9-6-2016

Identifying Association Between Pedestrian Safety Interventions and Street Crossing Behavior Considering Demographics and Traffic Context

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University of Puerto Rico at Mayagüez, 2013

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

At the

University of Connecticut

2016

APPROVAL PAGE

Master of Science

Identifying Association Between Pedestrian Safety Interventions and Street Crossing Behavior Considering Demographics and Traffic Context

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2016

ACKNOWLEDGEMENTS

This study is part of a larger project on analyzing the effect of social networks on people's attitude towards street crossing. Therefore I would like to acknowledge the effort and help of all the team members of this project. I would like to give special thanks to Dr. John Ivan for his impeccable advisory throughout the year, and for his support, patience and availability when I was away due to health problems. I would also like to thank Dr. Nalini Ravishanker for her expertise and valuable assistance in the statistical part of the study. Last but not least, I would like to thank Dr. Karthik Konduri for being part of my Advisory Committee, Dr. Rebecca Townsend from Manchester Community College for her advisory and logistics in the data collection process, Dr. Sha Mamun for his help in overall matters of the study and the development of the videos used in this study, and Yaohua Zhang for this help regarding the statistical software used in this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Pedestrian fatalities are becoming a larger percentage of overall fatalities in the United States, therefore pedestrian safety research is essential for understanding and improving pedestrian safety. Pedestrian safety interventions are often used to educate and consequently improve pedestrian behavior. This study used pedestrian safety interventions to assess their effect on the respondents' stated crossing behavior. Also, specific demographic data was used in this study to identify behavioral trends regarding street crossing behavior. The results show that pedestrian safety interventions are significantly associated with changes in pedestrian crossing behavior. The effect of the interventions was predominantly positive, since the respondents' behavior after the interventions were given showed improvement relative to a comparison group. This study also found significant association between demographic variables such as gender, age, marital status and having kids. Women were more compliant than men, and respondents aged twenty-five years or younger were more compliant after the interventions. Married respondents were more compliant than unmarried ones. Respondents who drive often were more compliant, but having been involved in a car accident was not significant in explaining crossing behavior. This study was able to assess the effect of pedestrian safety interventions and also was successful in identifying behavioral trends among respondents.

INTRODUCTION

Background and Objectives

The Governors Highway Safety Association (*1*) reports that the number of pedestrians killed in 2015 has increased ten percent (10%) since 2014. Despite a two percent decrease in pedestrians' fatalities from 2012 to 2013 (*2*), pedestrian fatalities are becoming a larger percentage of overall fatalities in the United States. Therefore, providing safe environments both for drivers and pedestrians is still a goal we continue to strive for. Aggressive driving, alcohol involvement, time of the day, site characteristics and location, are some of the numerous factors related to pedestrian fatalities (*2*), but it is also important to have a broader understanding of such fatalities from the pedestrian's perspective. The understanding of pedestrian behavior is an area that has not been developed to the same level as vehicular travel research (*3*).

Transportation safety-related interventions are implemented as an effort to provide safe facilities for the users. Such interventions are often focused on engineering and enforcement, but could also be implemented from an educational standpoint. Often, the general idea of pedestrian traffic safety tends to place the burden of responsibility on the pedestrians behavior and emphasizes education as one of the most important efforts for crash prevention (*4*). As education could lead to a better awareness of a certain event, it is also plausible that people might do what they feel is correct at a certain moment whether or not it complies with the rules. Freeman & Rakotonirainy (*5*) discuss the factors associated with pedestrians making errors versus deliberately violating crossing signage at rail crossings, and found that most of the people involved in the survey were aware of the rules for safe crossing, however chose to break such rules and cross whenever they felt it was safe. Pedestrians, as stated by Baass (*6*), due to their inherent mobility, will always be likely to shorten distances and waiting times, sometimes

disregarding the potential risks involved. It is important not to forget that every facility developed for any sort of safety intervention is going to be used by people. With that in mind, it is important to understand the people for whom the intervention is designed. A better understanding of the people that are going to be using a certain facility will lead to a better interaction between the user and such facility.

Demographic data are often used to characterize and identify trends and changes in people's behavior. While it is true that human behavior complexity involves factors not fully understood, it is also possible that external influences could play a crucial role in people's everyday decision-making processes. We could think of people as complex, unpredictable, and constantly changing beings, but we must not ignore the fact that we are social beings, susceptible to external influences due to the inevitable nature of our social instinct. Therefore, this study uses demographic data to identify behavioral trends and learn about people's choices when crossing a signalized intersection.

This study is part of a broader research project analyzing the effect that social networks might have on people's attitude towards street crossing. The broader project consists of a combination of in-person gatherings and online respondent driven sampling surveys. This study focuses on the "small data" gathered during in-person focus group surveys. The objective of this study is to assess the effect of pedestrian safety interventions on stated behavior choices of surveyed respondents and to identify association between certain demographic groups and these choices given different contexts: different lane configuration and traffic densities.

Relevance to Previous Research

Pedestrian behavior has been studied for decades, however it has been approached in many different ways. Existing research has focused on the risk factors, observed behaviors, and physical intersection characteristics that have influenced the pedestrian decision on whether or not to comply with the traffic signals (*7*). Recent studies have explored pedestrian behavior at intersections (*8*) (*9*); others have also looked at the relationships between the intersection traffic operations characteristics and the pedestrian crossing decisions (*10*). Hussein looked at pedestrian interactions using gait parameters such as walking speed, moving direction, and change in velocity (*3*). Schoon investigated the reaction time of pedestrians and head pitch movements at uncontrolled crossing locations (*11*). Studies have suggested that pedestrian crossing behavior is influenced by a person's attitude and perceived behavioral control and intention (*12*). Pedestrian crossing behavior is also influenced by several human and environmental factors, as well as demography (13).

Several studies have approached pedestrian behavior focusing on the pedestrian attitudes towards street crossing. These studies are often conducted using surveys of stated preferences (*14*), (*15*), (*16*), (*17*). Many studies have looked at the effect of pedestrian safety interventions, and have documented improvements in crossing behaviors. Particularly, most of the studies looking at the effects of interventions are focused on child pedestrian safety and behavior improvements were reported (*18*), (*19*), (*20*), (*21*), (*22*), (*23*), (*24*). Demographic factors and their relation to pedestrian compliance have also been studied. Gender and age have been discussed as relevant demographic factors influencing street crossing behavior (*13*), (*25*), (*26*), (*27*), (*28*). This study considers a wider range of demographic data as an effort to identify their association to street crossing behavior. Some studies, based on behavioral observations through

videos, often cannot collect detailed data about the pedestrians; therefore, one of the advantages of this study is that specific demographic data is given by the respondents.

STUDY DESIGN AND DATA

Data Collection

This study is a collaborative effort between researchers at the University of Connecticut and a faculty member and students at Manchester Community College. Students from Manchester Community College Communication classes (as part of their course credit) served as the starting point for participation in the study. To create the focus groups, students were separated into groups and were asked to gather people from their respective social circles. Therefore, this study employs in-person focus group surveys for gathering demographic data about each participant, including gender, age, race, town of residence, education level, general income level, and so on. Since the data used in this study are combined from ten different focus groups it is highly possible that the respondents know each other, therefore, their thought pattern might be similar. Rather than actual observations of the participants' behavior when crossing a street, stated preferences of the respondents are the source of data for this analysis. Their stated preferences might not represent their actual behavior but it tells us about their intentions.

In addition to asking for demographic data, the participants in each focus group were divided equally into four intervention groups, consisting of the same questions but with each group receiving a different mix of interventions. There are three intervention groups receiving either education or discussion or both, and one control group that receives neither intervention. Following is a brief description of each intervention group:

- Control Group – No intervention (NI): This is the control group, which does not receive any educational information nor does it participate in any discussion.

- Intervention Group 1 – Education Only (EO): A meeting facilitator provides facts about observed pedestrian behavior and safety experience to participants.
- Intervention Group 2 – Discussion Only (DO): A meeting facilitator moderates a twenty-minute discussion about general pedestrian safety attitudes and choices.
- Intervention Group 3 – Education and Discussion (ED): The respondents receive the educational material presented to Group 1 and also participate in a discussion about safe street-crossing behavior like Group 2, including discussion of the presented facts.

This survey design allows investigating whether or not the interventions have any effect on the respondents' attitudes about safe street crossing. All participants answered the same survey questions, and the survey was conducted in two parts, Part 1 and Part 2. In Part 1, the respondents answered the questions and watched four videos of different traffic contexts (two or four travel lanes, and 300 or 700 vehicles per hour per lane) and specified in which moment they would cross the street if they were there in real life. After Part 1, the participants were separated into randomly assigned Intervention Groups and received an intervention depending on what group they were in (except for the control group). After the interventions, the participants proceeded to answer Part 2 of the survey in which again, they watched another set of four videos (which were the same as in Part 1 but in different random order) and chose the time in which they would cross. Table 1 shows a layout of the data collection process depending on the Intervention Groups, and Figure 1 shows a screenshot of the videos used in the survey.

Table 1 - Data Collection Process: Intervention Groups

Control Group (NI)	Intervention Group 1 (EO)	Intervention Group 2 (DO)	Intervention Group 3 (ED)
Survey: Part 1	Survey: Part 1	Survey: Part 1	Survey: Part 1
Intervention: None	Intervention: Education	Intervention: Discussion	Intervention: Education & Discussion
Survey: Part 2	Survey: Part 2	Survey: Part 2	Survey: Part 2

Note: Both survey Parts 1 and 2 include questions regarding demographic data.

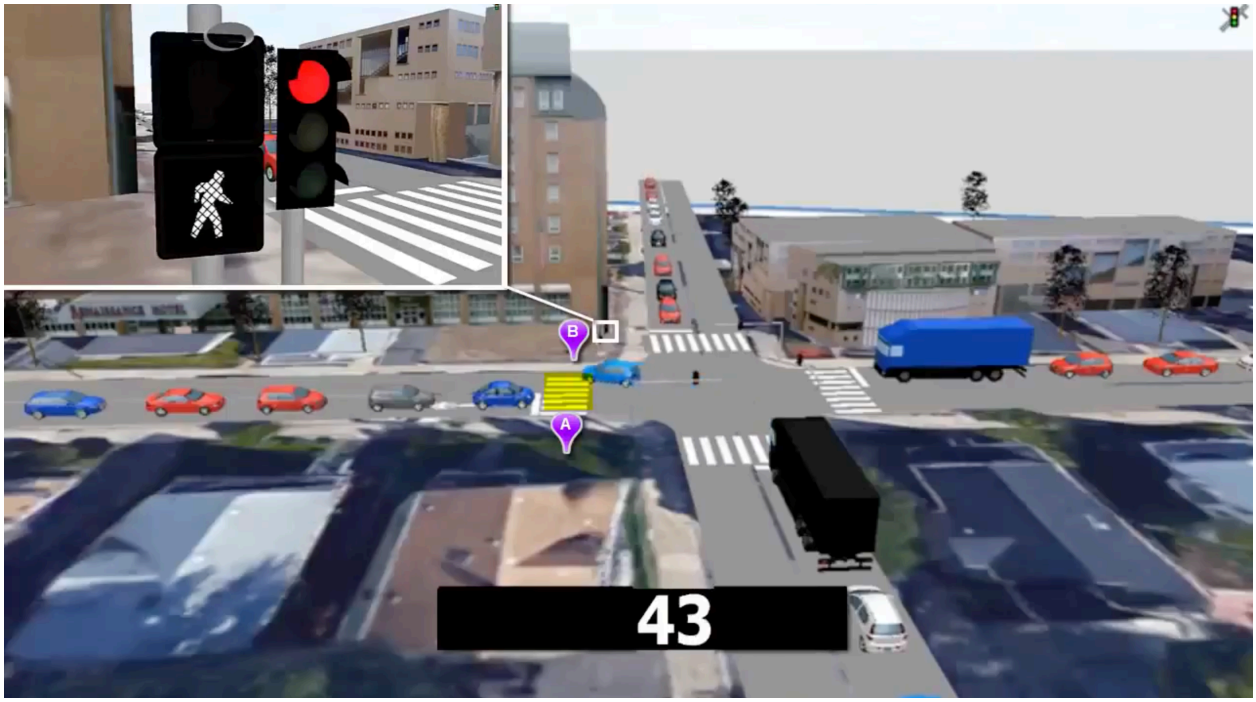

Figure 1 - Format of the video simulations used for the survey. Pedestrians were told to imagine they had to cross from point A to B and were asked to indicate how many seconds into the video they would cross.

Data Obtained

Response Variables

The response variables (CROSS1 and CROSS2) are the times in which the respondents stated they would cross the signalized intersection before and after the interventions, respectively. As previously discussed, as part of the survey, the respondents watched four videos presenting different traffic and geometric conditions of a certain intersection. Such conditions are presented in four different contexts; Table 2 shows the volume and lane configuration for each context. For easier interpretation of the responses obtained, the crossing times (CROSS1 and CROSS2), originally in seconds, were classified into three categories: "Red" (R), "Green" (G), and "Walk" (W), based on the signal phasing in effect during each time interval.

Table 2 - Lane and Volume Configuration Per Context

Context	Number of lanes	Volume (veh/h/ln)
2-low	2	300
4-low	4	300
2-high	2	700
4-high	4	700

Potential Explanatory Variables

As the respondents provided their answers to the in-person surveys, this project focuses in the survey questions that are mostly related to the demographic data, as well as the effect of the interventions on their responses. Table 3 shows the predictor variables considered for explaining the response variables (CROSS1 and CROSS2) along with the name of each variable, the survey question related to it, and the possible responses.

Table 3 - Potential Predictor Variables

Variable	Question	Choices
DRIVE	How often do you drive a car/truck:	Daily, Weekly but not daily, Monthly but not every week, Very seldom, Never
ACCIDENT	Have you been in a car/truck/bus accident involving pedestrians (people walking, or using wheelchairs) or know someone who has?	Yes, No
GENDER	Please indicate your gender:	Man, Woman, Transgender, Prefer not to answer
MARITAL	What is your current marital status?	Married, Unmarried
KIDS	What is the number of children you have, or care for?	0, 1, 2, 3 or more
WALK	How often do you walk in built up areas of towns or cities:	Daily, Weekly but not daily, Monthly but not every week, Very seldom, Never
AGE	What is your age?	18 and under, 19 - 25, 26 - 45, 46 - 65, 66 and over
EMPLOY	What is your current employment status?	Student and full time employed, Student and part time employed, Student not employed, Full time employed, Part time employed, Unemployed for less than a year, Unemployed for more than a year, Retired, Other
EDUC	What is your education level?	Still in school, High school, Some college, Associate's degree, Bachelor's degree, Master's and or Doctoral degree
RACE	What is your racial/ethnic identity?	African American/Black, American Indian or Alaskan native, Asian/Pacific Islander, Caucasian/White, Hispanic/Latino, African American/Black & Hispanic/Latino, African American/Black & Caucasian/White, Caucasian/White & Asian/Pacific Islander, African American/Black & American Indian or Alaskan native, Caucasian/White & Hispanic/Latino, Other

For consistency and simplicity, all variables were re-categorized into binary variables in order to perform 2 × 2 contingency table analyses. Table 4 shows the re-categorization of the variables as well as their respective frequencies. As previously mentioned, the majority of the respondents are college students; therefore, as shown in Table 4, seventy-seven percent (77%) of the respondents are twenty-five years old or younger. Consequently, eighty-eight percent (88%) of the respondents are not married, and seventy-nine percent (79%) don't have kids.

Table 5 shows the frequencies of the response variables (CROSS1 and CROSS2) chosen by the respondents. The majority of the respondents chose to cross under the "Walk" (W) signal, which indicates a compliant behavior among respondents. Slightly more compliance is observed for the "4-low" and "4-high contexts" for both before and after scenarios. This suggests that people are more likely to be compliant when the crossing distance is larger, agreeing with what other studies have found about the significance of crossing distance in crossing behavior (*15*) (*29*) (*30*).

Table 4 - Frequencies Percentages For All Variables

Variable	**Categories and Percentages (%)**			
DRIVE	Often	64%	Seldom	36%
GENDER	Male	45%	Female	55%
AGE	≤25	77%	>25	23%
MARITAL	Married	12%	Unmarried	88%
KIDS	Yes	21%	No	79%
WALK	Often	14%	Seldom	86%
ACCIDENT	Yes	23%	No	77%
EDUC	Secondary	32%	Higher	68%
EMPLOY	Employed	64%	Unemployed	36%
RACE	White	57%	Minority	43%

Table 5 - Frequency Percentages of CROSS1 and CROSS2 For All Contexts

	CROSS1 (%)			CROSS2 (%)		
Context	R	G	W	R	G	W
2-low	11	31	58	21	23	56
4-low	17	13	70	12	25	63
2-high	14	28	58	22	17	61
4-high	15	24	61	18	26	56

METHODOLOGY

This study's objectives were first to assess the effect of pedestrian safety interventions on people's street crossing behavior, and second to identify whether certain demographic data and groups are associated to the variability in street crossing behavior. First, this study employs the use of the McNemar's test for paired proportions to determine if there are significant changes in responses before and after interventions. Second, the Pearson's Chi-Square Test of Association was used to determine significant association between the independent variables and the response variables CROSS1 and CROSS2, as well for identifying behavioral trends among certain demographic groups.

Interventions Effect on Respondents

The McNemar's test was used to compare before and after responses for each respondent to identify any significant changes, either positive or negative, due to the pedestrian safety interventions. The level of compliance was determined by looking at each respondent's choice of when to cross the street, therefore, if the respondent chose to cross under the "Walk" signal then the behavior is considered "compliant", otherwise a "non-compliant" behavior was assigned. Response variables CROSS1 and CROSS2 were re-categorized from "Red" (R), "Green" (G), and "Walk" (W) into "Compliant" and "Non-compliant" in order to transform the variable into binary form so the McNemar's test could be performed.

McNemar's test is a statistical method used on paired dichotomous observations to test the significance of the difference between proportions, particularly used on before and after studies in which the effectiveness of a treatment needs to be assessed (*31*). It was introduced in 1947 by Quinn McNemar and is performed by using 2 × 2 contingency tables of the form shown in Figure 2. The statistic of the McNemar's test has a chi- square distribution with one degree of freedom, and the formula is shown in Equation 1, which is the formula used by Statistical Analysis Software (SAS) (*32*):

$$\chi^2 = \frac{(A - D)^2}{A + D} \qquad (1)$$

where A and D represent, in the case of this study, the number of respondents who changed their behavior from "compliant" to "non-compliant", and from "non-compliant" to "compliant", respectively. The outcome of this analysis provides the number of respondents who changed their answers positively or negatively, as well as the ones who stayed the same, giving insight about the effectiveness of the pedestrian safety interventions on their crossing behavior.

		(After)	
	Non-compliant	Compliant	
Compliant (Before)	A	B	A + B
Non-compliant	C	D	C + D
	A + C	B + D	n

Note: This table has been adapted to the analysis discussed in this study; its general form may vary upon the study type.

Figure 2 - McNemar's Test 2 x 2 Contingency Table Form

Association Between Study Variables and Crossing Time

The second part of this methodology consisted of determining significant association between the independent variables previously discussed and the crossing times CROSS1 and CROSS2, for each traffic context. Identifying significant association between the independent variables and the response variables allows for a better understanding of the factors influencing or explaining certain events. Also, besides determining association, this study looks at how certain demographic groups behave when crossing a street. Considering the independent variables previously discussed, many studies have analyzed street crossing behavioral trends of different demographic groups like men versus women (*33*) (*34*) (*35*) (*36*) (*37*) (*38*), as well as different age groups (*26*) (*27*) (*28*) (*39*) (*40*), therefore, this study focuses on adding more demographic groups (*e.g.*, employment status, education, race, marital status) to the discussion.

Pearson's Chi-square Test of Association was used for each variable as well as for each context (2-low, 4-low, 2-high, and 4-high) against the crossing time responses for before and after interventions (CROSS1 and CROSS2, respectively). This analysis was performed using 2 × 3 contingency tables of each pair of independent and dependent variables. Figure 3 shows the general form of the contingency tables prepared for this analysis. The results obtained from this analysis shed light about the association, if any, of the independent variables (demographic groups) considered in this study (DRIVE, WALK, GENDER, AGE, MARITAL, KIDS, ACCIDENT, EMPLOY, EDUC, and RACE). Also, the number and percentages of people choosing to cross on either "Red", "Green" or "Walk" provides the base for assessing the street crossing behavioral trends of each demographic group. Equation 2 shows the formula used for the chi-square test where O_i and E_i represent the observed and expected values, respectively:

$$\chi^2 = \sum_{cells} \frac{(O_i - E_i)^2}{E_i} \qquad (2)$$

		Dependent Variable (CROSS)			
		Red	Green	Walk	
Independent Variable	Category 1	O_A E_A	O_B E_B	O_C E_C	$O_A + O_B + O_C$
	Category 2	O_D E_D	O_E E_E	O_F E_F	$O_D + O_E + O_F$
		$O_A + O_D$	$O_B + O_E$	$O_C + O_F$	n

Note: This table has been adapted to the analysis discussed in this study; its general form may vary upon the study type.

Figure 3 - Contingency Table Form for Chi-square Test

RESULTS AND DISCUSSION

Interventions Effect on Respondents

The results from the McNemar's test for significant change in responses between the before-intervention scenario and the after-intervention scenario are shown in Table 6. The values are presented for each intervention group as well as for each context. Due to the small size of the samples ($n_{NI} = 26$; $n_{EO} = 41$; $n_{DO} = 37$; $n_{ED} = 33$), a significance level of $\alpha = 0.10$ was used to determine significant change in repeated measures responses. Table 6 shows the p-values for the control group NI, as well for the other three groups that were under the influence of an intervention (EO, DO, and ED). It is important to recall that NI being the control group of the survey provides a baseline for comparison and assessment of the effect of the interventions on the respondents' crossing behavior. Besides analyzing the before and after results of the effect of

the interventions, it is also important to assess the change between the control group and the groups with interventions to learn about the overall effect of the interventions on the respondents behavior regardless of the type of such interventions.

Table 6 - McNemar's Test of Significant Change (Before and After Intervention) For Each Intervention Group and Context (p-values)

Intervention Group	**Context**			
	2-low	4-low	2-high	4-high
NI	**0.0075**	**0.0075**	**0.0126**	**0.0045**
EO	**0.0635**	0.1797	0.1444	0.4142
DO	0.5316	0.7963	**0.0495**	**0.0290**
ED	0.4386	0.1967	0.2059	**0.0124**

Note: Bold values indicate significance at $\alpha = 0.10$.

Half of the scenarios resulted in significant change in response from before to after the intervention. In order to assess whether the change was positive ("non-compliant" to "compliant"), the proportion of how many respondents changed their answers needs to be observed. Table 7 shows the description of the changes found significant for each scenario. The no-intervention group (NI) was found to be the only group with significant changes throughout all four contexts, however the change was found to be negative for all contexts. This suggests that the control group's behavior worsened rather than not changing.

Table 7 - Details of the Significant Changes

Intervention Group	Traffic Context	Crossing Response	Initial Number	Number Changing	Percent Changing	Change (+/-)
NI	2-low	Non-compliant	11	2	18%	-
		Compliant	15	12	80%	
	4-low	Non-compliant	8	2	25%	-
		Compliant	18	12	67%	
	2-high	Non-compliant	8	2	25%	-
		Compliant	18	11	61%	
	4-high	Non-compliant	9	2	22%	-
		Compliant	17	13	76%	
EO	2-low	Non-compliant	18	13	72%	+
		Compliant	23	5	22%	
DO	2-high	Non-compliant	18	15	83%	+
		Compliant	19	6	32%	
	4-high	Non-compliant	16	13	81%	+
		Compliant	21	4	19%	
ED	4-high	Non-compliant	9	3	33%	-
		Compliant	24	13	54%	

Note: (+) accounts for a greater positive change ("non-compliant" to "compliant); (-) accounts for a greater negative change ("compliant" to "non-compliant")

For the education-only (EO) intervention group, only the "2-low" context showed a significant change. This change turned out to be positive, since seventy-two percent (72%) of the respondents who initially answered in a "non-compliant" manner switched their responses to a crossing time within the "compliant" behavior. Similarly, the discussion-only (DO) intervention group showed a significant positive effect on the contexts "2-high" and "4-high", with eighty-three percent (83%) and eighty-one percent (81%) changing from "non-compliant" to "compliant", respectively. The education and discussion (ED) intervention group showed a significant yet negative effect of the intervention on the respondents for context "4-high". Only thirty-three percent (33%) of the initial "non-compliant" responses changed to "compliant", the

other fifty-four percent (54%) of the respondents changed from "compliant" behavior to "non-compliant".

If we compare the groups under the influence of an intervention regardless of its type (EO, DO, or ED) versus the control group NI, we can assess in a more general way the effect of the interventions. The p-values shown in Table 6 indicate that eleven out of twelve scenarios reflected either no change or a positive change. Noting that the control group NI reflected a behavioral trend sliding towards non-compliance, we can suggest that the intervention groups did have a predominantly positive effect on people's street crossing behavior.

Considering that the interventions did have a positive effect on the respondents' behavior, we can also identify which intervention group was most effective. The DO group was the one showing significant positive change in more than one context. Contrary to what might have been expected, the ED group was not as effective as the DO, even when the ED group was the one with more information about pedestrian safety.

Association Between Study Variables and Crossing Time

The results from the chi-square tests of association between each variable against crossing times (CROSS1 and CROSS2) on all four contexts are shown in Tables 8, 9, 10, and 11. Each table shows the p-values for each variable for both the before and after intervention scenarios, as well as the percentages of people choosing to cross on "Green" (G), "Red" (R) and "Walk" (W). For convenience, a summary of the results shown on Tables 8, 9, 10, and 11 about which variables are significantly associated with CROSS1 and CROSS2 is presented in Table 12.

Table 8 - Chi-square Test of Association (2-low)

		2-low (Before)				2-low (After)			
		CROSS (%)				CROSS (%)			
Variable	**Value**	R	G	W	**p-value**	R	G	W	**p-value**
DRIVE	Often	7	33	60	**0.0606**	20	22	59	0.87
	Seldom	20	25	55		22	24	54	
GENDER	Male	18	32	50	**0.0842**	20	15	64	0.1391
	Female	6	30	64		21	29	50	
AGE	≤25	13	33	54	0.1793	22	19	59	0.1933
	>25	6	22	72		16	34	50	
MARITAL	Married	12	12	76	0.181	29	35	35	0.1486
	Unmarried	11	34	56		19	20	60	
KIDS	Yes	7	10	83	**0.0063**	27	40	33	**0.0082**
	No	13	36	51		19	18	64	
WALK	Often	15	30	55	0.8539	25	25	50	0.7809
	Seldom	11	31	59		20	22	58	
ACCIDENT	Yes	15	33	52	0.6096	21	27	52	0.722
	No	10	30	60		20	21	59	
EDUC	Secondary	13	27	60	0.7459	14	21	65	0.3489
	Higher	10	32	57		23	23	53	
EMPLOY	Employed	9	33	58	0.37	23	26	51	0.1367
	Unemployed	16	25	59		16	16	68	
RACE	White	13	31	56	0.8326	19	21	60	0.7455
	Minority	10	30	61		22	25	53	

Note: Bold values indicate significance at $\alpha = 0.10$.

Table 9 - Chi-square of Association (4-low)

		4-low (Before)				**4-low (After)**			
		CROSS (%)				CROSS (%)			
Variable	**Value**	R	G	W	**p-value**	R	G	W	**p-value**
DRIVE	Often	11	14	74	**0.0461**	11	28	61	0.6084
	Seldom	27	12	61		12	20	68	
GENDER	Male	26	19	55	**0.0049**	12	25	63	0.9983
	Female	10	9	81		12	25	63	
AGE	≤25	19	16	65	0.1074	13	20	66	**0.0538**
	>25	9	6	84		6	41	53	
MARITAL	Married	12	6	82	0.4572	18	41	41	0.1149
	Unmarried	17	15	68		11	22	67	
KIDS	Yes	7	3	90	**0.0222**	17	43	40	**0.0088**
	No	20	16	64		10	20	70	
WALK	Often	20	20	60	0.5597	5	35	60	0.3833
	Seldom	17	12	71		13	23	64	
ACCIDENT	Yes	12	21	67	0.2764	15	27	58	0.672
	No	19	11	70		11	24	65	
EDUC	Secondary	20	7	73	0.2519	12	16	72	0.2768
	Higher	16	17	68		12	29	60	
EMPLOY	Employed	13	14	72	0.2973	11	31	57	**0.0787**
	Unemployed	24	12	65		12	14	74	
RACE	White	18	11	71	0.6752	12	27	61	0.7426
	Minority	16	16	67		12	22	67	

Note: Bold values indicate significance at $\alpha = 0.10$.

Table 10 - Chi-square Test of Association (2-high)

		2-high (Before)				**2-high (After)**			
		CROSS (%)				CROSS (%)			
Variable	**Value**	R	G	W	**p-value**	R	G	W	**p-value**
DRIVE	Often	12	26	62	0.4292	24	11	64	**0.0868**
	Seldom	16	33	51		18	26	56	
GENDER	Male	16	35	48	0.1438	22	14	64	0.6134
	Female	12	23	65		22	20	58	
AGE	≤25	14	36	50	**0.0007**	22	16	62	0.9498
	>25	13	3	84		22	19	59	
MARITAL	Married	12	0	88	**0.0137**	41	12	47	0.1061
	Unmarried	13	33	54		19	18	64	
KIDS	Yes	7	0	93	**<.0001**	37	17	47	**0.0754**
	No	15	36	49		18	17	65	
WALK	Often	20	15	65	0.3024	20	30	50	0.2274
	Seldom	12	31	57		22	15	63	
ACCIDENT	Yes	12	27	61	0.9411	30	12	58	0.356
	No	14	29	57		19	18	63	
EDUC	Secondary	11	27	62	0.7674	16	21	63	0.457
	Higher	15	29	56		24	15	61	
EMPLOY	Employed	14	27	59	0.7983	25	15	60	0.4011
	Unemployed	12	31	57		16	20	64	
RACE	White	11	30	59	0.6492	23	13	64	0.3978
	Minority	16	26	57		20	22	58	

Note: Bold values indicate significance at $\alpha = 0.10$.

Table 11 - Chi-square Test of Association (4-high)

		4-high (Before)				**4-high (After)**			
		CROSS (%)				CROSS (%)			
Variable	**Value**	R	G	W	**p-value**	R	G	W	**p-value**
DRIVE	Often	12	24	63	0.4899	12	24	63	0.4899
	Seldom	20	24	57		20	24	57	
GENDER	Male	23	26	52	**0.059**	20	19	61	0.2353
	Female	9	23	68		17	32	51	
AGE	≤25	18	29	54	**0.0077**	20	22	58	0.1923
	>25	6	9	84		13	38	50	
MARITAL	Married	12	6	82	0.1195	24	41	35	0.1564
	Unmarried	15	27	58		18	23	59	
KIDS	Yes	7	3	90	**0.001**	20	43	37	**0.0244**
	No	17	30	53		18	21	62	
WALK	Often	15	15	70	0.5732	15	45	40	**0.0955**
	Seldom	15	26	60		19	22	59	
ACCIDENT	Yes	9	24	67	0.5483	24	27	48	0.5047
	No	17	24	59		16	25	59	
EDUC	Secondary	16	18	67	0.4799	14	28	58	0.6664
	Higher	15	27	58		20	24	55	
EMPLOY	Employed	12	28	60	0.2701	22	26	52	0.2712
	Unemployed	20	18	63		12	24	64	
RACE	White	15	25	60	0.9552	21	21	58	0.3106
	Minority	15	23	62		15	32	53	

Note: Bold values indicate significance at $\alpha = 0.10$.

Table 12 - Variables Found Significant at Different Significance Levels

Context	CROSS1		CROSS2	
	Significance Level (α)		Significance Level (α)	
	0.05	0.1	0.05	0.1
2-low	KIDS	DRIVE GENDER	KIDS	–
4-low	DRIVE GENDER KIDS	–	KIDS	AGE EMPLOY
2-high	AGE MARITAL KIDS	–	–	DRIVE KIDS
4-high	AGE KIDS	GENDER	KIDS	WALK

Note: (–) means that no variable was found significant for that combination.

The variables ACCIDENT, EDUC, and RACE were the only variables not found to be significant in any context. The variables found to be significantly associated with the crossing time (Table 12) are discussed below.

- *Do you have kids? (KIDS)*

The results show that KIDS is significantly associated with CROSS in all contexts, and before and after interventions. From Tables 8 – 11, the percentages of people choosing to cross during the "Walk" (W) phase suggest an interesting result for this particular demographic group. The respondents that had kids were more compliant than the ones without kids in the before-intervention scenario for all contexts. However, completely the opposite happened for the after-intervention scenario, that is, the respondents with no kids were more compliant in all four contexts. These results suggest that the interventions did have a positive effect on people without kids, which account for seventy-nine percent (79%) of all the survey respondents (Table 4).

Recalling that the no intervention group showed a bias towards the second response being less compliant, the lower compliance in the after response for people with kids is not surprising.

- *How often do you drive? (DRIVE)*

The variable DRIVE is significant for the contexts "2-low" for before and after interventions, "4-low" just for before interventions, and "2-high" just for after interventions. For context "2-low" before and after intervention (Table 8), the respondents chose to cross under the "Walk"(W) signal which indicates a compliant behavior, regardless of their choice of driving "often" or "seldom". However, the respondents who drive more often are slightly more likely to have a compliant behavior than the ones who seldom drive. This is true for both before and after scenarios. Similarly, contexts "4-low" before interventions (Table 9), and "2-high" after interventions (Table 8), show a compliant behavior for both "often" and "seldom" drivers, again, with the "often" drivers having a slightly higher compliance percentage than "seldom" drivers.

- *What is your gender? (GENDER)*

Table 12 shows that GENDER was significantly associated with CROSS1 for contexts "2-low", "4-low", and "4-high", which means they are significant for the before-intervention scenario. Tables 8, 9, and 11, show that females show a more compliant behavior than males, even though they both show a compliant behavior across those three contexts. Therefore, women are more compliant and are more likely to wait longer than men to cross a street in this sample.

- *How old are you? (AGE)*

AGE was significant for the following contexts: "4-low" after, "2-high" before, and "4-high" before (Table 12). The percentages from Table 8 show that the respondents (either ≤25 or >25 years old) reflected a compliant behavior since the majority of them chose to cross during

"Walk" (W). However, for this particular context, the group equal or younger than 25 years old has a higher compliance percentage. As for the "2-high" and "4-high" contexts (Table 10 and 11, respectively), completely the opposite was found. Both age groups were compliant but the group older than 25 years old reflected a more compliant behavior.

- *Marital status (MARITAL)*

The MARITAL variable was only significant in the "2-high" context before interventions. According to Table 10, eighty-eight percent (88%) of the married respondents chose to cross under "Walk" (W) versus fifty-four percent (54%) of the unmarried group. It is important to recall that the great majority of the people surveyed are not married (88%, Table 4), but still the married group was the one showing the higher compliance percentage, even though both groups were mostly compliant.

- *What's your employment status? (EMPLOY)*

Employment status was significant only for the after-intervention scenario of the "4-low" context (Table 9). Both employed and unemployed groups were compliant (crossed under "Walk"), but a higher compliance was reflected by the unemployed group.

- *How often do you walk? (WALK)*

The WALK variable was significantly associated with CROSS2 for context "4-high" (Table 11). According to the results, people who seldom walk are more compliant than people who walk often.

CONCLUSIONS

The findings of this study suggest that the use of pedestrian safety interventions do have an effect on pedestrian crossing behavior. The fact that their stated compliance with pedestrian signals did not worsen, as did the control group, and predominantly improved, indicates the positive effect of the interventions. Therefore, this study was successful at testing for the association of pedestrian safety interventions and pedestrian crossing behavior, as well as discussing the nature of such association.

This study was also able, by using stated preferences, to identify several demographic behavioral trends regarding street crossing behavior. Women showed a more compliant behavior, as well as people twenty-five years or younger after the interventions. Also, married people, people who drive more often, and people who seldom walk showed a more compliant behavior. Demographic variables that are not usually taken into consideration in street crossing behavior analyses were considered in this study. The findings of this study could serve as a guide of potential factors or variables to be taken into consideration when studying street crossing behavior and consequently could help to improve pedestrian street crossing behavior models.

This study also provides insight on what kind of interventions might have a better effect on people. The discussion only group (DO) was the one with more positive effects on the respondents; contrary, the education and discussion group (ED) was the only one with negative effect. This may suggest that perhaps the quality of information is more important than the amount. An open, concise, and inclusive discussion about pedestrian safety might be better than exhaustive educational material; therefore this research provides a guide on how to approach students at schools or people in general, and these could help in better designs of interventions.

This research focused on determining association, which serves as a starting point in predicting pedestrian crossing behavior. Future research on this matter may look into the development of

prediction models using the variables analyzed in this study. Another interesting research topic would be to look at how certain demographic groups react to the interventions. This paper shows the overall effect of the interventions on the respondents but does not provide specific information about on which demographic groups the interventions had a stronger effect (e.g. men v. women). This research could also serve as a guide for design and moderation of in-person surveys. Minor irregularities were observed during the data collection process that could be improved for future studies. For example, a slight portion of the respondents showed confusion regarding the first and second rounds of the videos since they realized the videos from both rounds were the same, therefore some respondents opted to not answer the second round of the videos. This slight confusion could be improved by having an expert on the research topic moderating the administration of the surveys and the intervention groups as well. Modifications to the layout of the videos could also be a good way to improve the completion of the surveys, as well as changes in the phasing of the signals shown in the videos. Minor changes in the administration of the surveys like the ones just mentioned could lead to significant improvements both in participation and completion rates of the surveys, and consequently major improvements in the quantity and quality of the data.

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APPENDIX A
Educational Material Used for the Education Only Intervention Group (EO)

Pedestrian Safety Facts

This flyer provides an overview of facts about pedestrian safety, especially with respect to overall road safety and interactions with motor vehicles.

In 2012, 4,743 pedestrians were killed and an estimated 76,000 pedestrians were injured in traffic crashes in the United States, as shown in Table 1. This means that, on average, there was **one pedestrian fatality every two hours** and an **injury every seven minutes**. Table 1 also shows that while total motor vehicle fatalities have **decreased** between 2006 and 2012, the number of pedestrian fatalities has **not**. In fact, pedestrian fatalities have **increased** from 11 to 15 percent as a percentage of total roadway fatalities.

Table 1 Total fatalities and pedestrian fatalities in traffic crashes

Year	Total Fatalities	Pedestrian Fatalities	**Percentage of Total**
2006	42,708	4,795	11%
2007	41,259	4,699	11%
2008	37,423	4,414	12%
2009	33,883	4,109	12%
2010	32,999	4,302	13%
2011	32,479	4,457	14%
2012	30,800	4,743	**15%**

UConn researchers (Ivan and Ravishanker) recently studied pedestrian safety when people crossed streets at intersections with traffic signals. They observed crossing behavior and experience for all pedestrians crossing at some time intervals at a sample of locations in central Connecticut.

Some traffic signals have lights where **all vehicle traffic is stopped** for pedestrians. This is called "an exclusive phase for pedestrians". During other signal phases, the pedestrian signal shows "Don't Walk."

- This means that pedestrians are **supposed to wait for the next walk signal**.
- However, **many pedestrians choose to not wait** for the walk signal, but cross on the green light, or even the red light.

What happens to pedestrians trying to cross the road during each kind of signal?

Four kinds of results could occur:

1. **Nothing** happened; signals were red, and vehicles were stopped.
2. **Some kind** of interaction occurred, but there was no risk of the pedestrian being struck by a vehicle. Pedestrians watched vehicles come to a stop before the pedestrian began to cross.
3. "**Minor conflicts**" occurred; the pedestrian and vehicle were on path to collide, but either the pedestrian or the driver did something to avoid the collision much more than two seconds before they would have collided.
4. "**Severe conflicts**" occurred; this was when the pedestrian and vehicle were on path to collide, but either the pedestrian or the driver did something to avoid the collision two seconds or less before they would have collided.

The figures on the next page illustrate the likelihood of minor or severe conflicts happening depending on what the pedestrian chooses to do.

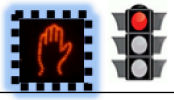
Pedestrians **WERE** in compliance with the signal.

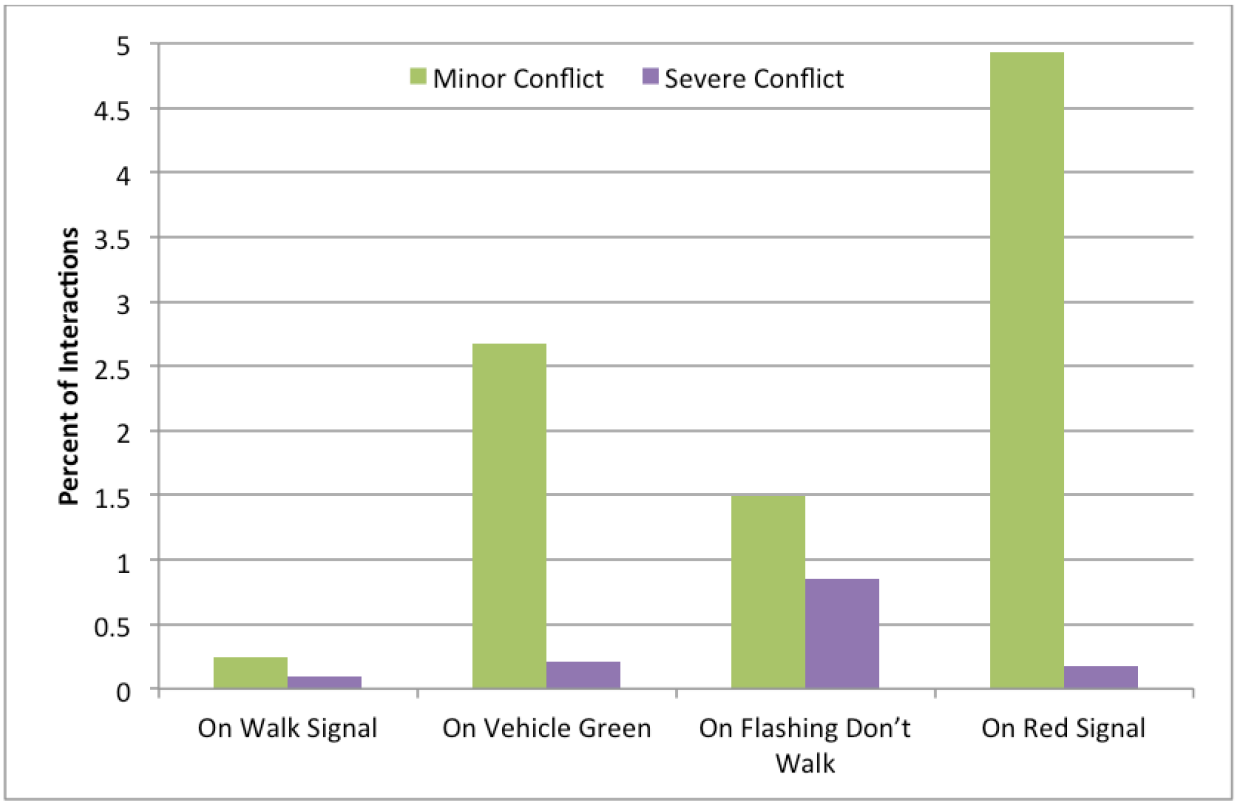
"Walk"

- Pedestrian signal said "Walk"
- All cars stopped at Red Light

0.33% chance of conflict

Pedestrians **were NOT** in compliance with the signal.

On Green	Flashing "Don't Walk"	On Red
Pedestrian signal said "Don't Walk" Cars going in the *same* direction the pedestiran was crossing had a Green Light	Pedestrian crossed after "Walk" signal ended, with a flashing Don't Walk" All cars still had Red Lights	Pedestrian signal said "Don't Walk" Cars going in *same* direction pedestrian was crossing had a Red Light.
		
2.88% chance of conflict (nearly 9 times than if crossed on a walk signal) Pedestrians experienced more highly severe conflicts.	2.34% chance of conflict	5.11% chance of conflict (more than 15 times greater chance than walk signal)



Percent of Pedestrians Experiencing Conflicts for Each Crossing Behavior

APPENDIX B
Questions for moderation of the Discussion Only Intervention Group (EO)

Ground Rules:

A. Speak so others want to listen; listen so others want to speak.

B. Expectations: we will encourage discussion participants to share the air. We want to hear from everyone.

C. The discussion will be semi-structured. You can feel welcome to talk with each other as well as choose whether to respond to questions from us.

D. Please try to speak one person at a time.

Questions

1. What should the street environment be like for pedestrians?
    a. Are there any benefits to this ideal?
    b. Are there any trade-offs or disadvantages to this ideal?
2. How should people cross the road? What approach is best? Why?
    a. When the light for cars in cross traffic turns green
    b. When the light for cars in cross traffic turns red
    c. Whenever they want
3. What times and places are the best to cross the street?
4. What, or who, might influence your decision to cross the street at a certain time or place?
5. What is most frustrating about trying to cross the street?
6. Tell a story about a time when you tried to cross the street but experienced a problem.
7. What is most important to consider about crossing the street?

For the Educational and Discussion group add these:

8. What makes this safety message believable or not believable?
9. Who would you believe?
10. What kinds of messages would be interesting to you?
11. How might you convince someone you care about to change the way they cross the street?

Follow-up: nod, or "mmhm", or a pause to encourage the participant to go on.

Repeating a significant word or phrase can help elicit more.

Probing: Could you say something more about that? Can you give a more detailed description of what happened? Do you have further examples of this?

Specifying: What did you think then? What did you actually do when you…? Have others experienced this?

Indirect: How do you believe other people regard _____?

Structuring: We would like to discuss….

Silence: Participants will have time to think about something to say and break the silence themselves.

Interpreting: Rephrase an answer. You then mean that…? Is it correct that you feel that…? Does the expression ___ cover what you have just expressed?

Do you see any links between ___ and ___?

Direct: (better at the end of the discussion) Have you ever…? When you mention ___ do you think of ___ or ___?

<u>Components of Communicating:</u>

Scene, setting –where, what it's like

Participants…roles, relationships, groups, organizations, lifestyles

Ends, outcomes—expectations, results

Act, act sequence…practices, episodes, actions

Key, or emotional pitch or tone

Instrumentalities means/methods

Norms for interaction and interpretation how things usually go, how we should take them/understand them

Genre type