

Modification of Driver Behavior Based on Information from Pedestrian Countdown Timers

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ABSTRACT

Pedestrian countdown timers (CDTs) are promoted as a means of improving pedestrian safety at intersections. However, there are concerns that drivers view the timers while approaching the intersection and use the information to drive more aggressively, an unintended consequence that may have adverse safety impacts. Pedestrian CDTs have been in widespread use in Lawrence, Kansas for three years, and so any novelty effect should have passed, allowing for an accurate analysis of the long-term effects of the devices on traffic.

Four intersections along an arterial corridor in Lawrence were studied, two with CDTs and two without. Continuous speed data were collected on approaching traffic and analyzed to determine if there were changes in speed between 400 ft. upstream from the intersection (the point when the CDT information could be read by drivers) and the intersection stop bar. Additionally, the ultimate decision of the driver (whether he/she stopped or not) was recorded. Analysis revealed that drivers were significantly less likely to increase their speed in order to reach the intersection before the beginning of the red phase when CDTs were present, and some drivers began to slow to a stop *before* the beginning of the amber phase. This indicates that drivers use the information provided from pedestrian CDTs to improve their driving decisions; even though the CDT information was not intended to be used by drivers, it appears that they are indeed doing so in a way that results in improved driving actions.

Key words: driver compliance—pedestrian countdown timers

INTRODUCTION

Pedestrian countdown timers (CDTs) continue to spread across the United States as their safety benefits for pedestrians become better understood. In addition to the traditional use of the symbolic or text-based WALK/DON'T WALK information, pedestrian CDTs provide pedestrians with a descending numerical countdown that reaches zero at the onset of the amber phase of the traffic signal. A typical pedestrian countdown display is shown in Figure 1. This provides pedestrians with information about whether they have enough time to safely make their crossing, allowing pedestrians to make more informed decisions.



Figure 1. Typical pedestrian countdown display

Previous research by the Minnesota Department of Transportation (Mn/DOT) found that the proportion of pedestrians which were successfully able to cross five urban intersections in appropriate times increased from 67 to 75% after the installation of CDTs (Farragher Undated). Additionally, when interviewed, an overwhelming majority (92%) of those pedestrians found the CDTs helpful in making their crossing decisions. Indeed, there is strong evidence that providing pedestrians with any kind of additional information beyond the traditional WALK/DON'T WALK indication can have a beneficial change in safety (Zegeer, Cynecki, and Opiela 1984). Other researchers have been able to show a significant reduction in pedestrian-involved crashes at intersections where CDTs have been installed (Markowitz et al. 2006).

However, because drivers can also see these indications, there are concerns that driver behavior may also change in a way that degrades safety (Streetsblog 2006; Metropolitan Transportation Commission 2007). While there have been many studies that examine how pedestrian actions are changed with the installation

of CDTs, only a few studies have explored how these devices might change the behavior of drivers passing through the intersection. One study found that drivers at one intersection with CDTs were less likely to enter an intersection at the end of the amber phase than those at another nearby intersection without the CDTs (Huey and Ragland 2007). Furthermore, it was found that drivers exhibited different stopping behavior at the two intersections, which could indicate different braking habits exhibited by drivers based on the type of information available to them. In another study that examined driver behavior, red light running was reduced from 2% to 1%, but the authors conjectured that this was due to drivers speeding up because of the CDTs and avoiding the red phase altogether (Markowitz et al. 2006). An increase in aggressive driving behavior would be an unintended and undesirable consequence of the presence of pedestrian CDT installations, and a better understanding of how drivers react to them is needed.

RESEARCH OBJECTIVES

There are two concerns regarding how drivers may change their behavior when exposed to pedestrian CDTs: first, that they may increase their speed in order to avoid having to stop for a red phase, and second, that when stopped at an intersection they may use the CDTs as a way to depart early just prior to the beginning of the green phase. This research examined the first case in order to determine if drivers' approach speeds are affected by the presence of CDTs. Of particular interest were changes in the speed profile of vehicles from the point upstream where the CDTs were just readable until vehicles passed the intersection stop bar.

RESEARCH METHODOLOGY

Pedestrian CDTs have been in widespread use in Lawrence, Kansas for over three years so any novelty effect should have passed, allowing for an accurate analysis of the long-term effects of the devices on traffic. Four intersections along 23rd Street in eastern Lawrence were observed for this research. Details about the intersections can be seen in Figure 2 and Table 1. These intersections were selected as they have similar geometric layouts, are on the same arterial corridor, and a high proportion of daily traffic passes through all four locations. Two of the intersections are equipped with CDTs, and two are not.

Continuous speed data were collected on approaching traffic using LIDAR speed collection equipment linked to a laptop equipped with special acquisition software. Data collection was performed in both the eastbound and westbound directions of each intersection. The data collection team was positioned downstream of the intersections facing oncoming traffic. In all but two locations (Ousdahl Rd. westbound and Alabama St. westbound), the data collection was done from behind objects near the sidewalk in order to collect speed data inconspicuously. At both Ousdahl Rd. and Alabama St. westbound, there were no desirable objects from which to hide the data collection team, and so at these locations the data collection was done from a location as far downstream as possible to minimize the data collectors' visibility to vehicles approaching these intersections.

Only vehicles that were judged to be in or near an intersection's indecision zone were targeted for data collection. That is, the research team was only interested in a vehicle if its driver would have to make a decision on whether to stop or go as the intersection's amber phase began and if the surrounding traffic would allow the driver to adjust his/her speed if desired. No data were collected when the pedestrian warning was not activated (don't walk hand or countdown activation). As a result of these data collection requirements, many cycles were observed where no useable vehicles were present.

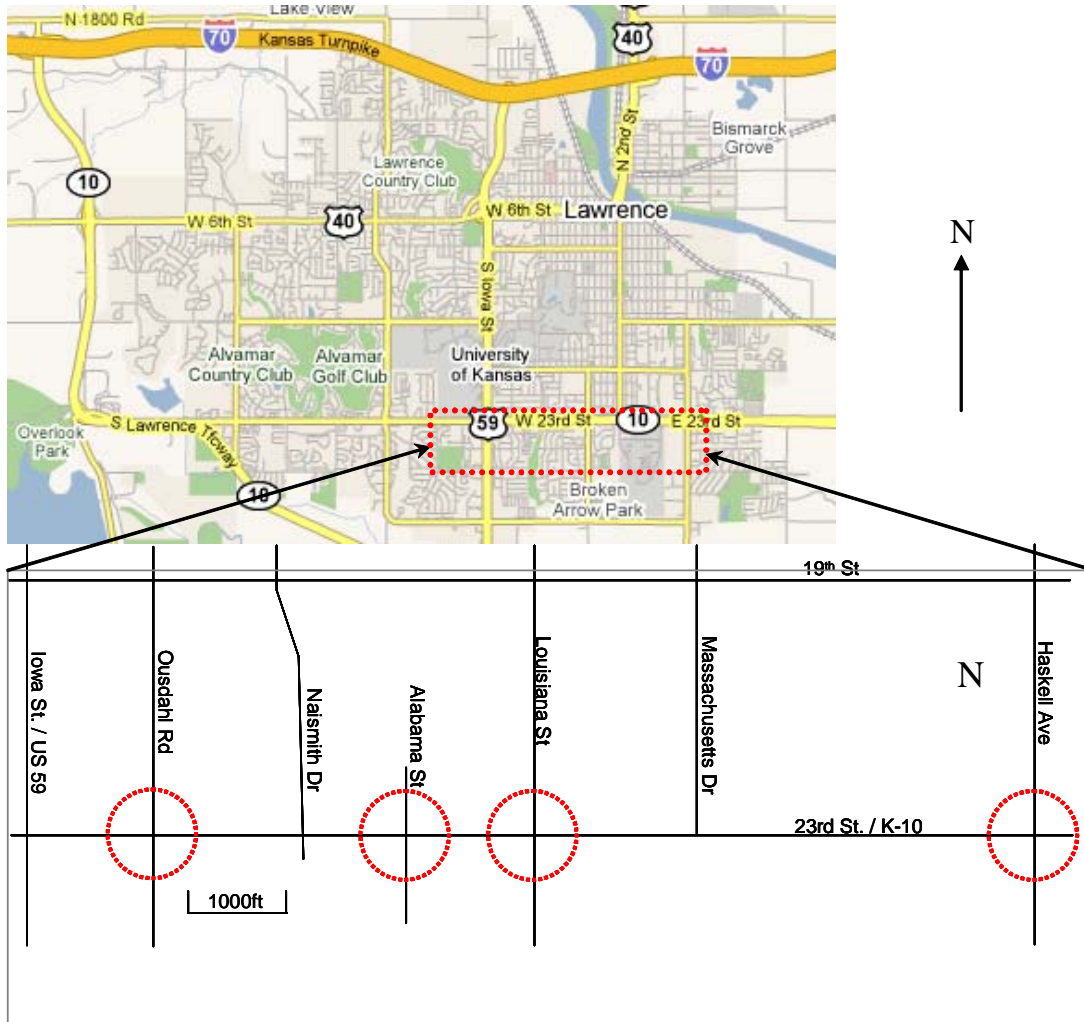


Figure 2. Location of four intersections along K-10 corridor in Lawrence, Kansas

Table 1. Properties of the four study intersections in Lawrence, Kansas

Minor Street Intersecting with 23 rd Street	Ousdahl Road	Alabama Street	Louisiana Street	Haskell Avenue
CDT	No	Yes	No	Yes
Amber phase (sec)	4	4	4	4.5
Pedestrian warning time (sec)	15	15	23	18
Major approach lanes (23 rd Street)	2 through 1 left	2 through 1 left	2 through 1 left	2 through 1 left
Minor approach lanes	1 through 1 left	1 through 1 left	2 through 1 left	2 through 1 left
Approach speed limit (mph)	35	35	35	45

In cases where the intersection had a CDT, the time on the CDT was noted at the instant the speed data collection began for each vehicle. At intersections without a CDT, data were taken when the flashing hand was present. For each vehicle, the position of the vehicle at the beginning of the amber phase and/or the red phase was determined. From this, it was possible to backcalculate the time displayed on the CDT when the vehicle was 400 ft. from the intersection. Data were collected on 11 clear, dry mid-week days in March through June 2007. Data were only collected at off-peak morning or afternoon time periods. In the observation of an estimated 600 cycles, 207 useable data points were generated.

Statistical Study Design

The CDTs each had nominal 8 in. character height, which conservatively correlates to a 400 ft. reading distance for drivers with normal vision, assuming 50 ft. of reading distance for every inch of letter height (Schwartz 1999). So then it could be reasoned that if a driver was likely to change his/her speed based on the information provided by the CDTs, it would happen at some point within 400 ft. upstream from the intersection. The data were analyzed to determine if there were more changes in speed during this range when CDTs were present.

For each vehicle, data were also collected on the ultimate decision the driver made (stop or go) and the status of the pedestrian display when the vehicle was 400 ft. upstream. Each vehicle was categorized based on whether the intersection that it passed through had a CDT or not and the action taken by the driver. The driver actions were subdivided into five categories:

- stopped (began decelerating at or after the beginning of the amber phase)
- stopped but began decelerating early (*before* the beginning of the amber phase)
- continued on normally through the intersection
- continued on through the intersection but accelerated in order to do so
- continued on through the intersection but ran the red light in order to do so

There were no observed instances of red light running, so this driver action category was removed from later analysis. In order to determine whether these distributions were different based on the presence or absence of CDTs, a chi square analysis was conducted to test the following hypotheses:

H_0 : There is no difference in driver actions based on the presence or absence of CDTs.

H_A : There is a difference in driver actions based on the presence or absence of CDTs.

KEY FINDINGS

The results were examined in two ways. First, an examination was conducted on how driver decisions (stop or go) related to the CDT information that was displayed when the vehicles were 400 ft. from the intersection. Second, a statistical analysis was performed to determine if the distribution of driver decisions changed based on the presence or absence of CDTs.

Examination of Driver Decisions Based on CDT Displays

Speed profiles were collected on 207 vehicles as they approached the four intersections of interest. An example of two typical vehicles, one that stopped at an intersection and one that did not, is shown in Figure 3.

For each observed vehicle the time remaining until the beginning of the amber phase when the vehicle was 400 ft. from the intersection was determined. Note that for the CDT intersections this corresponded directly to the CDT display. For the intersections that did not have CDTs the time was determined based on the elapsed time since the beginning of the flashing hand on the pedestrian signal displays. These data were graphed against the expected time it would have taken the vehicle to reach the stop bar assuming no changes in speed. Of the 207 speed profiles that were recorded, only 128 were useable in this analysis; for during the data collection it was not always possible to acquire a vehicle's speed profile 400 ft. upstream the intersection. This was a result discussed above about the need to collect data from far downstream from the intersections.

The results of this examination are shown in Figure 4. As shown in the figure, a driver's decision on whether to stop or go as they approached the intersection was based on his/her speed and the CDT information that they had available to them. The diagonal lines indicate how fast a vehicle would have to travel from 400 ft. upstream in order to just reach the intersection at the beginning of the amber and red phases, respectively. For example, if a driver that reached the point 400 ft. upstream from the intersection required eight seconds to reach the intersection at the exact point in time when eight seconds remained before the onset of the amber phase, the data point would fall exactly on the line representing the beginning of the amber phase.

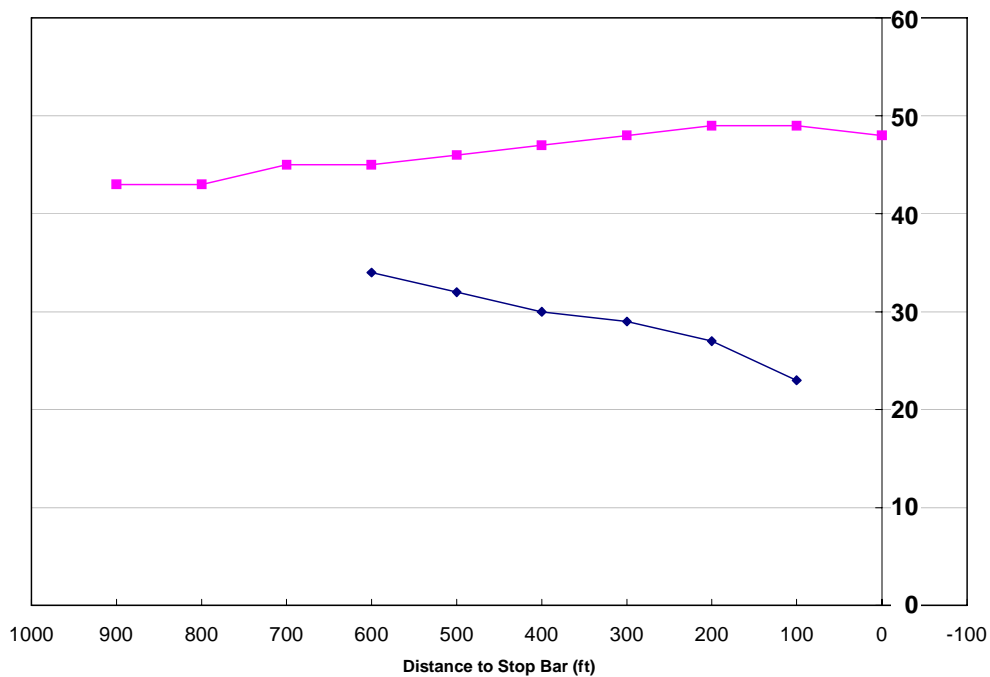
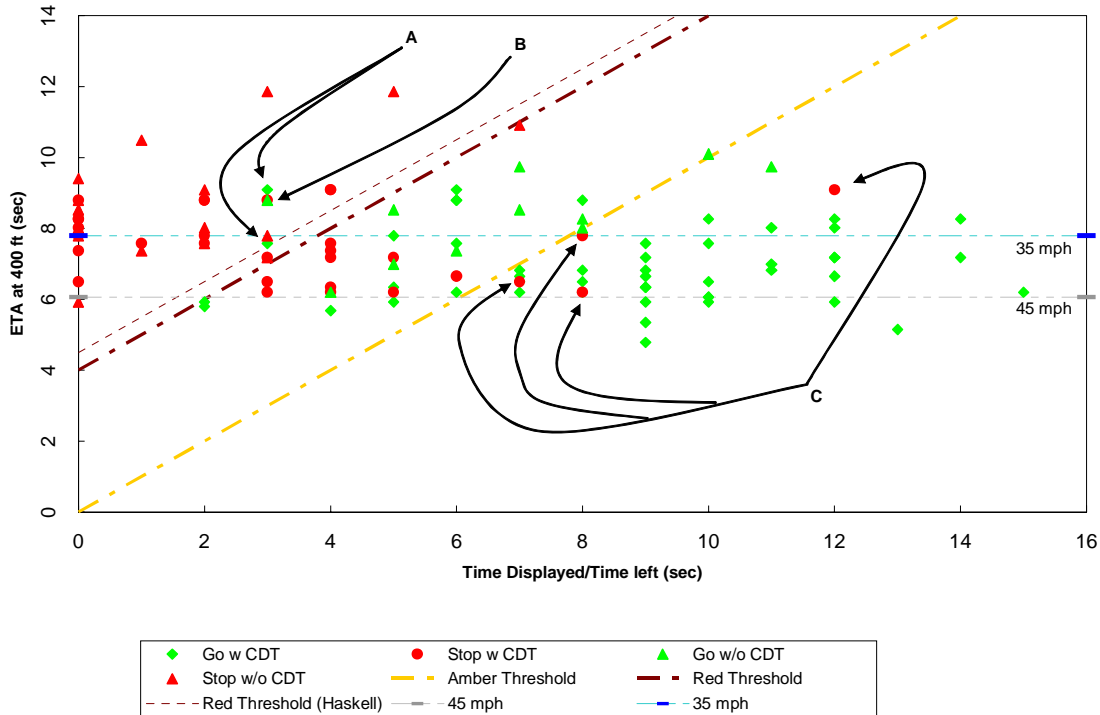


Figure 3. Two typical speed-distance profiles for observed vehicles



- A: Driver increased speed in order to clear the intersection prior to the beginning of the red phase, CDT present.
 B: Driver increased speed in order to clear the intersection prior to the beginning of the red phase, no CDT present.
 C: Driver decreased speed and stopped when it would have been possible to clear the intersection at initial speed, CDT present

Figure 4. Driver decisions compared to speed and CDT display

Data points in Figure 4 that are far to the left of the line, indicating the beginning of the red phase, correspond to vehicles that arrived 400 ft. upstream from the intersection when only a few seconds remained before the beginning of the amber or red phases, and these vehicles did not have enough time to reach the intersection. Not surprisingly, the drivers of these vehicles decided to stop at the intersections. Likewise, data points far to the right of the line, representing the beginning of the amber phase, corresponded to vehicles that arrived 400 ft. upstream from the intersection with ample time to reach the intersection, and no speed changes were required in order to reach the intersection during the green phase. As expected, the drivers of these vehicles decided to proceed through the intersection.

Of interest are the vehicles that fall between and to either side of the diagonal lines representing the beginning of the amber and red phases; these drivers had opportunity to change their speeds as they approached the intersections. If a driver needed to increase his/her speed to avoid stopping at the intersection, the data would show as a “go” decision to the left of the diagonal line indicating the beginning of the red phase. This atypical result also could have occurred due to red light running, but because no instances of this were observed during the data collection period, this indicated that these drivers increased their speed in the last 400 ft. in order to avoid the red phase. As shown in the figure, there were two instances of this occurring at intersections with CDTs, and one at intersections without CDTs.

The opposite of this was an atypical “stop” decision to the right of the line representing the beginning of the amber phase, indicating that a driver stopped when he/she could have proceeded at a constant speed

and legally cleared the intersection. As shown in the figure, there were four instances of this occurring at intersections with CDTs, and zero instances at intersections without CDTs.

Statistical Analysis of Driver Decisions

A comparison of the distributions of driver decisions based on the presence or absence of CDTs is shown in Table 2. A chi square test ($\alpha = 0.05$, $df = 3$) was performed to determine if the driver decision distributions were significantly different. It was determined that there was a statistically significant difference between the driver decision distributions (p -value = 0.0038).

Table 2. Cross classification of driver action by the presence of pedestrian CDTs

	Driver Action				Total
	Unchanged Stop	Stop, Early Deceleration	Unchanged Go	Accelerated During Go	
Pedestrian CDT	17 ^A (18.98) ^B	12 (8.86)	48 (43.66)	4 (9.49)	81
No Pedestrian CDT	13 (11.02)	2 (5.14)	21 (25.34)	11 (5.51)	47
Total	30	14	69	15	128

^A The top number in each cell is the observed value.

^B The bottom number each cell is the expected value based on total observations.

A cell-by-cell comparison of adjusted residuals between the observed and expected frequencies was also conducted in order to better understand the nature of the data. This was done in order to determine which parts of the distributions were significantly different from the expected values; any adjusted residuals with an absolute value of about two or three indicated a significant difference between the observed and expected observations for the given cell (Agresti 1996). As can be seen in Table 3, the adjusted residuals for the number of vehicles that accelerated in the last 400 ft. upstream from the intersection were found to be significant. Therefore, it can be concluded significantly fewer instances of drivers accelerating in the last 400 ft. upstream from the intersection were observed when CDTs were present. Also, a weaker association exists where drivers were more likely to begin to decelerate before the beginning of the amber phase when pedestrian CDTs were present.

Table 3. Adjusted residuals for testing independence

	Driver Action			
	Unchanged Stop	Stop, Early Deceleration	Unchanged Go	Accelerated During Go
Pedestrian CDT	-0.86	1.84	1.60	-3.13 ^A
No Pedestrian CDT	0.86	-1.84	-1.60	3.13 ^A

^A A strong indication that the observed values in these cells are significantly different from the expected values.

CONCLUSIONS

Drivers were found to drive less aggressively at intersections equipped with CDTs compared to similar nearby intersections on the same corridor that did not have CDTs. The proportion of drivers that increased their speed on the intersection approach was significantly less at the intersections with CDTs.

Additionally, drivers who stopped at the intersections were more likely to begin decelerating even before the beginning of the amber phase. These two findings seem to dispel the notion that drivers use CDTs to drive more aggressively. Rather, these findings indicate that drivers use the information presented on the CDTs to make better decisions about their ability to reach the intersections prior to the beginning of the red phase, and they are less likely to drive aggressively as a result.

The data analyzed in this research indicate that drivers use the information provided from pedestrian CDTs to improve their driving decisions; even though the CDT information was not intended to be used by drivers, it appears that they are indeed doing so in a way that results in improved driving actions. Additional research is needed to determine if these results can be replicated at other locations and under other conditions. Additionally, an important safety question not addressed from this research is how drivers might use CDT information when departing from an intersection at the beginning of the green phase.

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