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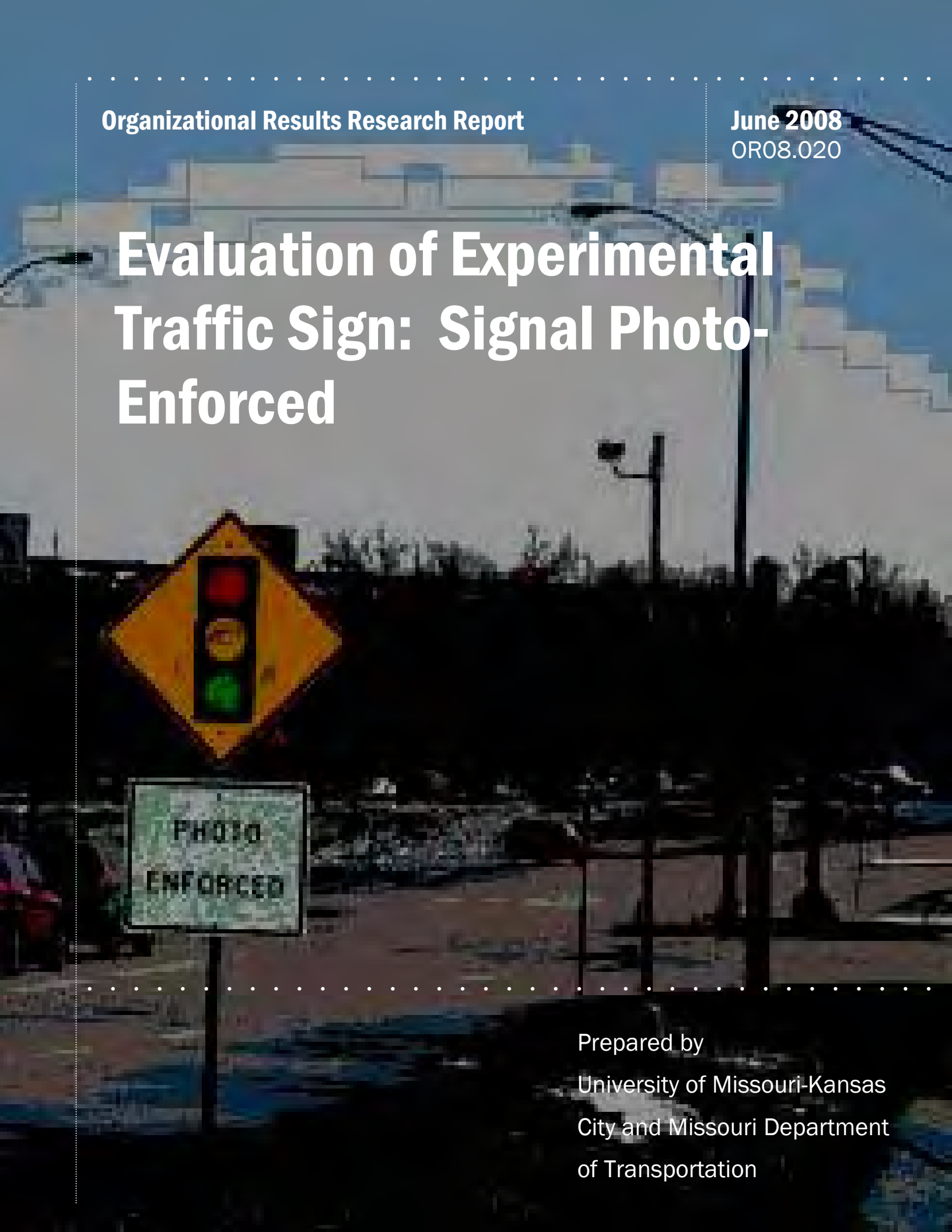
Evaluation of Experimental Traffic Sign: Signal Photo-Enforced



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Evaluation of Experimental Traffic Sign – Signal Photo-enforced

RI 06-007

Final Report

June 30, 2008

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Executive Summary

Evaluation of Experimental Traffic Sign – Signal Photo-enforced

This project intends to evaluate current and experimental photo-enforced signs. The evaluation is performed using three surveys conducted in the City of Arnold, Missouri where four photo-enforced signalized intersections exist. A total of 675 complete survey forms were collected and analyzed for this study. This study found that the experimental sign has potential to improve traffic safety at signalized intersections by facilitating drivers' correct identification of the sign at high-risk intersections. The experimental sign was more correctly identified by survey participants than the current signs (79.6% vs. 75.1%). Also, this study found that older drivers (age 65+) more correctly identified the meaning of the experimental sign compared to the current signs (75.8% vs. 62.5%). This indicates that the experimental sign has potential to improve intersection safety by better delivering its intended meaning particularly to older drivers.

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A. Introduction

1. Red Light Running and Traffic Safety

The incidence of red light running in the U.S. has gained increased attention as its negative safety effects have become better researched in the last two decades. Al-Ghami (2003) found that 9.09 percent of severe accidents could be attributed to red light running. The Insurance Institute of Highway Safety estimates that more than 900 people were killed and 144,000 injured in crashes involving red light running in 2006 (IIHS, 2008). Half of those deaths were either pedestrians or occupants of other vehicles hit by red light runners.

Given the risk and prevalence of red light running, safety experts and policy makers have sought new methods of curbing violations and accidents by increasing enforcement. However, the relative expense of routine police surveillance is somewhat prohibitive. Thus, Red Light Camera (RLC) programs have been developed to monitor intersections and to ticket red light runners by capturing violations on film and process offenders electronically rather than through routine surveillance and ticketing. The programs also act as a deterrent to potential violators and have been shown to reduce violations and crashes. This saves valuable time for police personnel and has the added benefit of capturing offenders. While this system is unable to offer the immediate feedback that police enforcement might, it captures almost every violation, day or night.

The propensity to stop at a signalized intersection at the onset of a yellow light has been attributed to an interaction between behavior and environmental attributes. This decision has been attributed to driver attitude and characteristics as well as relative speed, traffic volume, and geometric characteristics at intersections. These variables affect a driver's perception of consequences, interactions with nearby drivers, vehicle speed, and distance from the stop-line.

A number of studies have found this decision to be a function of demography and driving safety patterns. Retting et al. (1999) compared characteristics of at-fault drivers and not-at-fault drivers in

crashes where the cause was red light running. Red light runners were more likely to be under 30 years old, male, and to have had prior moving violations and convictions for driving while intoxicated. Those drivers were also more likely to have had invalid driver's licenses and to have consumed alcohol prior to the crash. Porter and Berry (2001) found 1 out of 5 drivers surveyed reported having run a red light when entering the last ten signalized intersections. Of several different demographic and attitude variables, only age could predict red light running. Younger drivers as well as those traveling alone or in a hurry were found more likely to run red lights.

Demographic characteristics are not the only features associated with a driver's compliance of a stop signal or sign. Beck et al. (2007) surveyed drivers about cell phone use and driving habits and found that drivers who had talked on a cell phone while driving at least once during the last month were twice as likely to have missed traffic signals and often run red lights or stop signs. Unbuckled drivers were more likely to run red lights (Porter and England, 2000). Retting and Williams (1996) compared the characteristics of red light violators to compliers and found significant differences in the ages and safety records of violators as compared to law-abiding drivers. It was reported that the violators tended not to wear seatbelts and to have had substantially more traffic convictions and crashes. Violators were more than three times as likely to have multiple speeding convictions. Safety records for those drivers also tended to be worse for younger drivers than older drivers.

While age and gender tend to be the two most commonly cited and strongly stated characteristics that predict an individual's likelihood of running a red light, other attitudes towards traffic safety also play a role in driver decision-making. The relative frequency of traffic convictions and crashes for red light violators as compared to compliers as well as differences in seatbelt and cell-phone use suggest that violators tend to take greater risks and exercise worse judgment behind the wheel. Other variables in the driving environment or at intersections may affect a driver's decision to stop. Porter and England (2000) found cities with typically larger intersections and higher traffic volumes were more prone to red light running.

Where safety risks of red light running were not previously sufficient deterrents to violations, a

greater probability of being caught has effectively reduced the frequency of violations. For example, Lum and Wong (2002) evaluated the propensity to stop at photo-enforced T-intersections along a busy commercial corridor in Singapore. The study found that the likelihood of stopping for a yellow light at a signalized intersection was 17.6 times higher at photo-enforced intersections than at non-photo-enforced intersections.

RLC systems have been shown to affect all drivers equally, regardless of driver characteristics. Martinez and Porter (2006) found no difference in the prohibitive effect of the cameras among drivers of different demographic characteristics. The cameras' unbiased enforcement and effect is one argument for their use.

Even though the effectiveness of RLC systems is clear, it is important to develop or improve proper photo-enforced sign to facilitate compliance of red signals, thus improving intersection safety. Whether motorists correctly identify the photo-enforced sign may significantly influence their red light stop compliance. This is particularly important as a preventive measure in promoting safety at high-risk signalized intersections.

2. Project Goal

The primary goal of the project is to improve traffic safety by appropriately indicating to drivers certain traffic signals on MoDOT right-of-ways in the City of Arnold are being enforced by photographic equipment. Road users' understanding of current photo-enforced traffic signs and the experimental photo-enforced sign are evaluated and compared in this project. The project provides recommendations on these two different types of signs to lead to a reduction in red light running at those signals.

3. Project Objectives

The objectives of this project are to evaluate current photo-enforced traffic signs (Figure 1) and an experimental photo-enforced traffic sign (Figure 2) in order to facilitate efforts to reduce red light running

crashes. This project consists of three surveys. The first survey evaluates the current traffic sign. The second and third surveys are to evaluate an experimental traffic sign (see Figure 2), which indicates an upcoming traffic signal is being photo-enforced. Surveys have been developed (Appendix A and B) which test whether road users are able to understand the meaning of the current and experimental signs, as well as the perceived visibility of the signs to road users. Both signs are evaluated based on identical surveys except for the sign graphic. The objective of the project as a whole is to produce measurable results that describe the effectiveness of the experimental sign compared to current signs, and the effectiveness of the experimental sign over time.

Figure 1: Current Traffic Signal Photo Enforced Sign

Figure 2: New Experimental Traffic Signal Photo Enforced Sign

B. Study Design

1. Survey Methods

The project is performed in a collaborative effort between the University of Missouri-Kansas City (UMKC) and Washington University in St. Louis (WashU). A group of faculty members and students from UMKC and WashU participate in survey data collection. The students and faculty who actively collect the data have received training in administering the project's survey. The surveyors are asked to greet people, ask them the survey questions, and transcribe their answers for them. This is done following a standard script (Appendix C). Surveyors fill out the survey form rather than asking respondents to fill out the survey themselves in order to achieve consistency in answers. This helps ensure that respondents properly understand each question and avoids related mistakes.

The project consists of three surveys. The first survey was conducted in March 2007, and the second survey was conducted in July 2007. The third survey was conducted in March 2008. The study area of this project is the City of Arnold, Missouri. The surveys were conducted at the City Hall and the Arnold Recreation Center. These two survey sites in the city were selected to ensure that various groups of road users would be included in the surveys. The sites were also selected where road users have driven past the signs to reach the location so that we can evaluate whether drivers did or did not notice the signs. The project team collected more than 200 individual responses in total in each survey to achieve an acceptable level of statistical significance of survey results.

2. Data Analysis

The survey results are compiled in a database to conduct descriptive statistical analyses. Sampling consistency across three surveys were tested to examine whether the samples were drawn from the same population groups. Cross-classification analyses along with Z-test and Cochran-Mantel-Haenszel statistics

were used to see if different personal characteristics give significantly different responses. The analyses are also used to examine whether respondents with different levels of familiarity to the area and roadway exposure give significantly different answers.

The results will facilitate understanding of how different groups of road users comprehend the signs and if these different groups perceive their visibility differently. The results will also indicate whether there are differences between current signs and the experimental sign, and if there are differences in comprehension and perception of visibility of the experimental signs over time. The overall results will be used to develop conclusions that may justify the use of the experimental sign if the results warrant.

3. Study Area and Photo-enforced Intersections

The study area of this project is the City of Arnold, Missouri. Arnold is located south of the St. Louis metropolitan region (Figure 3). In 1972, the six townships of Beck, Flamm City, Maxville, Old Town Arnold, Tenbrook and Wickes in the area were incorporated into what is now the City of Arnold. The city, just 15 miles south of downtown St. Louis, residing inside Jefferson County, was once a rural agricultural community and has now become a residential suburb in the St. Louis metropolitan region. According to the U.S. Census Bureau, in 2000, Arnold's population had grown to 19,965 , a 6% increase since 1990. If the amount of new construction in the city is any indication of a growing population, one can expect the population growth over the current decade to far exceed the growth from the previous one.

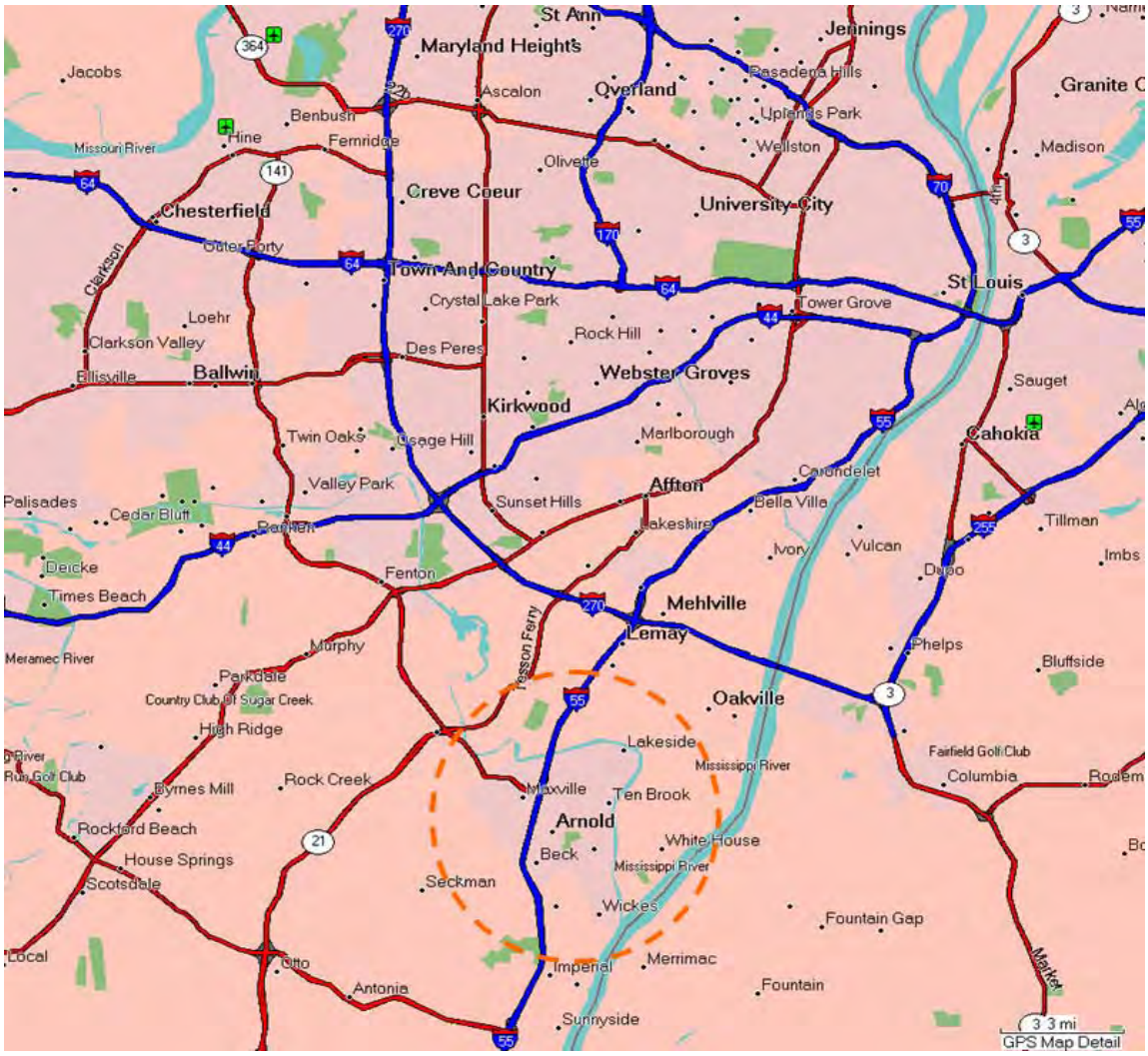

Figure 3 Regional Location of the City of Arnold, Missouri

The City has four intersections with photo-enforced signs. Figure 4 shows the intersections. These locations have heavy traffic and are characterized by high traffic accident risk, designated by the correlation between traffic volume and accident risk (Keller, 2006). Figure 4 also shows two survey locations (the Arnold Recreation Center and the Arnold City Hall). Both survey locations were close to existing photo-enforced intersections, which survey participants likely would have traversed on their way to the survey locations. In addition, the two survey locations are popular activity locations of the road users in the City of Arnold area. This is important to ensure that various road users are included in the surveys of the project.

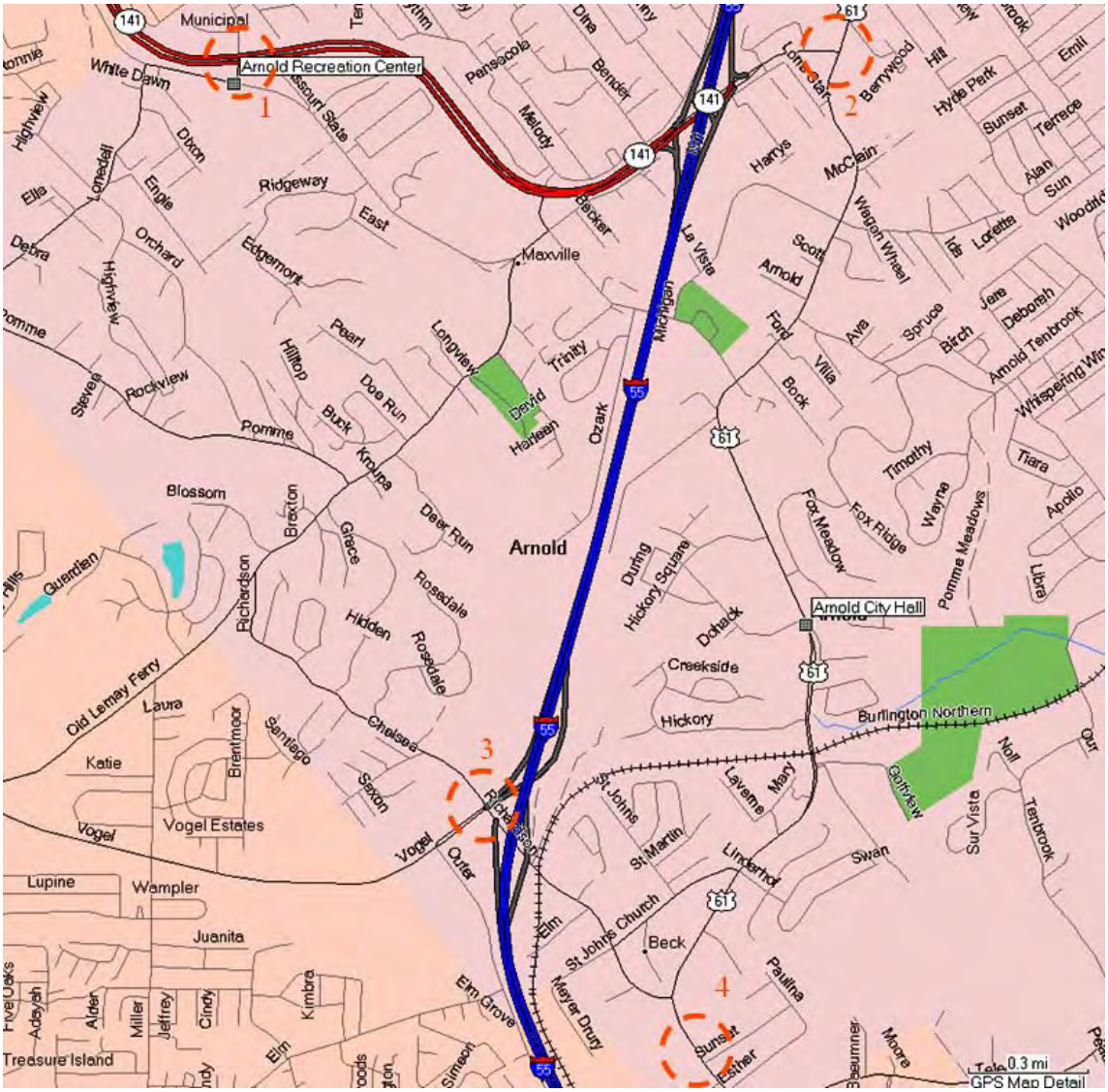

Figure 4 Locations of Photo-enforced Signs in the City of Arnold, Missouri

Figures 5-8 show the pictures of each intersection area with current photo-enforced signs marked on Figure 4. The first survey was conducted when the current signs on the figures were installed.

Figure 5: Intersection 1, Route 141 at Astra Way Drive with the Current Signs

Figure 6: Intersection 2, Route 141 at U.S. 61/67 with the Current Signs

Figure 7: Intersection 3, Richardson Road at Vogel/I-55 with the Current Signs

Figure 8: Intersection 4, U.S. 61/67 at Rockport Heights Elementary with the Current Signs

The Missouri Department of Transportation replaced the current signs with the experimental photo-enforced sign at the four intersections on June 22, 2007. Figures 9-12 show pictures of each

intersection area with the new sign. The second and third surveys were conducted in July 2007 and March 2008 after the new sign had been installed.

Figure 9: Intersection 1, Route 141 at Astra Way Drive with the Experimental Sign

Figure 10: Intersection 2, Route 141 at U.S. 61/67 the Experimental Sign

Figure 11: Intersection 3, Richardson Road at Vogel/I-55 the Experimental Sign

Figure 12: Intersection 4, U.S. 61/67 at Rockport Heights Elementary the Experimental Sign

C. Data Analysis

1. Survey Results

The first survey conducted in March 2007 collected 237 complete survey forms. The second survey was conducted in July 2007, a month after the installation of the experimental photo-enforced sign. A total of 227 complete survey forms were collected. The third survey was conducted in March 2008, eight months after the second survey, and a total of 211 complete survey forms were collected.

The characteristics of survey participants were diverse in gender, age, residency, and experience, suggesting a representative sample of typical drivers in the area. A quantitative summary of the characteristics of survey participants is reported in Table 1. The survey participants are found in all age groups. The age distribution of participants, while slightly skewed towards older adults, is for the most part even. The population aged 30-49 and 50-64 was more heavily represented than other age groups, but these groups combined represent 35 years as opposed to other groups, which span a narrower range of ages. The gender of the population was reasonably equitable. Females compose about 56-58 percent of the survey population in the three separate surveys, only slightly higher than Arnold's normal distribution of females to males reported in the 2000 decennial census.

Table 1 shows that close to half of the participants are from within the City of Arnold across the surveys. Even though the two survey locations, the Arnold City Hall and the Arnold Recreation Center, typically serve area residents, non-residents who lived either just outside the City of Arnold or in nearby municipalities participated in the survey.

Table 1 Results of Survey Response

		Survey I		Survey II		Survey III		p-value*
		Freq	Pct	Freq	Pct	Freq	Pct	
Has observed sign	Yes	210	88.6	197	86.8	175	82.9	0.21
	No	27	11.4	30	13.2	36	17.1	
Number of signs observed	0	27	11.4	30	13.2	36	17.1	0.00
	1	26	11.0	33	14.5	21	10.0	
	2	64	27.0	58	25.6	42	19.9	
	3	49	20.7	50	22.0	34	16.1	
	4	32	13.5	37	16.3	23	10.9	
	5+	39	16.5	19	8.4	55	26.1	
Sign meaning								
Speeding is photo enforced	Yes	70	29.5	56	24.7	55	26.1	0.48
	No	167	70.5	171	75.3	156	73.9	
Red light running is photo enforced	Yes	206	86.9	204	89.9	196	92.9	0.11
	No	31	13.1	23	10.1	15	7.1	
Jaywalking is photo enforced	Yes	15	6.3	24	10.6	16	7.6	0.23
	No	222	93.7	203	89.4	195	92.4	
Improper left turns are photo enforced	Yes	27	11.4	41	18.1	27	12.8	0.10
	No	210	88.6	186	81.9	184	87.2	
Improper right turns are photo enforced	Yes	25	10.5	45	19.8	27	12.8	0.01
	No	212	89.5	182	80.2	184	87.2	
Other	Yes	6	2.5	5	2.2	6	2.8	0.91
	No	231	97.5	222	97.8	205	97.2	
Understanding of signage	Easier to understand	123	51.9	93	41.0	76	36.0	0.00
	Similar	97	40.9	114	50.2	97	46.0	
	More difficult to understand	17	7.2	20	8.8	38	18.0	
Visability of signage	Clear	150	71.4	151	76.6	111	61.3	0.03
	Somewhat	46	21.9	36	18.3	54	29.8	
	Not Very	14	6.7	10	5.1	16	8.8	
Noticability of signage	Easier to notice	51	24.3	49	24.9	30	16.6	0.04
	Similar to others	117	55.7	125	63.5	118	65.2	
	More difficult to notice	42	20.0	23	11.7	33	18.2	
Arnold, MO resident	Yes	114	48.1	114	50.2	90	42.7	0.27
	No	123	51.9	113	49.8	121	57.3	
Years driven in area	0 to 4	49	20.7	43	18.9	37	17.5	0.81
	5 to 9	33	13.9	34	15.0	31	14.7	
	10 to 19	60	25.3	47	20.7	44	20.9	
	20 to 29	30	12.7	36	15.9	26	12.3	
	30 to 39	24	10.1	28	12.3	32	15.2	
	40+	41	17.3	39	17.2	41	19.4	
Hours driven per week	1 to 9	85	35.9	87	38.3	69	32.7	0.91
	10 to 19	73	30.8	67	29.5	71	33.6	
	20 to 29	48	20.3	46	20.3	41	19.4	
	30+	31	13.1	27	11.9	30	14.2	
Age	18 to 24	26	11.0	29	12.8	20	9.5	0.51
	25 to 29	17	7.2	11	4.8	13	6.2	
	30 to 49	76	32.1	62	27.3	62	29.4	
	50 to 64	54	22.8	53	23.3	54	25.6	
	65 to 74	47	19.8	44	19.4	48	22.7	
	75+	17	7.2	28	12.3	14	6.6	
Gender	Female	138	58.2	129	56.8	118	55.9	0.88
	Male	99	41.8	98	43.2	93	44.1	

*Based on the General Association Statistic of the Cochran-Mantel-Haenszel Statistics test

Roughly one fifth of participants were new to driving in the Arnold area, having only 0-4 years of driving experience in the area. Because the question asked how long survey participants had been driving in the area, the results suggest that this portion of respondents is new to Arnold, not necessarily new to driving. Despite the growing population suggested by this result, the great majority of participants reported having driven in or around Arnold for 10 or more years. The amount of time spent driving in a typical week was relatively evenly distributed, with most of those surveyed reporting driving less than 20 hours per week.

The Cochran-Mantel-Haenszel Statistics test, a popular statistical method to test an association in cross-tabulation, was employed to examine whether there are statistically significant variations in survey participants across the surveys as shown in Table 1. The p-values of age, gender, Arnold residency, years driven in area, and hours driven per week indicate that the survey participants across three surveys are not statistically significantly different. Those p-values are greater than 0.1, which is a reasonable threshold for this analysis, indicating that this study gathered survey forms from similar groups of people consistently across the surveys.

The majority of survey participants were quite familiar with photo-enforced signs. Across the surveys, more than 80 percent of survey participants have observed both the current signs and the experimental sign. Even though the percent of survey participants who denied having noticed the sign increases from the first survey to the third survey, the differences are not statistically significant at the 0.1 level.

As Table 1 shows, the rate of those participants who had observed the experimental sign tends to be lower than the rate of those participants who had observed the current signs even though the difference is not statistically significant. This may be related to a limited exposure to the experimental sign. The number of signs survey participants had observed remained similar. However, the difference is statistically significant. While the bell-curve distribution of the results from people who reported seeing 1-4 signs remained similar in all three surveys, the percentage of people observing the experimental signs

decreased by the third survey. In addition, there were substantial increases in the number of survey participants who observed no sign or more than 5 signs in the third survey.

Whether the participant had or had not seen the experimental sign, most respondents interpreted the sign to signify that red light running was photo-enforced. The percent of survey participants who were able to recognize the sign as red light running photo-enforced increased over time from 86.9 percent in the first survey with the current sign to 92.9 percent in the third survey with the experimental sign. The p-value of this is very close to 0.1. This indicates that the experimental sign delivers a more clear designation of photo enforcement. However, many participants also thought the sign denoted other photo-enforced violations as well, either mutually or exclusively. In this study, survey participants were asked to mark all meanings they thought applied. More than 20 percent responded that the sign meant speeding was photo-enforced, about 10 percent that jaywalking was photo-enforced, more than 10 percent that either improper left turns or right turns were photo-enforced, and about 2-3 percent thought the sign meant something else across the surveys. While these responses may suggest the sign might deter drivers from violating other traffic laws in addition to red light running, it diminishes the intended suggestion of the signs. Notably, the number of survey participants who responded that the sign meant improper left turns or rights was photo-enforced significantly decreased in the second and third surveys. This may be the cause of the significant p-values on those variables.

Survey participants were also asked subjective questions concerning ease of understanding, how noticeable the sign was, and its visibility. This is an important part of this study to evaluate the current signs and the experimental sign. As shown in Table 1, most survey participants feel that the current and the experimental signs are easier or similar to understand compared to other signs. However, in the comparison between the current signs and the experimental sign between the first and third surveys, significantly more of those surveyed found the experimental signs to be similar or more difficult to understand compared to other traffic signs. This difference could be attributed to the relative unfamiliarity of survey participants with the experimental sign, which had been posted on the roadway for a relatively short period of time.

A majority of survey participants who had seen the sign found the experimental sign to be clearly or somewhat visible in comparison to other signs. The percent of those who found the experimental sign to be clearly visible was substantially lower in the third survey compared to the second survey. However, the percent of those who found the experimental sign to be somewhat visible increased. The statistical significance of the variable may be because of this fluctuation.

A majority of survey participants also reported both signs to be similar or easier to notice than other signs on the road. However, there are substantial differences in the percentages between the second survey and the third survey in terms of "easier to notice" and "more difficult to notice". This probably caused the statistical significance of the variable as found in Table 1. Overall, the percent of those who found the experimental sign to be more difficult is lower than that of the current signs.

Survey participants who thought the experimental sign was more difficult to see or notice were asked why they reported so. Their responses were not officially recorded in the surveys. However, the majority of them indicated that the white background and the small size of the experimental sign make it difficult for them to notice it.

2. Analysis of Correct Understanding of Sign

Table 2 offers a more in-depth analysis of responses, dividing the sample into two groups: those who correctly understood the sign and those who did not. Those who stated the signs are red light running photo-enforced only are defined as those who correctly understood the sign. The z-test is employed to assess the statistical significance of the associations between correct/incorrect understanding of the sign and various factors in each survey period. The bolded values are statistically significant at the 0.1 level (a z-test statistic is greater than 1.65 or less than -1.65). Given the size of the sample, it seems reasonable to apply the 0.1 significance level.

Table 2 Correct Understanding of Signs

	Survey I				Survey II				Survey III				
	Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		p-value*
	Freq	Pct	Freq	Pct	Freq	Pct	Freq	Pct	Freq	Pct	Freq	Pct	
	178	75.1	59	24.9	160	70.5	67	29.5	168	79.6	43	20.4	0.09
Has observed sign													
Yes	159	75.7	51	24.3	**144**	**73.1**	**53**	**26.9**	138	78.9	37	21.1	0.19
No	19	70.4	8	29.6	**16**	**53.3**	**14**	**46.7**	30	83.3	6	16.7	
Number of signs observed													
0	19	70.4	8	29.6	**16**	**53.3**	**14**	**46.7**	30	83.3	6	16.7	0.45
1	20	76.9	6	23.1	26	78.8	7	21.2	15	71.4	6	28.6	
2	50	78.1	14	21.9	43	74.1	15	25.9	35	83.3	7	16.7	
3	34	69.4	15	30.6	33	66.0	17	34.0	29	85.3	5	14.7	
4	24	75.0	8	25.0	24	64.9	13	35.1	17	73.9	6	26.1	
5+	31	79.5	8	20.5	18	94.7	1	5.3	42	76.4	13	23.6	
Understanding of signage													
Easier to understand	90	73.2	33	26.8	65	69.9	28	30.1	**55**	**72.4**	**21**	**27.6**	0.11
Similar	76	78.4	21	21.6	85	74.6	29	25.4	81	83.5	16	16.5	
More difficult to understand	12	70.6	5	29.4	**10**	**50.0**	**10**	**50.0**	32	84.2	6	15.8	
Visability of signage													
Clear	111	74.0	39	26.0	109	72.2	42	27.8	84	75.7	27	24.3	0.23
Somewhat	36	78.3	10	21.7	26	72.2	10	27.8	45	83.3	9	16.7	
Not Very	12	85.7	2	14.3	9	90.0	1	10.0	13	81.3	3	18.8	
Noticability of signage													
Easier to notice	**31**	**60.8**	**20**	**39.2**	32	65.3	17	34.7	22	73.3	8	26.7	0.01
Similar to others	93	79.5	24	20.5	94	75.2	31	24.8	95	80.5	23	19.5	
More difficult to notice	35	83.3	7	16.7	18	78.3	5	21.7	25	75.8	8	24.2	
Arnold, MO resident													
Yes	86	75.4	28	24.6	80	70.2	34	29.8	69	76.7	21	23.3	0.64
No	92	74.8	31	25.2	80	70.8	33	29.2	99	81.8	22	18.2	
Years driven in area													
0 to 4	45	91.8	4	8.2	32	74.4	11	25.6	30	81.1	7	18.9	0.08
5 to 9	24	72.7	9	27.3	24	70.6	10	29.4	26	83.9	5	16.1	
10 to 19	42	70.0	18	30.0	33	70.2	14	29.8	34	77.3	10	22.7	
20 to 29	21	70.0	9	30.0	29	80.6	7	19.4	20	76.9	6	23.1	
30 to 39	**22**	**91.7**	**2**	**8.3**	19	67.9	9	32.1	24	75.0	8	25.0	
40+	**24**	**58.5**	**17**	**41.5**	23	59.0	16	41.0	34	82.9	7	17.1	
Hours driven per week													
1 to 9	61	71.8	24	28.2	**54**	**62.1**	**33**	**37.9**	55	79.7	14	20.3	0.22
10 to 19	56	76.7	17	23.3	**53**	**79.1**	**14**	**20.9**	55	77.5	16	22.5	
20 to 29	39	81.3	9	18.8	34	73.9	12	26.1	34	82.9	7	17.1	
30+	22	71.0	9	29.0	19	70.4	8	29.6	24	80.0	6	20.0	
Age													
18 to 24	22	84.6	4	15.4	23	79.3	6	20.7	15	75.0	5	25.0	0.00
25 to 29	13	76.5	4	23.5	6	54.5	5	45.5	12	92.3	1	7.7	
30 to 49	55	72.4	21	27.6	**55**	**88.7**	**7**	**11.3**	53	85.5	9	14.5	
50 to 64	**48**	**88.9**	**6**	**11.1**	40	75.5	13	24.5	41	75.9	13	24.1	
65 to 74	33	70.2	14	29.8	**22**	**50.0**	**22**	**50.0**	37	77.1	11	22.9	
75+	**7**	**41.2**	**10**	**58.8**	**14**	**50.0**	**14**	**50.0**	10	71.4	4	28.6	
Gender													
Female	101	73.2	37	26.8	92	71.3	37	28.7	94	79.7	24	20.3	0.99
Male	77	77.8	22	22.2	68	69.4	30	30.6	74	79.6	19	20.4	

*Based on the General Association Statistic of the Cochran-Mantel-Haenszel Statistics test

The Cochran-Mantel-Haenszel Statistics test, a popular statistical method to test an association in cross-tabulation, was also employed to examine whether there are statistically significant variations in survey participants across the surveys. The p-values smaller than .1 indicate that correct and incorrect identifications are significantly associated with variables adjusting for any effects of three different survey periods.

The results show that 75.1 percent of survey participants correctly understood the intended meaning of the current signs in the first survey. In the second survey with the experimental sign, the rate decreased to 70.5 percent. However, the rate increased significantly to 79.6 percent in the third survey. This clearly indicates that the experimental sign better delivers the intended meaning. This result is also supported by the fact that whether survey participants previously observed the signs is not significantly associated with correct identification of the signs. In the second survey, previous exposure to the sign was significantly associated with the correct identification. However, the association disappeared in the third survey. Therefore, the association between the previous exposure to signs and the correct identification is found to be weak overall. The association between the number of signs observed and the correct identification was found to be insignificant. The association was significant only in the case of no observation in the second survey.

In the first survey with the current signage, survey participants who felt it difficult to understand the sign were more likely to incorrectly identify the sign compared to those who felt it is similar or easier to understand the signs. The same results held true for the second survey. However, in the third survey, survey participants who felt it easier to understand the sign were more likely to incorrectly identify the sign. These mixed results indicate that the association between the ease of understanding of the signs and the correct identification is not clear.

The association between the visibility of signs and the correct identification is not significant. However, the percent of correct identification among those who felt the experimental sign easier to notice was significantly higher than the percent for the current sign. Also, the percent of correct identification among those who felt the experimental sign difficult to notice was significantly lower than the percent for

the current sign. This indicates the experimental sign's noticability is more important in facilitating people's correct identification of the sign than the current signs.

Residency had relatively little significance in correct identification of the signs. However, the number of years in driving in the study area shows an interesting pattern. Compared to the current sign, the variations of correct identification by the number of years of driving fluctuate less than the experimental sign. In the first survey, the percent of correct identification among those who have 40 or more years of driving experiences in the study area was significantly lower than others. However, it is possible that in this case, driving experience serves as a function of old age. The number of hours driven per week was not observed to be a statistically significant variable in correct/incorrect meaning identification even though those who drove less than 10 hours are less likely to correctly identify the meaning of the sign in the second survey.

Age was observed to be statistically significant in correct identification of the signs. A general pattern found in the surveys is that older survey participants (65+) are less likely to correctly identify the meaning of the signs. The association between age and the identification of the signs is statistically significant. This indicates careful consideration needs to be given in designing traffic signs. However, unlike age, gender was found to be not significant in correct identification of the signs.

3. Analysis of Correct Understanding of Sign by Age and Gender

Age was found to be an important factor associated with correct identification of the photo-enforced signs. Older survey participants tend to be less likely to identify the meaning of signs. However, gender was not found to be a significant factor in survey participants' ability to derive the signs' correct meaning.

Population aging in society has raised safety issues. It is expected the older population (65+) will double from about 35 million to more than 70 million between 2000 and 2030 and the proportion of older adults in the population is also projected to increase from 12.4% in 2000 to 19.6% in 2030 (US Census Bureau, 2004). Not surprisingly, the older population is also the fastest growing segment of licensed

drivers. The number of older drivers increased by 32% from 1991 to 2001, whereas the total number of licensed drivers increased by only 13% (US DOT, 2003). The proportions of licensed drivers and miles driven have increased significantly for the older population. A study found the percentage of licensed drivers among the older population increased from 63% to 75%, and their average annual driving mileage increased by 44% between 1983 and 1995 (Lyman et al., 2002). This growth has raised concerns, because traffic crash statistics show an increasing automobile collision risk per mile driven beginning around age 65. For example, on the basis of estimated annual travel, it was reported that the fatality rates of drivers aged 85+ are nine times those of drivers aged 25 to 69 (US DOT, 1999). The majority of crashes involving older drivers occur at intersections where multiple traffic signs often exists (Ulfarsson et al., 2006).

Table 3 shows more in-depth analysis on the association between basic personal characteristics (age and gender) and the ability to identify the signs correctly. The frequency of correct understanding of the sign is broken down by age and then by age and gender, splitting up male and female participants into groups of those under 65 and those 65 or older.

Table 3 Correct Understanding of Sign by Age and Gender

	Survey I				Survey II				Survey III				p-value*
	Correct		Incorrect		Correct		Incorrect		Correct		Incorrect		
	Freq	Pct	Freq	Pct	Freq	Pct	Freq	Pct	Freq	Pct	Freq	Pct	
Older (65+)	**40**	**62.5**	**24**	**37.5**	**36**	**50.0**	**36**	**50.0**	47	75.8	15	24.2	0.00
Younger (<65)	**138**	**79.8**	**35**	**20.2**	**124**	**80.0**	**31**	**20.0**	131	82.4	28	17.6	
Older Female (65+)	**21**	**56.8**	**16**	**43.2**	**20**	**48.8**	**21**	**51.2**	24	75.0	8	25.0	0.00
Older Male (65+)	19	70.4	8	29.6	**16**	**51.6**	**15**	**48.4**	23	76.7	7	23.3	
Younger Female (<65)	80	79.2	21	20.8	**72**	**81.8**	**16**	**18.2**	70	81.4	16	18.6	
Younger Male (<65)	58	80.6	14	19.4	52	77.6	15	22.4	51	81.0	12	19.0	

*Based on the General Association Statistic of the Cochran-Mantel-Haenszel Statistics test

The results show 62.5 percent of older survey participants (65+) correctly understood the intended meaning of the current signs in the first survey. In the second survey with the experimental sign, the rate decreased to 50.0 percent. However, the rate increased significantly to 75.8 percent in the third

survey. This clearly indicates that the experimental sign better delivers the intended meaning to older survey respondents in 9 months after installation. Note that the percentage of correct identification of younger survey participants (<65) does not change much across the surveys. In the first and second surveys, there were statistically significant differences between the two groups. However, the difference disappeared in the third survey.

In general, the result isolates older female drivers as the specific group of vulnerable drivers in identifying the signs' meaning correctly. In the first survey, older females had a significantly lower percent of correct identification. In the second, survey, both older females and males had significantly lower percents. However, in the third survey the statistically significant differences among the four groups disappeared even though the percents of older survey participants were lower than those of younger survey participants.

The result indicates the experimental signs may improve correct understanding of red light photo enforcement and improve the safety of an increasing number of older drivers in an aging society. This result also implies older survey participants dramatically improved their understanding of the experimental sign in a relatively short period of time.

D. Conclusions and Recommendations

This project evaluated current and experimental red light running photo-enforced signs. The key findings of this study include:

1. The experimental sign improved correct understanding of red light running photo enforced (75.1 percent with the current sign vs. 79.6 percent with the experimental signs 9 months after installation).
2. Among those who did not observe the signs previously, the experimental sign was more correctly identified than the current signs (83.3 percent vs. 70.4 percent).
3. Differences between the experimental and current signs' visibility and noticability are unclear. However, those who correctly identify the meaning of the experimental sign are more likely to state that the sign is clearer to see and notice.
4. The experimental sign significantly improved older survey participants' (older females in particular) correct identification of the sign.

Based on these key findings, this study proposes the following recommendations.

1. More implementation of the experimental photo-enforced sign can be considered.

This study shows that understanding of the signs improved with the experimental sign, which denotes potential for increased obedience of signs and decreased accidents. The study was conducted in a limited geographical area, in a short period of time, and with a relatively small sample size. Therefore, it may be necessary to consider conducting similar studies in other areas to get more universal findings. However, this study found the experimental signage better delivers the intended meaning of the sign in a relatively short period of time after installation in the study area. Also, whether survey participants previously

observed the sign was not significantly associated with correct identification of the sign. This indicates the experimental sign is fairly intuitive in delivering its intended meaning.

2. A design improvement on the experimental photo-enforced sign can be considered.

The survey team asked survey participants who had reported the experimental sign to be more difficult to see or notice why they reported so. The majority of them responded that the white background and small size of the experimental sign made it difficult for them to notice it on the roads. A bigger size and thicker black edge line on the experimental sign may significantly improve its noticability.

3. The effect of age in understanding of correct meaning of traffic signs needs more attention.

In this study, older survey participants (older females in particular) dramatically improved their understanding of the experimental sign. This indicates the level of understanding of traffic signs may be significantly correlated to one's age and/or gender. This may pose serious challenges in traffic safety in an aging society. The finding of this study indicates efforts to improve traffic signs to better deliver their meaning to older drivers need more attention to improve traffic safety in an aging society.

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Appendix A

Dear Survey Participant:

The Missouri Department of Transportation (MoDOT) has implemented a new traffic sign to promote safety of drivers, pedestrians, and other road users in the State of Missouri. With the coordination of the City of Arnold, this survey is to examine the public's awareness of the new sign and thus better serve you by promoting your traffic safety. Please contact Dr. Kim at (816) 235-6898 at the University of Missouri-Kansas City, if you have questions/concerns.

1. Have you seen the following sign on the roads? _____ Yes _____No

2. How many such signs have you observed? _____

3. What does this sign tell drivers (mark all you believe apply)?

___Speeding is photo enforced
___Red light running is photo enforced
___Jaywalking is photo enforced
___Improper left turns are photo enforced
___Improper right turns are photo enforced
___Other. Explain: _____

4. Please judge your understanding of this sign compared to other roadway signs:
_____Easier to understand _____Similar _____More difficult to understand

5. If you have seen the sign, was it clearly visible?
_____Yes _____Somewhat _____Not Very

6. If you have seen the sign, was it easier to notice this sign than other signs?
_____Easier to notice _____Similar to others _____More difficult to notice

7. Do you live in the city of Arnold? _____ Yes _____No

8. How many years have you driven in this area? _____ Year(s)

9. How many hours do you drive per week? _____ Hour(s)

10. Your age is ____18-19 ____20-24 ____25-29 ____30-49 ____50-64 ____65-74 ____75+

11. Your gender is: _____ Male _____Female

Thank you very much for your help and cooperation.

Appendix B

Dear Survey Participant:

The Missouri Department of Transportation (MoDOT) has implemented a new traffic sign to promote safety of drivers, pedestrians, and other road users in the State of Missouri. With the coordination of the City of Arnold, this survey is to examine the public's awareness of the new sign and thus better serve you by promoting your traffic safety. Please contact Dr. Kim at (816) 235-6898 at the University of Missouri-Kansas City, if you have questions/concerns.

1. Have you seen the following sign on the roads? _____ Yes _____No

2. How many such signs have you observed? _____

3. What does this sign tell drivers (mark all you believe apply)?

___Speeding is photo enforced
___Red light running is photo enforced
___Jaywalking is photo enforced
___Improper left turns are photo enforced
___Improper right turns are photo enforced
___Other. Explain: _____

4. Please judge your understanding of this sign compared to other roadway signs:

_____Easier to understand _____Similar _____More difficult to understand

5. If you have seen the sign, was it clearly visible?

_____Yes _____Somewhat _____Not Very

6. If you have seen the sign, was it easier to notice this sign than other signs?

_____Easier to notice _____Similar to others _____More difficult to notice

7. Do you live in the city of Arnold? _____ Yes _____No

8. How many years have you driven in this area? _____ Year(s)

9. How many hours do you drive per week? _____ Hour(s)

10. Your age is ____18-19 ____20-24 ____25-29 ____30-49 ____50-64 ____65-74 ____75+

11. Your gender is: _____ Male _____Female

Thank you very much for your help and cooperation.

Appendix C

Participation Solicitation

The survey will be administered by a team member who will approach adults in public places in the City of Arnold and ask if they would like to participate in the survey. Consent will be oral and received through the following script.

Participation Script Introduction (Phase I):
Hi, my name is X [name of Team Member], and I am from University of Missouri-Kansas City. The Missouri Department of Transportation has installed a new sign in the City of Arnold and the University of Missouri-Kansas City is conducting a survey to evaluate the public's awareness of the new sign in an effort to improve traffic safety. This is a survey that takes less than 5 minutes to complete.

Participation Script Introduction (Phase II and III):
Hi, my name is X [name of Team Member], and I am from University of Missouri-Kansas City. The Missouri Department of Transportation has installed a experimental sign in the City of Arnold and University of Missouri-Kansas City is conducting a survey to evaluate the public's awareness of the new sign in an effort to improve traffic safety. This is a survey that takes less than 5 minutes to complete.

Participation Script Questions (All Phases):

Are you an adult (18 or older)?

> **If no:** Unfortunately you cannot participate in the survey. We thank you very much for your time. [Give contact information in case person has questions later]

Are you a driver who would like to participate in the survey?

> **If no:** We thank you very much for your time. [Give contact information in case person has questions later]

Have you driven past (location TBD by Missouri Department of Transportation) in the last 3 days?

If no: You haven't had a recent opportunity to observe the sign, but we would like to show you a picture of the sign, and ask you to complete the survey.

> [Give contact information and continue to survey]

If yes: [Give contact information and continue to survey]

Contact Information to be given to participants

Project Director: Sungyop Kim, phone: (816) 235-6898, kims@umkc.edu

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