW from the CPS display would have an adverse effect on low-vision pedestrians. An adverse effect would be an increased likelihood of crossing during the pedestrian countdown if they could not read the numbers or mistaking the display for "WALK". It must be noted that although some low-vision pedestrians may not be able to see any of the pedestrian signal displays at some distances, they should not cross if they cannot verify the status of the signal.

The results of this study show that persons with low vision typically are cautious crossing the street. In all but one case, the participants would not cross unless they could identify the "WALK" signal or read the number on a countdown that displayed sufficient time to cross. The one exception was in the FDW plus CPS condition: four participants chose to cross even though they could not read the numbers. One pedestrian even mentioned that he had to be careful because he did not know how much time was left. No participants in the CPS Alone condition who could not read the countdown elected to cross. It is not possible to conclude that the FDW plus CPS was less safe than the CPS Alone because of the sample size; however, these data do not undermine the grounds for removal of the FDW.

It is interesting to note that the CPS are significantly smaller than the walking person and hand icons. Because many of the pedestrians with low vision did successfully use the CPS at shorter length crossings, it is possible to recommend that the size of the countdown display be increased to the same height as the other signals. This height increase would improve recognition distance and would allow low-vision pedestrians to read the numbers sooner if they started after they saw the end of the "WALK". The results also show that pedestrians with low vision are relying on color for crossings of 30.5 m (100 ft), without being able to identify the shape of the icon. These results support the need for accessible signals for wider crossings.

Study 2 contained interesting results. The study consisted of a naturalistic observation of pedestrian crossings at intersections under different pedestrian signal configurations. The results of this study show some similarity to the results of the Singer and Lerner[(6)] study and also some differences. These results are not surprising given the small number of sites and the many differences between the types of sites examined. It should also be noted that the Singer and Lerner[(6)] study was completed 10 yr prior to the present study. CPS signals have been installed at many more locations since the first study, and people have had a long time to adapt to the change.

One other major difference should be pointed out. In the Singer and Lerner[6] study, there was a 5 s buffer time between the start of the SDW and the release of conflicting traffic. In the present study the size of the buffer varied between sites, with one site having a 5 s buffer, one having a 5.8 s buffer, one having a 6 s buffer and the remaining site having a 7.2 s buffer. Six months after the flashing hand was removed, a statistically significant increase in pedestrians finishing before cross-traffic is released was found during the CPS Alone Follow-up at all but one site. The only site where the reduction was not found was at the site with the largest buffer (7.2 s). The most likely reason there was no statistical difference at the site with a 7.2 s buffer is most likely due to a ceiling effect, in that 7.2 s gives pedestrians plenty of time to finish before cross-traffic is released, therefore most of them cross.

One of the key dependent variables in this study was whether pedestrians who arrive at the curb during the pedestrian change interval begin to cross or wait for the next "WALK" signal instead. Regardless of the CPS present, pedestrians were very likely to begin crossing both during the first 5 s (early) of the pedestrian change interval and during the remaining seconds (late) of the pedestrian change interval.

The research team also did not find much of a change in the percentage of pedestrians crossing during the pedestrian change interval with the exception of the site with the shortest buffer, which showed an increase during treatment. This increase was statistically significant at the .05 level. This finding is similar to that obtained by Singer and Lerner.[6]

Overall, there was a decrease in crossing time, which reflects faster crossing, at three of the four sites during the CPS Alone condition. This effect increased a little at these three sites during the 6-mo follow-up measure and crossing time decreased for the remaining site but none of these changes was statistically significant.

During the original CPS Alone phase, there was also an increase in the percentage of pedestrians who ran at two of the four sites during the crossing. However, only one of these sites was statistically significant at the .05 level. The increase was maintained at these two sites, but the increase was not as substantial nor as statistically significant as at that other site.

A third site saw an increase in running during the Follow-up phase as well, but again was not statistically significant. The one site that did not show a change in running also did not show a decrease in crossing time. These data conflict with the slight decrease in running during the CPS Alone condition reported by Singer and Lerner.[6]

There was also an increase in the percentage of pedestrians crossing during the SDW condition at three of the four sites. The effect was small and not statistically significant for all but one site. It is interesting to note that this increase was balanced by a decrease in the percentage crossing during the "WALK" phase at this site. Singer and Lerner[6] found no change in the percentage of pedestrians starting to cross during the SDW.

The starting time distributions were highly variable, with statistically significant differences appearing at 3 of the 4 sites. However, the direction was not consistent, with some sites displaying an increase in starting time and others a decrease in starting time when the flashing hand was removed. These results may very well be due to the natural variability in starting times rather than due to the actual removal of the flashing hand. However, the finishing times show fewer people under the curve after the cross-traffic was released at all four sites during the CPS Alone Follow-up condition than during the CPS + FDW condition. These differences were statistically significant at three of the four sites when alpha was set to the .05 level. The site that did not show a significant change, is also the site with the best pedestrian compliance during all conditions.

The site with the poorest compliance was located in the area that served people who required social services, while the crosswalk with the best compliance was in the business district. It is interesting that compliance improved the most at the crosswalk serving pedestrians with more need for social services.

Like the Singer and Lerner(6) study the research team observed very few evasive conflicts between pedestrians and vehicles during the current study. There was one pedestrian crash observed, but this was between a pedestrian who started to cross during the "WALK" signal and a turning vehicle. This type of crash should not be related to the type of clearance used. Because there were so few evasive conflicts, no statistical analysis of evasive conflicts was performed.

The overall results of this research support dropping the FDW from the pedestrian clearance interval and replacing it with the countdown display. This change would increase the percentage of pedestrians who can walk at a higher speed than the slower speed that the clearance display is calculated to support to cross safely. By clearing more pedestrians each cycle, the number of pedestrians left who might choose to violate the signal will decrease. At the time of this research (2015), this change would have also required a change to the UVC to not count pedestrians as violators if they start crossing during the countdown, provided that they finish crossing before the end of the countdown. Another option would have been to leave the FDW in place but change the MUTCD and the UVC to not count pedestrians who start to cross during countdown with flashing hand as violators, provided they finish before countdown times out. One disadvantage of the latter option is that many pedestrians that could cross would continue not to cross because they understand the FDW to mean that they can't start to cross. In either case a change in the MUTCD and State and local laws that specify allowable pedestrian behaviors when facing various traffic control device displays would have been recommended at the time of this research (2015).

# APPENDIX A. QUESTION PROTOCOL FOR STUDY 1A

1. General question for all signal heads

    a. For every signal head, people were asked: “Imagine yourself at a crosswalk, about to cross the street, and you see this display. What does this display mean? And what should you do?”

2. Walk alone

    a. If they responded: “I could cross.”; “I could walk.”; or any variant of these sentences with the same meaning, their response was scored as correct.

    b. Any other response was coded as incorrect.

    c. There were no follow-up questions as all respondents made the correct response.

3. Don’t Walk alone

    a. If they responded: “I would wait for the walk.”; or “I can’t cross the street.”; or any variant with the same meaning, their response was scored as correct.

    b. Any other response was coded as incorrect.

    c. There were no follow-up questions as all respondents made the correct response.

4. Countdown Pedestrian Signal plus FDW, the Countdown Pedestrian Signal alone, and the Countdown Pedestrian Signal plus the Flashing Walk (this option was only presented to the 200 participants in MI). These three options are always presented with 17 s displayed.

    a. If they responded: “Walk across the street.”; “Cross the street.”; “Make a decision on whether to cross or not cross.”; “‘17’ seconds left to cross the street, therefore, I can cross.”; or any other way of saying that they can cross the street, they were marked as correct.

    b. If they only responded: “‘17’ seconds to cross the street.” they were asked: “What should you do?”

        i. If they responded: “I can cross the street.” they were scored as correct. Any other response was coded as incorrect.

    c. If they responded: “I must stay at the crosswalk.” they were asked: “Why?”

i. If they responded: “There is not enough time to cross.” they were also asked, how much time they would need to cross? They were then asked: “What should you do if the display showed that amount of time?” If they answered: “Cross the street.” Their response was scored as correct. Any other response was marked as indicating they are not permitted to start crossing the street.

ii. If they answered: “It did not matter how much time was displayed, I would not cross.” they were then asked, what about the sign is telling them to stay? At this point, the response was recorded, and their response was scored as prohibited from starting to cross the street.

d. If they responded: “I can’t walk.”; or “I can’t cross the street.”; or any variant of this idea, they were asked what about the sign is telling them they can’t walk. If they responded: “The flashing hand.”; “The flashing hand.”; “The color of the sign.”; or “The sign is broken and means the same thing as the flashing man.”; or any variant of these responses with the same meaning, their response was recorded, and they were scored as being prohibited from starting to cross the street.

e. If they responded: “‘17’ seconds until I can cross the street. Therefore, I need wait until the end of the countdown then begin to cross the street.”; or any variant with the same meaning, they were marked as incorrect.

## APPENDIX B. CROSSING TIMES FOR STUDY 1B

The crossing times for each of the 60 participants from Study 1B is provided in this appendix. Note that the order of crossings was counterbalanced. For clarity of presentation, crossings are provided in a consistent order within table 19 through table 20

**Table 18. Participant crossing times, Study 1B.**

| Participant | Crossing | 3 m (10 ft) | 6 m (20 ft) | 9 m (30 ft) | 12 m (40 ft) | 15 m (50 ft) | 18 m (60 ft) | 21 m (70 ft) | 24 m (80 ft) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 12 m | 1.62 | 1.46 | 1.37 | 1.31 | NA | NA | NA | NA |
| 1 | 18 m | 1.62 | 1.52 | 1.31 | 1.52 | 1.31 | 1.13 | NA | NA |
| 1 | 24 m | 1.92 | 1.37 | 1.71 | 1.71 | 1.37 | 1.37 | 1.46 | 1.22 |
| 2 | 12 m | 1.62 | 1.37 | 1.71 | 1.71 | NA | NA | NA | NA |
| 2 | 18 m | 1.71 | 1.31 | 1.37 | 1.71 | 1.31 | 1.28 | NA | NA |
| 2 | 24 m | 1.37 | 1.52 | 1.52 | 1.62 | 1.31 | 1.37 | 1.46 | 1.13 |
| 3 | 12 m | 1.52 | 1.28 | 1.52 | 1.31 | NA | NA | NA | NA |
| 3 | 18 m | 1.62 | 1.52 | 1.37 | 1.28 | 1.37 | 1.22 | NA | NA |
| 3 | 24 m | 2.04 | 1.52 | 1.37 | 1.46 | 1.37 | 1.52 | 1.46 | 1.62 |
| 4 | 12 m | 1.31 | 1.10 | 1.04 | NA | NA | NA | NA | NA |
| 4 | 18 m | 1.46 | 1.16 | 1.28 | 1.16 | 1.16 | 0.91 | NA | NA |
| 4 | 24 m | 1.31 | 1.28 | 1.28 | 1.16 | 1.28 | 1.04 | 1.28 | 0.94 |
| 5 | 12 m | 1.52 | 1.28 | 1.62 | 1.13 | NA | NA | NA | NA |
| 5 | 18 m | 1.52 | 1.31 | 1.71 | 1.37 | 1.52 | 1.13 | NA | NA |
| 5 | 24 m | 1.46 | 1.62 | 1.37 | 1.62 | 1.37 | 1.71 | 1.28 | 1.13 |
| 6 | 12 m | 1.62 | 1.80 | 1.52 | 1.22 | NA | NA | NA | NA |
| 6 | 18 m | 1.80 | 1.31 | 1.52 | 1.37 | 1.37 | 1.37 | NA | NA |
| 6 | 24 m | 1.92 | 1.71 | 1.71 | 1.71 | 1.71 | 1.46 | 1.46 | 1.04 |
| 7 | 12 m | 1.71 | 1.31 | 1.62 | 1.16 | NA | NA | NA | NA |
| 7 | 18 m | 1.37 | 1.52 | 1.10 | 1.37 | 1.31 | 1.16 | NA | NA |
| 7 | 24 m | 1.62 | 1.52 | 1.46 | 1.31 | 1.52 | 1.37 | 1.52 | 1.31 |
| 8 | 12 m | 1.62 | 1.52 | 2.04 | 1.80 | NA | NA | NA | NA |
| 8 | 18 m | 1.52 | 1.46 | 1.52 | 1.37 | 1.52 | 1.28 | NA | NA |
| 8 | 24 m | 1.46 | 1.52 | 1.62 | 2.53 | 1.52 | 1.62 | 1.52 | 1.31 |
| 9 | 12 m | 2.53 | 1.62 | 1.37 | 1.16 | NA | NA | NA | NA |
| 9 | 18 m | 2.04 | 1.62 | 1.62 | 1.46 | 1.16 | NA | NA | NA |

**Table 19. Participant crossing times, Study 1B (continued).**

| Participant | Crossing | 3 m (10 ft) | 6 m (20 ft) | 9 m (30 ft) | 12 m (40 ft) | 15 m (50 ft) | 18 m (60 ft) | 21 m (70 ft) | 24 m (80 ft) |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 24 m | 3.38 | 1.80 | 1.71 | 1.71 | 1.52 | 1.80 | 1.52 | 1.37 |
| 10 | 12 m | 1.52 | 1.16 | 1.10 | 1.10 | NA | NA | NA | NA |
| 10 | 18 m | 1.31 | 1.13 | 1.31 | 1.13 | 1.28 | 0.98 | NA | NA |
| 10 | 24 m | 1.52 | 1.37 | 1.62 | 1.71 | 1.37 | 1.37 | 1.46 | 1.04 |
| 11 | 12 m | 1.46 | 1.31 | 1.52 | 1.22 | NA | NA | NA | NA |
| 11 | 18 m | 1.52 | 1.71 | 1.52 | 1.62 | 1.28 | 1.22 | NA | NA |
| 11 | 24 m | 1.31 | 1.80 | 1.52 | 1.22 | 1.31 | 1.37 | 1.13 | 1.13 |
| 12 | 12 m | 1.31 | 1.37 | 1.52 | 1.28 | NA | NA | NA | NA |
| 12 | 18 m | 1.92 | 1.52 | 1.71 | 1.28 | 1.52 | 1.52 | NA | NA |
| 12 | 24 m | 1.62 | 1.52 | 1.46 | 1.62 | 1.62 | 1.62 | 1.52 | 1.28 |
| 13 | 12 m | 1.04 | 1.52 | 1.37 | 1.16 | NA | NA | NA | NA |
| 13 | 18 m | 1.28 | 1.10 | 1.28 | 1.46 | 1.62 | 1.16 | NA | NA |
| 13 | 24 m | 1.52 | 1.71 | 1.62 | 1.37 | 1.37 | 1.80 | 1.28 | 1.37 |
| 14 | 12 m | 1.52 | 1.52 | 1.62 | 1.46 | NA | NA | NA | NA |
| 14 | 18 m | 1.52 | 1.52 | 1.62 | 1.52 | 1.52 | 1.28 | NA | NA |
| 14 | 24 m | 1.52 | 1.37 | 1.31 | 1.46 | 1.46 | 1.52 | 1.37 | 1.22 |
| 15 | 12 m | 1.46 | 1.28 | 1.52 | 1.04 | NA | NA | NA | NA |
| 15 | 18 m | 1.31 | 1.28 | 13.11 | 1.71 | 1.46 | 1.13 | NA | NA |
| 15 | 24 m | 1.46 | 1.52 | 1.62 | 1.62 | 1.52 | 1.52 | 1.52 | 1.62 |
| 16 | 12 m | 1.80 | 2.35 | 2.04 | 2.35 | NA | NA | NA | NA |
| 16 | 18 m | 1.46 | 1.62 | 1.71 | 1.46 | 1.52 | 1.37 | NA | NA |
| 16 | 24 m | 1.52 | 1.52 | 2.04 | 1.71 | 1.71 | 1.52 | 1.46 | 1.31 |
| 17 | 12 m | 1.31 | 1.46 | 1.62 | 1.37 | NA | NA | NA | NA |
| 17 | 18 m | 1.28 | 1.80 | 1.71 | 1.71 | 1.71 | 1.46 | NA | NA |
| 17 | 24 m | 1.80 | 1.80 | 2.04 | 1.71 | 1.71 | 1.71 | 3.05 | 2.77 |
| 18 | 12 m | 1.80 | 1.31 | 1.31 | 1.13 | NA | NA | NA | NA |
| 18 | 18 m | 1.37 | 1.52 | 1.31 | 1.37 | 1.31 | 1.28 | NA | NA |
| 18 | 24 m | 1.31 | 1.52 | 1.46 | 1.52 | 1.37 | 1.37 | 1.37 | 1.46 |
| 19 | 12 m | 1.16 | 1.31 | 1.22 | 1.28 | NA | NA | NA | NA |
| 19 | 18 m | 1.52 | 1.37 | 1.28 | 1.31 | 1.28 | NA | NA | NA |
| 19 | 24 m | 1.31 | 1.52 | 1.46 | 1.46 | 1.10 | 1.37 | 1.46 | 1.13 |

**Table 20. Participant crossing times, Study 1B (continued).**

| Participant | Crossing | 3 m (10 ft) | 6 m (20 ft) | 9 m (30 ft) | 12 m (40 ft) | 15 m (50 ft) | 18 m (60 ft) | 21 m (70 ft) | 24 m (80 ft) |
|---|---|---|---|---|---|---|---|---|---|
| 20 | 12 m | 1.46 | 1.52 | 1.46 | 1.37 | NA | NA | NA | NA |
| 20 | 18 m | 2.53 | 1.62 | 1.80 | 1.52 | 1.71 | 1.28 | NA | NA |
| 20 | 24 m | 1.80 | 1.80 | 1.46 | 1.71 | 1.52 | 1.46 | 1.31 | 1.22 |
| 21 | 12 m | 1.46 | 1.52 | 1.46 | 1.37 | NA | NA | NA | NA |
| 21 | 18 m | 2.53 | 1.62 | 1.80 | 1.52 | 1.71 | 1.28 | NA | NA |
| 21 | 24 m | 1.80 | 1.80 | 1.46 | 1.71 | 1.52 | 1.46 | 1.31 | 1.22 |
| 22 | 12 m | 1.46 | 1.71 | 1.46 | 1.22 | NA | NA | NA | NA |
| 22 | 18 m | 1.52 | 1.71 | 1.52 | 1.52 | 1.28 | 1.28 | NA | NA |
| 22 | 24 m | 2.16 | 2.16 | 1.80 | 1.80 | 1.52 | 1.71 | 1.46 | 1.31 |
| 23 | 12 m | 1.22 | 1.31 | 1.37 | 1.13 | NA | NA | NA | NA |
| 23 | 18 m | 1.31 | 1.52 | 1.31 | 1.46 | 1.52 | 1.01 | NA | NA |
| 23 | 24 m | 1.46 | 1.31 | 1.37 | 1.52 | 1.52 | 1.37 | 1.46 | 1.10 |
| 24 | 12 m | 1.92 | 1.62 | 1.62 | 1.28 | NA | NA | NA | NA |
| 24 | 18 m | 1.52 | 1.92 | 1.92 | 1.52 | 1.52 | 1.52 | NA | NA |
| 24 | 24 m | 1.71 | 1.62 | 1.80 | 1.71 | 1.62 | 1.71 | 1.52 | 1.52 |
| 25 | 12 m | 1.31 | 1.31 | 1.16 | 0.79 | NA | NA | NA | NA |
| 25 | 18 m | 1.37 | 1.62 | 1.46 | 1.46 | 1.37 | 1.28 | NA | NA |
| 25 | 24 m | 1.16 | 1.62 | 1.71 | 1.31 | 1.46 | 1.62 | 1.37 | 1.52 |
| 26 | 12 m | 1.62 | 1.52 | 1.37 | 1.28 | NA | NA | NA | NA |
| 26 | 18 m | 1.37 | 1.37 | 1.28 | 1.31 | 1.31 | 0.73 | NA | NA |
| 26 | 24 m | 1.71 | 2.04 | 1.71 | 1.62 | 1.71 | 1.62 | 1.62 | 1.31 |
| 27 | 12 m | 1.71 | 1.52 | 1.37 | 1.28 | NA | NA | NA | NA |
| 27 | 18 m | 1.52 | 1.52 | 1.52 | 1.46 | 1.46 | 1.16 | NA | NA |
| 27 | 24 m | 1.46 | 1.37 | 1.31 | 1.22 | 1.37 | 1.37 | 1.31 | 1.16 |
| 28 | 12 m | 1.52 | 1.37 | 1.16 | 1.28 | NA | NA | NA | NA |
| 28 | 18 m | 1.62 | 1.31 | 1.31 | 1.46 | 1.31 | 1.31 | NA | NA |
| 28 | 24 m | 1.37 | 1.80 | 1.22 | 1.28 | 1.46 | 1.37 | 1.37 | 1.13 |
| 29 | 12 m | 1.22 | 1.28 | 1.37 | 1.31 | NA | NA | NA | NA |
| 29 | 18 m | 1.31 | 1.52 | 1.37 | 1.52 | 1.37 | 1.13 | NA | NA |
| 29 | 24 m | 1.52 | 1.28 | 1.31 | 1.37 | 1.52 | 1.52 | 1.92 | 1.22 |
| 30 | 12 m | 1.22 | 1.28 | 1.16 | 1.16 | NA | NA | NA | NA |

**Table 21. Participant crossing times, Study 1B (continued).**

| Participant | Crossing | 3 m (10 ft) | 6 m (20 ft) | 9 m (30 ft) | 12 m (40 ft) | 15 m (50 ft) | 18 m (60 ft) | 21 m (70 ft) | 24 m (80 ft) |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 18 m | 1.13 | 1.28 | 1.28 | 1.16 | 1.31 | 1.31 | NA | NA |
| 30 | 24 m | 1.71 | 1.52 | 1.37 | 1.37 | 1.46 | 1.31 | 1.37 | 1.10 |
| 31 | 12 m | 1.28 | 1.10 | 1.62 | 0.88 | NA | NA | NA | NA |
| 31 | 18 m | 1.04 | 1.13 | 1.46 | 1.31 | 1.28 | 1.28 | NA | NA |
| 31 | 24 m | 1.22 | 1.22 | 1.46 | 1.37 | 1.37 | 1.22 | 1.16 | 1.37 |
| 32 | 12 m | 2.35 | 1.46 | 1.31 | 1.28 | NA | NA | NA | NA |
| 32 | 18 m | 2.04 | 1.71 | 1.37 | 1.46 | 1.31 | 1.52 | NA | NA |
| 32 | 24 m | 1.80 | 1.52 | 1.31 | 1.31 | 1.52 | 1.37 | 1.31 | 1.31 |
| 33 | 12 m | 2.04 | 2.35 | 1.92 | 1.62 | NA | NA | NA | NA |
| 33 | 18 m | 3.05 | 1.92 | 2.26 | 1.80 | 1.80 | 1.71 | NA | NA |
| 33 | 24 m | 2.04 | 2.04 | 1.80 | 1.71 | 1.92 | 1.92 | 1.92 | 1.92 |
| 34 | 12 m | 2.53 | 1.80 | 1.62 | 1.62 | NA | NA | NA | NA |
| 34 | 18 m | 1.62 | 1.52 | 1.62 | 1.62 | 1.37 | 1.31 | NA | NA |
| 34 | 24 m | 1.92 | 1.52 | 1.62 | 1.80 | 1.52 | 1.52 | 1.46 | 1.31 |
| 35 | 12 m | 1.04 | 1.52 | 1.46 | 1.31 | NA | NA | NA | NA |
| 35 | 18 m | 2.26 | 1.31 | 1.31 | 1.31 | 1.46 | 1.31 | NA | NA |
| 35 | 24 m | 1.92 | 1.13 | 1.31 | 1.37 | 1.46 | 1.71 | 1.92 | 1.37 |
| 36 | 12 m | 2.35 | 1.37 | 1.28 | 1.22 | NA | NA | NA | NA |
| 36 | 18 m | 1.52 | 1.31 | 1.52 | 1.31 | 1.52 | 1.22 | NA | NA |
| 36 | 24 m | 1.46 | 1.37 | 1.62 | 1.62 | 1.13 | 1.52 | 1.62 | 1.22 |
| 37 | 12 m | 1.46 | 1.62 | 1.62 | 1.37 | NA | NA | NA | NA |
| 37 | 18 m | 2.26 | 1.37 | 1.62 | 1.52 | 1.37 | 1.31 | NA | NA |
| 37 | 24 m | 1.80 | 1.62 | 1.71 | 1.52 | 1.62 | 1.62 | 1.46 | 1.46 |
| 38 | 12 m | 1.62 | 1.01 | 1.16 | 0.94 | NA | NA | NA | NA |
| 38 | 18 m | 1.92 | 1.16 | 1.28 | 1.16 | 1.10 | 0.98 | NA | NA |
| 38 | 24 m | 1.13 | 1.10 | 1.16 | 1.22 | 1.28 | 1.13 | 1.10 | 1.16 |
| 39 | 12 m | 1.62 | 1.10 | 1.13 | 1.04 | NA | NA | NA | NA |
| 39 | 18 m | 1.52 | 1.22 | 1.10 | 1.28 | 0.88 | 1.10 | NA | NA |
| 39 | 24 m | 3.05 | 1.04 | 1.31 | 1.22 | 1.28 | 1.46 | 1.62 | 1.10 |
| 40 | 12 m | 2.04 | 1.04 | 1.16 | 1.01 | NA | NA | NA | NA |
| 40 | 18 m | 1.62 | 1.22 | 1.31 | 1.28 | 1.52 | 1.16 | NA | NA |

**Table 22. Participant crossing times, Study 1B (continued).**

| Participant | Crossing | 3 m (10 ft) | 6 m (20 ft) | 9 m (30 ft) | 12 m (40 ft) | 15 m (50 ft) | 18 m (60 ft) | 21 m (70 ft) | 24 m (80 ft) |
|---|---|---|---|---|---|---|---|---|---|
| 40 | 24 m | 1.52 | 1.16 | 1.22 | 1.31 | 1.37 | 1.46 | 1.52 | 1.37 |
| 41 | 12 m | 1.71 | 1.71 | 1.71 | 1.28 | NA | NA | NA | NA |
| 41 | 18 m | 1.80 | 1.52 | 1.71 | 1.28 | 1.62 | 1.16 | NA | NA |
| 41 | 24 m | 1.71 | 1.37 | 1.52 | 1.62 | 1.46 | 1.46 | 1.62 | 1.22 |
| 42 | 12 m | 1.31 | 1.37 | 1.28 | 1.13 | NA | NA | NA | NA |
| 42 | 18 m | 1.46 | 1.10 | 1.28 | 1.22 | 1.31 | 0.98 | NA | NA |
| 42 | 24 m | 1.80 | 1.22 | 1.16 | 1.31 | 1.13 | 1.28 | 1.22 | 0.91 |
| 43 | 12 m | 1.80 | 1.16 | 1.31 | 1.10 | NA | NA | NA | NA |
| 43 | 18 m | 1.52 | 1.62 | 1.37 | 1.62 | 1.62 | 1.28 | NA | NA |
| 43 | 24 m | 2.04 | 1.13 | 1.28 | 1.31 | 1.37 | 1.28 | 1.37 | 1.13 |
| 44 | 12 m | 1.62 | 1.46 | 1.52 | 1.31 | NA | NA | NA | NA |
| 44 | 18 m | 2.04 | 1.37 | 1.71 | 1.37 | 1.37 | 1.22 | NA | NA |
| 44 | 24 m | 2.04 | 1.52 | 1.62 | 1.31 | 1.31 | 1.37 | 1.37 | 1.13 |
| 45 | 12 m | 1.46 | 1.28 | 1.28 | 1.01 | NA | NA | NA | NA |
| 45 | 18 m | 1.46 | 1.52 | 1.37 | 1.52 | 1.37 | 1.37 | NA | NA |
| 45 | 24 m | 1.71 | 2.53 | 1.46 | 1.28 | 1.31 | 1.52 | 1.37 | 1.31 |
| 46 | 12 m | 1.22 | 1.71 | 1.71 | 1.92 | NA | NA | NA | NA |
| 46 | 18 m | 1.10 | 1.80 | 1.80 | 1.71 | 1.80 | 1.62 | NA | NA |
| 46 | 24 m | 1.13 | 1.62 | 1.71 | 1.71 | 1.92 | 1.80 | 1.71 | 1.71 |
| 47 | 12 m | 1.04 | 1.28 | 1.37 | 1.22 | NA | NA | NA | NA |
| 47 | 18 m | 1.37 | 1.31 | 1.37 | 1.31 | 1.28 | 1.16 | NA | NA |
| 47 | 24 m | 1.16 | 1.37 | 1.46 | 1.52 | 1.46 | 1.46 | 1.37 | 1.46 |
| 48 | 12 m | 1.04 | 1.46 | 1.31 | 1.28 | NA | NA | NA | NA |
| 48 | 18 m | 1.28 | 1.31 | 1.31 | 1.22 | 1.13 | 1.13 | NA | NA |
| 48 | 24 m | 1.28 | 1.22 | 1.37 | 1.37 | 1.31 | 1.31 | 1.37 | 1.16 |
| 49 | 12 m | 1.01 | 1.31 | 1.10 | 0.98 | NA | NA | NA | NA |
| 49 | 18 m | 1.28 | 1.28 | 1.28 | 1.62 | 1.46 | 1.31 | NA | NA |
| 49 | 24 m | 1.04 | 1.31 | 1.31 | 1.31 | 1.37 | 1.46 | 1.37 | 1.37 |
| 50 | 12 m | 1.71 | 1.62 | 1.37 | 1.46 | NA | NA | NA | NA |
| 50 | 18 m | 1.52 | 1.62 | 1.52 | 1.52 | 1.52 | 1.46 | NA | NA |
| 50 | 24 m | 2.04 | 1.71 | 1.62 | 1.62 | 1.31 | 1.80 | 1.71 | 1.28 |

**Table 23. Participant crossing times, Study 1B (continued).**

| Participant | Crossing | 3 m (10 ft) | 6 m (20 ft) | 9 m (30 ft) | 12 m (40 ft) | 15 m (50 ft) | 18 m (60 ft) | 21 m (70 ft) | 24 m (80 ft) |
|---|---|---|---|---|---|---|---|---|---|
| 51 | 12 m | 1.92 | 1.71 | 1.80 | 1.46 | NA | NA | NA | NA |
| 51 | 18 m | 1.37 | 1.71 | 1.80 | 1.46 | 1.80 | 2.26 | NA | NA |
| 51 | 24 m | 1.31 | 1.80 | 1.92 | 1.80 | 1.92 | 1.52 | 1.80 | 1.31 |
| 52 | 12 m | 1.62 | 1.52 | 1.46 | 1.16 | NA | NA | NA | NA |
| 52 | 18 m | 1.37 | 2.26 | 1.52 | 1.71 | 1.46 | 1.37 | NA | NA |
| 52 | 24 m | 1.37 | 1.62 | 1.71 | 1.71 | 1.71 | 2.26 | 2.53 | 1.92 |
| 53 | 12 m | 1.37 | 1.71 | 1.52 | 1.31 | NA | NA | NA | NA |
| 53 | 18 m | 1.62 | 1.52 | 1.46 | 1.37 | 1.31 | 1.16 | NA | NA |
| 53 | 24 m | 1.46 | 1.37 | 1.46 | 1.37 | 1.28 | 1.31 | 1.22 | 0.98 |
| 54 | 12 m | 1.80 | 2.26 | 2.04 | 1.37 | NA | NA | NA | NA |
| 54 | 18 m | 1.92 | 1.62 | 1.16 | 1.04 | 1.01 | 1.37 | NA | NA |
| 54 | 24 m | 2.26 | 1.92 | 1.80 | 1.62 | 1.62 | 1.80 | 2.35 | 1.46 |
| 55 | 12 m | 1.31 | 1.37 | 1.46 | 1.22 | NA | NA | NA | NA |
| 55 | 18 m | 1.80 | 1.71 | 1.80 | 1.71 | 1.62 | 1.31 | NA | NA |
| 55 | 24 m | 1.92 | 1.80 | 1.46 | 1.46 | 1.28 | 1.52 | 1.46 | 1.13 |
| 56 | 12 m | 1.37 | 1.37 | 1.13 | 1.13 | NA | NA | NA | NA |
| 56 | 18 m | 1.52 | 1.62 | 1.52 | 1.46 | 1.62 | 1.52 | NA | NA |
| 56 | 24 m | 1.71 | 1.46 | 1.37 | 1.46 | 1.46 | 1.37 | 1.71 | 1.22 |
| 57 | 12 m | 1.16 | 1.10 | 0.98 | 1.01 | NA | NA | NA | NA |
| 57 | 18 m | 1.31 | 1.28 | 1.28 | 1.37 | 1.16 | 1.22 | NA | NA |
| 57 | 24 m | 1.22 | 1.04 | 1.01 | 1.13 | 1.01 | 1.13 | 1.31 | 1.52 |
| 58 | 12 m | 1.28 | 1.52 | 1.52 | 1.22 | NA | NA | NA | NA |
| 58 | 18 m | 1.46 | 1.62 | 1.46 | 1.52 | 1.46 | 1.16 | NA | NA |
| 58 | 24 m | 1.92 | 1.46 | 1.62 | 1.46 | 1.37 | 1.28 | 1.31 | 1.04 |
| 59 | 12 m | 1.28 | 1.28 | 1.10 | 0.82 | NA | NA | NA | NA |
| 59 | 18 m | 1.37 | 1.28 | 1.16 | 1.62 | 1.37 | 1.04 | NA | NA |
| 59 | 24 m | 1.31 | 1.52 | 1.80 | 1.52 | 1.52 | 1.22 | 1.22 | 1.16 |
| 60 | 12 m | 2.26 | 1.92 | 2.53 | 2.35 | NA | NA | NA | NA |
| 60 | 18 m | 1.62 | 1.46 | 1.37 | 1.52 | 1.92 | 1.62 | NA | NA |
| 60 | 24 m | 1.62 | 1.52 | 1.46 | 1.52 | 1.37 | 1.52 | 1.46 | 1.52 |

## APPENDIX C. INDIVIDUAL RESPONSES FROM STUDY 1C

The individual participant responses to the different signal signals in Study 1C are provided within this appendix in table 25 through table 34.

**Table 24. Participant responses to the WALK signal at a 12 m (40 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Crossing Action |
|---|---|---|---|
| 1 | No | No | Not cross |
| 2 | Yes | No | Cross |
| 3 | Yes | Yes | Cross |
| 4 | Yes | Yes | Cross |
| 5 | Yes | Yes | Cross |
| 6 | Yes | Yes | Cross |
| 7 | Yes | No | Cross |
| 8 | Yes | Yes | Cross |
| 9 | Yes | Yes | Cross |
| 10 | Yes | Yes | Cross |
| 11 | Yes | Yes | Cross |
| 12 | Yes | Yes | Cross |
| 13 | Yes | Yes | Cross |
| 14 | Yes | Yes | Cross |
| 15 | Yes | Yes | Cross |
| 16 | Yes | Yes | Cross |
| 17 | Yes | Yes | Cross |
| 18 | Yes | Yes | Cross |
| 19 | Yes | Yes | Cross |
| 20 | Yes | Yes | Cross |

**Table 25. Participant responses to the WALK signal at a 30.5 m (100 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Crossing Action |
|---|---|---|---|
| Participant 1 | No | No | Not cross |
| Participant 2 | Yes | No | Cross |
| Participant 3 | No | No | Not cross |
| Participant 4 | No | No | Not cross |
| Participant 5 | Yes | Yes | Cross |
| Participant 6 | Yes | Yes | Cross |
| Participant 7 | No | No | Not cross |
| Participant 8 | No | No | Not cross |
| Participant 9 | Yes | Yes | Cross |
| Participant 10 | Yes | Yes | Cross |
| Participant 11 | Yes | Yes | Cross |
| Participant 12 | Yes | No | Cross |
| Participant 13 | Yes | No | Not cross |
| Participant 14 | No | No | Not cross |
| Participant 15 | No | No | Not cross |
| Participant 16 | Yes | Yes | Cross |
| Participant 17 | Yes | Yes | Cross |
| Participant 18 | No | No | Not cross |
| Participant 19 | Yes | Yes | Cross |
| Participant 20 | Yes | Yes | Cross |

**Table 26. Participant responses to the DON'T WALK signal at a 12 m (40 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Crossing Action |
|---|---|---|---|
| 1 | Yes | No | Not cross |
| 2 | Yes | Yes | Not cross |
| 3 | Yes | Yes | Not cross |
| 4 | Yes | Yes | Not cross |
| 5 | Yes | Yes | Not cross |
| 6 | Yes | Yes | Not cross |
| 7 | Yes | No | Not cross |
| 8 | Yes | Yes | Not cross |
| 9 | Yes | Yes | Not cross |
| 10 | Yes | Yes | Not cross |
| 11 | Yes | Yes | Not cross |
| 12 | Yes | Yes | Not cross |
| 13 | Yes | Yes | Not cross |
| 14 | Yes | Yes | Not cross |
| 15 | Yes | Yes | Not cross |
| 16 | Yes | Yes | Not cross |
| 17 | Yes | No | Not cross |
| 18 | Yes | Yes | Not cross |
| 19 | Yes | Yes | Not cross |
| 20 | Yes | Yes | Not cross |

**Table 27. Participant responses to the DON'T WALK signal at a 30.5 m (100 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Crossing Action |
|---|---|---|---|
| 1 | No | No | Not cross |
| 2 | No | No | Not cross |
| 3 | Yes | Yes | Not cross |
| 4 | Yes | Yes | Not cross |
| 5 | Yes | Yes | Not cross |
| 6 | Yes | Yes | Not cross |
| 7 | No | No | Not cross |
| 8 | No | No | Not cross |
| 9 | Yes | No | Not cross |
| 10 | Yes | Yes | Not cross |
| 11 | Yes | No | Not cross |
| 12 | Yes | Yes | Not cross |
| 13 | Yes | Yes | Not cross |
| 14 | Yes | No | Not cross |
| 15 | Yes | No | Not cross |
| 16 | Yes | No | Not cross |
| 17 | Yes | No | Not cross |
| 18 | No | No | Not cross |
| 19 | Yes | Yes | Not cross |
| 20 | Yes | Yes | Not cross |

**Table 28. Participant responses to the DON'T WALK to WALK transition at a 12 m (40 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Crossing Action |
|---|---|---|---|
| Participant 1 | No | No | Not cross |
| Participant 2 | Yes | No | Cross |
| Participant 3 | Yes | Yes | Cross |
| Participant 4 | Yes | Yes | Cross |
| Participant 5 | Yes | Yes | Cross |
| Participant 6 | Yes | Yes | Cross |
| Participant 7 | Yes | No | Cross |
| Participant 8 | Yes | Yes | Cross |
| Participant 9 | Yes | Yes | Cross |
| Participant 10 | Yes | Yes | Cross |
| Participant 11 | Yes | Yes | Cross |
| Participant 12 | Yes | Yes | Cross |
| Participant 13 | Yes | Yes | Cross |
| Participant 14 | Yes | Yes | Cross |
| Participant 15 | Yes | Yes | Cross |
| Participant 16 | Yes | Yes | Cross |
| Participant 17 | Yes | No | Cross |
| Participant 18 | Yes | Yes | Not cross |
| Participant 19 | Yes | Yes | Cross |
| Participant 20 | Yes | Yes | Cross |

**Table 29. Participant responses to the DON'T WALK to WALK transition at a 30.5 m (100 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Crossing Action |
|---|---|---|---|
| 1 | No | No | Not cross |
| 2 | Yes | No | Cross |
| 3 | No | No | Not cross |
| 4 | Yes | No | Cross |
| 5 | Yes | No | Cross |
| 6 | Yes | No | Not cross |
| 7 | No | No | Not cross |
| 8 | No | No | Not cross |
| 9 | Yes | No | Cross |
| 10 | Yes | Yes | Cross |
| 11 | Yes | Yes | Cross |
| 12 | Yes | Yes | Cross |
| 13 | Yes | No | Cross |
| 14 | Yes | No | Cross |
| 15 | No | No | Not cross |
| 16 | Yes | No | Cross |
| 17 | Yes | No | Cross |
| 18 | No | No | Not Cross |
| 19 | Yes | Yes | Cross |
| 20 | Yes | Yes | Cross |

**Table 30. Participant responses to the CPS + FDW at a 12 m (40 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Read Numbers | Crossing Action |
|---|---|---|---|---|
| 1 | Yes | No/No | No | Not cross |
| 2 | Yes | Yes/No | No | Not cross |
| 3 | Yes | Yes/Yes | Some | Not cross |
| 4 | Yes | Yes/Yes | Yes | Not cross |
| 5 | Yes | Yes/Yes | Yes | Not cross |
| 6 | Yes | Yes/Yes | Yes | Not cross |
| 7 | Yes | No/No | No | Not cross |
| 8 | Yes | Yes/Yes | Yes | Not cross |
| 9 | Yes | Yes/Yes | Yes | Cross |
| 10 | Yes | Yes/Yes | Yes | Cross |
| 11 | Yes | Yes/Yes | Yes | Not cross |
| 12 | Yes | Yes/No | No | Not cross |
| 13 | Yes | Yes/Yes | Some | Cross |
| 14 | Yes | Yes/Yes | No | Not cross |
| 15 | Yes | Yes/Yes | Some | Cross |
| 16 | Yes | Yes/Yes | Some | Not cross |
| 17 | Yes | No/Yes | No | Not cross |
| 18 | Yes | Yes/Yes | Yes | Cross |
| 19 | Yes | Yes/Yes | Yes | Not cross |
| 20 | Yes | Yes/Yes | Yes | Cross |

**Table 31. Participant responses to the CPS + FDW at a 30.5 m (100 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Read Numbers | Crossing Action |
|---|---|---|---|---|
| 1 | No | No/No | No | Not cross |
| 2 | No | No/No | No | Not cross |
| 3 | No | No/No | No | Not cross |
| 4 | Yes | Yes/Yes | No | Not cross |
| 5 | Yes | No/No | No | Not cross |
| 6 | Yes | Yes/Yes | No | Not cross |
| 7 | No | No/No | No | Not cross |
| 8 | No | No/No | No | Cross |
| 9 | Yes | Yes/Yes | No | Cross |
| 10 | Yes | Yes/Yes | No | Cross |
| 11 | Yes | Yes/Yes | No | Not cross |
| 12 | Yes | No/No | No | Not cross |
| 13 | Yes | No/No | No | Not cross |
| 14 | No | No/No | No | Not cross |
| 15 | Yes | No/No | No | Not cross |
| 16 | Yes | No/No | No | Not cross |
| 17 | Yes | No/No | No | Cross |
| 18 | No | No/No | No | Not cross |
| 19 | Yes | No/Yes | No | Not cross |
| 20 | Yes | Yes/Yes | No | Not cross |

**Table 32. Participant responses to the CPS Alone at a 12 m (40 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Read Numbers | Crossing Action |
|---|---|---|---|---|
| 1 | Yes | No | No | Not cross |
| 2 | Yes | Yes | No | Not cross |
| 3 | Yes | Yes | Some | Not cross |
| 4 | Yes | Yes | Some | Not cross |
| 5 | Yes | Yes | Yes | Not cross |
| 6 | Yes | Yes | Yes | Cross |
| 7 | Yes | No | No | Not cross |
| 8 | Yes | Yes | Yes | Not cross |
| 9 | Yes | Yes | Yes | Cross |
| 10 | Yes | Yes | Yes | Cross |
| 11 | Yes | Yes | Yes | Not cross |
| 12 | Yes | Yes | Yes | Not cross |
| 13 | Yes | Yes | Some | Cross |
| 14 | Yes | No | No | Not cross |
| 15 | Yes | Yes | Some | Cross |
| 16 | Yes | Yes | Some | Not cross |
| 17 | Yes | Yes | No | Not cross |
| 18 | Yes | Yes | Yes | Not cross |
| 19 | Yes | Yes | Yes | Cross |
| 20 | Yes | Yes | Yes | Cross |

**Table 33. Participant responses to the CPS Alone at a 30.5 m (100 ft) distance.**

| Participant Number | Identified Color | Identified Shape | Read Numbers | Crossing Action |
|---|---|---|---|---|
| 1 | No | No | No | Not cross |
| 2 | Yes | No | No | Not cross |
| 3 | Yes | No | No | Not cross |
| 4 | Yes | Yes | No | Not cross |
| 5 | Yes | No | No | Not cross |
| 6 | Yes | Yes | No | Not cross |
| 7 | No | No | No | Not cross |
| 8 | No | No | No | Not cross |
| 9 | Yes | No | No | Not cross |
| 10 | Yes | Yes | No | Not cross |
| 11 | Yes | Yes | No | Not cross |
| 12 | Yes | Yes | No | Not cross |
| 13 | Yes | No | No | Not cross |
| 14 | Yes | No | No | Not cross |
| 15 | No | No | No | Not cross |
| 16 | Yes | No | No | Not cross |
| 17 | Yes | Yes | No | Not cross |
| 18 | No | No | No | Not cross |
| 19 | Yes | Yes | Some | Cross |
| 20 | Yes | Yes | No | Not cross |

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